Scientific Report

ESF/PESC Exploratory Workshop

Is Mobile Ad hoc Networking part of the future of mobile networking in Europe?

Hotel Cinque Terre
Monterosso al Mare - La Spezia (Italy)

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http://www.iit.cnr.it/esf2002

Co-sponsored by:

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1.1 Executive Summary

The aim of the workshop was the investigation of the technical issues, potentialities and market perspective of the Mobile Ad hoc NETwork" (MANET) paradigm.
A MANET is a system of wireless mobile nodes dynamically self-organising in arbitrary and temporary network topologies. **People** and **vehicles** can thus be internetworked in areas without a pre-existing communication infrastructure, or when the use of such infrastructure requires wireless extension. Therefore, such networks are designed to operate in widely varying environments, from military networks (with hundreds of nodes) to low-power **sensor networks** and other embedded systems.
The workshop debated challenging aspects of Mobile Ad-hoc Networking from different points of view (the researchers community of this workshop is very heterogeneous), in order to evaluate the future impact of this technology in the European research world, as well as in real life in Europe.
In a MANET, **no infrastructure** is required to enable information exchange among users' mobile devices. These devices -- which we call terminals -- as an evolution of current mobile phones and emerging PDA's equipped with wireless interfaces. Terminals are goods that many people can purchase at (relatively) low cost and operate without per-use service fees. The only external resource needed for operation is the bandwidth, i.e. in the (unlicensed) ISM band. This is the band in which wireless access technologies such as IEEE 802.11 and Bluetooth operate. Nearby terminals can communicate directly; **specialized media access control (MAC) protocols** are necessary to coordinate their transmissions in order to avoid radio interference. Terminals that are not directly connected communicate by forwarding their traffic via a sequence of intermediate terminals. As the network topology changes due to user mobility, traffic must be re-routed to compensate. Because the users' terminals provide this **cooperative multi-hop forwarding** functionality, no specialized devices (such as Internet routers or cellular towers) are required. In addition to connectivity, the terminals of a MANET must also cooperatively provide the host of services -- naming, security, service discovery, data replication -- needed to support applications used in the MANET network.
MANET are not intended as a replacement for current infrastructure based (wired and wireless) networks. It is intended to complement them and to enable new application scenarios in which a centralized infrastructure is impossible, undesirable or unnecessary. In addition the intercommunication between a MANET and the Internet is envisaged. This can be provided by terminals, which have simultaneous access to the MANET and to the Internet, perhaps via special access points or via user terminals with multiple network interfaces (e.g. a PDA equipped with both Bluetooth and GRPS interfaces). The challenges of building a self-organized MANET are substantial: How can we achieve self-organization in a highly dynamic and completely decentralized network environment? The issues that need to be addressed include: **Wireless ad hoc technology**, **Network and**

transport layer protocols, supporting social-operated networking. **Cooperative middleware** services.
A MANET supports a kind of "**citizen's network**" which can reduce communication costs and complexity and improve people's ability to share information anywhere and anytime. MANET will enable the self-organization of people that share common interests (e.g. students at a school) into virtual ad-hoc networks in which they can **freely communicate**. MANETs can play a key role in advancing this **user-centric** approach to the information society, enhancing open communication and the free flow of information within society.
The MANET approach also has **industrial relevance**. It complements existing wireless communications services with efficient, low-cost local multimedia services. It offers a solution to the problem of "wireless operator as kingmaker" by introducing a new technical, economic and social model of a self-organized network. For emerging wireless commerce, some analysts say, "wireless operators are best placed to assume the role of kingmaker because they control the wireless networks and own the subscriber relationships". In the infrastructure-less approach this position is challenged, and the economic and social model changes. Moreover, the deployment of new developments does not require involvement from major infrastructure players, significantly **reducing the cost-barriers** to creating services on a temporary or experimental basis. The new paradigm of a low cost self-organized local network communication can effectively complement the services available in wireless infrastructure.
Finally, the MANET paradigm has humanitarian relevance, considering Europe's increasing role providing aid during conflicts and natural disasters. A MANET can support local emergency communications, without relying on expensive and vulnerable infrastructure.
The MANET approach constitutes, therefore, a challenging research area that may lead to the creation of a secondary wireless market. Through research and industrial efforts, Europe has established world-renowned leadership in infrastructure-based mobile communications. Long-term research in infrastructure-less mobile communications has the potential for technological innovation that will allow Europe to continue being an actor in future generation mobile systems. Currently, the US drives research this area, mainly in the context of defence-related projects. It is important that this project be carried out at the **European** level, bringing together complementary expertise and heterogeneous user requirements and overcoming geographical barriers that could negatively affect the significance of results obtained at the national level.

The aim of the workshop has been threefold:

i) to make an analysis of the state-of-art in the European research in this field;
ii) to construct an European community that can balance the current US leadership in this area.
iii) To analyze the role of the MANET paradigm on the future mobile ad hoc networking in Europe.

1.2 Workshop Final Program and Schedule

For details on the presentations see the Workshop Brochure (Attached) and the Workshop Web site: http://www.iit.cnr.it/esf2002

10 October 2002

15.00 – 15.30	**Welcome & Opening Remarks**
15.30 – 16.00	**Session 1: Standardization of Ad Hoc Networking**
16.00 – 16.30	Coffee Break
16.30 – 18.00	**Session 2: Technologies for Ad Hoc Networking**
20.30	**Social dinner**

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9.00 – 10.30	**Session 3: Ad Hoc Networking**
10.30 – 11.00	Coffee Break
11.00 – 13.00	**Session 4: Cooperation and Security in Ad Hoc Networking**
13.00 – 15.00	Lunch
15.00 – 16.30	**Session 5: Ongoing Mobile Ad Hoc Projects in Europe**
16.30 – 17.00	Coffee Break
17.00 – 18.30	**Session 6: Ongoing Mobile Ad Hoc Projects in Europe**
20.30	Social dinner

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9.00 – 10.30	**Session 7: Ongoing Mobile Ad Hoc Projects in Europe**
10.30 – 11.00	Coffee Break
11.00 – 13.00	**Panel Discussion and Conclusions**
13.00	Lunch

1.3 Scientific content of the event

The workshop was organized in **three main parts**:

i) A discussion on the main MANET **technical issues** and the way they are currently addressed by European researchers in this field. The workshop covered issues as the enabling technologies (wireless networks, multiple access protocols, etc.), the network-layer issues (addressing, location, routing, etc.), as well as the higher layers.

ii) A **presentation of the main projects** (at the national and at the European level) that are addressing the problems of self-organizing networks.

iii) A **final discussion** that provided an answer (yet partial) to the workshop main question: "Is Mobile Ad Hoc Networking Part of The Future of Mobile Networking in Europe?" As further action, with the aim of continuing the discussion and the collaboration, it was considered the **creation a European community** that can balance the current US leadership.

1.3.1 Technical issues

To better understand the status of the European research. The first session of the workshop was devoted to make the state of the art on the standardization activities related to the MANET paradigm currently ongoing in the IETF framework. Therefore this presentation gave an overview of the main USA research activities Then we started analyzing the European research. To these end the activities were grouped into three main areas: i*) Wireless Technologies for Ad Hoc Networks ii) Ad Hoc Networking*, iii) *Cooperation and Security*.

Session 1: Standardization of Ad Hoc Networking

L. Feeney presented the status of activities relevant to ad hoc networking in the IETF, rather than to review the details of the ad hoc routing protocols that are under discussion by the IETF MANET working group.

Most work is taking place in the MANET working group, where four routing protocols are currently under active development. These include two reactive routing protocols, AODV(Nokia/UCSB) and DSR (CMU/Rice), and two proactive routing protocols, OLSR(INRIA) and TBRPF (SRI). It should be noted that the progress of TBRPF within the IETF has been significantly hampered by intellectual property rights (IPR) issues, due to SRI's patent claims on the protocol.

There has been good progress in studying protocol behavior --- almost exclusively in simulation --- as can be seen in the large conference literature in this area. The focus of the IETF working group is to define a detailed specification for each protocol, sufficient for developing independent, interoperable implementations. Progress continues to be made in this key area.

The most important area in which progress must be still made is the development of interoperable implementations. There are full implementations of each protocol. AODV appears to have the greatest traction, with three or four mature implementations. An AODV interoperability test was held this summer, and was generally successful. The extremely limited scope of testing -- only half a dozen nodes -- suggests that only the most basic functionality was exercised. The absence of performance data in non-trivial networks continues to be a major problem. The Uppsala University APE testbed is one of the largest, having run tests with more than thirty nodes (carried by students walking through scripted scenarios). It is not entirely clear how these protocols will move forward within the IETF. It seems likely that three or possibly four protocols (IPR issues may impact TBRPF) will move to "Experimental RFC" status, probably in the next year or so. It is somewhat unusual to advance a diverse collection of protocols in this way, in that the goal of standardization is generally unification of existing work. However, a variety of technical and non-technical issues have made it difficult to reach the goal of standardizing single protocols for proactive and reactive operation. At least in part, this is because there is not yet a sufficient body of experience to make informed assessment of protocol -- ad hoc routing is still a very much a research problem as well as an engineering and standardization
problem. It is not yet clear how ad hoc networking will evolve within the IETF. One possibility is that the work will move to the IETF's sister organization, the IRTF (Internet Research Task Force). Another possibility is that there will be ongoing work in the IETF MANET working group developing a single, minimal protocol.
There have also been some activity in the IETF related to non-routing issues. This includes a collection of minor AODV extensions, such as AODV with QoS support and AODV with service location support. Much more important is progress being made in the IETF zero-conf working group. Although this group does not explicitly address the case of a multihop ad hoc network, they continue to make progress in areas such as decentralized address autoconfiguration, multicast address allocation, service location and multicast DNS. There is also a growing awareness of the role that link characteristics play in the operation of IP protocols in a wireless environment.

Session 2: Wireless Technologies for Ad Hoc Networks.

M. Conti talk was devoted to analyze the current state of the art of wireless technologies for ad hoc networking. The talk focused on two emerging technologies for constructing a Mobile ad hoc network: IEEE 802.11 and Bluetooth. The IEEE 802.11 standard is a good platform to implement a single-hop ad hoc network because of its extreme simplicity. Furthermore, multi-hop networks covering areas of several square kilometers could be built by exploiting the IEEE 802.11 technology. On smaller scales, technologies like Bluetooth can be exploited (perhaps in combination with the 802.11-type technology) to build ad-hoc wireless Personal Area Networks, i.e. networks that connect devices placed inside a circle with radius of 10 meters. The talk pointed out the main research issues related to the use of Bluetooth and 802.11 technologies in the ad hoc networking field. Specifically, as far as Bluetooth is concerned the focus is related to the **Scatternet formation**, while 802.11 research activities are concentrated on **802.11 performance** when it operates in the Ad Hoc mode. These topics were investigated in depth in the successive talks of the session. Specifically, Bluetooth Scatternets was the topic of **R. Bruno** talk, while 802.11 performance were analyzed by **C. Hoene and E. Borgia.**

R. Bruno discussed the Bluetooth Scatternets formation problem. The Bluetooth (BT) technology as described in the Specifications of the Bluetooth System Version 1.1, includes several features that makes it one of the most promising technology for enabling multi-hop wireless networks, or, simply, ad hoc networks. The way the BT technology is used to form ad hoc topologies is via forming a scatternet. If two BT devices are into each others communication range (i.e., they are neighbors), in order to set up a communication link, one of them assumes the role of master of the communication and the other becomes its slave. This simple ``one-hop" network is called a piconet, and may include several slaves, no more than seven of which can be actively communicating with the master at the same time. A scatternet is finally formed by joining piconets. The inter-piconet connection is enabled by the possibility for a BT device to have multiple roles: a node can be a master in one piconet and a slave in multiple piconets. The devices with multiple roles will act as gateways to adjacent piconets.
Among the solutions proposed so far in the literature for solving the scatternet formation problem, some rely upon the unrealistic assumption that all BT devices are in each other transmission range ,"single-hop" topologies. Among the solutions that apply to the more general case of multi-hop topologies, some schemes generate a tree-like scatternet starting from a designated node. Other schemes produce topologies different from a tree, but either require that each node to be equipped with additional hardware that provides to the node its current (geographic) location (e.g., a GPS receiver), or are not able to guarantee theconnectivity of the resulting scatternet. In general, these previous works do not provide a detailed description form the perspective of BT implementation. Furthermore, no thorough performance evaluation is given.
In this talk, Bruno presented and evaluated the performance of a novel scatternet formation protocol, described in details both from the algorithmic and BT implementation perspective, the BlueSar protocol. The protocol produces connected scatternets that have a mesh-like topology in three successive phases: 1) When a BT device starts its operations, it enters the device discovery phase, in which it discovers neighboring BT devices. 2) Using the knowledge of its one-hop neighbors each nodes starts the piconet formation phase, which leads to the assignment of the roles of either master or slave to each node, resulting in a set of disjoint piconets that covers the entire network. 3) The final phase, scatternet formation, concerns the selection of gateway nodes for interconnecting adjacent piconets into a connected scatternet.
The performance evaluation conducted via simulations has focused on: 1. measuring the time needed for scatternet formation (the three phases); 2. assessing the effect of the duration of the device discovery phase on the entire scatternet formation process, 3. counting the average number of piconets; 4. counting the average number of slaves per piconets; 5. counting the average number of roles (either master or slave) assigned to each node, and 6. comparing the average length of the routes between any two BT devices in the scatternet with respect to the average shortest path length between any pairs of nodes in the original network topology. The numerical results show that the Bluestar protocol is able to form a connected scatternet ina reasonable amount of time.

The presentation of **Christian Hoene** focused on how to verify WLAN protocols and enhancements experimental. It is intended for scientist and students. Scientist should know how much can be verified experimentally using commercial, today's available technology. Students learn what WLAN radio modems can be bought, how to program them and how to conduct measurements. Furthermore, we present some of our recent research on WLAN. For example, he conducted packet loss and delay measurements of VoIP streams during slow movement. Our results show that during slow movement, the link quality gets better and the loss rate is reduced as compared to the stationary case.

Finally, **E. Borgia** discussed the performance of the TCP protocol over an IEEE 802.11 Ad Hoc Network. The results presented were obtained by taking measurements on a real testbed. To reduce the complexity of the study, static ad hoc networks were considered, i.e., the network nodes do not change their position during an experiment. Both indoor and outdoor scenarios have been investigated.

> INDOOR EXPERIMENTS. In this case the experiments were performed in a scenario characterized by hidden stations. Four nodes, numbered from 1 to 4 were considered. In the analyzed scenario, a reinforced concrete wall is located between node 1 and node 2, and between node 2 and 3. As a consequence, the three transmitting nodes are hidden to each other, e.g., the nodes 2 and 3 are outside the transmission range of node 1. Node 4 is in the transmission range of all the other nodes. Two sets of experiments were performed by adopting the DCF mechanism, with or without the RTS/CTS mechanism. Two main observations can be achieved from these experiments:
> i) no significant performance differences exist between adopting the RTS/CTS mechanism, or the basic access mechanism only;
> ii) due to the additional overheads of the RTS and CTS packets, the aggregate network throughput with the RTS/CTS mechanism is a bit lower respect to the basic access mechanism.
> These results seem to indicate that the carrier sensing mechanism is still effective even if transmitting stations are "apparently" hidden to each other. Indeed, a distinction must be made between transmission range, interference range and carrier sensing range.
>
> OUTDOOR EXPERIMENTS. In this case the reference scenario is of four ordered aligned nodes. The nodes represent four portable computers, each with an IEEE 802.11 network interface. Two ftp sessions are contemporary active. Node 1 (3) transmits to node 2 (4). Several experiments were performed by varying the distance, *d*, among nodes 2 and 3. In all the experiments, the receiving node is always in the transmission range of its transmitting node --i.e., node 2 (4) is in the transmitting range of node 1 (3)-- while, by varying the distance *d*, the other couple of nodes can be:
> i) in the same transmitting range (Exp#1);
> ii) out of the transmitting range but inside the same carrier sensing range (Exp#2);
> iii) out of the same carrier sensing range (Exp#3).
> The achieved results show that:

i) Exp#1. In this case (all stations are inside the same TX_Range), a fair bandwidth sharing is almost obtained: the two ftp sessions achieve (almost) the same throughput. The RTS/CTS mechanism is useless as (due to its overheads) it only reduces the throughput.
ii) Exp#3. In this case the two sessions are independent (i.e., outside their respective carrier sensing ranges), and both achieve the maximum throughput. The RTS/CTS mechanism is useless as (due to its overheads) it only reduces the throughput.
iii) Exp#2. In the intermediate situation a "capture" of the channel by one of the two TCP connections is observed. In this case the RTS/CTS mechanism provides a little help in solving the problem.

To summarize, measurement experiments have shown that, in some scenarios, TCP connections may suffer significant throughput unfairness, even capture. The causes of this behavior are: the hidden terminal problem, the 802.11 backoff scheme, and large interference ranges.

Session 3: Ad Hoc Networking

Sergio Palazzo gave a presentation entitled "Grouping operations in self-organizing ad-hoc networks" and based on a work jointly carried out at the University of Catania, Italy, by himself, Laura Galluccio, and Giacomo Morabito. This work deals with the problem of Location Management in mobile ad hoc networks where users are organized in groups. In the following this type of systems are referred to as Mobile Ad hoc Networks for Group Operations (MANGO). This work proposes a framework for location management which exploits the tendence of mobile users to spontaneously form groups in MANGOs. The management procedures required to support such spontaneous groups, which are by nature dynamic, are introduced as well. The proposed spontaneous group management is based on a hierarchical location database architecture and the concept of Group Leader, which is a terminal responsible for the location update of a group of terminals. Objective of the proposed framework is minimizing the burden on location databases and, at the same time, the signaling issued by terminals. In this work, distributed operations required to support the whole framework are properly introduced and described. Simulation experiments have been run in order to assess the proposed scheme. Performance results show that the introduced methodology allows faster call delivery, and reduced signaling and location updates.

In his presentation **Chistian Tschudin** first reviewed four major wireless ad hoc networking activities of the Communications Research group at Uppsala University (Per Gunningberg and Christian Tschudin). Which are: conformant implementations of major ad hoc routing protocols, protocol improvements e.g. due to communication gray zones, exploration of new protocol designs (LUNAR) and the Ad hoc Protocol Evaluation testbed (APE). The second part of this talk is on serious obstacles for the mass deployment of ad hoc functionality. Based on their experiences he postulated the existence of a usability "ad hoc horizon" of 3 hops beyond which IEEE 802.11 based ad hoc networking becomes unsatisfactory. Another serious limit is the lack of efforts to turn the technology into an easy to use product. As a consequence he suggests to focus on a) simplicity and modesty regarding the scope of ad hoc functionality and b) on the seamless integration of other link layer technologies which are also part of the realm of self-managed ad hoc networking.

Nasos Vaios focussed on hybrid routing mechanisms. WLANs can be deployed in either infrastructure-based mode or on a pure ad hoc basis. The two most known WLAN standards like IEEE 802.11 and HIPERLAN/2 support ad hoc networking; the first one through the Distribution Control Function while the latter through a mechanism that dynamically selects local coordinators of the traffic demands, the so-called Central Controllers. Although the ad hoc networking concept is already specified in the Home Extension Environment part of the standard, a lot of effort has been directed toward expanding the one-hop cluster network into a multi hop one. This can be achieved by deploying mobile terminals that can play the role of a forwarder and switch between frequency channels in order to keep the inter-cluster link active. Nevertheless, the Broadway project introduces a new challenge for future mobile networks: combination of a WLAN's infrastructure with an ad hoc network. Incorporating ad hoc functionality at 60 GHz into the 5 GHz HIPERLAN/2 OFDM technology is the main objective in Broadway as far as ad hoc networking is concerned. This can be achieved by applying a hybrid routing mechanism and defining the enabling functionalities and key decision metrics. The neighborhood discovery phase needs to be well designed in order for every mobile terminal to discover its one-hop away neighbors by exchanging hello messages at 60 GHz; this information is then sent back to the Access Point that is responsible for all routing decisions. Optimal or good routing decisions need to be taken by selecting the appropriate paths at 5/60 GHz, and assigning specific roles among the nodes inside the 5 GHz cell (cluster head, forwarder node). Metrics needs to be defined and effectively be incorporated in the routing decisions (available bandwidth, on-going traffic, node's battery lifetime, number of hops that constitute a candidate path etc). Obviously, in hybrid environments there can be hybrid routing solutions that limit the concept of traditional fully ad hoc algorithms. Nevertheless, there are always many alternatives when dealing with highly dynamic wireless topologies: some of them "more" and some other "less" ad hoc!

Session 4: Cooperation and Security in Ad Hoc Networking.

This session was concerned with the problem of service unavailability due to either intentional denial of service attacks or selfishness of the nodes. Selfishness is a new problem that arises specifically in the context of ad hoc networks where the nodes belong to multiple administrative domains. In these networks, nodes may tend to deny providing ser-vices for the benefit of other nodes in order to save their own resources (e.g., battery power). P. Michiardi, S. Buchegger, and N. Ben Salem addressed selfishness in the context of packet forwarding.

The presentation of **P. Michiardi** focuses on a security issue specific to mobile ad hoc networks: node selfishness. Unlike networks using dedicated nodes to support basic functions like packet for-warding, routing, and network management, in MANET those functions are carried out by all available nodes. In such networks there is no good reason to assume that a node will cooperate and provide services to each other: service provision consumes energy, a scarce resource that nodes are induced to use for their own communications. It is a realistic assumption that selfish nodes do not perform active attacks, due to the high energy consumption thereof. In the proposed security scheme (CORE), node co-operation is stimulated by a collaborative monitoring technique and a reputation mechanism.

Sonja Buchegger described a work on cooperation of nodes. In game-theoretic terms, cooperation is a dilemma. The dominating strategy for individual nodes is not to cooperate, as cooperation consumes resources and it might result in a disadvantage. But if every node follows that strategy, the outcome is undesirable for everyone as it results in a non functional or entirely absent network. Learning by Observing – CONFIDANT: their approach is to find the selfish and/or malicious nodes and to isolate them, so that misbehavior will not pay off but result in isolation and thus cannot continue. CONFIDANT is short for 'Cooperation Of Nodes, Fairness In Dynamic Ad-hoc NeTworks' and detects malicious nodes by means of observation or reports about several types of attacks, thus allowing nodes to route around misbehaved nodes and to isolate them.

Naouel Ben Salem presented a way for Stimulating Cooperation by Means of Nuglets. In civilian applications of ad hoc networks, where each node is its own authority, nodes may selfishly deny cooperation in order to save their own resources (e.g., battery power, memory, CPU cycles). One approach to solving this problem would be to make the nodes tamper resistant, so that their behavior cannot be modified by their users. However, this approach does not seem to be very realistic, since ensuring that the whole device is tamper resistant may be very difficult, if not impossible. Therefore, they propose another approach that requires only a tamper resistant hardware module (such as the SIM card in GSM phones), called security module, in each node. Under the assumption that the user can possibly modify the behavior of the node, but never that of the security module, our design ensures that tampering with the node is not advantageous for the user, and therefore, it should happen only rarely.

1.3.2 Projects

In the remaining sessions, the following European projects and activities were presented and discussed for identifying common directions and collaborations for the future:

- M. Mauve, Universitat Mannheim, Germany: FleetNet Vehicular Ad-Hoc Networks

  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.
http://www.fleetnet.de/

- S. Giordano, Swiss Federal Institute of Technology, Lausanne (EPFL), Switzerland, Terminodes: self-organised networks - Swiss National Fondation.

  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.
  http://www.terminodes.org/

- E. Gregori, Italian National Research Council (CNR) - IIT Institute, Italy
  Virtual Immersive Communications (VICOM)

  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.

- H. Karl, Making sensor networks useful: Distributed services in sensor networks, Technisches Universitat 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 servives 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

- L. Gambardella, IDSIA, Switzerland, BISON: Biology-Inspired techniques for Self Organization in dynamic Networks - IST-2001-38923

  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. http://www.cs.unibo.it/bison/

- S. Ostring, Technical, Economic and Regulatory Aspects of Spectrum Allocation in the Modern Era, 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.
  http://www.cl.cam.ac.uk/users/jac22/out/cmi.pdf

- M. Conti, MobileMAN - an ad hoc network for the citiziens, Italian National Research Council (CNR) - IIT Institute, Italy

  MobileMAN is a Future Emerging Technology (FET) project funded by the European Commission in the framework of the IST program. http://cnd.iit.cnr.it/mobileMAN This project investigates the potentialities of the Mobile Ad hoc NETwork (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. The research activities cover all layers in the networking hierarchy and combines advanced communications and networking research with basic research. ii) Physical implementation of this architecture for lowers layers (i.e., wireless technologies). This will be done by improving the existing IEEE 802.11 wireless technologies for dealing in bursty access environments as self-organized networks. iii) Integration of applications on top of our self-organized network. iv) Validation of the self-organizing paradigm from the social and economic standpoint.

- R. Kantola, Service Discovery Integrated with Routing in Ad Hoc Networks, Helsinki University of Technology, Finland

  Service discovery is an open issue in Ad Hoc networks. Due to the lack of fixed infrastucture in an ad hoc network well known approaches such as the Domain Name System of the Internet will not be applicable as such. Service discovery has to work both in case of reactive as well as proactive routing protocols. In looking for the solution for Service discovery we need to study the applicability of the Service Location Protocol and other similar protocols, the DNS and the possibility of integration of service discovery with routing.
  http://keskus.hut.fi/tutkimus/projects.shtml#comm

- Stavrakakis, A. Vaios, University of Athens, Greece, The Broadway Project : the way to broadband access at 60GHz - IST-2001-32686

  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.
http://www.ist-broadway.org/

1.3.3 Discussion

The ambitious goal for the development of Europe will be based, among other technologies, on knowledge and deployment of ad hoc networking. This development requires that researchers in the field of information technology develop a shared vision on where we should go and join forces in working towards the envisioned goals. Cooperation among all the European researchers and projects in the field holds great potential in this respect: the bringing together of advanced research results provides a forum for discussion of ad hoc networking issues as they affect Europe leading to strategy and policy inputs;

From this first sharing opportunity, several issues already came out:

1. Current ad hoc networks are just few hops

2. 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.

3. Security and cooperation is a must for economic and social development of ad hoc networking

4. 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.

5. Ad hoc networking is a rare example of technology that is in the hands of the users.

1.4 Assessment of the results, contribution to the future direction in the field

1. Mobile ad hoc networking is one of the future direction of mobile networking
2. Mobile ad hoc networking is one of the technologies that is going to impact the most the social and economic life of end users in a direct way
3. Mobile ad hoc networking is going to have a high impact on future European activities
4. There is a large high quality research in Europe at all levels
5. There is monopoly by small group of US researchers in major fora and conferences on wireless and ad hoc networking (IETF, Mobicom, MobiHoc)
6. There is the need of a higher collaboration and communication in Europe among researchers in order to result more effective in the community
7. In order to better contribute to this field, the participants agreed in group together in a network for better communicating, collaborating and support each other.

1.5 Statistical information on Participants

Participants Countries			
Country	Number Senior Researchers	Number Junior Researchers	Total
Finland	1	-	1
France	1	1	2
Germany	2	1	3
Greece	1	1	2
Italy	5	6	11
Sweden	2	-	2
Switzerland	2	2	4
UK	1	-	1
Total	15	12	27

1.6. List of Participants

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