MOBILEMAN

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Mobile Metropolitan Ad hoc Networks

MOBILEMAN

Project Plans

Deliverable D2

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Project Co-ordinator: Consiglio Nazionale delle Ricerche (Italy)

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

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ABSTRACT

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 present 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.

1. OBJECTIVES

This project investigates the potentialities of the Mobile Ad hoc NETwork (MANET) 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).

This project will analyze the MobileMAN paradigm from three different and complementary perspectives:

- ***Technical Standpoint:*** Development, validation, implementation, and testing of the architecture, and related protocols, for configuring and managing a MobileMAN.
- ***Social Standpoint:*** Validation of the self-organizing paradigm from the social standpoint.
- ***Economic Standpoint:*** Creation of an environment for promoting new business activities and processes.

The main expected results of the project are:

- The development, and validation of effective solutions for the relevant technical issues of self-organizing networks: routing and forwarding, location, medium access control protocols, power management, security and cooperation.
- The hardware/software implementation of the above solutions.
- The integration of the developed solutions in a fully functioning testbed.
- Large-scale testbed with a large users' community.
- Measures (on the real testbed) of the users' satisfaction of the ad hoc networking paradigm.
- Exploitation of the MobileMAN solutions for: i) the creation of start-ups, and ii) novel business processes.

2. WORK ORGANIZATION

According to the different perspectives of the MANET-paradigm investigation, the project activities are 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.

In the following subsections, for each area, are presented its detailed activities.

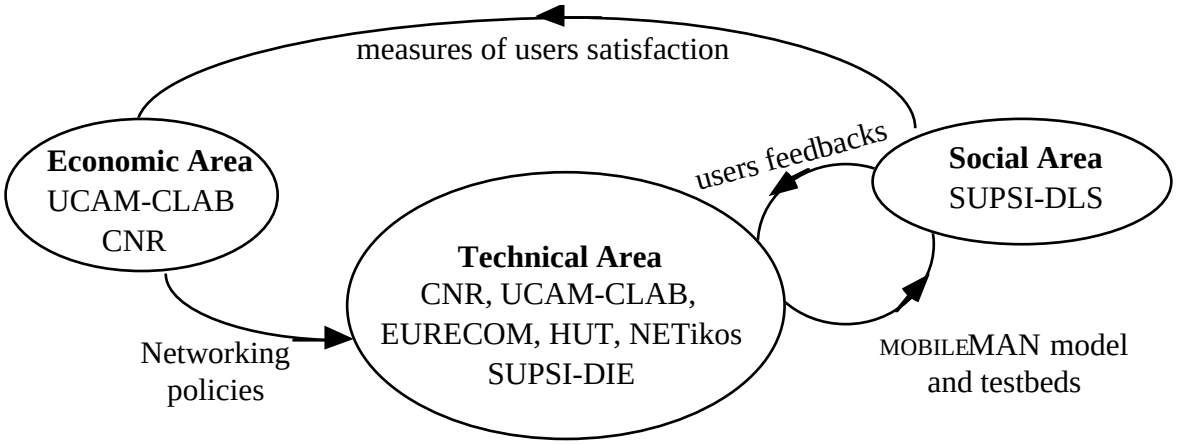

Figure 1: Relationships among the project activities

A Technical Committee (TC) has been set up to coordinate all the activities at technical level. This committee includes (at least) a representative of each project partner, and thus guarantees continuous interactions, and feedbacks among the three areas. The TC will meet during the project meetings. The MOBILEMAN TC, established during the kickoff meeting, is presented in Table I. SUPSI participates with two departments: the Department of Computer Science and Electronics (**SUPSI-DIE**), and the Department of Social Work (**SUPSI-DLS**). For this reason in the TC there are two SUPSI representatives.

Table I. MOBILEMAN Technical Committee

Participant name	Participant short name	Country	Technical Committee members
Consiglio Nazionale delle Ricerche	CNR	I	Marco Conti
University of Cambridge	UCAM-CLAB	UK	Jon Crowcroft
Institut Eurecom	EURECOM	F	Refik Molva
Helsinki University	HUT	FIN	Raimo Kantola
NETikos	NETikos	I	Piergiorgio Cremonese
Scuola Universitaria Professionale della Svizzera Italiana	SUPSI	CH	Ivan Defilippis (SUPSI-DIE) Jennifer Duyne Barenstein (SUPSI-DLS)

2.1 Technical Area

The activities of the Technical Area are summarized by the reference architecture presented in Figure 2. This figure is the refined version of Figure 1 in the Annex 1 "Work Description". Specifically, as shown in Figure 1, the activities of the Technical Areas have been subdivided into three Working Groups (WG):

- WG 1: Applications and Middleware
- WG 2: Networking
- WG 3: Wireless Technologies

Informal meetings will be organized, when necessary, among the partners participating to a WG to promptly coordinate the WG activities. The interactions among WGs are managed during the project meetings, and by the project-manager continuous monitoring of all activities.

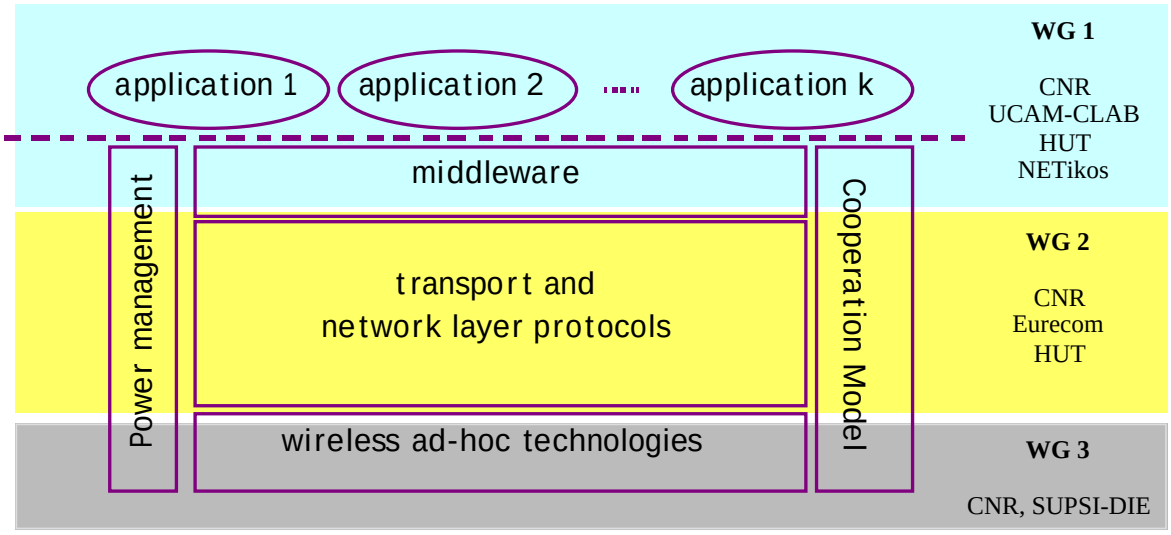

Figure 2. Reference Architecture

As shown in the figure, two research issues span all the three working groups:

- Power management. Battery power is a strategic resource for each mobile device. Therefore, MOBILEMAN devices, as they not only must perform their own tasks but also contribute to the management of the whole network, must have strategies both for power saving and to modify their behaviour under low power conditions. This means that, for example, a device could decide to keep active functions as transmission or location, but refuses to forward other devices' packets. Power management is a complex process that will be addresses in all

MobileMAN functionalities, i.e., from the wireless ad hoc technologies to the middleware. In addition the co-operation model itself will interact with the power management.

- Cooperation Model. A self-organising network must be based on the incentive to the users to collaborate. There must be a mechanism that encourages users to behave as "good citizens" by i) letting their device relay packets for the benefit of other users, ii) making their data available, and iii) providing support to the other computations. Cooperation can be enforced at all levels of the reference architecture. However, the main efforts of the MOBILEMAN project to enforce cooperation will be concentrated stimulate the co-operation in the location, routing and forwarding services. Hence, the activities on the cooperation model will be concentrated in the WG 2. This activity is under the responsibility of EURECOM. CNR will also participate to this activity.

2.1.1 WG 1: Applications and Middleware

MOBILEMAN will not develop new applications, but the project aims to identify existing applications that can become a customer advantage by exploiting the self-organizing paradigm (e.g., messaging exchange and net chatting). Specifically, the added values of the self-organizing paradigm that we wish to emphasize are: free and ubiquitous information sharing, and novel forms of interaction among people (i.e., virtual community of users). The activities related to the Applications are under the responsibility of NETikos that will be in charge to identify and integrate the applications in the MOBILEMAN platform. Both client-server and peer-to-peer (p2p) applications suitable for the MobileMAN environment will be considered. The analysis of MOBILEMAN applications will define the type of services that the middleware layer have to provide. The analysis of existing middleware solutions for mobile environments, and their extension to the mobile ad hoc paradigm, will be performed by CNR, UCAM-CLAB, and HUT. Specifically, CNR will work on p2p platforms for unifying (at application level) systems based on heterogeneous devices, UCAM-CLAB will concentrate on p2p information distribution in ad hoc networks, while HUT will be responsible for development of services discovery mechanisms for ad hoc networks.

2.1.2 WG 2: Networking

In a MobileMAN all the main functionalities of the network and transport layers need to be re-designed to cope with a self-organizing, dynamic, volatile, peer-to-peer communication environment. The first research issues are related to the **location** of users terminals and the definition of suitable **addressing** mechanisms. The purpose of the location mechanism is to dynamically map the terminal logical address to its current location-dependent address. HUT will be the main responsible for this activity. Once a user is located, **routing and packet-forwarding algorithms** must be provided to route the information through the MobileMAN.

Two different directions we be investigated based, respectively, on legacy IETF approaches, and on new ideas emerging after the first experiments on real ad hoc network testbeds.

- IEFT solutions. We intend to include in the MobileMAN architecture (and testbed) some widely accepted routing protocols (e.g., AODV and/or DSR) emerging in the IETF MANET working group. This will enable us to compare and validate our results with the existing literature. In addition, we will understand the suitability of IETF approaches in the MobileMAN environment. We will approach these tasks with simulation tools, in parallel with the development of a real network. This area will be primarily under the HUT responsibility.

- New routing and packet-forwarding approaches are based on the claim --emerged also in the ESF/PESC Exporatory Workshop "*Is Mobile Ad hoc Networking part of the future of mobile networking in Europe?"* (see Section 5)-- of a usability "ad hoc horizon" of 3 hops. Beyond this threshold the IEEE 802.11-based ad hoc networking becomes unsatisfactory. This makes interesting to look at simpler approaches based on low-level routing and forwarding solutions. Specifically, we intend to investigate solutions at level 2.5 (LUNAR)[1] and 2 (DCMA).[2] These analyses will be mainly based on simulations, and will be primarily under the CNR responsibility.

The study of the security in the routing protocols will be performed by Eurecom.

Finally, the low reliability of communications (due to wireless communications, users' mobility, etc.), the 3 hops "ad hoc horizon", the existence of "congestion control" mechanisms at the MAC level will require an analysis, and probably a **re-design of Transport Layer mechanisms.** Specifically, CNR will investigate the performance of the TCP protocol in the Ad Hoc environment and, if necessary, will design a "Simplified TCP" more suitable for a MobileMAN.

2.1.3 WG 3: Wireless Technologies

The aim of this working group is the **design of a new MAC protocol** for MobileMAN, and the **design and prototype of a new MAC card** that implements such protocol. CNR will design the new MAC protocol, while SUPSI-DIE is in charge for designing and prototyping the MAC card. These activities will be performed according to the following guidelines:

- Develop an enhancement wireless multiple access layer using **IEEE 802.11b** (Wi-Fi) as the **reference technology**.

[1] C. Tschudin, R. Gold, "LUNAR: Lightway Underlay Network Ad Hoc Routing", available at http://www.docs.uu.se/docs/research/projects/selnet/lunar/lunar.pdf.

[2] A. Acharya, A. Misra, S. Bensal, "A Label-switching Packet Forwarding Architecture for Multi-hop Wireless LANs", Proceedings of the *ACM Workshop on Mobile Multimedia (WoWMoM 2002)* Marco Conti and Dipankar Raychaudhuri (Editors), Atlanta (GA), September 28, 2002.

- **Minimal changes:** modifications only at the IEEE 802.11b MAC layer (not to the physical layer).
- **Compatibility** with original 802.11b cards.

2.2 Economic Area

This part of the work is under the main responsibility of the University of Cambridge (with a minor participation of CNR). The basic idea is to realise a secondary (with respect to the cellular market) wireless market based also on the ad hoc paradigm. There are four main reasons to go in this direction (see also 6.6 and 6.7 in the Appendix):

- the **low cost-barrier** for a service provider to enter in the market (no expensive infrastructure is required to start with);
- the emerging tendency **to deregulate the spectrum environment** to create a secondary market;
- the **success** of **Wi-Fi hot spots;**
- the needs for users' immersive environments.

The activities performed in this Area, will constitutes an input for the Technical activities. Specifically, expected outputs are policies to control the access to the network bandwidth. Once implemented, these policies will be evaluated by the users. The results of this evaluation will provide a measure of their economic-social value, and will provide a feedback on the economic activities.

2.3 Social work

This part of the work is under the main responsibility of the "Dipartimento del Lavoro Sociale" (DLS) at SUPSI. However, continuous interactions will be established among DLS and partners working in the Technical Area. Specifically, the technical activities will provide the system model and the testbed to be evaluated by the users. This evaluation will be achieved by:

- *Empirical research based on forms to be filled*. A relatively large population will be used to gain perception of the system's potentials and limits in broadening people's network of social relationships
- *Field-trial evaluation*. A large population of users will be provided with MobileMAN terminals and through the developed methodology their satisfaction will be evaluated. This will avoid traditional misunderstandings between information technology designers and their recipient groups.

The results of these evaluations that provide measures of the users acceptance of the MobileMAN system, will be used as a feedback on the technical activities.

3. WORK PLAN

The work described above will be conducted in four work-packages: a common baseline for the project activities (WP1), Domain Modelling (WP2), System Development (WP3) and Integration, Evaluation and Social Analysis (WP4). On top of them, we introduce a work-package for the project management (WP0). An additional work-package will deal will all aspects of exploitations and dissemination (WP5). Figure 2 shows the correspondence among project phases and work-packages, which are presented thereafter.

WORKPAKAGE LIST

WP N.	WP Title	WP Leader	Person Months	Start Month	End Month	Deliverable N.
WP0	Project Management	CNR	17	1	36	1
WP1	Baseline	CNR	23	1	36	2,3,4, 9,20
WP2	Domain Modelling	EURECOM	59	2	30	5, 7, 10, 13
WP3	System development	SUPSI-DIE	106	6	32	6, 11, 12,14
WP4	Integration, Evaluation and Social Analysis	CNR	85.4	16	35	8,16,17
WP5	Dissemination, and Exploitation	UCAM-CLAB	27.3	12	36	15, 18, 19
	TOTAL		**317.7**			

Hereafter a brief description of the each WP objectives is given. In addition, the WP coordinators are identified. The details of each WP activities, and the temporal diagram of each activity are reported in the Annex 1 “Work Description”.

WP0– Project Management (WP coordinator: Marco Conti, CNR)

Objectives: Guarantee: the successful completion of the project within agreed time, cost and quality, compliance with the EC standard and procedures for the project management and tracking, an effective communication channel among the consortium partners.

WP1– Baseline (WP coordinator: Marco Conti, CNR)

Objectives: Establish a common baseline for the project activities to be accomplished during its lifetime, ensuring that all consortium partners have a clear understanding and agree with respect to project goals, planning, success criteria and results exploitation policy.

WP2 – Domain Modelling (WP coordinator: Refik Molva, EURECOM)

Objectives: The aim of this WP is to define the MobileMAN architecture and protocols, in line with the needs virtual communities (VC). Applications relevant for our VC will be identified. In addition, the WP will provide models and methods for investigating the socio and economic value

of the ad hoc networking paradigm. In order to evaluate the project successes and to the reduce the risks, after a first domain model definition, the WP's work will proceed with continuous feedback from users (WP4). Specifically, Self assessment phases will be performed at months 12 and 24 to compare and contrast the project results versus the project success criteria defined in WP1.

WP3 – System Development (WP coordinator: Ivan Defilippis, SUPSI)

Objectives: The aim of this WP is to implement the MobileMAN innovative components at networking and service layer of the architecture as defined by WP2.

WP4 – Integration, Evaluation and Social Analysis (WP coordinator: Marco Conti, CNR)

Objectives: This WP will integrate the HW/SW developed into the final system; install the integrated architecture in each node, make the installed solution operational (with some "innovative" applications) for the selected virtual communities, and collect and analyse the impact in the different virtual communities. Qualitative study of the social and anthropological consequences of the utilization of the system. The collected information through the test with the selected VC allows a revision of the experimental methodology for evaluating the social, anthropological and economic potential of MobileMAN previously designed (WP2).

WP5 Dissemination and Exploitation (WP coordinator: Jon Crowcroft, UCAM-CLAB)

Objectives: Analyse the market for the MobileMAN solution, define the exploitation plan and disseminate the project results in different forums.

4. SUCCESS CRITERIA

In this section we describe the success criteria we have identified for assessing project success in terms of project execution and final result. Specifically, we have defined, in detail, the criteria for assessing the success of the first year of the project. For the second, and third year of the project we have defined the major goals that the project have to achieve during these phases. More detailed success criteria for the second and third year of the project will be defined at the end of the first and second year of the project, respectively, in order to align the success criteria with the learned lessons. The updated success criteria for the second, and third year of the project will be reported in the *Project intermediate evaluation reports* (i.e., deliverables D4 and D9).

4.1 First Year

The objectives reported below constitutes 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, Jaxta, 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 location and functionalities (routing, forwarding, and location).

Wireless Technologies

- Analysis of the limits in 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

4.2 Second Year

- 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.

- Investigate market-based mechanisms for exploiting the self-organised paradigm as output of both the users' satisfaction and the advantages of some class of applications in MobileMAN environment.

4.3 Third Year

- The harware implementation of the MobileMAN enhanced NIC.

- A large-scale testbed with a large users' community.

- Measures, on the real testbeds, of the users' satisfaction of the ad hoc networking paradigm.

- Exploitation of the MobileMAN solutions for the creation of start-ups and novel business processes

5. IDEAS, METHODS AND TOOLS

The MOBILEMAN project will concentrate on the novel concepts required to achieve the project goals, **avoiding the not-invented-here attitude**. To this end, whenever possible we will complete our results with existing tools methods and ideas. Moreover, we will work to create an ad hoc community, among other European projects in the area. A forum where discussing and exchanging these information and ideas. In this section we summarize the external ideas, methods and tools that will be exploited for the MOBILEMAN project.

5.1 ESF/PESC Exporatory Workshop

In order to support ad hoc networking, we worked towards the creation of such a forum, and organised a workshop that brought together the major researchers on this field in Europe: the ESF/PESC Exporatory 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.The aim of the workshop was the investigation of the technical issues, potentialities and market perspective of the Mobile Ad hoc NETwork" (MANET) paradigm. Specifically, this workshop provides the following important contributions to the MOBILEMAN project (see, http://www.iit.cnr.it/esf2002 and http://www.esf.org/pesc/workshops/02):

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.

In addition, from the workshop discussions the participants agreed on the following important conclusions:

- Current ad hoc networks are just few hops
- The current 802.11 cannot support ad hoc networking as it is. 802.11 has been developed mainly for supporting infrastructure-based WLANs. Evolution of the 802.11 technology for an efficient support of the ad hoc mode is expected.
- Security and cooperation is a must for economic and social development of ad hoc networking
- Research must not concentrate on killer applications for ad hoc networking but stress the fact that applications can be killer because of the ad hoc technologies.
- Ad hoc networking is a rare example of technology that is in the hands of the users. Hence, it is one of the technologies that is going to impact the most the social and economic life of end users in a direct way.
- Mobile ad hoc networking is one of the future direction of mobile networking, and it is going to have a high impact on future European activities.

It is worth pointing out that the Workshop coordinators, Marco Conti and Silvia Giordano, are highly involved in the MOBILEMAN project. Specifically, Marco Conti is the project manager and

Silvia Giordano is the contact person for SUPSI. Therefore, as evident from the descriptions given in the appendix, the ESF workshop results have been (and will be) directly used as inputs for the MOBILEMAN activities, and the presentations and discussions given at this workshop represent now an important source of ideas for the MOBILEMAN project. Additionally, all the contacts established with this workshop will be fundamental for the future co-ordination of MobileMAN activities in the Europe.

In addition, to the projects presented in the framework of the ESF workshop, other projects and research activities provide interesting and relevant ideas for MOBILEMAN.

5.2 Other Relevant Research Activities

5.2.1 Forwarding in Ad Hoc Networks

In ad hoc networks each station logically operates similarly to a router. However, from the physical standpoint, there is a significant difference between a router and a station in an ad hoc network. The difference, from the forwarding standpoint, between an ad hoc station and a router, has been recently pointed out in:

> A. Acharya, A. Misra, S. Bensal, "A Label-switching Packet Forwarding Architecture for Multi-hop Wireless LANs", Proceedings of the *ACM Workshop on Mobile Multimedia (WoWMoM 2002)* Marco Conti and Dipankar Raychaudhuri (Editors), Atlanta (GA), September 28, 2002.

The first question addressed in this work is which is the best architecture for forwarding a packet in ad hoc networks. By answering to this question the authors have proposed an architecture for efficient packet forwarding at stations in multi-hop ad hoc networks. In this architecture the forwarding is completely managed by the network interface card (NIC). Upon receiving a packet, the NIC (by exploiting some local information) determines whether or not the packet has to be retransmitted. Only packets destined to the station itself are passed to higher level protocols. Due to its behavior the proposed architecture has been named Cut-through architecture.

5.2.2 Ad Hoc Networks and the First Mile

An important idea that is emerging in the literature (see the work by A. Acharya et. Alt., and also 6.1 in Appendix), and that constitutes a relevant input for MobileMAN is related to the possibility of utilizing the ad hoc paradigm as an important and promising building block for solving the first mile problem in hot spots. This perspective, given the success of Wi-Fi hot spots, adds an important economic value to the ad hoc paradigm. The basic idea is related to the decrease of the transmission range when the data rate is increased. It is expected that the bandwidth request in hot spots will increase very fast, thus requiring higher speed access technologies. On the other hand, increasing the transmission rate (while maintaining the same transmission power) produces a

reduction in the coverage area of an access point. It seems not a feasible solution to spread in a hot spot a large number of Access Points uniformly and closely spaced. Using multi-hop technology seems to be a promising approach to cope with this problem.

5.2.3 Other Projects

Other relevant inputs for the MobileMAN project will come from the Cambridge Mobile projects (see http://www.cl.cam.ac.uk/~rc277/gprs.html), and The Equator Interdisciplinary Research Challenge (http://www.crg.cs.nott.ac.uk/~cmg/Equator).

5.3 Software Methods and Tools

For the implementation of the MobileMAN solutions, the open source software approach will be adopted. Specifically, the software will be developed using the Linux operating system. We have also selected, as reference hardware platform, the Personal Digital Assistants of the IPAQ family.

Finally, for the simulations of the overall MobileMAN architecture we will mainly adopt Glomosim and its commercial version Qualnet. Preliminary analyses have indeed pointed out the limitations and difficulties in using the ns-2 simulation tool. For the simulation of single components, e.g., the enhanced MAC, we envisage to use also the RESQ simulation tool.

6. APPENDIX

In this appendix, we summarized the projects and activities related to ad hoc networking that are currently performed at the European level and that constitute valuable inputs to MOBILEMAN. The abstracts reported below summarize the presentations given at the ESF/PESC Exporatory 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.

6.1 The Broadway Project: the way to broadband access at 60GHz

IST-2001-32686 http://www.ist-broadway.org/ (presented by I. Stavrakakis, A. Vaios, University of Athens, Greece)

Broadway aims at developing a hybrid dual frequency system based on a tight integration of HIPERLAN/2 OFDM high spectrum efficient technology at 5 GHz and an innovative fully ad hoc extension of it at 60 GHz named HIPERSPOT. This concept extends and complements existing 5 GHz broadband wireless LAN systems in the 60 GHz range in order to provide for a new solution to very dense urban deployments and hot spot coverage. This system will support nomadic terminal mobility in conjunction with higher capacity (achieving data rates exceeding 100 Mbps). The main objective is to offload the 5 GHz radio band in dense deployment areas, to exactly focus radio beams and to allow unlicensed and self-organising autonomous operation. Seamless switching between 5 GHz and 60 GHz is supported. Two 60 GHz operation modes are specified yielding 2 device classes: high end (exceeding 100 Mbps) and lower cost. HIPERSPOT is based on HIPERLAN/2 hardware extensions ensuring backward compatibility with 5 GHz WLANs. Five main scenarios of application requiring such extensions of current 5GHz WLAN technologies have been identified. These are the scenarios of vendors' hot spot coverage, public Internet access, high-density residential dwellings and flats deployment, corporate environment and campus environment that have specific functional requirements and physical parameters. The main contribution of Broadway is the research and development of the integrated 5 GHz and 60 GHz QMMIC front end based on hybrid HEMPT technology and the implementation and demonstration of the self-organizing multi hop functionalities. This tight integration between both types of system (5/60 GHz) will result in a wider acceptance and lower cost of both systems through massive silicon reuse. The new radio architecture will inherently provide - by design - backward compatibility with current 5 GHz WLANs (ETSI BRAN HIPERLAN/2) and thus, the innovations coming out of this project will be a driver for standardization and spectrum allocation for the next ETSI BRAN HIPERLAN generations.

6.2 Making sensor networks useful: Distributed services in sensor networks

http://www.eyes.eu.org (presented by H. Karl, Technical University Berlin, Germany)

While wired sensor networks are used in many application scenarios, wireless sensor networks are a fairly new area of research. They are enabled by progress in low-power electronics and simple yet efficient radio communication. Developing concepts and communication protocols that are suitable for the specific needs of wireless sensor networks has been and is the topic of many research projects. One of these projects is the new EYES project. This talk presented one of the aspects of the EYES project where it differentiates itself from other projects: It is claimed that simple sensor networks that are only capable of transporting bits from one node to another are only of limited usefulness and that adding distributed services and algorithms to sensor networks is imperative for making them practical. Specifically, the EYES project will investigate group management, semantic addressing, aggregation and collaboration algorithms as well as supporting mechanisms like failure detection in the context of sensor networks. First

results are expected within the next couple of months; more information can be found at http://www.eyes.eu.org and http://ww-tkn.ee.tu-berlin.de

6.3 Biology-Inspired techniques for Self Organization in dynamic Networks

BISON: IST-2001-38923 http://www.cs.unibo.it/bison/ (presented by L. Gambardella, IDSIA, Switzerland)

BISON will explore the use of ideas derived from complex adaptive systems (CAS) to enable the construction of robust and self-organizing information systems for deployment in highly dynamic network environments. BISON will cast solutions to important problems arising in Ad-Hoc and Virtual networks, P2P and Grid computing systems as desirable global properties that systems should exhibit. It will then search for CAS, which can bring about these global properties. Yet BISON will seek to go even further than this, by working to systematize this process to develop a coherent set of heuristics that can guide the search for CAS giving a desired global behavior. Progress in this direction will give us a systematic framework for constructing solutions to the original problem that inherit the attributes of CAS, including self-repair and self-organization. We expect to achieve this goal by restricting the class of problems and by drawing inspiration from nature systems like insect colonies and immune networks.

6.4 FleetNet Vehicular Ad-Hoc Networks

http://www.fleetnet.de/ (presented by M. Mauve, Universitat Mannheim, Germany)

The FleetNet project aims at the development and deployment of ad-hoc network technology for inter-vehicle communication. The main goal is to enhance both safety and comfort of the passengers. For example, vehicles can use other vehicles as remote sensors to detect dangerous situations, such as ice on the road or the beginning of a traffic jam. By employing multi-hop ad-hoc routing this information can be forwarded over multiple vehicles from the sender to the receiver. This increases the range for the detection of dangerous situations dramatically. In the context of FleetNet all aspects of vehicle-to-vehicle communication by means of ad-hoc network technology are investigated. Examples include the radio hardware, medium access protocols, routing, and applications. One particular challenging problem is the forwarding of messages through the highly dynamic topology formed by the vehicles. For this task position-based routing strategies seem to be a very good fit, since they do not require the maintenance of routes and since position information is available through vehicular navigation systems. Within FleetNet it was shown that for realistic movement patterns position-based routing performs very well, even when oncoming traffic is used to forward messages, i.e., when the topology of the network is extremely dynamic. Existing position-based routing mechanisms were further improved by eliminating the need for beacons and thus reducing overhead and the appearance of routing loops as well as increasing connectivity.

6.5 Terminodes: self-organised networks

Funded by Swiss National Foundation http://www.terminodes.org (presented by S. Giordano, Swiss Federal Institute of Technology, Lausanne (EPFL), Switzerland)

The Terminodes project's goal is to study fundamental and applied questions raised by new generation mobile communication and information services, based on self-organisation. This is supported by athe MICS center. The Center's distinguishing feature is to bring together a broad set of researchers (about 30 faculty members and 70 PhD students at term) to study most aspects of self-organizing, distributed communication and information services in a coherent manner. These investigations range from fundamental mathematical issues (statistical physics based analysis, information and communication theory) to networking, signal processing, security, distributed systems, software architecture and economics. It is believed that this

integrated, cross layer view is necessary to address coherently the issues, and thus to potentially have a substantial impact.

6.6 Virtual Immersive Communications (VICOM)

Funded by Italian Ministry for Research (presented by E. Gregori, Italian National Research Council (CNR) - IIT Institute, Italy)

The VICOM project is a three-year project funded by the Italian Ministry for University and Research. VICOM aims to study and develop techniques, protocols and applications leading to the implementation and evaluation of two major demonstrators in the field of Virtual Immersive Telepresence (VIT)). The demonstrators have been chosen to represent complementary needs in terms both of applications scenarios and technologies (infrastructure platforms, development systems, support terminals). With this goal in mind the demonstrators will deal respectively with mobility in immersive environments and with immersive tele-training. Both these environments will require the study of enabling technologies - in particular mobile and fixed telecommunications networks and distributed information processing.

6.7 Technical, Economic and Regulatory Aspects of Spectrum Allocation

http://www.cl.cam.ac.uk/users/jac22/out/cmi.pdf (Presented by S. Ostring, University of Cambridge, United Kingdom)

The current approach used by regulatory bodies in allocating spectrum, (where bands are employed to ensure that interference between different groups of users does not occur) is being challenged by technologists and special task force groups within government agencies. It is considered that optimal use of spectrum is not being achieved, and that the theoretical capacity of radio spectrum can be approached by dynamic spectrum allocation. In this open spectrum paradigm, we have identified technical, economic and regulatory issues that need to be addressed. In particular, we seek a fundamental understanding of spectrum capacity and protocols that can approach these capacity limits. Coordination between users must also be addressed, as open spectrum no longer strictly defines bands in which these users can communicate. Finally, we consider the role of the regulator, which moves from having primary responsibility for spectrum allocation to a secondary role, where interactions between users are regulated.