

The logo for iMdea Networks, featuring the word "institute" in small white text above "iMdea" in large white and blue text, with "networks" in blue text below.

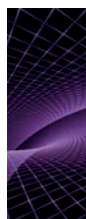
annual report

2010

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madrid institute
for advanced studies



institute
IMdea
networks

annual report 2010

foreword



Albert Banchs

Deputy Director of the IMDEA Networks Institute
June 2011

It is a great pleasure to write this foreword for the Institute IMDEA Networks Annual Report for the year 2010.

IMDEA Networks operates in an area of knowledge that is fundamental to present day society: Information and Communications Technology (ICT). The last few years have seen a transformation in the industrial landscape of ICT. Telecommunications liberalization, the explosive growth of the Internet, and a growing tide of mergers between computer, media and telecommunications companies, all point to one thing: the computing, communication and content industries are converging. While this wave offers a unique opportunity for new, world-conquering products and services, the impact on the way manufacturers make and supply their goods, on how public administrations operate, on how doctors work, and on how people live will be just as profound.

IMDEA Networks conducts research of excellence in the ICT field of networking technologies, which provides the platform on which the future Internet shall be built. As illustrated by our motto "*Developing the Science of Networks*", IMDEA Networks aims to perform high quality scientific research in the area of networks, and also to develop these results by bringing them into practical deployments. We believe that the results included in this annual report show that we are being successful in achieving this goal.

IMDEA Networks was legally founded in 2006, starting operations at the end of 2007 and it has steadily grown in numbers and results over its first embryonic years. The year 2010 has marked a significant leap toward its consolidation as a model of reference. By now, IMDEA Networks has managed to put together a team of top scientists that have made the institute, despite its youth, one of the leading networking research centers in Europe, and is contributing to bring Madrid upfront as a technology-oriented region.

The number of faculty researchers (those holding a PhD) at the Institute has significantly increased during 2010, reaching a critical mass that guarantees a stable incremental scientific production heretofore. This international team of faculty researchers is backed by our Research Assistants. Strong in number and trained in the latest technologies, our Research Assistants are PhD candidates essential to the organization, as they take on a significant part of research development under the direction of their supervisors.

Along with the growth in personnel, the scientific productivity of the institute and, even more importantly, its impact, has also been boosted in 2010. Just to name a few of our achievements in this period, we have been very successful in extremely selective competitive calls, we have continued to publish in the chief conferences and journals in our field of research, receiving several best paper awards, and we have also transferred some of our results to industry, in the form of standardization, patent licensing and direct contracts.

As for the future, in the coming years the Institute faces challenges that are essential to its short and long term success, as they define our strategy of competitive placement within the international scientific community as well as the fulfillment of our socio-economic objectives. Firstly, we must consolidate our international recognition as a centre of excellence, continuing with our policy of recruiting first-rate scientists and of publishing our results in the most prestigious international fora. Secondly, we aim to assist in establishing Madrid as a pioneering region in the ICT sector. Finally, we direct our work towards strengthening collaboration ties with industry, particularly through joint participation in projects and technology transfer.

My gratitude goes to all of those who are contributing to transform this exciting project into a daily reality of meritorious achievement.



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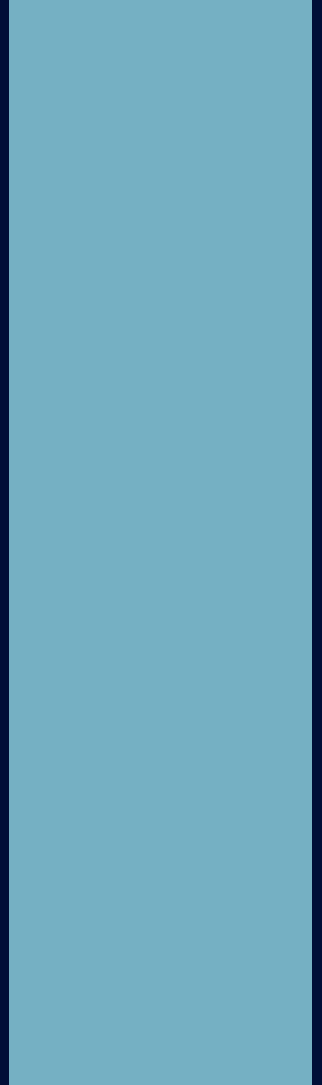
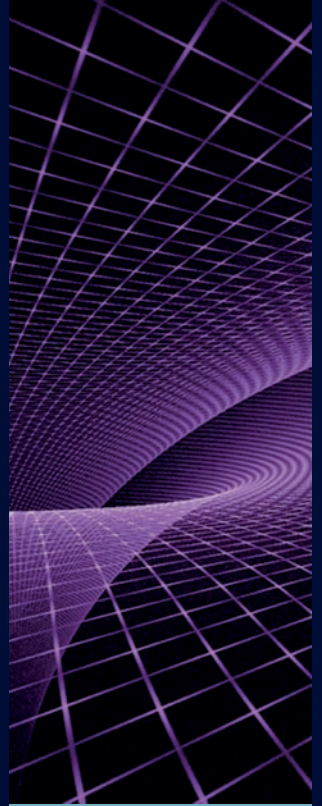
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executive summary

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IMDEA Networks is fast becoming a pre-eminent internationally-recognized research Institute, achieving excellence in the development of the science of networks. 2010 has been a great year for us in a number of ways. Our international call for researchers has delivered a choice set of incoming team members from a broad pool of applicants, after an extremely selective recruitment program. We have been awarded funding to conduct new projects following highly competitive open selection processes and we have completed others with outstanding grades. **IMDEA Networks research activities are focused on providing disruptive technological solutions to real-world problems.** Our strategy to transfer scientific and technological developments and knowledge to industry and, ultimately, society has been realized through formalized collaboration agreements with industrial partners targeted to the creation of products and services. Our publications have been issued in top venues, having also found an echo in the mass media. **The scientific community and our stakeholders, including the Spanish public, are aware and listening. We still have a lot to give. We are growing. And we are willing.**

The research team of IMDEA Networks consists of top technical leaders. All IMDEA Networks researchers have an **outstanding research record**, including publications in the most prestigious venues in the field. To mention but a few of the achievements of our organization: Chief Researchers Nick Maxemchuk and Marco Ajmone Marsan are both listed by ISI as two of the most cited researchers in Computer Science, Nick Maxemchuk is the recipient of the 2006 IEEE Koji Kobayashi Award for Computer and Communications, Marco Ajmone is the Italian Delegate in ICT Committee of EC's 7th Framework Program, and Joerg Widmer, a Senior Researcher, is author of a paper that has received more than 1500 citations. Additional evidence of the value of our researchers is the fact that most of them are **awardees of prestigious individual grants or fellowships** to fund their working activities.

Further to having a commendable research and publications record, most of our scientists also possess significant **industry experience**. Indeed, **our researchers do not only originate from eminent international universities** such as Columbia University, Politecnico di Torino, MIT, UT Austin, UC Berkeley, EPFL or Rice University, **but have also been employed in leading industrial research laboratories** such as NEC, Telefonica, AT&T, Alcatel, Philips, NTT Docomo or Telecom Italia. An additional fact that further illustrates the industrial background of **our researchers** is that they **have been granted, during their professional career, over 40 patents in total**. This background is essential to develop research that can be transferred to companies, which in turn can be transformed into profitable products and consequent economic returns.

One of the key challenges faced in 2010 has been to further strengthen our research team. The **calls for senior researchers and research assistants conducted for this purpose have been very successful**. The 4 faculty members hired were chosen from a pool of over 150 applicants, among which there were many candidates with wide-ranging and prolific trajectories. The same applies to candidates for research assistant positions. There

were 500 plus applications received, originating from over 50 countries, out of which the best 14 were selected. This **highly selective process** guarantees that **we are attracting first-rate researchers** to the Madrid region.

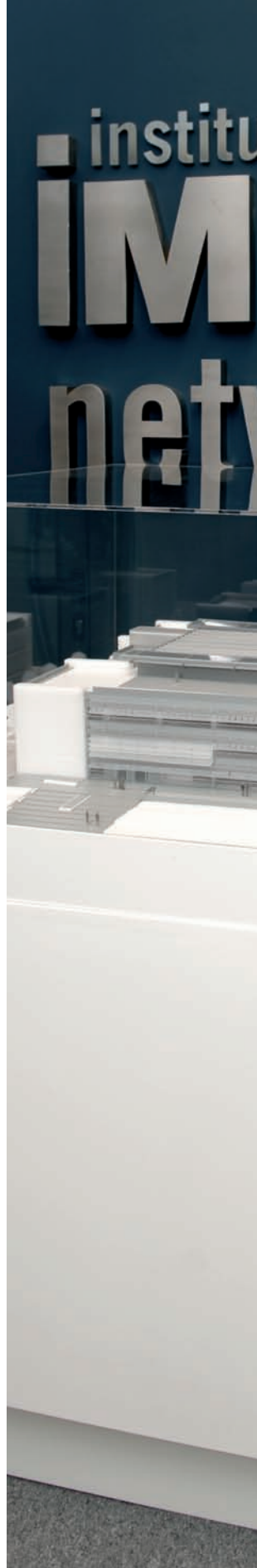
Another pivotal accomplishment of 2010 has been the participation of the institute in research projects. These projects bring external funding, extremely productive collaborations with top research institutions and industrial partners, and the opportunity to transform our research ideas into practical deployments. **IMDEA Networks is currently working on 11 projects**, which is a notable quantity considering the size of the institute. Out of these 11 projects, **6 are European and 2 are funded by industrial partners**. Additionally, **2 more shall commence in 2011**, one of which is funded by the National Natural Science Foundation of China, our **first success in securing funding outside the EU**.

IMDEA Networks has been particularly **successful in the last calls of the ICT FP7 program of the EU**. In call 5, only 9 out of 79 STREP proposals were awarded funding (around 10%). From the 3 proposals in which IMDEA Networks was involved, 2 of them were awarded funding (ranked 3rd and 8th out of the 79 bids, respectively). Whereas IMDEA Networks also participated in ICT Call 7 **“Networks of Excellence” (NoE) proposal**, which was the only one to receive funding as the **highest ranking** proposal. These favorable outcomes are a sign of the excellent quality of the research being conducted by the institute.

The efforts made by our team to impact the networking field have been repaid in 2010 with **43 research publications**. The evolution in the number of publications since the Institute's inception is a clear sign of the fruitfulness of the enterprise, a testimony of sure progress, and a promise of future successes. In 2006, we published 7 papers, 13 in 2007, 11 in 2008, 37 in 2009 and, as previously stated, 43 in 2010. However, rather than figures, at IMDEA Networks we are mostly concerned about the caliber of our dissemination. Indeed our publications in 2010 were issued through conferences and journals of international repute, and **several were rewarded with best paper awards**.

Among our choice publications, our work titled “Is Content Publishing in BitTorrent Altruistic or Profit Driven?” is worth highlighting. This output was published at ACM CoNEXT 2010, one of the highest ranking conferences in the field. It analyzes the **Internet users responsible for posting content on P2P networks**, reaching the striking conclusion that 75% of all content is uploaded by only 100 sources. Motivated by the interesting results obtained, this **finding** has been **referenced by over 170 international media**, including some of the main Spanish TV channels, such as TVE and Antena3, and newspapers, such as ABC or El Pais, providing significant visibility to the IMDEA initiative.

A fundamental objective of the research conducted by IMDEA Networks is that of having real-life impact, beyond the publication of research articles, mostly destined to have a





bearing on the scientific community. Impact can be made in various forms, such as standardization, patent licensing or via the transfer of scientific results with the objective of developing marketable products. Research performed at IMDEA Networks during 2010 has attained very substantial impact.

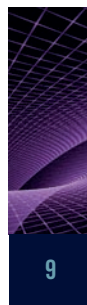
IMDEA Networks researchers have been particularly **active in standardization** during 2010, bringing some of their ideas into **IEEE and IETF standards**. This is a fundamental success as **these standards will be the basis for future products**. It is worth mentioning in this context, the work performed to create a new Study Group within the Working Group of the IEEE specialized on Media Independent Services.

Another example of the impact of our research is the **agreement signed with NEC Germany in 2010 to exploit IMDEA Networks research**. This agreement has led to many joint research activities, including a patent that is in the process of being filed and the development of a solution for power saving in NEC mobile phones.

Further illustration of the impact of our research is the **contract** recently signed **with Albentia Systems to implement our research results into their WiMAX products**. Albentia is a company located in the Madrid region, which is particularly rewarding for the IMDEA initiative. Indeed, while one of the principal goals of IMDEA Networks is to establish strong ties with international industry, collaborating with local companies and thereby bringing value to the region is as much (if not more) crucial.

Last but not least, another chief activity throughout this period has consisted of **the setting up of a networking laboratory**. Networking science requires the rigorous validation of new algorithms and protocols. The **infrastructure for experimentation** provided by fully equipped laboratories is **an essential working tool**. During 2010 the institute has acquired specialized equipment indispensable to conduct its research activities. Part of this equipment has been provided by the companies with which we collaborate.

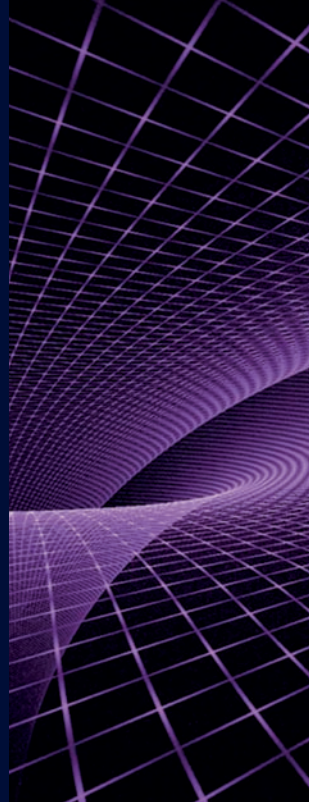
We believe we are on track to build on these foundations to achieve ever growing success in 2011 and beyond.



about us

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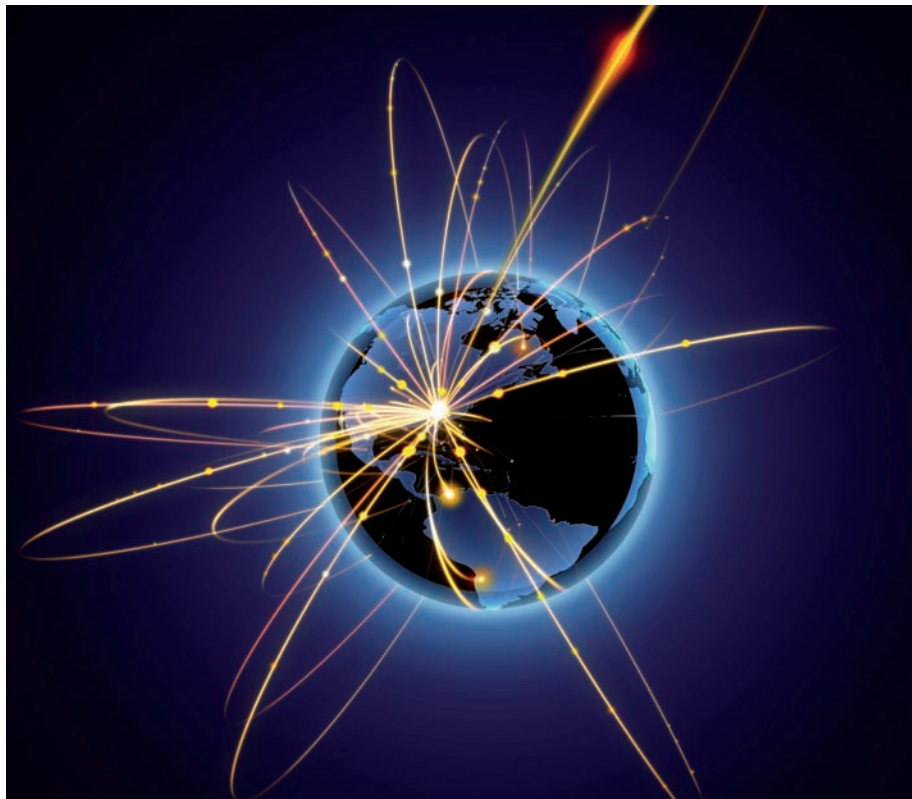
2.1. Profile

IMDEA Networks is an independent, non-profit research institute whose multinational team is engaged in cutting-edge fundamental science in all areas of networking. As a growing, English-speaking institute located in Madrid, Spain, IMDEA Networks offers a unique opportunity for scientists to develop their pioneering ideas and to shape the future of networking over the coming years. Our researchers share the potential to shape the future of networking science over the coming years.

2.2. Strategic goals

The Institute's strategic goals, in line with the objectives presented by Madrid's Fourth Regional Plan for Scientific Research and Technological Innovation (*PRICIT – Plan Regional de Investigación Científica e Innovación Tecnológica*), are the following:

- Conduct first class research on an international level in the area of computer networking
- Transfer technology to the industrial sector, in order to improve its capacity for innovation and competitiveness
- Transfer technology to spin-off-companies in order to promote the release of new products and services to the global market
- Attract and retain human capital of excellence with the aim to internationalize research within the Madrid Region



2.3. Mission

Our mission is to create value by leading research in protocol, algorithm and systems developments that enable the Future Internet. We do this by conducting research and developing innovative and useful scientific and technical advances in the above areas, while actively promoting their successful transfer to market.

The Institute provides the best working conditions and the most attractive and best-equipped environment in which researchers can focus on this process of innovation and scientific advance.

2.4. Our values

A culturally-diverse team, such as IMDEA Networks', needs goals, but it also has to share values that transcend our social, religious and other cultural differences. These values serve to unify us by defining how we conduct ourselves, both within the team and in our dealings with others. Our core values will remain constant and will be promoted actively within the Institute:

- To be open to the new
To be constantly adapting to our changing environment
- To value diversity
We seek out and cherish different perspectives and diversity. We understand the value of diversity
- To be positive
We encourage positive critical thought with a view to addressing the issue of generating better solutions, not simply identifying problems
- To act with integrity
We act with integrity and honesty, delivering on our commitments in all our interactions. The trust this engenders provides the foundations for productive partnerships
- To listen well and speak clearly
We listen actively to other people and take responsibility for explaining ourselves as we wish to be understood
- To respect individual brilliance
We respect, honor and reward exceptional individual contributions when they are in the service of shared goals

- To work collaboratively

Our individual contributions are more fruitful when performed in a team environment. We work in a spirit of partnership in all our activities with others. We achieve this by identifying and pursuing shared objectives in an open and honest way

- To innovate always

We always look at problems from different points of view. We aim to do breakthrough research, not incremental research

- To compete sportingly across the globe

We compete fairly but intensely, according to the letter and spirit of accepted standards. Competition drives us to be the best and most successful in our field

- To enjoy our work

We enjoy what we do and share that enjoyment with each other

2.5. Our credo

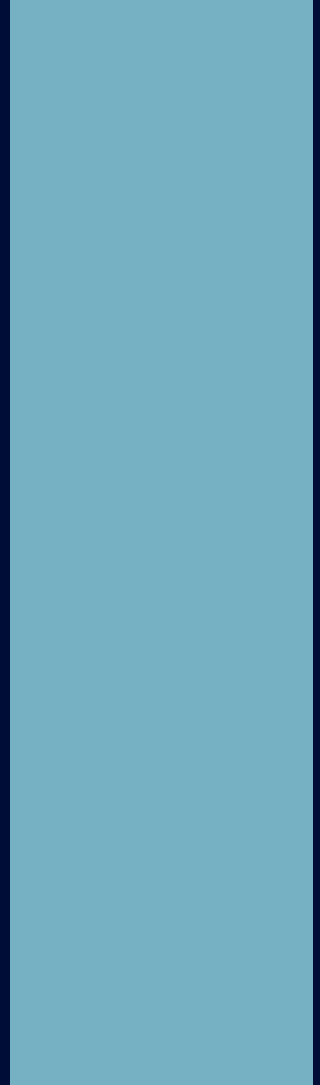
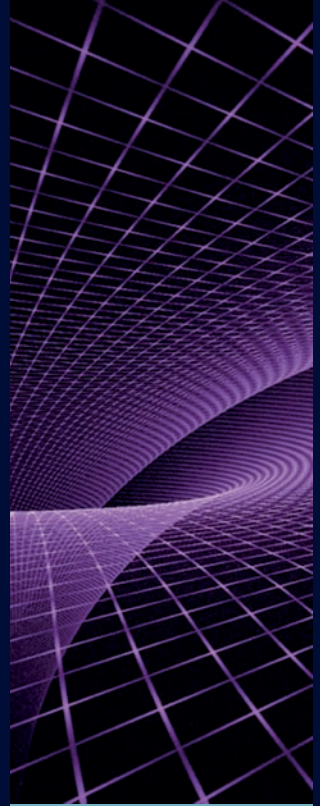
- We believe in group discussion and in bright individual ideas
- We do not believe in voting and committees. We believe in running code and rough consensus
- Demo or die (in addition to publish or perish)
- Genius is 1% inspiration and 99% perspiration (T.A. Edison)



research areas

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Institute IMDEA Networks identifies and addresses major scientific and engineering challenges in communications and computer networks. The nature of these challenges changes with ever-greater rapidity. To ensure the relevance of our research activities, we continuously adjust our research agenda to stay at the forefront of the technological innovation. We organize our scientific activities into research areas that reflect our current working priorities, ensuring sufficient flexibility to allow us to respond to emerging technological challenges. The research mission of our Institute also adapts to the strengths of our growing research team and our external collaborators. Currently, our research is focusing on the following three general areas:

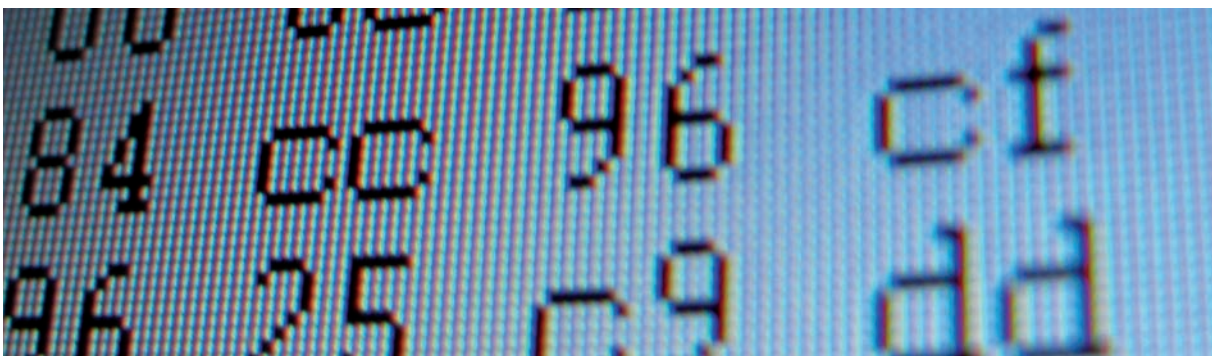


3.1. Network Protocols and Algorithms

Any network has a structure and needs protocols to achieve its objectives. The researchers of Institute IMDEA Networks have an extensive expertise in architectures and protocols for communication networks, e.g., for network topology design, routing, forwarding, in-network storage, congestion control, and media access control. Besides, we have research interests in other networking domains such as social networks, energy networks, and transportation networks.

Our research takes a multi-disciplinary approach to the design and understanding of network protocols and architectures. We go beyond technological constraints and account also for social and economic factors. For example, our research on Internet routing and forwarding accounts for the multitude of Internet service providers and their individual economic interests. In working on either centralized or decentralized solutions to problems, we assume that perfect information is never available. To deal with such uncertainty as well as selfishness of individual entities, our analysis adopts game-theoretic techniques. Our protocol design assumes that behaviour of counterparts is always unpredictable to some extent. Hence, the designed protocols rely on continuous learning and adaptation as the main modes of operation.

Practicality is another distinguishing aspect of our research. Real data serves as a departing point for our analytical efforts as well as a basis for validating our analytical conclusions. For instance, our large-scale simulation studies of Internet routing rely on real Internet topologies. Furthermore, we implement our theoretical ideas and make the prototypes available to the public, either directly or through our commercial partners.



This research area targets the following objectives:

- Novel architectures and protocols for behavioral networking
 - Internet is modeled as an association of independent entities
 - Behavior of counterparts is not taken for granted
 - Continuous learning and adaptation are main modes of operations
- Bridging the gap between network economics and networking
 - Deployment of innovative designs becomes the primary concern
 - Economic and political landscapes of the Internet are analyzed with higher fidelity
 - Economic-political knowledge guides the technical design

3.2. Wireless Networking

Given the scarcity of wireless spectrum resources and the rising demand for mobile applications, optimizing wireless communication is currently one of the most important and challenging research topics in networking. The proliferation of inexpensive, high-rate mobile devices and ubiquitous connectivity open up a vast spectrum of possible new services but also pose unique challenges concerning wireless interference and the unpredictability of the wireless medium.

Institute IMDEA Networks is involved in a number of different wireless research areas. Part of our efforts aim at improving existing wireless technologies such as WiFi (IEEE 802.11), WiMAX (IEEE 802.16), and LTE, for example, through the design of opportunistic scheduling mechanisms and interference management schemes. We further have an extensive track record in the areas of ad hoc and mesh networks, in particular on routing and MAC layer design. To improve the flexibility and programmability of future wireless technologies, we explore novel programmable interfaces that expose low-level operations to foster network evolution and enable performance optimization and service customization. One of the goals of this work is to implement application specific optimizations, for example, to provide efficient wireless video streaming. Our work on wireless capacity improvements focuses on topics such as intelligent interference management, cooperative coding and network coding, improved medium access control mechanisms that make use of advanced physical layer technologies such as MIMO, successive interference cancellation, etc.

We recognize the importance of bridging the gap between theoretic results and applied wireless research and have deployed a range of wireless testbeds (IEEE 802.11, WiMAX, software defined radios) on which we implement and evaluate our research ideas.



This research area targets the following objectives:

- Heterogeneous wireless networks
 - We are facing the proliferation of many different wireless technologies
 - Supporting them in the current Internet is highly complex
 - Existing solutions are based on technology specific interfaces
 - The wireless Internet architecture needs to be rethought for efficient support of heterogeneity
- Self organizing wireless networks
 - Scaling and increased heterogeneity require self-organization
 - Solutions needed to track and exploit changing spatial traffic loads
 - Complex dynamics of wireless system and user behavior are involved
 - Significant performance gain and energy savings can be achieved



3.3. Energy-efficient Networking

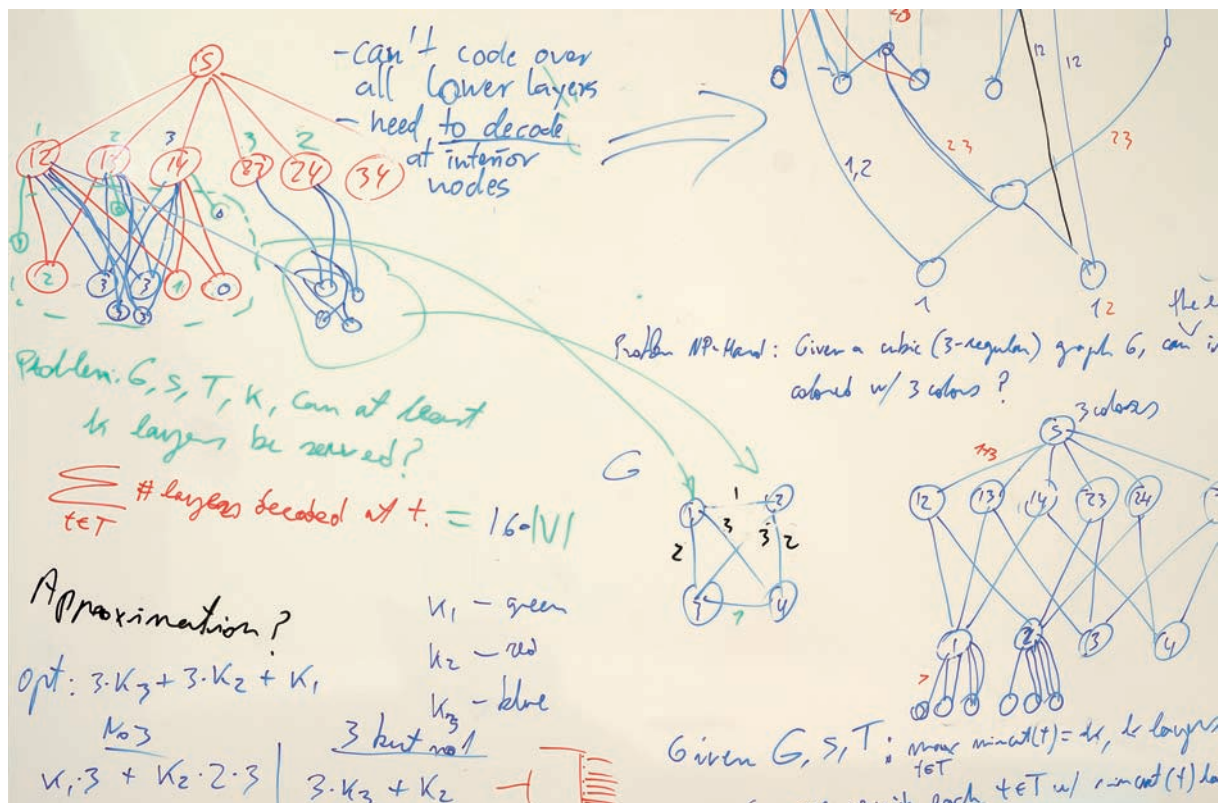
Energy production, distribution, and consumption are becoming topics of interest worldwide, due to issues like climate change and the greenhouse effect. Institute IMDEA Networks is actively involved in research conducted to increase energy performance with the use of computation and communication. These research efforts can be simply grouped into two lines. The first line involves research that attempts to save energy in computing and communication systems, like computers and networks, named *energy-efficient ICT*. The second line involves research that attempts to design ICT systems that improve energy production and distribution, and optimize consumption, named *ICT for energy efficiency*.

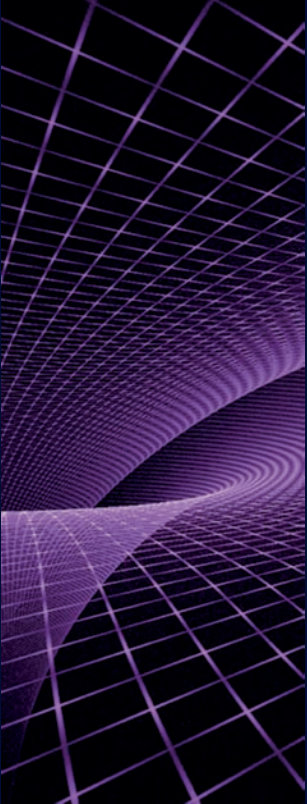
In the area of energy-efficient ICT, researchers of the institute have developed techniques to save energy in wireless networks, for instance switching off access points in periods of low traffic. In wireline networks, research efforts have been conducted to propose algorithms for smart routing and scheduling of packets to save energy in underused networks. One interesting line is the study of the optimal deployment of Energy Efficient Ethernet equipment.

In the area of ICT for energy efficiency, researchers from the institute have, e.g., proposed algorithms to schedule appliance use in order to reduce peak electricity consumption, and techniques to provide good service for the users of an electric vehicles charging station. The novelty is that these solutions use concepts taken from networking, like load balancing and fairness. Future lines of research in this area include the extraction and modification of user energy consumption patterns by means of social networks.

This research area targets the following objectives:

- Design of energy-efficient algorithms and protocols
 - ICT accounts for a substantial portion of the total energy consumption
 - We need solutions that reduce consumption without affecting service quality
 - Novel algorithms that adapt the network infrastructure to the variations of traffic demand over time
- Support for smart energy management
 - Communications can help reduce energy consumption in many activities
 - This poses new requirements on networking solutions
 - Novel protocols and algorithms for smart energy management





4 research projects, grants and fellowships

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4.1. Funding awards

We dedicate extensive resources to obtaining external funding to support our research team and in particular those members who excel in their capacities, with the objective to promote the scientific and technical potential of our human capital and as a direct result the outreach of the institute's activities.

The funding of our individual researchers takes the form of awarded Grants, Scholarships and Fellowships. These awards are similar to externally-funded research in their openness and the strict selection processes used. These awards confer prestige on the awardee as well as on the organization he is affiliated to.

RAMÓN Y CAJAL GRANTS | I3 SUBVENTIONS |

“MARIE CURIE” AMAROUT EUROPE PROGRAMME | FPU SCHOLARSHIPS

Ramón y Cajal Grants

(Programa Ramón y Cajal)

Awardees: Dr. Sergey GORINSKY, Senior Researcher

Funded by: Spanish Ministry of Science and Innovation (*Ministerio de Ciencia e Innovación – MICINN*)



I3 Subventions

(Programa I3)

Awardees: José Félix KUKIELKA, Senior Researcher

Funded by: Department of Education, Regional Government of Madrid (*Consejería de Educación, Comunidad de Madrid*)



«MARIE CURIE» AMAROUT Europe Programme

Awardees: Dr. Sergey GORINSKY, Senior Researcher

Dr. Vincenzo MANCUSO, Staff Researcher

Dr. Balaji RENGARAJAN, Staff Researcher

Dr. Gianluca RIZZO, Staff Researcher

Dr. Joerg WIDMER, Senior Researcher

Funded by: European Union. ICT Programme FP7-PEOPLE COFUND



FPU Scholarships

(*Becas del Programa de Formación de Profesorado Universitario*)

Institute IMDEA Networks has been granted 4 out of 26 (15%) scholarships awarded nationally to researchers in «Electronic Technology and Communications».

Awardees: Alex BIKFALVI, Research Assistant
Michal KRYCZKA, Research Assistant
Marco GRAMAGLIA, Research Assistant
Paul PATRAS, Research Assistant

Funded by: Spanish Ministry of Education (*Ministerio de Educación*)

4.2. Externally-funded research projects

Externally-funded research projects enable us to collaborate with researchers from other organizations and backgrounds. Research funding is awarded following an open competitive selection process in which project proposals, and the private or public sector organizations presenting them, are subject to rigorous scrutiny. Such thoroughness helps to ensure that research undertaken with those funds is relevant, well-managed and with high probabilities of success in achieving its stated goals.

Currently IMDEA Networks is collaborating with the NETCOM (Networks and Communications Services) Research Group from the Telematics Department at University Carlos III of Madrid, in several research projects.



CARMEN

(CARrier grade MESH Networks)

Participating entity: Universidad Carlos III de Madrid

Collaborating researchers from IMDEA Networks: Albert Banchs, Deputy Director
Paul Patras, Research Assistant

Project Website: www.ict-carmen.eu

Funded by: European Union. ICT Programme FP7

Duration: January 2008 – December 2010

Project partners: Universidad Carlos III de Madrid, AGH University of Science and Technology, Alcatel-Lucent Deutschland AG, British Telecommunications PLC, Deutsche Telekom AG, Fraunhofer Gesellschaft Zur Foerderung Der Angewandten Forschung E.V., NEC Europe Ltd., University College Dublin, National University of Ireland, Dublin

Description: CARMEN, CARRIER grade MESH Networks, will study and specify a wireless mesh network supporting carrier grade triple-play services for mobile/fixed network operators. Future operator networks will be comprised of a common core network and several access networks, and the CARMEN access network will complement other access technologies by providing a **low cost and fast deployment mesh network access technology**. The project proposes the integration of heterogeneous wireless technologies in a multi-hop fashion to provide scalable and efficient ubiquitous quad-play carrier services.

To address the integration complexity of heterogeneous radio technologies, CARMEN introduces a control layer (Layer 2.5) located between the link layer and the IP layer, in order to abstract technology specific issues into a common set of events and commands. Upper layers will use the abstract interface of layer 2.5 to dynamically adapt functions such as routing, mobility and monitoring. One relevant issue is that CARMEN will provide capacity handling algorithms to exploit specific features of the mesh networks such as the availability of multiple links between two peers (i.e. multipath) or the use of radio broadcast instead of unicast to alleviate the load of broadcast services (e.g. video) in the mesh network. CARMEN will focus on three planes: technology, message transfer, and self-configuration and management, to provide a complete solution for setting up and maintaining a cost-effective carrier grade wireless mesh access network.

Soundness of the obtained results is guaranteed by the strong operator involvement, and by performing a use-case implementation. The experience of the consortium guarantees that the developed solutions will produce significant advances with respect to the current state of the art, which will be reflected in IPR creation, proposals of standards (with focus on IETF and IEEE), and dissemination of the results in high impact conferences and journals.

The CARMEN project forms part of the Seventh Framework Programme (FP7) of the European Union (EU).





FLAVIA

(FLexible Architecture for Virtualizable wireless future Internet Access)

Participating entity: Institute IMDEA Networks & Universidad Carlos III de Madrid

Project website: www.ict-flavia.eu

Funded by: European Commission. ICT Programme FP7

Project partners: Consorzio Nazionale Interuniversitario per le Telecomunicazioni, Alvarion, NEC Europe, Telefonica Research, Sequans Communications, MobiMesh s.r.l., Ben Gurion University of the Negev, Institute for Information Transmission Problems of the Russian Academy of Science, Institute IMDEA Networks, Hamilton Institute of the National University of Ireland Maynooth

Duration: July 2010 – June 2013

Description: The importance of wireless networks for the Future Internet is raising at a fast pace as mobile devices increasingly become its entry point. However, **today's wireless networks are unable to rapidly adapt to evolving contexts and service needs due to their rigid architectural design.**

We believe that the wireless Internet's ability to keep up with innovation directly stems from its reliance on the traditional layer-based Internet abstraction. Especially, the Link Layer interface appears way too abstracted from the actual wireless access and coordination needs. FLAVIA fosters **a paradigm shift towards the Future Wireless Internet:** from pre-designed link services to programmable link processors. The key concept is to expose flexible programmable interfaces enabling service customization and performance optimization through software-based exploitation of low-level operations and control primitives, e.g., transmission timing, frame customization and processing, spectrum and channel management, power control, etc.

FLAVIA's approach is based on three main pillars: i) lower the interface between hardware-dependent layers and upper layers, ii) apply a hierarchical decomposition of the MAC/PHY layer functionalities, and iii) open programmable interfaces at different abstraction levels. To prove the viability of this new architectural vision, FLAVIA will prototype its concept on two wireless technologies currently available, IEEE 802.11 and IEEE 802.16, representing today's two main radio resource allocation philosophies: contention-based and scheduled. Moreover, FLAVIA will assess the applicability of the proposed architecture concepts to the emerging 3GPP standards.

FLAVIA's concept will allow **boosting innovation and reducing the cost of network upgrades.** Operators, manufacturers, network designers, emerging third-party solution developers, and even spontaneous end users, will be able to easily and rapidly optimize and upgrade the wireless network operation, quickly prototype and test their new protocols, and adapt the wireless access operation to emerging scenarios or service needs.

GEONET

(Geoaddressing and Georouting for vehicular communications)



Participating entity: Institute IMDEA Networks

Project website: www.geonet-project.eu

Duration: February 2008 – January 2010

Project partners: INRIA, EFKON, HITA, NEC Europe Ltd., Broadbit Kft, Lesswire, Institute IMDEA Networks.

Funded by: European Commission. ICT Programme FP7

Description: The goal of the GeoNet Project is **to contribute to increase road safety in Europe**. The European Commission (EC) and the automotive industry have committed themselves to halving loss of life by 2010. GeoNet will significantly contribute to this goal by implementing a reference implementation of a geographic addressing and routing protocol, with support for IPv6 to be used **to deliver safety messages between cars and the roadside infrastructure within a designated area**.

GeoNet shall take the basic results of the CAR 2 CAR Communication Consortium's work to the next step by further improving these specifications and creating a baseline software implementation that interfaces with IPv6. The goal of GeoNet is thus to implement and formally test a networking mechanism as a standalone software module that can be incorporated into Cooperative Systems. This implementation shall enable transparent IP connectivity between a vehicle and the infrastructure, even in cases when delivery must hop over several vehicles or be cached along the way.

The GeoNet project forms part of the Seventh Framework Programme (FP7) of the European Union (EU).

IMDEA Networks is a member of the **Car 2 Car Communication Consortium**.

IPv6 deployment monitoring



Participating entity: Institute IMDEA Networks

Project Website: <http://www.ipv6monitoring.eu/>

Funded by: TNO Information and Communication Technology (Planning Performance and Quality Department)

Duration: January 2009 - December 2010

Project partners: TNO Information and Communication Technology, GNKS Consult, RIPE Network Coordination Centre

Description: In 2008, the European Commission launched the IPv6 Action plan 2008 “**Advancing the Internet**”. The reason for this was the understanding that the pool of IPv4 addresses would soon be depleted. The introduction of IPv6 is envisaged as a solution. However, the IPv6 Monitoring Deployment measurement campaign shows that availability of on-line content on IPv6 enabled web sites, and actual usage of IPv6 protocols has hardly increased. Based on the research, we strongly recommend the European Commission to define concrete and realistic goals. With these actions, the European Commission will enable Europe to take the **unavoidable next steps in IPv6 deployment**.

Institute IMDEA Networks provided an expert reviewer for this research.

MEDIANET

(Integración de Servicios Multimedia de Siguiente Generación en la Internet del Futuro – Integration of Next Generation Multimedia Services in the Internet of the Future)

Participating entity: Institute IMDEA Networks

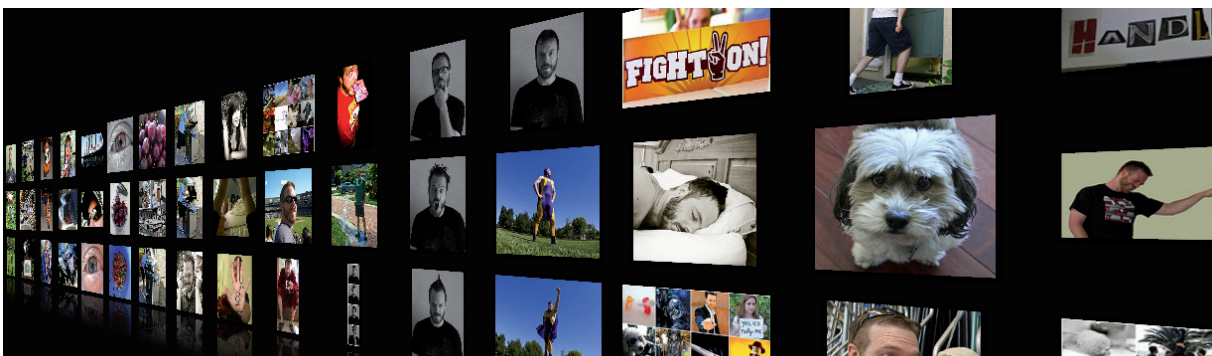
Project website: www.medianet-cm.es

Funded by: Department of Education, Regional Government of Madrid (*Consejería de Educación, Comunidad de Madrid*)

Duration: January 2010 - December 2013

Project partners: Universidad Carlos III de Madrid, Universidad Complutense de Madrid, Institute IMDEA Networks, Universidad de Alcalá de Henares

Description: This program strives for a significant **scientific advance in the future media Internet where important advances are necessary to allow end-users to perceive a good quality of experience**. The network technologies objectives consist of the definition and validation of new proposals for the efficient transport of high bandwidth, real-time data flows in a decentralized way where the network provides mechanisms to seamlessly request and configure devices to increase the quality of experience perceived by end-users. Furthermore, new experiences with layer 2 networks and a cross-layer design will be tested with high bandwidth demanding media services. The global result will be an integrated and independent advancement in future media Internet protocols, algorithms, switching architectures and standards.



MEDIEVAL

(MultimEDIA transport for mobile Video AppLications)



Participating entity: Institute IMDEA Networks & Universidad Carlos III de Madrid

Project website: www.ict-medieval.eu

Funded by: European Union. ICT Programme FP7

Duration: July 2010 – June 2013

Project partners: ALCATEL – LUCENT BELL Labs France, Telecom Italia S.p.a., Portugal Telecom Inovação, Docomo Communications Laboratories Europe, Comsys, Communication & Signal Processing Ltd, LiveU, Instituto de Telecomunicacoes, Universidad Carlos III de Madrid, Institute IMDEA Networks, Consorzio Ferrara Ricerche, Universita Degli Studi di Padova, EURECOM.

Description: **Video is a major challenge for the future Internet.** This traffic type is foreseen to account for close to 90 percent of consumer traffic already by 2012. However, the current Internet, and in particular the mobile Internet, was not designed with video requirements in mind and, as a consequence, its architecture is very inefficient when handling video traffic. It is the vision of this consortium that, as video is going to represent the majority of the traffic, the future Internet architecture should be tailored to efficiently support the requirements of this traffic type. Specific enhancements for video should be introduced at all layers of the protocol stack where needed, ideally supporting an incremental deployment.

Following the above vision, the main goal of the project is **to evolve the Internet architecture for efficient video traffic support**. The proposed architecture will follow a cross-layer design that, by exploiting the interaction between layers, can raise performance to values unattainable with individual developments. The following key issues will be addressed by the architecture: i) enhanced wireless access support to optimise video performance, ii) novel IP mobility architecture adapted to the requirements of video traffic, iii) transport optimisations for video distribution and iv) network-aware video services that interact with the underlying layers.

The technology developed by the project will be designed taking into account the requirements of network operators for commercial deployment, and will aim at improving the Quality of Experience by users as well as reducing the associated costs for operators. Standardization and early incremental testing are considered key success factors for MEDIEVAL.

The consortium is well balanced and combines the integrated perspectives of three mobile operators, a major manufacturer and an innovative video technology company, in addition to leading academic partners and research institutes.



PASITO

(Plataforma de experimentación de servicios de telecomunicaciones –Telecommunications Service Analysis Platform)

Participating entity: Institute IMDEA Networks

Project website: www.rediris.es/proyectos/pasito

Duration: Starting on September 2007 - TBD

Funded by: State Secretariat for Telecommunications and the Information Society (*Secretaría de Estado de Telecomunicaciones y para la Sociedad de la Información – SETSI*) of the Spanish Ministry of Industry, Tourism and Trade (*Ministerio de Industria, Turismo y Comercio – MITYC*)

Project partners: Red.es/RedIRIS, CESCO (Centro de Supercomputación de Cataluña), CESA (Centro de Supercomputación de Galicia), CICA (Centro Informático Científico de Andalucía), red académica vasca I2BASK, Universidad del País Vasco (UPV/EHU), Fundación I2CAT, Institute IMDEA Networks, Universidad Autónoma de Madrid (UAM), Universidad Carlos III de Madrid (UC3M), Universidad de Granada (UGR), Universidad de Murcia (UMU), Universidad Politécnica de Cataluña (UPC), Universidad Politécnica de Madrid (UPM), Universidad Politécnica de Valencia (UPV), Universidad de Vigo (UVIGO)

Description: The platform for telecommunications services analysis (PASITO) is **a distributed tests laboratory, which offers engineers the chance to construct, refine and evaluate test scenarios for telecommunication services.**

The laboratory contributes to:

- Optimizing communications resources
- Designing and adapting new services to the current needs
- Certifying equipment and services

PASITO is a public infrastructure, based upon the Spanish RedIRIS academic network. It uses varied technologies to enable it to test a wide range of telecommunication services and at the same time guarantee that its activities are isolated from the rest of the academic network's services. This avoids interference with other activities that are in operation within the Spanish scientific community.

The platform's main research areas are:

- Internet architectures
- Communication protocols
- Transport technologies with service quality
- Virtualization and autoconfiguration of networks and services
- Technologies and tools to monitor networks and services
- Optical services for intensive data projects

- Large scale information distribution technologies
- Peer-to-peer systems
- Mobility services
- Technologies to improve network security
- Standards for new generation collaboration services

QUARTET

(QUALity of seRvice enabled IP heTeroogeneous vEhicular neTworks)

Participating entity: Universidad Carlos III de Madrid

Collaborating researcher from IMDEA Networks: Marco Gramaglia, Research Assistant

Funded by: Spanish Ministry of Science and Innovation (*Ministerio de Ciencia e Innovación – MICINN*)

Duration: October 2009 – September 2012

Description: Vehicular communications will become a reality in the near future. Driven by the goals of improving road safety and efficiency, governments, car manufacturers and telecommunication players are working towards the **definition of a geonetworking-based architecture that enables vehicles to benefit from communication capabilities**. The goal is to support different types of applications: critical safety (e.g., forward collision warning), non-critical safety (e.g., traffic efficiency applications), and non-safety (infotainment or generic Internet connectivity), but most efforts have been devoted so far to standardise critical safety applications, while ensuring coexistence with other types of applications. Bringing IP connectivity to cars will also enable classical and new Internet applications to be provided in cars.

This advance will also help **speeding up the adoption of vehicular communication systems by the users**, since they will see an additional benefit in the installation of a communication system in their cars. In order to help this become a reality, this project focuses on the design of Quality of Service enabled IP heterogeneous vehicular networks, where two fundamental needs are identified:

- Integration of IP into a geonetworking-based vehicular architecture. This comprises the definition of IP autoconfiguration mechanisms, as well as protocols to transport IP datagrams inside vehicular networks.
- Support of heterogeneous wireless technologies. This includes the design and evaluation of mechanisms that efficiently and transparently support mobility across different access technologies.

This mobility support will provide the IP services through the geonetworking based architecture wherever its coverage is available. If it is not, the mobility support will select the LTE network to handover the communication, since this is an emerging 4G technology with a promising broadband access.

Finally, an experimentation test-bed will be designed and deployed. This demonstrator will be used to validate and analyse the key mechanisms designed within each of the three areas above.

Additionally, a sub-set of mechanisms will be integrated, in order to gather some insight on the operation of the integrated architecture.



TREND

(Towards Real Energy-efficient Network Design) - The Network of Excellence on Energy-Efficient Networking

Participating entity: Universidad Carlos III de Madrid

Collaborating researcher from IMDEA Networks: Marco Ajmone Marsan, Chief Researcher

Project website: <http://www.fp7-trend.eu/>

Funded by: European Commission. Programme FP7 (*FP7-ICT-257740*)

Project partners: Politecnico di Torino (PoliTO), Alcatel-Lucent Bell Labs France (ALBLF), Huawei Technologies Dusseldorf GmbH (HWDU), Telefonica Investigación y Desarrollo SA (TID), France Telecom SA (FT), Fastweb SPA (FW), Universidad Carlos III de Madrid (UC3M), Interdisciplinary Institute for Broadband Technology (IBBT), Technische Universität Berlin (TUB), École Polytechnique Fédérale de Lausanne (EPFL), Consorzio Nazionale Interuniversitario per le Telecomunicazioni (CNIT), Panepistimio Thessalias - University of Thessaly (UTH)

Duration: September 2010 – September 2013

Description: TREND is a **Network of Excellence**, coordinated by Politecnico di Torino and funded by the European Commission within the Seventh Framework Programme.

TREND aims at integrating the activities of major European players in networking, including manufacturers, operators and research centers, **to quantitatively assess the energy demand of current and future telecom infrastructures, and to design energy-efficient, scalable and sustainable future networks.**

The NoE will integrate and drive the many recent research efforts in energy-efficient networking towards commonly agreed technical goals, laying down the basis for **a new holistic approach to energy-efficient networking**, investigating effective strategies and mechanisms

to reduce energy consumption in current and future networks in general, and the future Internet in particular. We aim at identifying the best answers to the following questions:

- What is the real power consumption of ICT?
- What are the means to best reduce the energy consumption of today's networks without compromising requirements in network and service performance?
- What are the best suited engineering criteria and principles to actively support energy efficiency along the sequence of network design, planning, and operation?
- What changes in the design of network equipment are necessary in the short and long term in order to obtain the largest possible energy saving?
- Which communication and management paradigms and protocols will be able to mediate and ensure the most effective distributed energy control?
- What are the most promising and sustainable long-term approaches to energy efficient networking, assuming that a clean slate network design is possible, and what are potential migration strategies to achieve this?
- What kind of mutually beneficial incentives can be proposed to network operators, service providers, and users, in order to maximize energy efficiency?

The aim of TREND is to establish the **integration** of the EU research community in green networking with a **long term** perspective to consolidate the European leadership in the field.

TRILOGY

(Re)Architecting the Internet. An Hourglass Control Architecture for the Internet, Supporting Extremes of Commercial, Social and Technical Control)



Participating entity: Universidad Carlos III de Madrid

Collaborating researcher from IMDEA Networks: Iljitsch van Beijnum, Research Assistant
Andra Lutu, Research Assistant

Project website: www.trilogy-project.org

Funded by: European Union. Program FP7-ICT (ICT-2007-216372).

Project partners: British Telecommunications PLC (Coordinator), Deutsche Telekom AG, NEC Europe Ltd., NOKIA Oyj, Roke Manor Research Limited, Athens University of Economics and Business – Research Center, Universidad Carlos III de Madrid, University College London, Université catholique de Louvain, EURESCOM - European Institute for Research and Strategic Studies in Telecommunications GmbH, Stanford University Law School

Duration: January 2008 – March 2011

Description: **The Internet is out-growing its original design.** Evidence for this is widespread and the problem is affecting all the various stakeholders in different ways. End users are

plagued by security worries; operators are spending ever more effort to mitigate the effects of address space depletion and the limitations of current inter-domain routing protocols; enterprises face complex trade-offs when trying to ensure resilience through multi-homing or protection from distributed denial-of-service attacks, and application developers have a mountain to climb in order to circumvent the presence of middleboxes in the end-to-end path. **It is now the right time to develop a new design that is cognizant of the competing technical, economic and social demands that must be met by the global information network.**

The aim of the Trilogy project is to develop new solutions for the control architecture of the Internet and remove the known and emerging technical deficiencies while avoiding prejudging commercial and social outcomes for the different players. The focus is the generic control functions of the Internet - the neck of the hour-glass but for control. Our architectural design activities focus on **a radical approach to develop a Future Internet for the next 20+ years**. This design is tempered and refined by considering the need for incremental deployment.

Trilogy project forms part of the Seventh Framework Programme (FP7) of the European Union (EU).

WiMAX SCHEDULING OPTIMIZATION

Participating entity: Institute IMDEA Networks

Funded by: Alcentia Systems, S.A.

Duration: November 2010 – November 2011 (extendable until November 2014)

Description: The purpose of this collaboration agreement is the promotion of joint research projects between Institute IMDEA Networks and Alcentia, focusing on **high quality research with direct relevance to industry** in the field of communication networks and new information technologies.

The collaboration between the parties targets the following areas:

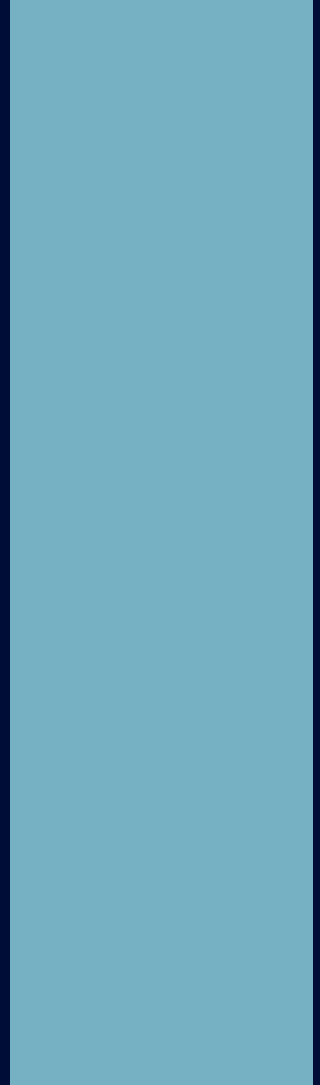
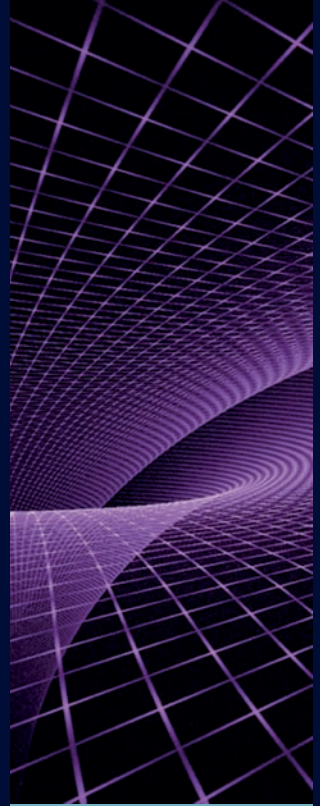
- Optimization of WiMAX scheduling and queue management
- Cross-layer optimization using ARQ/HARQ
- Implementation of the algorithms on a WiMAX base station
- Performance analysis in a WiMAX testbed



scientific activities

5

- 5.1. Publications [33]
- 5.2. Scientific service [38]
- 5.3. Major events [41]
- 5.4. Workshops, seminars, lectures [44]



5.1. Publications

- 1. S. Ali, A. Mitschele-Thiel, A. Diab, A. Rasheed**
A Survey of Services Placement Mechanisms for Future Mobile Communication Networks
The 8th International Conference on Frontiers of Information Technology (FIT 2010)
21-23 December 2010 (Islamabad, Pakistan)
- 2. A. Sevilla, A. Mozo, M. Araceli Lorenzo, J. L. López-Presa, P. Manzano, A. Fernández Anta**
Biased Selection for Building Small-World Networks
The 14th International Conference on Principles of Distributed Systems (OPODIS 2010)
Lecture Notes in Computer Science, 2010, Vol. 6490/2010, pp. 32-47,
14-17 December 2010 (Tozeur, Tunisia)
- 3. F. Campoccia, V. Mancuso**
A fast heuristic for solving the D1EC coloring problem
The 3rd International Workshop on Wireless Network Algorithm and Theory (WiNA2010)
11-13 December 2010 (Hong Kong SAR, China)
- 4. R. Al-Zubi, M. Krunz, L. Lopes**
Resource utilization mechanism for multi-rate ultrawide band networks
The 53rd IEEE Global Communications Conference (IEEE GLOBECOM 2010)– Wireless Networking Symposium
6-10 December 2010 (Miami, Florida, USA)
- 5. A. Fernández Anta, M. A. Mosteiro**
Contention Resolution in Multiple-Access Channels: k-Selection in Radio Networks
Discrete Mathematics, Algorithms and Applications, World Scientific (DMAA), Vol. 2, Issue 4, pp. 445-456
Publisher: World Scientific Publishing Company
December 2010
- 6. R. Cuevas, M. Kryczka, A. Cuevas, S. Kaune, C. Guerrero, R. Rejaie**
Is Content Publishing in BitTorrent Altruistic or Profit Driven?
The 6th International Conference on emerging Networking EXperiments and Technologies (ACM CoNEXT 2010)
30 November – 3 December 2010 (Philadelphia, USA)
- 7. S. Yadav, A. Kumar Reddy, A. L. Narasimha Reddy, S. Ranjan**
Detecting algorithmically generated malicious domain names
The 10th Internet Measurement Conference (IMC 2010)
1-3 November 2010 (Melbourne, Australia)
- 8. T. Shue, M. Krunz**
Exploiting microscopic spectrum opportunities in cognitive radio networks via coordinated channel access
IEEE Transactions on Mobile Computing (TMC), Vol. 9, No. 11, pp. 1522-1534
November 2010
- 9. A. Fernández Anta, E. Jiménez, M. Raynal**
Eventual leader election with weak assumptions on initial knowledge, communication reliability, and synchrony
Journal of Computer Science and Technology, Vol. 25, No. 6, pp. 1267–1281
November 2010
- 10. E.M. Arkin, A. Fernández Anta, J. S. B. Mitchell, M. A. Mosteiro**
The Length of the Longest Edge in Multi-dimensional Delaunay Graphs
The 20th Annual Fall Workshop on Computational Geometry
29 -30 October 2010 (Stony Brook, New York, USA)

11. A. Cuevas, M. Urueña, G. de Veciana

*Dynamic Random Replication for Data Centric Storage (*BEST PAPER AWARD)*

The 13th ACM International Conference on Modeling, Analysis and Simulation of Wireless and Mobile Systems (MSWIM 2010)

17-21 October 2010 (Bodrum, Turkey)

12. C. Zhou, N. F. Maxemchuk

Bandwidth Balancing in Mobile Ad Hoc Networks

The 6th IEEE International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob 2010)

11-13 October 2010 (Niagara Falls, Canada)

13. A. Fernández Anta, A. Milani, M. A. Mosteiro, S. Zaks

Opportunistic Information Dissemination in Mobile Ad-hoc Networks: The Profit of Global Synchrony

Lecture Notes in Computer Science, 2010, Vol. 6343/2010, pp. 374-388

The 24th International Symposium on Distributed Computing (DISC 2010)

September 2010 (Cambridge, Massachusetts, USA)

14. I. Vidal, J. Garcia-Reinoso, A. de la Oliva, A. Bikfalvi, I. Soto

Supporting mobility in an IMS-based P2P IPTV service: a Proactive Context Transfer mechanism

Computer Communications (Special Issue on Multimedia Networking and Security in Convergent Networking), Vol. 33, Issue 14, pp. 1736 – 1751

1 September 2010

15. A. García-Martínez, M. Bagnulo, I. van Beijnum

The Shim6 architecture for IPv6 multihoming

IEEE Communications Magazine, Vol.48, Issue 9, pp. 152 – 157, ISSN: 0163-6804

September 2010

16. C. J. Bernardos, M. Gramaglia, L. M. Contreras, M. Calderon, I. Soto

Network-based Localized IP mobility Management: Proxy Mobile IPv6 and Current Trends in Standardization

Journal of Wireless Mobile Networks, Ubiquitous Computing, and Dependable Applications (JoWUA), Vol. 1, No. 2/3 (2010): Advances in Wireless Mobile and Sensor Technologies, ISSN (print): 2093-5374, ISSN (on-line): 2093-5382

September 2010

17. P. Devakota, A. L. Narasimha Reddy

Performance of Quantized Congestion Notification in TCP Incast scenarios in data centers

The 18th Annual Meeting of the IEEE International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems (IEEE MASCOTS 2010)

17-19 August, 2010 (Miami Beach, Florida, USA)

18. X. Wu, A. L. Narasimha Reddy (*BEST PAPER AWARD NOMINATION)

Exploiting concurrency to improve latency and throughput in a hybrid storage system

The 18th Annual Meeting of the IEEE International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems (IEEE MASCOTS 2010)

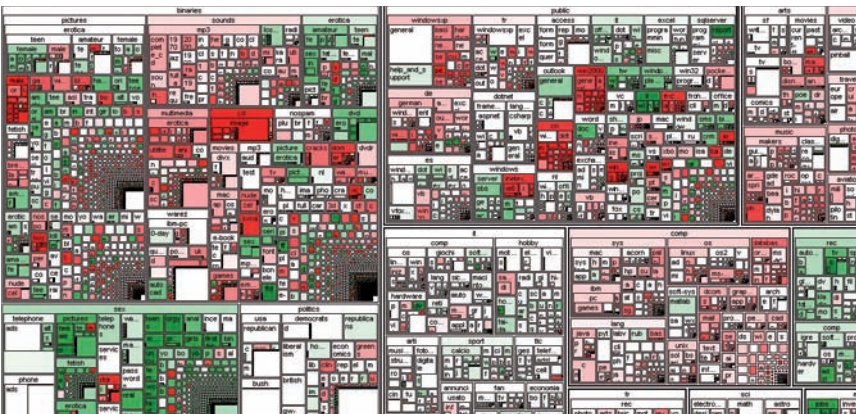
17-19 August 2010 (Miami Beach, Florida, USA)

19. A. Banchs, P. Serrano, L. Vollero

Providing Service Guarantees in 802.11e EDCA WLANs with Legacy Stations

IEEE Transactions on Mobile Computing, Vol. 9, No. 8, pp. 1057-1071, ISSN: 1536-1233

August 2010



20. A. Fernández Anta, M. A. Mosteiro, C. Thraves

Deterministic Recurrent Communication and Synchronization in Restricted Sensor Networks

The 6th International Workshop on Algorithms for Sensor Systems, Wireless Ad Hoc Networks and Autonomous Mobile Entities (ALGOSENSORS 2010), Revised Selected Papers

Series: Lecture Notes in Computer Science, 2010, Vol. 6451/2010

Subseries: Computer Communication Networks and Telecommunications 2010, ISBN 978-3-642-16987-8

Editor: Scheideler, Christian

5 July 2010 (Bordeaux, France)

21. T. Shue, M. Krunz, S. Liu

Secure data collection in wireless sensor networks using randomized dispersive routes

IEEE Transactions on Mobile Computing (TMC), Vol. 9, No. 7, pp. 941-954

July 2010

22. T. Shue, M. Krunz

Exploiting microscopic spectrum opportunities in cognitive radio networks via coordinated channel access

The 7th Annual IEEE Communications Society Conference on Sensor, Mesh and Ad Hoc Communications and Networks (IEEE SECON 2010) 21 -25 June 2010 (Boston, Massachusetts, USA)

23. L. Badia, R. Aguiar, A. Banchs, T. Melia, M. Wetterwald, M. Zorzi

Wireless access architectures for video applications: the approach proposed in the MEDIEVAL project

The 31st IEEE Symposium on Computers and Communications (ISCC 2010), The 5th IEEE Workshop on multiMedia Applications over Wireless Networks (MediaWiN 2010), pp. 991 – 996, ISSN: 1530-1346, ISBN: 978-1-4244-7754-8 (Print)

22 – 25 June 2010 (Riccione, Italy)

24. J. Lessmann, M. Schoeeler, F. Zdarsky, A. Banchs

Rope ladder routing: Position-based multipath routing for wireless mesh networks

The IEEE International Symposium on World of Wireless Mobile and Multimedia Networks (WoW-MoM 2010), IEEE HotMESH 2010, pp. 1-6, E-ISBN: 978-1-4244-7263-5, ISBN: 978-1-4244-7264-2 (Print)

14 -17 June 2010 (Montreal, Canada)

25. M. Desai, N. F. Maxemchuk

Polar Coordinate Routing for Multiple Paths in Wireless Networks

The IEEE International Symposium on a World of Wireless Mobile and Multimedia Networks, (WoWMoM 2010), pp. 1-9, ISBN: 978-1-4244-7264-2

14-17 June 2010 (Montreal, Canada)

26. P. Serrano, A. Banchs, P. Patras, A. Azcorra

Optimal Configuration of 802.11e EDCA for Real-Time and Data Traffic

IEEE Transactions on Vehicular Technology, Vol. 59, No. 5, pp. 2511-2528, ISSN: 0018-9545

June 2010

27. I. van Beijnum, A. Azcorra, M. Bagnulo,

OmtTCP: Increasing Performance in Server Farms

The - IEEE International Conference on Communications (ICC 2010), pp. 1-6, ISSN: 1550-3607

23-27 May 2010 (Cape Town, South Africa)

28. Y. Oh Lee, A. L. Narasimha Reddy

Disjoint Multipath Routing and Failure Recovery

The IEEE International Conference on Communications (ICC 2010)

23-27 May 2010, (Cape Town, South Africa)

29. M. Podlesny, S. Gorinsky

Stateless RD Network Services

IFIP Networking 2010, pp. 135-147

11-15 May 2010 (Madras, India)

30. N. Sakr, N.D. Georganas, J. Zhao, E.M. Petriu
Multimodal Vision-Haptic Perception of Digital Watermarks Embedded in 3D Meshes

IEEE Transactions on Instrumentation and Measurement, Vol. 59, No. 5
May 2010

31. A. Azcorra, M. Kryczka, A. Garcia-Martinez
Integrated routing and addressing for improved IPv4 and IPv6 coexistence

IEEE Communications Letters, Vol. 14, Issue 5, pp. 477 – 479, ISSN: 1089-7798
May 2010

32. P. Serrano, M. Hollick, A. Banchs
On the Trade-Off between Throughput Maximization and Energy Consumption Minimization in IEEE 802.11 WLANs

Journal of Communications and Networks, Vol. 12, No. 2

Publisher: Korea Information and Communications Society. ISSN 1976-5541 (Online), ISSN 1229-2370 (Print)
30 April 2010

33. M. Ajmone Marsan, L. Chiaraviglio, D. Ciullo, M. Meo

A Simple Analytical Model for the Energy-Efficient Activation of Access Points in Dense WLANs
The 1st International Conference on Energy-Efficient Computing and Networking (E-Energy 2010) (In cooperation with ACM SIGCOMM)
University of Passau
13-15 April, 2010, (Passau, Germany)

34. M. Kryczka, R. Cuevas, C. Guerrero, E. Yoneki, A. Azcorra

A First Step Towards User Assisted Online Social Networks
The 3rd ACM EuroSys Workshop on Social Network Systems (co-located with The 5th EuroSys Conference 2010)
13 April 2010 (Paris, France)

35. P. Serrano, A. Garcia-Saavedra, M. Hollick, A. Banchs

On the energy efficiency of IEEE 802.11 WLANs
The 16th European Wireless Conference (EW 2010) - Invited Session on Greening of the Wireless Internet
12 – 15 April 2010 (Lucca, Italy)

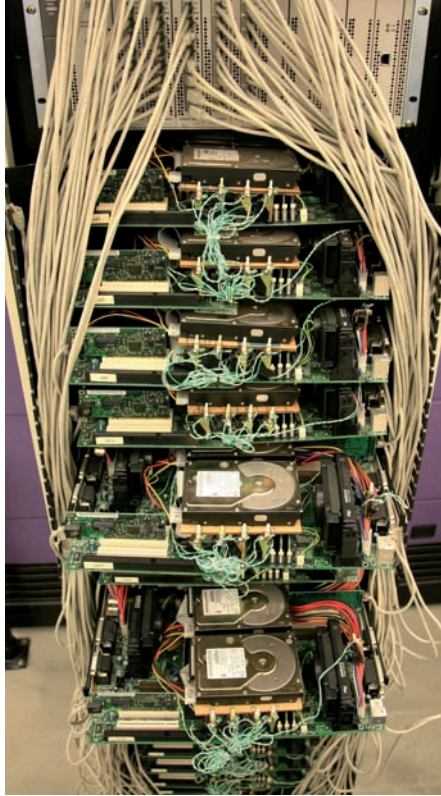
36. P. Serrano, C. J. Bernardos, A. de la Oliva, I. Soto

Lessons Learned from the Deployment of a Multihop IEEE 802.11g Testbed Using COTS Devices
The 16th European Wireless Conference (EW 2010) - Invited Session on Wireless Mesh Networks
12 – 15 April 2010 (Lucca, Italy)

37. P. Serrano, C. Bernardos, A. de la Oliva, A. Banchs, I. Soto, M. Zink

FloorNet: Deployment and Evaluation of a Multihop Wireless 802.11 Testbed
EURASIP Journal on Wireless Communications and Networks - Special issue on simulators and experimental testbeds design and development for wireless network, Vol. 2010 (2010), Article ID 153102, ISSN: 1687-1472. EISSN: 1687-1499
April 2010





38. B. Rengarajan; A.L. Stolyar, H. Viswanathan
Self-organizing Dynamic Fractional Frequency Reuse on the uplink of OFDMA systems
 The 44th Annual Conference on Information Sciences and Systems (CISS 2010), pp.1-6, ISBN: 978-1-4244-7416-5
 17-19 March 2010 (Princeton, New Jersey, USA)

39. D. Chieng, D. V. Hugo, A. Banchs
A Cost Sensitivity Analysis for Carrier Grade Wireless Mesh Networks with Tabu Optimization
 The 29th Annual IEEE International Conference on Computer Communications (IEEE INFOCOM 2010), The 2nd International Workshop on CARrier-grade wireless MESH Networks (CARMEN Workshop 2010), pp. 1-6, ISBN: 978-1-4244-6739-6 (Print)
 19 March 2010 (San Diego, California, USA)

40. P. Serrano, A. Banchs, V. Targón, J. F. Kukiélka
Detecting Selfish Configurations in 802.11 WLANs
 IEEE Communications Letters, Vol. 14, Issue 2, pp. 142-144, ISSN: 1089-7798
 February 2010

41. C.J. Bernardos, A. Festag, N.F. Maxemchuk, C. Pinart, C. Weiß
Advances in Vehicular Communications Networks
 IEEE Network, Vol. 24, No.1
 January-February 2010

42. H. Yu, N. F. Maxemchuk
Improving QoE using a Novel Multipath Routing based on Source and Intermediate Node Forwarding
 The 2nd International Conference on Future Networks (ICFN 2010), pp. 372-375, ISBN: 978-0-7695-3940-9
 22 – 24 January 2010 (Sanya, Hainan, China)

43. R. Boutaba, S. Murphy, A. Banchs
Special Issue on Wireless Multi-Hop Networking for Infrastructure Access [Editorial]
 Computer Networks
 Publisher: Elsevier
 Vol. 54, Issue 2, pp.175-177
 January 2010

5.2. Scientific service

IMDEA Networks conducts its scientific activities with the final objective of ensuring the widest possible dissemination of the results of the work carried out by the Institute, both within the scientific community and towards the general public. Our scientific service includes participation by our researchers at different levels of involvement in leading conferences and journals in the field, R&D committees, standardization bodies, awards, publications, projects or sponsorships:

M. Ajmone Marsan

- Keynote speech «Energy Efficient Wireless Internet Access with Cooperative Cellular Networks» at The 4th International Conference on Next Generation of Mobile Applications, Services and Technologies (NGMAST 2010) – 26-29 July 2010, (Amman, Jordan)
- TPC co-chair for the Work-in-Progress track at The 29th Annual IEEE International Conference on Computer Communications (IEEE INFOCOM 2010)
- TPC member of The 1st international conference on energy-efficient computing and networking (e-Energy 2010)
- TPC member of The 6th International Conference on emerging Networking EXperiments and Technologies (ACM CoNEXT 2010)
- TPC member of The 17th European Wireless Conference (EW 2010)
- Guest editor of the Special Issue of the journal Transactions on Petri Nets and Other Models of Concurrency on Networks, Protocols, and Services
- Steering Committee member of the journal IEEE/ACM Transactions on Networking
- Member of the Italian delegation in the European Commission Information and Communication Technologies (ICT) Committee of the Seventh Framework Programme (FP7)

A. Fernández Anta

- Steering Committee member of The 24th International Symposium on DIStributed Computing (DISC 2010)
- TPC for The 14th International Conference on Principles of Distributed Systems (OPODIS 2010)
- TPC for The 29th Annual ACM SIGACT-SIGOPS Symposium on the Principles of Distributed Computing (PODC 2010)
- TPC for The 24th IEEE International Parallel and Distributed Processing Symposium (IPDPS 2010)



A. Banchs

- TPC co-chair for EW 2010
- TPC co-chair for The Second IEEE WoWMoM Workshop on Hot Topics in Mesh Networking (IEEE HotMESH 2010), in conjunction with The 11th IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks (IEEE WoWMoM 2010)
- Panel co-chair for The 2nd International Conference on Mobile Lightweight Wireless Systems (MOBILIGHT 2010)
- TPC member of The Work-in-Progress track at IEEE INFOCOM 2010
- TPC member of The 19th Future Network & Mobile Summit 2010
- TPC member of The 53rd IEEE Global Communications Conference (IEEE GLOBECOM 2010)
- Editor of the journal Computer Communications
- Senior Editor of the journal IEEE Communications Letters
- Guest Editor of the journal Computer Networks , Special Issue on «Multi-Hop Wireless Access Networks», 2010

S. Gorinsky

- Publication Chair for The annual conference of the ACM Special Interest Group on Data Communication (SIGCOMM) on the applications, technologies, architectures, and protocols for computer communication (ACM SIGCOMM 2010)
- TPC member of IEEE INFOCOM 2010
- TPC member of The 18th IEEE International Conference on Network Protocols (ICNP 2010)
- TPC member of The 4th International Conference on COMMunication Systems and NETWORKS (COMSNETS 2010)
- TPC member of The 13th IEEE Global Internet Symposium 2010 (Global Internet 2010), held in conjunction with IEEE INFOCOM'10
- Editor of the Journal of Communications
- Editor of the Journal of Internet Engineering
- Vice-Chair of the IEEE Communications Society (ComSoc) Technical Committee on High-Speed Networking (TCHSN)

J. Widmer

- TPC member of The 3rd Joint IFIP Wireless Mobile Networking Conference (IFIP WMNC 2010)
- TPC member of The 4th IEEE International Workshop on Web and Pervasive Security (IEEE WPS 2010)
- TPC member of The ACM Student Research Competition (SRC) at The 16th Annual International Conference on Mobile Computing and Networking (MobiCom 2010) and The Eleventh ACM International Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc 2010)
- TPC member of The 3rd IEEE Workshop on Green Communications 2010 (Green-Comm3 2010), in conjunction with IEEE GLOBECOM 2010
- TPC member of Industry track at IEEE WoWMoM 2010
- TPC member of The 72nd IEEE Vehicular Technology Conference (IEEE VTC-Fall 2010)
- TPC member of The 1st ACM SIGCOMM Workshop on Green Networking, in conjunction with ACM SIGCOMM 2010
- TPC member of The 2nd IEEE Workshop on Pervasive Group Communication (IEEE Per-Group 2010)
- TPC member of The 3rd IEEE Cooperative and Cognitive Mobile Networks Workshop (IEEE CoCoNet3 2010), in conjunction with IEEE ICC 2010
- TPC member of The 13th IEEE Global Internet Symposium 2010, in conjunction with IEEE INFOCOM 2010
- TPC member of The 6th IEEE International Symposium on Network Coding (NetCod 2010)
- TPC member of e-Energy 2010
- TPC member of IEEE INFOCOM 2010
- TPC member of The 2010 Communications and Technology Conference (PlaNet 2010)
- TPC member of The 3rd GI/ITG KuVS 2010 Workshop on «The Future Internet»
- TPC member of The 71st IEEE Vehicular Technology Conference (IEEE VTC-Spring 2010)
- TPC member of EW 2010
- TPC member of The 7th International Conference on Wireless On-demand Network Systems and Services (WONS 2010)
- Associate Editor of the journal IEEE Transactions on Communications
- Awarded senior member status of IEEE and ACM



5.3. Major events



The 2nd IMDEA Networks Annual International Workshop: Energy Efficiency and Networking

Attendees & Speakers:

- Albert Banchs (Deputy Director at IMDEA Networks)
- Jean-Yves Le Boudec (Full Professor at EPFL): ***Greening Of Mobile Networks: Myths and Opportunities***
- Michael J. Bennett (Senior Network Engineer at Lawrence Berkeley National Laboratory, U.S. Department of Energy): ***Ethernet: An Energy-efficient Technology***
- Jon Crowcroft (Marconi Professor of Communications Systems at University of Cambridge): ***The INTelligent Energy aWare NETWORKS (INTERNET) project***
- Yvon Gourhant (R&D Program Manager at Orange Labs): ***Energy aware networks from a point of view of a telecom operator***
- Suresh Goyal (Green Research Leader at Bell Labs, Alcatel-Lucent): ***GreenTouch™ Inventing Sustainable, Ultra-Energy-Efficient ICT Networks***
- Thomas Hillman (Marketing Manager at Texas Instruments): ***Communication as the foundation of the smart grid***
- Nicholas F. Maxemchuk (Full Professor at Columbia University and Chief Researcher at IMDEA Networks): ***Communicating Appliances***
- Mark A. Monroe (President at Energetic Consulting): ***State of the Art and Research Needs In Data Center Efficiency***
- Hermann De Meer (Professor, Chair of Computer Networks and Computer Communications at University of Passau): ***Security and Privacy Concerns vs. Energy Efficient Computing and Networking***
- Dejan Kostic (Assistant Professor at EPFL - Networked Systems Laboratory): ***Energy-Proportional Networks***
- Paul J. Kühn (Professor Emeritus at University of Stuttgart)

Panel: The Future of Green Networking

- Moderator: Marco Ajmone Marsan, Full Professor at Politecnico di Torino and Chief Researcher at IMDEA Networks
- Panel members: Jon Crowcroft (Marconi Professor of Communications Systems at University of Cambridge), Yvon Gourhant (R&D Program Manager at Orange Labs), Mark Monroe (President at Energetic Consulting), Jean-Yves Le Boudec (Full Professor at EPFL), Mary Luz Mouronte (Division Manager at Telefonica Research, Madrid)

Dates:

31st May 2010, 11:00 - 20:00 / 01st June 2010, 09:00 – 18:00

Abstract:

IMDEA Networks has organized its 2nd Annual **International Workshop**, this year focusing on **Energy Efficiency and Networking**, on 31st May - 1st June, 2010 in Madrid, Spain. The workshop included presentations and a panel dealing with the latest advances and challenges facing the field. Energy efficiency is becoming one of the most important issues of our time. Population growth and exhaustion of available energy sources makes clever use of energy one of the main challenges for our society. The objective of this workshop was to explore the role of networking in the general effort towards sustainable use of energy.

This workshop presented **an opportunity to understand how network operators, network device manufacturers, and data center operators are impacted by this emphasis on energy conservation**. The complexity of this issue derives from it involving a mix of technical, economical, social and political challenges. This workshop brought together some representative industrial perspectives with prominent researchers engaged in energy efficiency and networking, in order to exchange technical ideas and experiences and reach a better understanding of the problem and of the most promising future approaches.



Technology Transfer Symposium

Institute IMDEA Networks – AETIC – UC3M

Speakers:

Opening of the Symposium

- D. Arturo Azcorra (Director General, CDTI), D. Francisco Marín (President of Area of Activities for Technological Innovation, AETIC), D. Albert Banchs (Deputy Director, Institute IMDEA Networks), D. Carlos Balaguer (Vice-Rector of Research, UC3M)

Presentations

- D. Albert Banchs: **Presentation of Institute IMDEA Networks**
- D. Juan Gascón (Director for Digital Content & R&D, AETIC): **Presentation of the department for I+D+i of AETIC**

Energy Efficiency

- D. Antonio Fernández Anta (Senior Researcher, Institute IMDEA Networks) **Energy-efficient Networking at Institute IMDEA Networks**
- D. Francisco Romero (Director for Business Development, TELVENT Energía): **TEL-VENT Energía: Electric Vehicle - Telvent's Value Added Proposal**
- Dña. Marta Arias (General Manager for Energy Efficiency, INDRA): **INDRA: Energy-Efficient, e-Houses, 3e-HOUSES**



Wireless Communications

- D. Joerg Widmer (Senior Researcher, Institute IMDEA Networks): ***Wireless Networking at Institute IMDEA Networks***
- D. Francisco Cañas (Technical Director for Engineering and Solutions Division, AT4 WIRELESS): ***AT4 WIRELESS: Wireless Communications - Research and Development Areas***

Internet Economics

- D. Sergey Gorinsky (Senior Researcher, Institute IMDEA Networks): ***Internet Economics at Institute IMDEA Networks***
- D. Nikolaos Laoutaris (Senior Researcher, TELEFÓNICA I+D): ***Some thoughts on pricing broadband***

Presentation of research lines at University Carlos III of Madrid

- D. Carlos Balaguer (Vice-Rector of Research, UC3M)

Date:

10th November, 2010



X Semana de la Ciencia

Institute IMDEA Networks Open House: Research and Development

Speakers:

- Dr. Sergey Gorinsky (Senior Researcher, Institute IMDEA Networks): ***Institute IMDEA Networks and its Research Assistants***
- Paul Patras (Research Assistant, Institute IMDEA Networks): ***Student Perspective on Institute IMDEA Networks***
- Dr. Vincenzo Mancuso (Staff Researcher, Institute IMDEA Networks): ***Games: live experiments involving audience participation***
- Dr. Vincenzo Mancuso: ***The Effects of Frame Collisions in 802.11-based Mesh Networks***
- Dr. Antonio Fernández Anta (Senior Researcher, Institute IMDEA Networks): ***Small World Networks***

Date:

19th May 2010, 10:30 - 14:00

Abstract:

Why should I consider a future in research? What sort of opportunities does a PhD open up for me? What makes research in the science of networks such an exciting career choice?

*How can we ensure that the Internet can grow and adapt to ever-changing needs over the coming decades? What lies beyond the Internet? **What inspires network research?***

Join us on **Research Day** to explore the answers to some exciting questions. Learn what our Research Assistants, (who are themselves PhD students) do when they're not in the classroom and check out the many research paths that are open to you as a researcher once you have your doctorate. This is a rare opportunity to find out more about a range of career options from the people who really know what it's all about – our Research Assistants.

The **Institute IMDEA Networks one-day Open House event** gives you the chance to experience first-hand the full range of our computer networking research activities and collaborations via direct conversation with the researchers and students involved. The IMDEA Networks Open House will feature science and technology exhibits, displays of student posters, research presentations, networking career information and more. IMDEA Networks scientists will share with you their excitement about the institute's latest work. More details will be available as the day approaches, including the speakers' program.

With researchers on hand to demonstrate field work and discuss ongoing studies, the Open House is a great way to find out how we're helping society face the communication challenges of the 21st century.

5.4. Workshops, seminars, lectures

Weekly seminars alternated invited talks with presentations by internal researchers. Out of the 40 events in which the Institute participated, 18 were conducted by our researchers and 22 by invited speakers. We hereby list the latter:



Peer-to-peer Session Initiation Protocol (P2PSIP)

Speaker: Gonzalo Camarillo, Head of the Advanced Signaling Research Laboratory - Nomadic Laboratory, Ericsson Finland (Suomi, Finland)

Date: 22nd November 2010



WHY I AM A SCIENTIST - Researchers' Night, Madrid 2010 - Creativity for progress in Europe

Speakers:

Eloy García Calvo - Director of Institute IMDEA, Water.

Manuela Juárez - Director of Institute IMDEA Food

Benigno Valdés - Director of Institute IMDEA Social Sciences

David Serrano - Director of Institute IMDEA Energy
Javier Llorca - Director of Institute IMDEA Materials
Rodolfo Miranda - Director of Institute IMDEA Nanoscience
Albert Banchs - Deputy Director, Institute IMDEA Networks
Manuel Hermenegildo - Director of Institute IMDEA Software
Date: 24th September 2010



Presentation of research lines:

Speakers:

- Dr. Kenichi Mase, Professor, Graduate School of Science and Technology, Niigata University (Niigata, Japan): *"Mesh networks"*
- Dr. Toshinori Tsuboi, Professor, School of Computer Science, Tokyo University of Technology (Tokio, Japan): «TPC scheme for ad hoc networks»
- Dr. Hiromi Ueda, Professor, School of Computer Science, Tokyo University of Technology (Tokio, Japan): «Optical burst receiver for optical switched access network»

Date: 20th September 2010



Routers and Networks with Near-Zero Buffers

Speaker: Dr. Vijay Sivaraman, University of New South Wales (Sydney, Australia)

Date: 7th July 2010



P2P Content Distribution

Speaker: Prof. Dah Ming Chiu, Department of Information Engineering, Chinese University of Hong Kong (Hong Kong, China)

Dates: 5th – 7th July 2010



CloudNet: Enterprise Ready Virtual Private Clouds

Speaker: Dr. K. K. Ramakrishnan, AT&T Labs Research (Florham Park, New Jersey, USA)

Date: 1st July 2010



Has the Internet delay gotten better or worse?

Speaker: Dr. Sue Moon, Daejeon Universit (South Korea)

Date: 30th June 2010



Towards the integration of heterogeneous sensor/actuator networks into context-aware systems

Speaker: Andreas Reinhardt, Technische Universität Darmstadt (Darmstadt, Germany)

Date: 2nd June 2010



Deployment of mission-critical surveillance applications on wireless sensor networks

Speaker: Prof. Dr. CongDuc Pham, University of Pau (Pau, France)

Date: 19th May 2010



Routing and capacity resilient network design

Speaker: Prof. Dr. Michal Pioro, Institute of Telecommunications, Warsaw University of Technology (Warsaw, Poland)

Dates: 11th – 13th May 2010



Multimedia Streaming in Dynamic Peer-to-Peer Systems and Mobile Wireless Networks

Speaker: Prof. Dr. Mohamed Hefeeda, Assistant Professor, School of Computing Science, Simon Fraser University (Canada)

Date: 27th – 30th April 2010



inEXT and An Energy Driven Architecture for Modelling Energy Consumption in Wireless Sensor Networks

Speaker: Dr. Doan B. Hoang, Professor in the School of Computing and Communications, Faculty of Engineering and Information Technology, the University of Technology, Sydney (UTS)(Australia); Visiting Researcher, Telematics Department, Universidad Carlos III de Madrid

Date: 21st April 2010



Social Network Analysis for Delay Tolerant Networks

Speaker: Dr. Thrasyvoulos Spyropoulos, Senior Researcher and Lecturer, Swiss Federal Institute of Technology (ETH), (Zurich, Switzerland)

Date: 9th April 2010



Overview of the IEEE 802.21 standard and its future steps

Speaker: Dr. Juan Carlos Zuniga, Senior staff member, Interdigital Corporación Tecnológica (Barcelona, Spain); Vice-Chair, IEEE 802.21.

Date: 6th April 2010



Broadcasting in Wireless Ad Hoc Networks

Speaker: Dr. Majid Khabbazzian, Postdoctoral fellow, Computer Science and Artificial Intelligence Lab, Massachusetts Institute of Technology (MIT) (Massachusetts, USA)

Date: 31st March 2010



Binary Program Analysis and Model Extraction for Security Applications

Speaker: Juan Caballero, Carnegie Mellon University and University of California, Berkeley (USA)

Date: 25th March 2010



CacheCast: Eliminating Redundant Link Traffic for Single Source Multiple Destination Transfers

Speaker: Prof. Dr. Thomas Plagemann, University of Oslo (Norway)

Date: 24th March 2010



Networked 3-D Virtual Collaboration in Science and Education: Towards 'Web 3.0' (A Modeling Perspective)

Speaker: Prof. Dr. Michael Devetsikiotis, IEEE Communication Society Distinguished Lecturer 2008-2011; Professor, Department of Electrical and Computer Engineering, NC State University, Raleigh, North Carolina (USA)

Date: 22nd March 2010



Analysis and Experimental study of operational 802.11-based Wireless Mesh Networks

Speaker: Dr. Vincenzo Mancuso, Post-Doc Researcher. INRIA Sophia Antipolis -Méditerranée. (Le Chesnay, France)

Date: 5th March 2010

This talk was delivered before Vincenzo Mancuso joined the Institute



Cloud elasticity at a flat fee

Speaker: Dr. Rade Stanojevic, Post-Doc Researcher, Telefonica Research (Barcelona, Spain)

Date: 26th February 2010

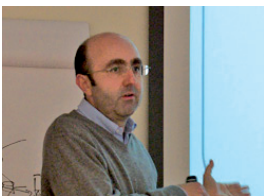
This talk was delivered before Rade Stanojević joined the Institute



Workshop: The GeoNet Final Workshop

Speakers: Emilio Davila Gonzalez (European Commission); Arnaud de La Fortelle (INRIA); Thierry Ernst (INRIA); Carlos J. Bernardos (Universidad Carlos III de Madrid); Wenhui Zhang (NEC); Hamid Menouar (Hitachi)

Date: 29th January 2010

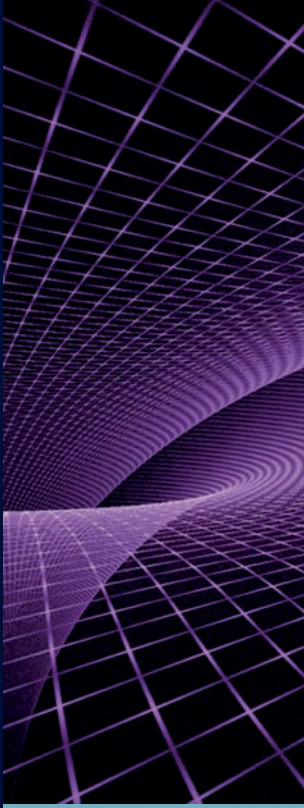


Conference: Energy Efficient Ethernet (IEEE 802.3az): Performance Evaluation

Speaker: Dr. Pedro Reviriego, Universidad Antonio de Nebrija (Madrid)

Date: 18th January 2010





6

impact and technology transfer

- 6.1. Paper awards [50]
- 6.2. Patents [51]
- 6.3. Participation on standardization bodies [52]
- 6.4. Research projects highlights [55]
- 6.5. Technology transfer [57]
- 6.6. Media impact [60]

Institute IMDEA Networks monitors and evaluates its scientific results in order to obtain a sound appraisal of its strategy and objectives, optimizing the management of its resources and maximizing its impact. The pursuit of excellence is at the core of all of our activities.

6.1. Paper awards

The following publications have either received or been nominated to a Best Paper Award. They are listed in order of publication, starting by the most recent:



1. A. Cuevas, M. Urueña, G. de Veciana

Dynamic Random Replication for Data Centric Storage (*BEST PAPER AWARD)

The 13th ACM International Conference on Modeling,
Analysis and Simulation of Wireless and Mobile Sys-
tems (MSWIM 2010)
17-21 October 2010 (Bodrum, Turkey)

2. **X. Wu, A. L. Narasimha Reddy** (*BEST PAPER AWARD NOMINATION)

Exploiting concurrency to improve latency and throughput in a hybrid storage system

The 18th Annual Meeting of the IEEE International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems (IEEE MASCOTS 2010)
17-19 August 2010 (Miami Beach, Florida, USA)

3. A. Bikfalvi, J. Garcia-Reinoso, I. Vidal, F. Valera (*BEST PAPER AWARD)

Nozzilla: A Peer-to-Peer IPTV Distribution Service for an IMS-based NGN

The 5th International Conference on Networking and Services (ICNS 2010) (Valencia, Spain)

6.2. Patents

Announcement of upcoming patent filing for energy efficiency of computer networks



Institute IMDEA Networks, in collaboration with NEC Laboratories Europe and University Carlos III of Madrid, has announced the imminent filing of a patent application. It will establish a novel method for the reduction of the energy consumption of a network by minimizing the number of active nodes involved in any given communication.

The importance of energy saving solutions for networking has steadily increased over the last few years due to environmental and economic reasons. In order to reduce the energy footprint of current and future systems, engineers are now working on enhancements to all networking layers with the objective of optimizing their energy efficiency. Some optimizations focus on energy saving while the network is operative, and other approaches consider solutions that aim at minimizing the number of active nodes within the network. The new proposed mechanism to reduce the energy consumption of the network is elegantly simple, both in design and application. For a given network topology and traffic matrix, it produces optimal routing in terms of energy and throughput, by providing a routing system which maximizes the number of flows that can be admitted into the network while powering down (fully or partially) nodes that are not required to transport the given traffic.

This mechanism has been shown to produce excellent results in different tests, outperforming other approaches very substantially in terms of throughput as well as energy consumption. The reductions achieved correspond to up to 40% of the amount of energy consumed.

The expected patent filing is one of the awaited results of the European Project CARMEN, which is predicted to conclude in early 2011 with outstanding grades. CARMEN focuses on the provision of carrier-grade services over wireless mesh networks. Manufacturers, operators, universities and research institutes work on the design of next generation multi-hop networks, comprised of heterogeneous radio technologies, meaning more available, easier-to-deploy and more cost-effective services.



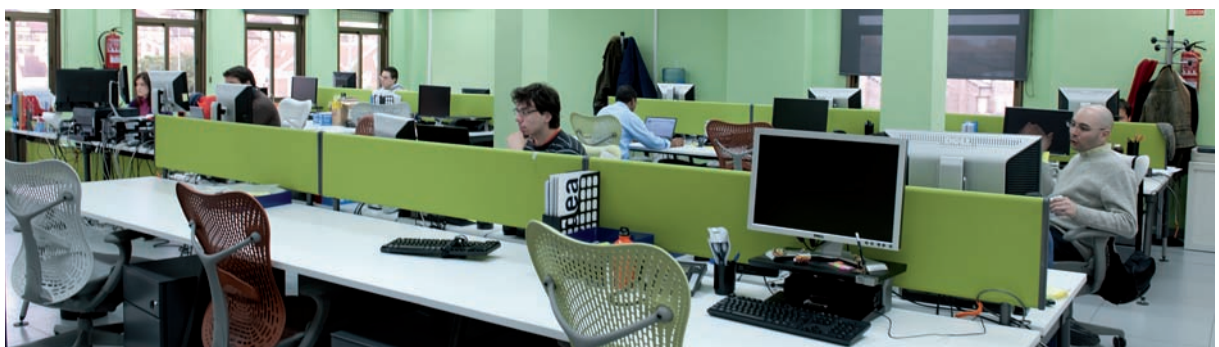
6.3. Participation on standardization bodies

In networking, standardization is much more important than in many other technological fields. The reason for this is that many different vendors make networking equipment, network-attached devices and software running on such devices. Without strong standardization efforts, the industry has to rely on de-facto proprietary standards that may or may not evolve well as bandwidth and usage go up. **Standardization means research has a high likelihood of being deployed in practice.**

The IEEE Standards Association is one of the premier standards organizations working on the lower layers in the network model. The most widely known series of IEEE standards are 802.3 (Ethernet) and 802.11 (Wi-Fi). Many researchers at UC3M Netcom and Institute IMDEA Networks perform research on the 802.11 wireless protocols standardized by the IEEE SA.

The IETF (Internet Engineering Task Force) works across all layers of the network model in as far as such work relates to the internet, with perhaps the core focus on IP at the network layer and the protocols such as TCP running directly on top of IP. Marcelo Bagnulo of NETCOM Research Group was one of the leaders in taking on the NAT64 work in the IETF BEHAVE working group that allows IPv6 clients to communicate with IPv4 servers. **Iljitsch van Beijnum, a Research Assistant at IMDEA Networks**, whose doctorate Bagnulo supervises, also participated in this effort, especially in the areas of IP packet translation and fragmentation and allowing the FTP protocol to work through the translation mechanism. Iljitsch was also involved in early Multipath TCP work and on a new BGP routing preference attribute.

Marcelo Bagnulo served a term as a member of the Internet Architecture Board (IAB) - a body of 13 experts who play a major role in the process of definition of Internet Protocols, and as a result, on the worldwide evolution of the Internet. The IAB is a committee of the IETF that oversees the technical and engineering development of the Internet by the Internet Society (ISOC). As such, it wields a lot of influence over the architectural direction towards which IETF standards evolve. Marcelo had the honor of being the first member of a Spanish Institution (UC3M) to be elected to the IAB. He was the fourth research collaborator of IMDEA Networks to have been appointed to the IAB in recent years, the other three being members of its Scientific Council: Gonzalo Camarillo of Nomadic Labs Ericsson Research, Professor Jon Crowcroft of University of Cambridge and Professor Lixia Zhang of UCLA.



IMDEA Networks develops ongoing work on standardization within the IEEE and the IETF:



I E T F®

IETF

Iljitsch van Beijnum has worked on the following within the IETF:

Shim6 (RFC 5534)

RFC 5534 specifies a protocol for detecting and repairing broken connectivity. It is used within Shim6, a mechanism to allow networks, including small ones such as home networks, to be connected to multiple internet service providers at the same time (multihoming), switching dynamically from one to the other if the connection over one ISP stops working. Shim6 is related to efforts to make internet routing more scalable as it avoids the existing multihoming mechanism where the routing system takes on additional work.

draft-van-beijnum-shim6-shim6to4 is a proposed extension to Shim6 that would also work with IPv4 to some degree.

NAT64 (RFCs 6146 and 6147)

Stateful NAT64 is a mechanism developed within the BEHAVE working group to allow IPv6 clients to connect to IPv4 servers through a translation device (the NAT64) with help from a modified DNS server (the DNS64). Stateful NAT64 is based on stateless NAT64 with several modifications. *draft-van-beijnum-behave-frag64* and the *NAT64 fragmentation presentation* were meant to further discussion on how to handle the translation of fragmented packets in stateful and stateless NAT64s.

FTP64 is a specification adopted by the BEHAVE working group for an application layer gateway that makes it possible for an IPv6 FTP client to connect and exchange files with an IPv4 FTP server.

One-ended Multipath TCP

The IETF Multipath TCP (MPTCP) working group is tasked with developing an extension to TCP that allows TCP to work over multiple paths simultaneously. *draft-van-beijnum-1e-mp-tcp* was a proposal for the working group to work on a variant that only requires changes in the TCP sender. However, the working group adopted a variant where both the sender and the receiver are modified.

Origin Preference Attribute

The OPA (known previously as IAC in *draft-van-beijnum-idr-iac*) is an extension to BGP that makes it possible for the originator of routing updates to indicate a preference regarding which of multiple routes traffic should take preferentially. BGP as it exists today doesn't have a good way to express such a preference, hence network operators are relegated to using techniques that inflate the global routing table, increasing costs for the industry as a whole.

Router buffer sizing

At the summer 2009 IETF meeting in Stockholm, there were discussions about establishing a HOMEGATE working group that would create specifications or recommendations about home gateways that are used to connect home users to the internet. One issue relevant to HOMEGATE and also to the LEDBAT working group is the delay caused by buffering packets in home gateways. A short presentation highlighted this issue as a means to initiate work on limiting the harmful effects.

IEEE



Institute IMDEA Networks had a key role on the strong impact of the CARMEN project in the IEEE standardization body. One of the Working Groups of this body corresponds to the IEEE 802.21, LAN/MAN standard on Media Independent Handover Services. This standard proposes several media abstraction ideas that were extended during the CARMEN project. In particular IMDEA researchers worked on the following key issues:

Study Group created to analyze Heterogeneous Wireless Backhaul Networks

IMDEA Networks together with UC3M, NEC and Fraunhofer Institute worked for several years in explaining the concept Heterogeneous Wireless Backhuls and the possibility of using .21 as a media independent service layer offering mechanisms to abstract the specific technologies to the management plane.

Different contributions to IEEE 802.21

Within the study group, several contributions such as applicability use cases, new research on abstracting the parameters of the underlying technologies and contacts with different companies were performed.

Innovation leadership via participation in the Future Projects planning sessions

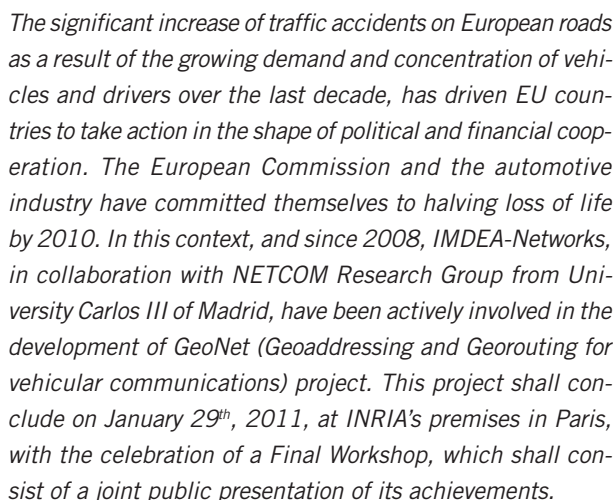
The IEEE 802.21 WG is now looking at new problems and standardization challenges to continue its work, since the base specification is finished and the three amendments planned are advancing as foreseen. In order to find new projects, the WG celebrates special sessions in the plenary meetings, called Future Projects planning sessions. IMDEA Networks and UC3M are leading partners in these meetings, providing new ideas and pushing for the development of new technologies.

Ongoing effort in IEEE 802.19.1 Coexistence of Wireless Networks in the TV White Space

Within the Future Planning sessions, one of the ideas that got a major support from the companies on the WG was the idea of using the MIHF defined in IEEE 802.21 as part of the upcoming IEEE 802.19.1, standard that analyses the coexistence of wireless technologies on the TV White Spaces spectrum. Researchers at IMDEA Networks contributed to defining this interaction between .21 and .19.1, which was submitted as a contribution to this working group.

annual report 2010

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The goal of the GeoNet Project has been to contribute to improve road safety in Europe by means of the development and practical application of new technologies to driving. Thus, it has researched a reference implementation of a geographic addressing and routing protocol, with support for IPv6 (the latest version of the IP protocol for Internet addressing), to be used to deliver safety messages between cars and the roadside infrastructure within a designated area.

Car-to-Car Communications and those with the surrounding roadside infrastructure mean, in practical terms, that vehicles will be able to detect and share information about the state of the roads, such as the existence of icy patches, or warn others about potential-

ly “dangerous” maneuvers, such as the application of the brakes. This flow of information promises to enable security applications to activate their alarm functionalities and mechanisms to reduce risk in dangerous situations and, as a direct consequence, reduce the incidence of fatal accidents.

GeoNet has taken the basic results of the CAR 2 CAR Communication Consortium’s work to the next step by further improving these specifications and creating a baseline software implementation that interfaces with IPv6. Thus, the goal of GeoNet has been to implement and formally test a networking mechanism as a standalone software module that can be incorporated into Cooperative Systems. This implementation enables transparent IP connectivity between a vehicle and the infrastructure, even in cases when delivery must hop over several vehicles or be cached along the way, which provides more reliable and scalable road information.

The GeoNet consortium has been composed of the following organizations, representing the private and public sectors: INRIA, IMDEA Networks, BroadBit, EFKON, Hitachi, NEC y Lesswire.

CARMEN project fosters carrier-grade mesh networking

The CARMEN project will allow the provision of carrier-grade services over wireless mesh networks comprised of heterogeneous radio technologies, meaning more available, easier-to-deploy services at lower cost.

IMDEA Networks awaits the coming conclusion with outstanding grades of the European Project CARMEN (CARrier grade MESH Networks), designed to enable the provisioning of carrier-grade services over wireless mesh networks comprised of heterogeneous radio technologies. The project will have ran from the beginning of January 2008 to the end of January 2011, and included the participation of nine partners from the public and private sectors, counting four universities, three telecommunications companies and two equipment vendors. The project was initially led by Prof. Dr Arturo Azcorra, currently on leave from his post as Director of IMDEA Networks, and later by Dr. Albert Banchs, the Institute’s Deputy Director.

Current backhaul solutions for radio access networks consist mostly of wired leased lines or point-to-point, high-capacity radio links, both of which are slow to deploy, expensive and not always available. Mesh networks, on the other hand, are «self-healing», making them very reliable, and are also economical, reusable, and significantly easier and faster to deploy than current systems. These features make them particularly well suited to incremental deployments or temporary scenarios such as natural disasters.



Among the achievements embodied in the CARMEN architecture are support for multiple wireless technologies, the efficient use of radio resources, capacity-aware mobility management, support for broadcast and multicast services, and self-configuration capabilities, features supported through the creation of new protocols and algorithms. The success of CARMEN will pave the way for the development of new carrier-grade mesh wireless products, lower deployment and maintenance costs for operators and better services at lower cost for users.

The project has resulted in the creation of a specialized IEEE study group, 12 different patent filings by the industrial partners, the publication of an RFC and contributions to various IETF working groups, 56 articles published in recognized journals and presented at international conferences and workshops, as well as special issues of journals and magazines, panels and sessions and public workshops. Additionally, the project operators are planning to showcase CARMEN-derived technology in different events and field-trials, and the academic partners are planning further research into radio resource management and heterogeneous wireless systems.

The partners participating in CARMEN are University Carlos III of Madrid with Institute IMDEA Networks, Alcatel-Lucent Deutschland AG, British Telecommunications PLC, Deutsche Telekom AG, Fraunhofer Gesellschaft Zur Foerderung DerAngewandten Forschung E.V., NEC Europe Ltd., AGH University of Science and Technology, University College Dublin and National University of Ireland, Dublin.

6.5. Technology transfer

We direct our work towards strengthening collaboration ties with industry, particularly through joint participation in projects and technology transfer. **We aim to develop technologies that have genuine socio-economic impact;** that is to say, projects that deliver value and that can be transferred to industry and, ultimately, to society. In order to ensure that our focus remains on addressing real-world problems and that our development activities result in generating value, we continue to build on our strong links with the business community both in the Madrid region of Spain and in the rest of the World.

Our **technology transfer strategy** is aimed to ensure that the Institute's research activities remain relevant, that its innovations are diffused and their full value to society realised through **various transfer processes** such as licensing and the sale of patents, creation and support of spin-off companies in the region that seek to commercialize products exploiting innovations developed within the Institute.

We carry out several forms of **collaboration**, including direct contracts with industry, as well as participation in joint projects financed by public entities. The projects listed in

section 5 include both types of partnerships with specific listings of those enterprises and organizations currently working with us.

Patents are important steps in the process of transferring technology to marketplace. Patent creation has strong implications for the Institute: patents are incentives for their creators, as they imply recognition for their creativity and material reward when these inventions are marketable. These incentives encourage innovation, the guarantee to the continuous improvement in the quality of research, and ultimately, of human life. It is Institute IMDEA Networks' policy to share a very high percentage of financial proceeds with inventors (our researchers) as reward for their excellence and hard work.

As an **example of work addressed to patenting**, in collaboration with NEC Laboratories Europe and Universidad Carlos III de Madrid, IMDEA Networks has worked towards the development of an invention to establish an original method for reducing the energy consumption of a network by minimizing the number of active nodes participating in a given communication. The collaborators intend to file a provisional patent application in early 2011 (For more information see section 7.2. above).

Joint, funded research projects enable us to establish solid ties to business. We are engaged in various **research projects with private sector collaborators**. These companies currently include:



Albentia Systems
(Madrid, Spain)



Alcatel-Lucent

Alcatel-Lucent Bell Labs,
France



Alcatel-Lucent

Alcatel-Lucent Bell Labs,
Deutschland AG



Alvarion



British Telecommunications
PLC



Broadbit Kft



Comsys Communication &
Signal Processing Ltd



Deutsche Telekom AG



Docomo Communications
Laboratories Europe
(Munich, Germany)



EFKON



Fastweb SPA (FW)



France Telecom SA (FT)



Hitachi



Huawei Technologies
Dusseldorf GmbH (HWDU)



Lesswire



LiveU



MobiMesh s.r.l.



NEC Europe Ltd.



NOKIA Oyj



Portugal Telecom Inovação



Roke Manor Research
Limited (Hampshire, UK)



Sequans Communications



Telecom Italia S.p.a.



Telefonica Research
(Telefonica Investigación
y Desarrollo SA (TID))

We continue to build firm relationships and sound collaborative arrangements with these companies and other key players in the field, including various regional, national and international bodies.

Institute IMDEA Networks collaborates with the Madrid-region network of Scientific Parks and Clusters (Madrid Network) that brings together industry and research institutes in the region. We are members of the Audiovisual Cluster (*Cluster Audiovisual*) and the Security and Trust Cluster (*Cluster de Seguridad y Confianza*).



Madrid Network

Madrid Network – Red de
Parques y Clusters de la
Comunidad de Madrid



Cluster Audiovisual



Cluster de Seguridad
y Confianza

6.6. Media impact

A research study by Institute IMDEA Networks identifies who uploads the majority of the content to the P2P piracy networks (referenced by over 170 international media articles)

Report on the media impact of the joint publication by Institute IMDEA networks, the Universidad Carlos III de Madrid, Technische Universität Darmstadt and the University of Oregon

While it is not the Institute's approach to produce and broadcast results to reach the mass media, diffusion of our research activities amongst the general public contributes to create awareness of their relevance to society, improving the Institute's public profile, whilst increasing its overall visibility. Science has a capacity to catalyze positive change. **It is IMDEA Networks' shared responsibility towards the individual and the community to employ adequate instruments to diffuse the benefits of its scientific output and potential widely and competently.**

The media repercussion of the publication *Is Content Publishing in BitTorrent Altruistic or Profit Driven* ([«Is Content Publishing in BitTorrent Altruistic or Profit Driven?»](#)) presented at one of the leading international conferences on network research - the ACM CoNEXT 2010 held in San Diego, California (USA) from the 30 November to 3 December last - was dramatically enhanced at both a national and international level due to two news items: the first sent out by the Press and Public Relations Service at the Institute IMDEA Networks (26/11/2010) and posted on our website to coincide with the conference kick-off, and the second released by the Universidad Carlos III de Madrid (24/01/2010), which also appeared in Madrimasd's "notiweb" service.

Due to the publication of both news items and the work carried out by IMDEA Networks and the UC3M to maximize their take up, foremost national and international media echoed the results of this joint study led by the UC3M, the Institute IMDEA Networks, Technische Universität Darmstadt (TUD) and the University of Oregon. The news was carried online (in news boards, articles and blogs), in print (magazines) and the audiovisual media (in news reports and interviews that appeared on various national television channels).

The authors of the study

Ruben Cuevas (Univ. Carlos III de Madrid), Michal Kryczka (Institute IMDEA Networks and Univ. Carlos III de Madrid), Angel Cuevas (Univ. Carlos III de Madrid), Sebastian Kaune (TU Darmstadt), Carmen Guerrero (Univ. Carlos III de Madrid), Reza Rejaie (Univ. of Oregon).

The collaboration with national and international research bodies that has made such excellent research results possible

IMDEA Networks strives to bring together scientists, researchers, institutions, governing bodies and companies that share our interest in carrying out and promoting top level, cutting-edge research in the field of network technologies. We seek to provide a consistent meeting point where individuals and institutions can foster collaboration and go on to design new lines of work, through specific research-related activities.

The levels of collaboration behind this work are as follows:

- NEC Laboratories Europe (Heidelberg, Germany) and Technische Universität Darmstadt (TUD) (Darmstadt, Germany) - Memorandum of Understanding.
- Universidad Carlos III de Madrid (UC3M) – a wide-reaching collaboration agreement.
- University of Oregon – a temporary contract (September 2009 – August 2010) that has enabled Dr. Reza Rejaie to work at the Institute IMDEA Networks as a Visiting Researcher, where he also played an active role in the NETCOM research group at the UC3M's Telematics department.

The media impact of this publication only serves to consolidate the Institute's mission to promote international collaboration throughout Europe. Collaboration with other research bodies is, and will continue to be, vital if we are to address and resolve the most pressing challenges facing the technological development of communication networks. This is one specific example of how scientific research can be of great social, political and economic relevance; this relevance can even be immediate and clearly recognized as such, when research adds scientific arguments to a discussion that affects numerous interest groups. In this particular instance, the research proved relevant to the controversial additional stipulation of the Spanish "Ley de Economía Sostenible" (Law for a Sustainable Economy or LES), otherwise known as the "Ley SINDE", which represented the first "anti-download" legislation introduced in Spain, i.e. the first rules proposed by the Government to shut down websites that link to content subject to copyright.

The recognition generated can only serve to strengthen the bonds that unite the organizations involved in this research project still further, and to incentivize the international community to pay an interest in getting to know and collaborating with this research institution which, in spite of its youth, is already more than able to make a significant socio-economic impact.

In the words of Dr. Albert Banchs, Deputy Director of the Institute IMDEA Networks: IMDEA Networks operates in a field of knowledge that is key to today's society: that of information and communication technologies. ICT plays a vital role in our day-to-day activities, whether they are of an economic, political or cultural nature. Information in

all its forms and expressions serves to generate wealth and society's capacity to understand, communicate and thereby tap knowledge determines its economic development.

Summary of the research results on network piracy

The study found that the distribution of largely copyright files on major BitTorrent portals, such as The Pirate Bay, is dominated by about 100 publishers.

Around 40 profit-making content publishers are responsible for 40 percent of BitTorrent downloads of content largely subject to copyright, such as TV series or Hollywood movies. Furthermore, 25% of downloads are associated to fake content published by either antipiracy agencies or malicious users.

The authors concluded that «Content publishing in BitTorrent is largely driven by companies with financial incentive. Therefore, if these companies lose their interest or are unable to publish content, BitTorrent traffic/portals may disappear or at least their associated traffic will significantly reduce».

Media impact

A selection of the most relevant media impact follows:

TV



*TVE (Number one Spanish state-owned television channel):
01/26/2011*

*"Las asociaciones de internautas estudian llevar al
Constitucional la ley Sinde"*

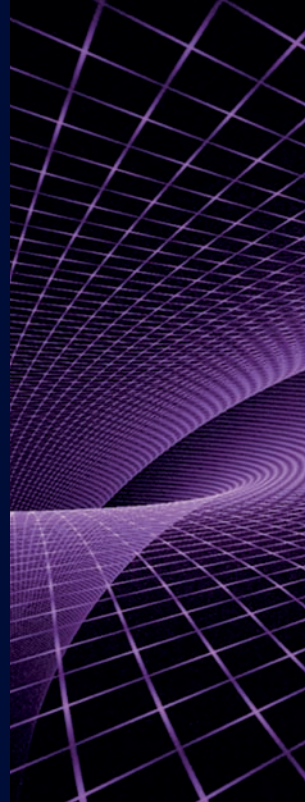
*"Asociaciones de internautas proponen que se aparque la Ley
Sinde y que se elimine el canon digital"*



*Antena3 (Spanish private television channel): 01/30/2011
"¿Quién está detrás de los contenidos subidos a internet?"*

7 personnel

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deputy director

The Deputy Director is responsible for managing and overseeing the scientific activities and the administration and of the institute, with the powers, duties and responsibilities conferred to it by the Board of Trustees, to which it reports.



Dr. Albert BANCHS

Deputy Director

Affiliation: IMDEA Networks and University Carlos III of Madrid

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Short biography:

Albert Banchs got his Telecommunication Engineering degree at the Polytechnical University of Catalonia in 1997, and the PhD from the same university in 2002. His PhD thesis, supervised by Professor Sebastia Sallent, addressed the issue of fairly sharing the network resources among users both in the wired and wireless Internet. Albert Banchs received for his PhD the mention of European Doctor and was awarded by COIT (the Spanish official association of Telecommunication Engineers) the ONO prize to the best Spanish PhD thesis on Broadband Networks.

From April to December 1997, Albert Banchs worked in the Networks Group of the International Computer Science Institute (ICSI), Berkeley, California. His work at ICSI focused on active networks research. From January to August 1998 he was with the Telefonica I+D Labs in Madrid, Spain, where he was

appointed coordinator of an 8-people development team working on the videoconference over IP project. In September 1998 he joined NEC Network Laboratories in Heidelberg, Germany. He started as a Research Staff Member and was promoted to Senior Research Staff Member in April 2001. At NEC, Albert Banchs worked on a number of projects, including multicast over ADSL, Diff-Serv and 802.11e standardization.

Since October 2003, Dr. Banchs is with the University Carlos III of Madrid, where he currently holds the position of Associate Professor. From 2003 to 2008 he worked on the EU projects Daidalos I and Daidalos II, where he led the activity of QoS over heterogeneous networks. His current major effort is on the EU project CARMEN (CARrier grade MESH Networks), which he is coordinating. Since October 2009, he is also Deputy Director of IMDEA Networks. His research interests include performance evaluation and resource allocation in wireless networks.

chief researchers

Chief Researchers are our most published and cited researchers. They are recognized and respected leaders in their field of research. They have already made a difference. Their expertise and research interests have a significant impact on the Institute's scientific output and on the careers of their charges.



Dr. Marco AJMONE MARSAN
Chief Researcher

Affiliation: IMDEA Networks and Politecnico di Torino, Italy

PhD: Budapest University of Technology and Economics (honoris causa), Hungary

Research: High-speed telecommunication networks, with particular emphasis on wireless and all-optical networks and performance evaluation of data communication and computer systems, with Markovian models, queueing networks, and Generalized Stochastic Petri Nets

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Short biography:

Marco Ajmone Marsan holds a double appointment as Chief Researcher at IMDEA Networks (Spain) and Full Professor at the Department of Electronics (Dipartimento di Elettronica) of the Politecnico di Torino (Polytechnic University of Turin) (Italy). He is the founder of the Telecommunication Networks Group, one of the top research groups in networking in Europe, based at the Politecnico di Torino.

From 2003 to 2009 he was Director of the IEIIT-CNR (Institute for Electronics, Information and Telecommunication Engineering of the National Research Council of Italy). From 2005 to 2009 he was Vice-Rector for Research, Innova-

tion and Technology Transfer at Politecnico di Torino.

He earned his graduate degree in Electrical Engineering (Laurea (110/110)), from the Politecnico di Torino in 1974. This was the highest degree in the field obtainable in Italy at the time. He went on to complete his M.Sc. Electrical Engineering at the University of California at Los Angeles (USA) in 1978 and, in 2002, he was awarded an "Honoris Causa" Ph.D. in Telecommunication Networks from the Budapest University of Technology and Economics.

Marco Ajmone Marsan is involved in several national and international scientific groups: He is Chair of the Italian Group of Telecommunication Professors (GTTI); Italian Delegate in the ICT Committee of the EC's 7th Framework Program; and Fellow of the IEEE. He was also principle investigator for a large number of research contracts with industries, and coordinator of several national and international research projects.

His outstanding contributions to his field were recognized in 2006, when the President of Italy, Carlo Azeglio Ciampi, awarded him the "Comandatore" of the "Ordine al Merito della Repubblica Italiana" (Commander of the Republic of Italy's Order of Merit). In 2003, he was also listed by Thomson-ISI amongst the most highly-cited researchers in Computer Science.





Dr. Nicholas F. MAXEMCHUK

Chief Researcher

Affiliation: IMDEA Networks and Columbia University in the City of New York, USA

PhD: University of Pennsylvania, USA

Research: Random Coding network services; advanced network design for QoS deployment; traffic engineering in wireless networks

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Short biography:

Nicholas Maxemchuk, a networking pioneer, holds a permanent double appointment as Professor at the world-leading Columbia University of New York City (New York, USA) and Chief Researcher at IMDEA Networks.

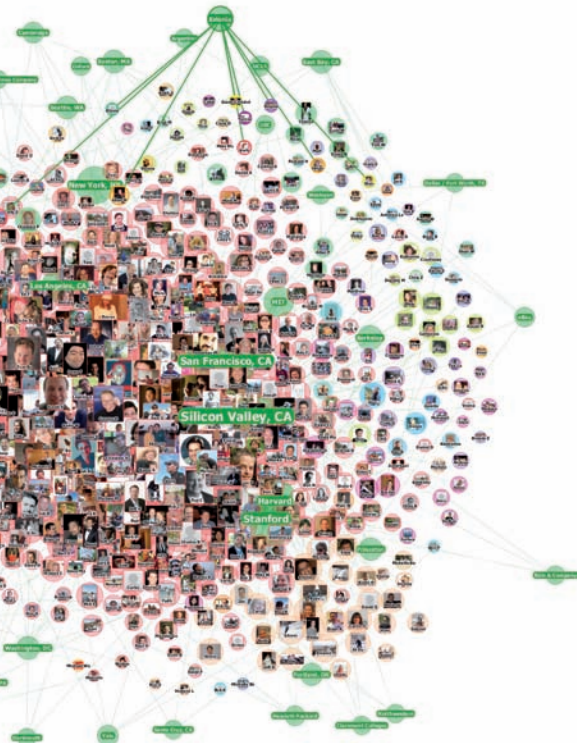
He holds a M.Sc. in Electrical Engineering and a Ph.D. in Systems Engineering, both from the University of Pennsylvania (Philadelphia, USA). Before joining Columbia University and IMDEA Networks, Nick Maxemchuk held the position of Technical Leader at AT&T Research Laboratories (1996 – 2001) and, prior to that, was the Head of Distributed Systems Research Department at AT&T Bell Laboratories (1976 – 1996).

Many of his far-sighted contributions to computer-communications networking have been years ahead of their time and have led to the development of groundbreaking new systems. His invention of Dispersy Routing in the 1970s, for example, has recently been applied to ad hoc networks. In 2006, his achievements in the field were recognized by the world's leading professional association for the advancement of technology, the IEEE, when he was awarded the prestigious 2006 IEEE

Koji Kobayashi Computers and Communications Award.

Amongst other awards that he has been given, some of the most noteworthy are the RCA Laboratories Outstanding Achievement Award in 1970, the Bell Laboratories Distinguished Technical Staff Award in 1984, the IEEE's Leonard G. Abraham Prize Paper Award in 1985 and 1987, and the William R. Bennett Prize Paper Award in 1997. He was also made a fellow of the IEEE in 1989, and received the 1996 R&D 100 award for his work on document marking

As well as owning 30 patents and publishing three books, Nicholas Maxemchuk has co-authored over 100 publications. His strong reputation as an eminent scientist has earned him many editorial and advisory positions with organizations including the IEEE, ACM, NSF Expert Group and the United Nations. He has published three award winning papers and had two of his publications voted into the Communication Society 50th Anniversary Issue. He is a member of the Board of Governors of the Armstrong Foundation and also works as a Consultant on Data Networks in Transportation Networks for The National Academies/Transportation Research Board.



senior researchers

Senior Researchers are typically researchers with several years' experience who assume a position of responsibility in leading the day-to-day activities of our research teams.



Dr. Antonio FERNÁNDEZ ANTA
Senior Researcher

PhD: University of Southwestern Louisiana (now University of Louisiana at Lafayette). USA

Previous position: Full Professor. Universidad Rey Juan Carlos. Madrid. Spain

Research: Communications and Networks; Distributed Computing; Algorithms; Discrete and Applied Mathematics

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Short biography:

'Antonio Fernández Anta is a Senior Researcher at Institute IMDEA Networks since the fall of 2010. Previously he was a Full Professor at the Universidad Rey Juan Carlos in Madrid, where he has been on the Faculty since 1998. Prior to that he

was before on the Faculty of the Universidad Politécnica de Madrid. He has been a postdoc at the Massachusetts Institute of Technology from 1995 to 1997.

Antonio has more than 15 years of research experience, with a steady productivity of more than 5 papers per year on average. He has published in top conferences and journals like INFOCOM, STOC, FOCS, PODC, DISC, Journal of the ACM, SIAM Journal on Computing, or IEEE Transactions on Computers. He is member of the Steering Committee of DISC and has served in the TPC of numerous conferences and workshops. He is a senior member of the IEEE since 2002 and of the ACM since 2007.

Antonio received his M.Sc. and Ph.D. degrees in Computer Science from the University of Louisiana in 1992 and 1994, respectively. His PhD thesis studied the Cartesian product of graphs as a mean to construct efficient interconnection networks for multiprocessors. He completed his undergraduate studies (Licenciado and Diplomado en Informática) at the Universidad Politécnica de Madrid, Spain, in 1988 and 1991 respectively, having received awards at the university and national level for his academic performance.



Dr. Sergey GORINSKY
Senior Researcher

PhD: University of Texas at Austin. USA

Previous position: Assistant Professor. Washington University in St. Louis. USA

Research: Computer networking and distributed systems.

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Short biography:

Sergey Gorinsky received the Engineer degree from Moscow Institute of Electronic Technology, Zelenograd, Russia in 1994 and M.S. and Ph.D. degrees from the University of Texas at Austin, USA in 1999 and 2003 respectively. From 2003 to 2009, he served on the tenure-track faculty at Washington University in St. Louis, USA. Dr. Gorinsky currently works as a Senior Researcher at Institute IMDEA Net-

works, Madrid, Spain. The areas of his primary research interests are computer networking and distributed systems. His research contributions include multicast congestion control resilient to receiver misbehavior, analysis of binary adjustment algorithms, efficient fair transfer of bulk data, network service differentiation based on performance incentives, and economic perspectives on Internet routing. His work appeared at top conferences and journals such as ACM SIGCOMM, IEEE INFOCOM, IEEE/ACM Transactions on Networking, and IEEE Journal on Selected Areas in Communications. Sergey Gorinsky has served on the TPCs of INFOCOM (2006-2012), ICNP (2008, 2010, 2011), and other networking conferences. He co-chaired the TPCs of HSN 2008 (High-Speed Networks 2008, an INFOCOM 2008 workshop) and FIAP 2008 (Future Internet Architectures and Protocols 2008, an ICCCN 2008 symposium) and served as a TPC Vice-Chair of ICCCN 2009.



Dr. José Félix KUKIELKA

Senior Researcher

PhD: University of California at Berkeley, USA

Previous position: Visiting Professor, University Carlos III of Madrid, Spain

Research: Wideband access to private networks; Quality of Service in Wireless networks; Service-aware Wireless Routing; Wireless Protocol Optimization for High-throughput Data and Voice

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Short biography:

José Félix Kukielka is Senior Researcher at IMDEA Networks and Lecturer at the University Carlos III of Madrid (UC3M) (Madrid, Spain). From 2003 until 2007, he worked at the UC3M as Ramón y Cajal Researcher. He obtained his undergraduate degree at the Universidad Nacional Autónoma de México (Federal District, Mexico) in 1972, and went on to complete a M.Sc. and a Ph.D., both at the University of California, Berkeley (Berkeley, USA).

He was the Technical Director of REDIMadrid from 2007 until 2009. REDIMadrid was created in collaboration with the UC3M in 2003. It is a regional research network for education and research institutions based in the Madrid Region. The program contributes to the consolidation of a dedicated, high-performance telecommunications infrastructure for its scientific community. Such infrastructure eases and promotes collaborative work, the establishment of eminent working groups and participation in national and international networks.

José Félix Kukielka has 23 years of industrial experience in designing, manufacturing and marketing communications and Radio Frequency products for the semiconductor and telecommunications industries. Throughout his career, he has worked in both academia and industry, working for Grupo AIA (Spain), Alcatel España, Philips Consumer Communications (Le Mans, France), Alcatel Telecom (Spain) and Avantek, Inc. (California, USA).

He is the creator of the Kukielka Configuration, a topology for high-frequency monolithic amplifier circuits with multiple feedback loops that show excellent gain bandwidth characteristics, and which have been implemented in several semiconductor technologies.



Dr. Joerg WIDMER

Senior Researcher

PhD: University of Mannheim, Germany

Previous position: Manager, Docomo Euro-Labs, Munich, Germany

Research: Computer Networks and Distributed Systems (Wireless Communication; Network Coding; Peer-to-peer Communication; Ad-hoc Networking; Internet Architectures; Transport Protocols)

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Short biography:

Since September 2010, Joerg Widmer is Senior Researcher at Institute IMDEA Networks. From June 2005 to July 2010, he was manager of the Ubiquitous Networking Research Group at DOCOMO Euro-Labs in Munich, Germany, working on several projects in the area of wired and wireless networking. Before joining DOCOMO Euro-Labs, he was senior researcher in the group of Prof. Jean-Yves Le Boudec at EPFL. There, his main research focus was on UWB networks and MAC layer design as well as network coding in wireless networks. Joerg Widmer received his M.S. and PhD degrees in computer science from the University of Mannheim, Germany in 2000 and 2003, respectively. In 1999 and 2000 he was a visiting researcher at the ICSI Center for Internet Research in Berkeley, CA, USA.



staff researchers

Staff Researchers at IMDEA Networks are early-stage, post-doctorate researchers who are looking to establish their research career, working with top senior researchers and a team of young pre-doctorate researchers.

Dr. Vincenzo MANCUSO

Staff Researcher

PhD: University of Palermo, Italy
Previous position: Post-Doc Researcher. INRIA Sophia Antipolis- Méditerranée, France

Research: Network Protocols; QoS; Wireless Networks; Green IT; Performance Analysis

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Short biography:

Dr. Vincenzo Mancuso received his master degree in Electronics from the University of Palermo, Italy, in 2001, and a PhD in Electronics, Computer Science and Telecommunications from the same University in 2005. In 2004-2005 he was with University of Roma «Tor Vergata», working on SATNEX, an IST Network of Excellence. He was then back to University of Palermo as postdoc, from June 2005 to May 2009. Also, during that period he has been visiting scholar at the ECE department of Rice University, Houston, Texas (September 2006 to January 2008). In June 2009 he joined the MAESTRO team at INRIA Sophia Antipolis, France. In September 2010 he moved to IMDEA Networks in Madrid, Spain.

Dr. Balaji RENGARAJAN

Staff Researcher

PhD: University of Texas at Austin, USA

Previous position: Graduate Research Assistant

Research: Measurement, Modeling and Performance Evaluation of Wireless Networks, Ad-hoc and Sensor Networks

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Short biography:

Balaji Rengarajan is a staff researcher at IMDEA networks since Oct. 2009 received his Ph.D. and M.S. in electrical engineering from the University of Texas at Austin in 2009 and 2004 respectively, and his B.E. in Electronics and Communication from the University of Madras in 2002. He was the recipient of a 2003 Texas Telecommunications Engineering Consortium (TxTEC) graduate fellowship and a 2010 Marie-Curie "Amarout Europe Programme" fellowship. His research focuses on the analysis and design of wired and wireless networks, and architectures and protocols to enable pervasive computing.

Dr. Gianluca RIZZO

Staff Researcher

PhD: EPFL Lausanne, Switzerland
Previous position: System engineer - Utility Communications. ABB Switzerland, Suiza

Research: Performance Evaluation of Communication Networks; Network Calculus; Quality of Service

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Short biography:

Gianluca Rizzo was born in Galatina (Lecce), Italy, in 1975. He received a degree in Electronic Engineering from Politecnico di Torino, Italy, in 2001. From September 2001 to December 2003, he has been a researcher in Telecom Italia Labs, Torino, Italy. From January 2004, to October 2008, he has been at EPFL Lausanne, where in 2008 he received his PhD in Computer Science. From November 2008 to August 2009 he has been with ABB Switzerland. Since September 2009 he is staff researcher at Institute IMDEA Networks. His research interests are: Performance evaluation of communication networks, Network Calculus, Quality of Service, Green Networking.

Dr. Rade STANOJEVIĆ

Staff Researcher

PhD: National University of Ireland, Maynooth, Ireland

Previous position:

Post-Doc Researcher. Telefonica Research, Barcelona, Spain

Research: Performance Evaluation; Network Economics

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Short biography:

Rade Stanojevic obtained his B.Sc. in Mathematics from University of Nis, Serbia and a Ph.D. from Hamilton Institute, NUIM, Ireland. His current research interests span performance evaluation, network economics and energy aware computing. His work on decentralized cloud control has been awarded the ACM SIGMETRICS 2008 Kenneth C. Sevcik Outstanding Student Paper Award and the IEEE IWQoS 2009 Best Paper Award. Since fall 2010 he is a staff researcher in the IMDEA Networks Institute, Madrid. Prior to that he was a post-doc with Telefonica Research, Barcelona.



visiting researchers

Visiting researchers share our research interests and spend their sabbatical with us for either one or two terms. They usually have several years' post-doctoral research experience and are interested in extending their horizons with a temporary assignment in a new environment.



Dr. Marwan M. KRUNZ

Visiting Researcher

Affiliation: IMDEA Networks and University Carlos III of Madrid (*Cátedra de Excelencia*)

PhD: Michigan State University, USA

University of origin: The University of Arizona, USA

Research: Communications Technology and Networking, with particular emphasis on Optimal Resource Allocation, Adaptive Control, and Distributed Protocol Design

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Short biography:

Marwan M. Krunz received the Ph.D. degree in electrical engineering from Michigan State University in July 1995. He joined the University of Arizona in January 1997, after a brief postdoctoral stint at the University of Maryland, College Park. He is currently a professor of electrical and computer engineering. He previously held visiting research positions

at INRIA (Sophia Antipolis, France), HP Labs (Palo Alto, California), Paris VI University, and US West (now Qwest) Advanced Technologies (Boulder, Colorado). Dr. Krunz's research is in communications technology and networking, with particular emphasis on optimal resource allocation, adaptive control, and distributed protocol design. Recently, he has been involved in projects related to cognitive radio networks (CRNs); power/rate/spectrum adaptation for wireless networks; medium access control (MAC) design in wireless ad hoc networks; network protocols for wireless systems with adaptive MIMO, beam-forming antennas, and UWB capabilities; topology management and clustering in location-unaware sensor networks; adaptive video streaming over wireless networks; routing, fault monitoring, and detection in all-optical networks; path selection for MDC (multiple description coding) based media streaming; quality-of-service routing; WWW caching and prefetching; and adaptive packet encapsulation. Previously, he worked on packet scheduling and buffer management in switches and routers, QoS provisioning, effective-bandwidth theory, traffic characterization, and video-on-demand systems. He has published more than 150 journal articles and peer-reviewed conference papers, and holds three US patents (see Publications for details).

Dr. Krunz is an IEEE Fellow (class of 2010). He is a recipient of the National Science Foundation CAREER Award (1998-2002). He served on the editorial board for the

IEEE/ACM Transactions on Networking, and currently serves on the editorial boards for the IEEE Transactions on Mobile Computing, and the Computer Communications Journal. He was a guest co-editor for special issues in IEEE Micro and IEEE Communications Magazines. He served as a technical program chair for the IEEE INFOCOM 2004 Conference, Hong Kong, March 2004, the IEEE International Conference on Sensor and Ad hoc Communications and Networks (SECON 2005), Santa Clara, Sep. 2005, the IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM 2006), Buffalo, New York, June 2006, and the 9th Hot Interconnects Symposium, San Francisco, California, August 2001. He has served and continues to serve on the executive and technical program committees of numerous international conferences, and on the panels of several NSF directorates. He was a keynote speaker at the Fourth IEEE Workshop on Wireless Mesh Networks (WiMesh 2009), Rome, June 2009, and an invited panelist at various international conferences (e.g., INFOCOM 2009, SECON 2009, etc.). He gave tutorials at premier wireless networking conferences (e.g., MobiCom, MobiHoc). He frequently consults for companies in the telecommunications sector.



Dr. Narasimha REDDY

Visiting Researcher

Affiliation: IMDEA Networks and University Carlos III of Madrid (*Cátedra de Excelencia*)

PhD: University of Illinois at Urbana-Champaign (UIUC). USA

University of origin: Texas A&M University. USA

Research: Computer Networking; Storage Systems; Multimedia

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<http://www.ece.tamu.edu/~reddy/>

Short biography:

Narasimha Reddy received a B.Tech. degree in Electronics and Electrical Communications Engineering from the Indian Institute of Technology, Kharagpur, India, in August 1985, and the M.S. and Ph.D. degrees in Computer Engineering from the University of Illinois at Urbana-Champaign in May 1987 and August 1990 respectively. Reddy is currently a Professor in the department of Electrical Engineering at Texas A & M University. Reddy's research interests are in Computer Networks, Multimedia Systems, Storage systems, and Computer Architecture. During 1990-1995, he was a Research Staff Member at IBM Almaden Research Center in San Jose, where he worked on projects related to disk arrays, multiprocessor communication, hierarchical storage systems and video servers.

Reddy holds five patents and was awarded a technical accomplishment award while at IBM. He has received an NSF Career Award in 1996. He was a faculty fellow of the College of Engineering at Texas A&M during 1999-2000. His honors include an outstanding professor award by the IEEE student branch at Texas A&M during 1997-1998, an outstanding faculty award by the department of Electrical and Computer Engineering during 2003-2004, a Distinguished Achievement award for teaching from the former students association of Texas A&M University and a citation «for one of the most influential papers from the 1st ACM Multimedia conference». Reddy is a senior member of IEEE Computer Society and is a member of ACM.



Dr. Reza REJAIE

Visiting Researcher

PhD: University of Southern California (USC). USA

University of origin: University of Oregon. USA

Previous position: Senior Technical Staff, AT&T Labs - Research

Research: Multimedia Networking; P2P Networking; Network Measurement; Online Social Networks

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Short biography:

Reza Rejaie is currently an Associate Professor at the Department of Computer and Information Science at the University of Oregon. From October 1999 to March 2002, he was a Senior Technical Staff member at AT&T Labs-Research in Menlo Park, California. Reza received a NSF CAREER Award for his work on P2P streaming in 2005. At UO, Reza has founded Multimedia & Internetworking Research Group (Mirage). In the research community, Reza is on the editorial board of IEEE Communications Surveys and Tutorials, Journal of Advances in Multimedia, and Springer Journal in Peer-to-Peer Networking and Applications. He has been the TPC chair for NOSS-DAV'07, Global Internet '07, MMCN'08 and MMCN'09, and has also served on the program commit-

tee of numerous conferences and workshops. He has been a senior member of both the ACM and IEEE since September 2006.

Reza received his M.S. and Ph.D. degrees in computer science from the University of Southern California (USC) in 1996 and 1999 respectively. During his graduate study at USC, he participated in several projects at Information Sciences Institute (ISI), the Computer Networks and Distributed Systems Research Laboratory and the Database Laboratory. He completed his B.S. degree in Electrical Engineering at Sharif University of Technology, Tehran, Iran, in 1991.

research assistants

Our Research Assistants are young, aspiring researchers who occupy a salaried position in our research team whilst undertaking their Ph.D. at a leading Madrid University for up to five years. An offer of a Research Assistant position implies your acceptance to the Ph.D. program at University Carlos III of Madrid (UC3M). Institute IMDEA Networks has a far-reaching collaboration agreement with UC3M which includes the provision of a Postgraduate program for our early-stage researchers. In the future we may have similar arrangements with other Madrid Universities.



Shahzad ALI

Research Assistant

Affiliation: Institute IMDEA Networks and University Carlos III of Madrid

Previous position: Department of Computer Science, COMSATS Institute of Information Technology, Abbottabad, Pakistan

Research: Wireless Sensor Networks; Vehicular Ad hoc Networks; Opportunistic Networks; Future Mobile Communication Networks

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Jordi ARJONA

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Research: WSN's; WSN's; Real Time Networks; QoS; Security.

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Pradeep BANGERA

Research Assistant

Affiliation: Institute IMDEA Networks and University Carlos III of Madrid

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Research: Routing in Vehicular Ad Hoc Networks; Security and Privacy Issues in VANET; MAC Layer Routing in VANET

Contact: pradeep.bangera@imdea.org



Alex BIKFALVI

Research Assistant,
financed by FPU scholarship from
Spanish Ministry of Education

Affiliation: Institute IMDEA Networks and University Carlos III of Madrid

Previous position: Universitatea Tehnica din Cluj-Napoca, Romania

Research: Peer-to-peer; Overlay Networks; Hierarchical Overlay Networks; Distributed Hash Tables; Application Level Multicast; Video Streaming; Grid Resource Discovery; Content Distribution

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Juan Camilo CARDONA
Research Assistant

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Research: Network Optimization; Metro and Transport Networks; Inter-domain Routing; OpEx and CapEx Analysis

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Syed Asfandiyar GILANI
Research Assistant

Affiliation: Institute IMDEA Networks and University Carlos III of Madrid

Previous position: Network Consulting Engineer and Junior Researcher, Nokia-Siemens Network. Islamabad. Pakistan

Research: Distributed Systems; Network Security; Cryptography; Mobile Agent Security Architectures; Secure Electronic Voting; Video Streaming and Mobile IP

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Fabio GIUST
Research Assistant

Affiliation: Institute IMDEA Networks and University Carlos III of Madrid

Previous position: Alcatel-Lucent Bell Labs. France

Research: Mobility in IPv6 Networks; Routing for Multihomed/Multi-Interface Devices; IP Flow Management

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Marco GRAMAGLIA
Research Assistant,
financed by FPU scholarship from Spanish Ministry of Education

Affiliation: Institute IMDEA Networks and University Carlos III of Madrid

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marco.gramaglia@imdea.org

Michal KRYCZKA
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Previous position: Technical University of Lodz. Poland

Research: A Framework for the extension of addressing spaces

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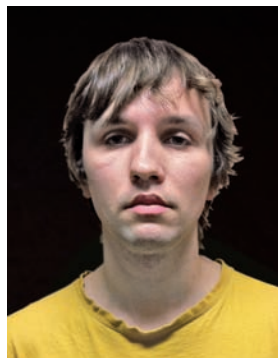
Andra LUTU
Research Assistant

Affiliation: Institute IMDEA Networks and University Carlos III of Madrid

Previous position: Polytechnical University of Madrid. Spain

Research: Inter-domain Routing; Traffic Engineering; BGP; Routing Scalability

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Andrea MANNOCCI

Research Assistant

Affiliation: Institute IMDEA Networks and University Carlos III of Madrid
Previous position: University of Pisa. Pisa. Italy; University of Southern Denmark. Odense. Denmark
Research: Wireless Networks; Wireless Mesh Networks; 802.11 protocols; LTE and WiMax; QoS; Intra/Inter domain routing protocols; BGP security.
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Paul PATRAS

Research Assistant,
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Spanish Ministry of Education

Affiliation: Institute IMDEA Networks and University Carlos III of Madrid
Previous position: Universitatea Tehnica din Cluj-Napoca. Romania
Research: Wireless Mesh Networks; IEEE 802.11; Adaptive MAC Mechanisms; Performance Optimisation; Dynamic Spectrum Access; Wide-Spectrum Networks
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José Pablo SALVADOR

Research Assistant

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Previous position: Intern, Network Research Division, NEC Laboratories Europe. Heidelberg. Germany
Research: Mobile IP; Wireless Networks; Ad hoc Networks
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María Isabel SÁNCHEZ

Research Assistant

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Research: Wireless communications, vehicular networks, IPv6 mobility
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Syed Anwar UI HASAN

Research Assistant

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Iljitsch VAN BEIJNUM

Research Assistant

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Previous position: Haagse Hogeschool. The Hague University. Netherlands
Research: Routing; BGP (Border Gateway Protocol); Inter-domain Routing; Routing Scalability; TCP (Transmission Control Protocol); Multipath; Multipath Routing; Multipath TCP; IPv6
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Kshitiz VERMA

Research Assistant

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Previous position: Indian Institute of Technology. Kanpur. India; National Center for Biological Sciences. Bangalore. India
Research: Cryptography; Number Theory; Information Security; Computer Networks
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research team structure



Group Leader:

Dr. Sergey Gorinsky

- Dr. Rade Stanojevic
- Dr. Reza Rejaie
- Dr. Narasimha Reddy

Research Assistants:

- Peter Iljisch van Beijnum
- Alexandru Bikfalvi
- Michal Kryczka
- Andra Lutu
- Syed Anwar Ul Hasan
- Ignacio de Castro
- Juan Camilo Cardona



Group Leader:

Dr. Joerg Widmer

- Dr. Nicholas Maxemchuk
- Dr. José Félix Kulielka
- Dr. Vincenzo Mancuso
- Dr. Marwan Krunz

Research Assistants:

- Paul Patras
- Marco Gramaglia
- Pradeep Bangera
- Andrea Manocci
- Syed Asfandiyar Gilani
- José Pablo Salvador
- Lucas Eznarriaga
- Fabio Giust



Group Leader:

Dr. Antonio Fernández Anta

- Dr. Marco Ajmone Marsan
- Dr. Gianluca Rizzo
- Dr. Balaji Rengarajan

Research Assistants:

- Kshitiz Verma
- Jordi Arjona
- Shahzad Ali
- Israel Gutiérrez Rojas
- María Isabel Sánchez Bueno

Our current team of researchers



administrative unit

The Institute is managed by the Deputy Director – Dr. Albert Banchs – and the General Manager. They are accountable to the Board of Trustees to whom they report regularly.

They are supported by a small administration team who are dedicated to the efficient and effective achievement of the Institute's goals and to providing the levels of support required by its team of international researchers.



Brian DUNNE
H.R. Manager

Degree in Business and French
Contact: brian.dunne@imdea.org



Rebeca DE MIGUEL
Operations Support Manager

Degrees in Communication Sciences (Journalism) and in History and Theory of Art & Film Studies
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Ana GONZÁLEZ
Projects & Funding Manager

Degree in Modern European Studies and Postgraduate Diploma in "European Studies"
Contact: ana.gonzalez@imdea.org



Joel ROSENAL
Systems Administrator

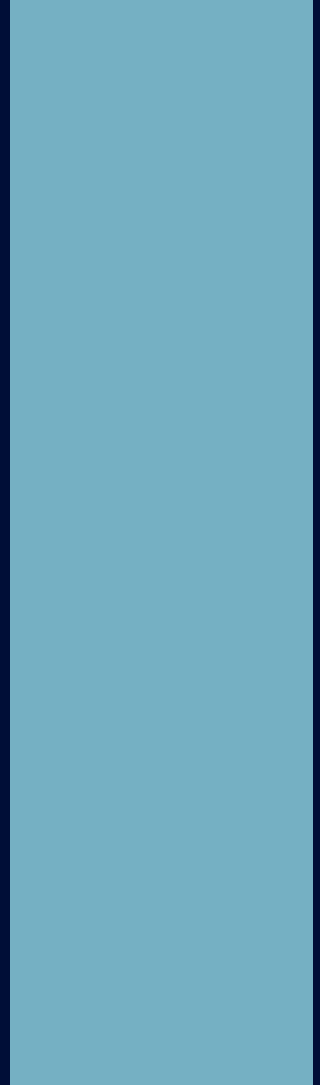
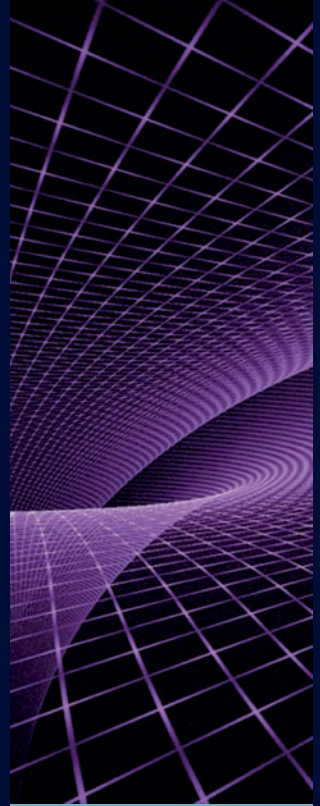
Degree in Computer Engineering
Contact: joel.rosental@imdea.org



premises and research laboratories infrastructure

8

- 8.1. Research laboratories [79]
- 8.2. Future purpose-built permanent research centre [81]
- 8.3. Provisional headquarters [84]



8.1. Research laboratories

In order to support cutting-edge research, IMDEA Networks invests in the latest, state-of-the-art laboratories and laboratory test equipment, endowing the Institute with the capacity of transforming research into high added value products and services.

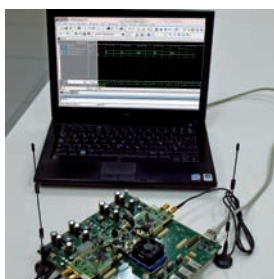
These laboratories are used for:

- Constructing prototypes and measuring the devices, protocols and algorithms developed by the researchers.
- Simulating complex base-band and medium access systems, as well as sophisticated radio subsystems.
- Measuring radio parameters involved in mobile, fixed and satellite communications, designing and characterizing radiating elements, and measuring the effects on the radio electric spectrum of new protocols and algorithms designed by the Institute.

Examples of the laboratories capabilities include:



Analysis and processing of RF signals up to 7 GHz using the Agilent N9010 Signal Analyzer.



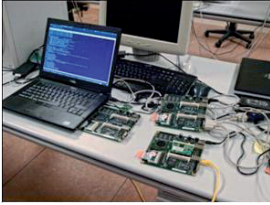
Development of new baseband processing architectures using software-defined radio boards.

These devices form a radio communication system where components that have been typically implemented in mixers, filters, amplifiers, modulators/demodulators, detectors, etc., are instead implemented by means of embedded computing devices, in particular Field Programmable Gate Arrays (FPGA).



Development of experimental hardware routers using open and programmable platforms (NetFPGA).

This equipment allows researchers to build high speed (giga-bit) switches and IP router prototypes in hardware, on which to test experimental routing prototypes. This type of equipment is more realistic than the one based on the use of software only platforms.



Research and development on mesh network topologies using Meshnode devices. These are programmable wireless nodes equipped with multiple radios that can provide network communication coverage for large areas.



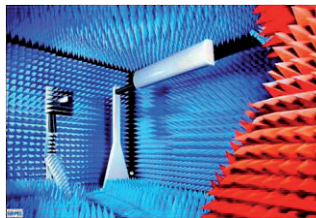
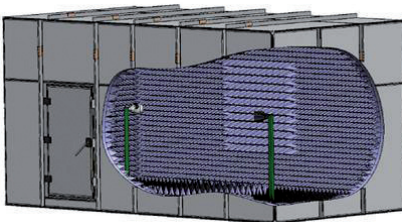
Optimization of WiMAX scheduling, queue management and cross-layer optimization using ARQ/HARQ. The newly developed algorithms are implemented on special WiMAX base stations provided by Albentia Systems under a collaborative agreement.

The laboratories are supported by a **high-performance scientific computing infrastructure** consisting of a dedicated server cluster equipped with a Dell R710 (8 cores Intel Xeon E5640, 48 GB RAM, 6 TB local storage), a Dell C6100 (32 cores Intel Xeon E5640, 192 GB RAM, 24 TB storage local), and a Dell Equallogic PS610 (10 Gb/s Storage Arrays with 32 TB raw disk space).

Additionally, IMDEA Networks provides and runs an IT **support infrastructure for telematic services** that permits pervasive and easy access to information over different media, as well as providing the required hardware and software tools to facilitate daily operational activities, Network Research and security. It also provides telephone communications services with VoIP capability, videoconference, VPN remote secure connection, wireless access, intranet and document management systems.

While current facilities are located at the provisional site, as well as some laboratory space at the Telematics Department of UC3M, **plans for the laboratories of the new building are under way. They include the provision for a radiofrequency anechoic chamber.** This particular structure is an enclosure with metallic shielding on its walls, like a Faraday cage, and padded with radiofrequency absorbing material on the inside, that isolates the chamber from external interferences and simulates free space conditions.

The chamber is planned to be located in the basement, and its approximate dimensions will be 8 m x 5 m x 4,5 m.



8.2. Future purpose-built permanent research centre

IMDEA Networks will soon start building its purpose-built permanent research centre with cutting edge and well-equipped research facilities. This centre will be located in one of the science and technology parks that are being created by the joint ventures between regional public universities and the Regional Government of Madrid. Science and technology parks are high quality spaces and installations where knowledge and technology flow is stimulated and managed between universities and research institutions, companies and markets; they promote the creation and growth of innovative companies through incubation and spin-off mechanisms as well as provide other added value services. Science and technology parks provide their clients with advanced professional support services, reinforcement and promotion of research, innovation and development, collaboration mechanisms and specialized training schemes.

IMDEA Networks permanent headquarters will be constructed on a plot of land of 7,716 m² that has been kindly ceded by Universidad Carlos III de Madrid (UC3M) in TECNOLEGANES, (also known as “LEGANES TECNOLÓGICO”) the largest Science and Technology Park in Spain, and part of the Madrid Network initiative. TECNOLEGANES is located in the South-East area of Madrid, alongside the Toledo road, and between two major Madrid highways, the M-40 and the M-45, which provide fast links to the airport and Madrid city center. The park is also located near UC3M's Leganes Campus. The site has a total surface of 2,804,878 square meters, and it is expected that around 500 companies will find a space to thrive there, and will in turn employ around 15,000 people. The park is being built in 3 phases: on the recently concluded first phase, 229,7 million Euros have been invested to develop a space of 507,374 m², which has been distributed amongst 53 businesses, generating over 2000 jobs.

IMDEA Networks will be strategically located for the development of its activities due to its proximity to the TECNOLEGANES' Headquarters. UC3M houses its innovation centers, university institutes, business incubators and laboratories in this park, **facilitating the dissemination of knowledge, and the transfer of ideas, experiences and capabilities within the science and business communities.**



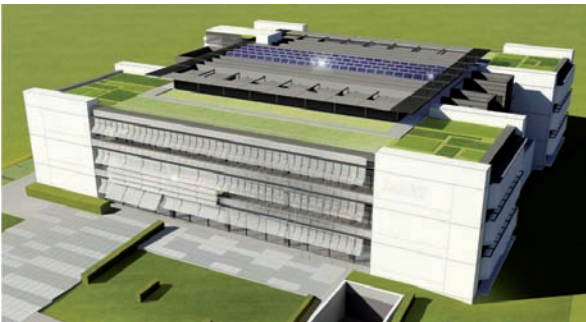
Parcel of Land – TECNOLEGANES

8.2.1. Providing a Centre for World-Class Research

Our purpose-built research centre on the TECNOLEGANES park is intended to fulfill the functional requirements of a leading-edge research centre and to attract researchers from around the World. Its physical presence at the park is critical with regards to the Institute's role within the international research arena and especially in respect to its technology transfer oriented objectives. The location will provide a meeting place for public and private sector researchers in order to maximize the Institute's potential as a driving force for technological evolution and economic growth.

The main aim of the building design is to provision a high quality working environment for researchers. **It has been conceived primarily with researchers' needs and preferences in mind, including open spaces, discussion areas, laboratories, support service etc. Thinking about the future and the natural evolution of any scientific enterprise (new research lines, projects, equipment, team members etc), the interior design will be very flexible, allowing relatively quick, easy and inexpensive reconfiguration of space to adapt to changing requirements.**

Our research centre is to be built in 2 phases, comprising two adjacent and integrated buildings with an interior atrium to serve as structural meeting place and a meaningful centre point to our networking philosophy. The building will occupy approximately 4.610 m² on 3 floors (ground, first and second) above ground level.



Basic Design Project – Aerial view – Front entrance



Basic Design Project – Aerial view – Side view



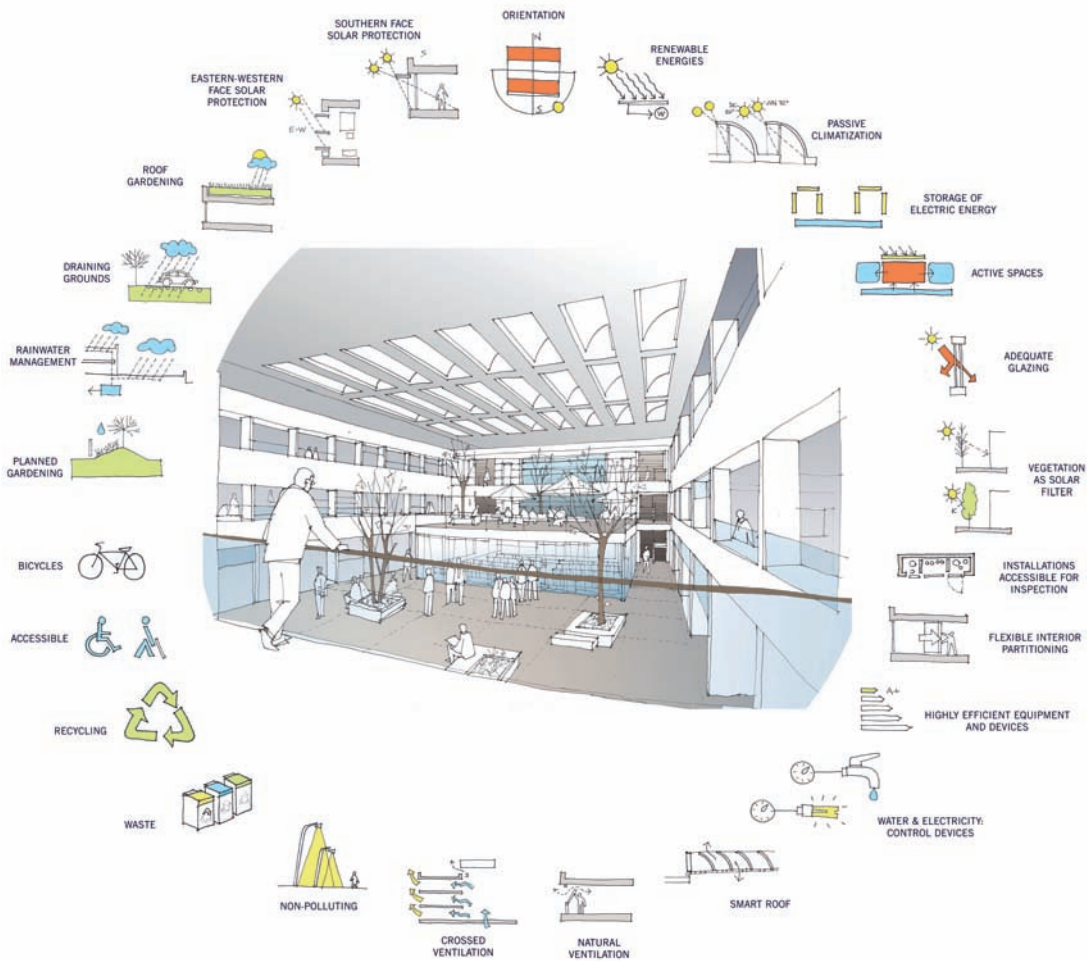
Basic Design Project –Interior views (atrium)



8.2.2. An Eco Friendly Building

Our future workplace has been designed with an array of characteristics to guarantee an environmentally friendly approach to its construction and maintenance:

- Sustainable building
- Environmentally responsible and resource-efficient
- Efficient use of energy, water, and other resources
- Taking advantage of renewable resources
- Highly efficient heating and cooling system
- Green roof
- Optimization of sunlight
- Most modern ICT for energy efficiency
- ICT for research on energy efficiency networks



8.2.3. Networking Infrastructure and Equipment

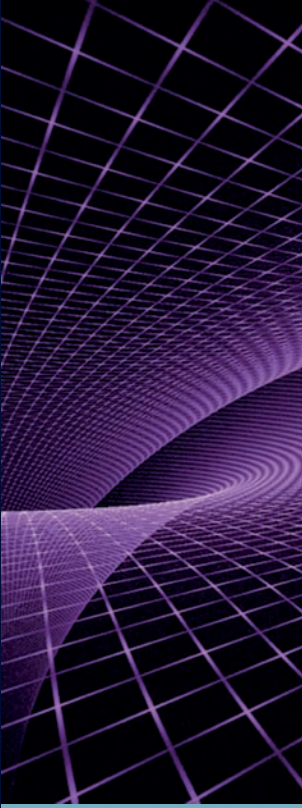
The infrastructure and equipment to be integrated within the building are at the core of its purpose to be: **to be innovative and to do innovation**. They will complement the space and will fit in with the design to provide researchers with the right balance to encourage scientific ideas and experimental performance of the highest order. Thus, the building shall accommodate:

- A customized infrastructure for networking research
- The most modern and sophisticated equipment
- Laboratories and demo rooms
- Terrace with antennas
- Anechoic chamber
- Internet of Things Laboratory
- Raised floor over the entire building

8.3. Provisional headquarters

The construction of IMDEA Networks' purpose built research center will take between 2-3 years. Thus, provisional headquarters have been refurbished in office space ceded by UC3M at Avenida del Mar Mediterráneo in Leganés, near its future permanent location. This temporary office space will be utilized until the final move to the purpose built research centre is completed. It provides fully renovated facilities for researchers to carry out their work in an atmosphere of openness, collaboration and a common driving force: the pursuit of excellence.





9 organization

9.1. Legal status [86]

9.2. Governing bodies & organizational structure [86]

9.1. Legal status

Institute IMDEA Networks was legally constituted under Spanish law at the end of 2006 as a public, not-for-profit Foundation. It is governed by a Board of Trustees, consisting of representatives from the various stakeholders in the Institute.

The full, registered name of the Institute is Fundación IMDEA Networks. The Institute is registered in the Register of Foundations of the Autonomous Region of Madrid (Registro de Fundaciones de la Comunidad de Madrid), personal sheet number 476.

Our Spanish tax identification number (CIF) is G-84912708.

Institute IMDEA Networks' registered address is:

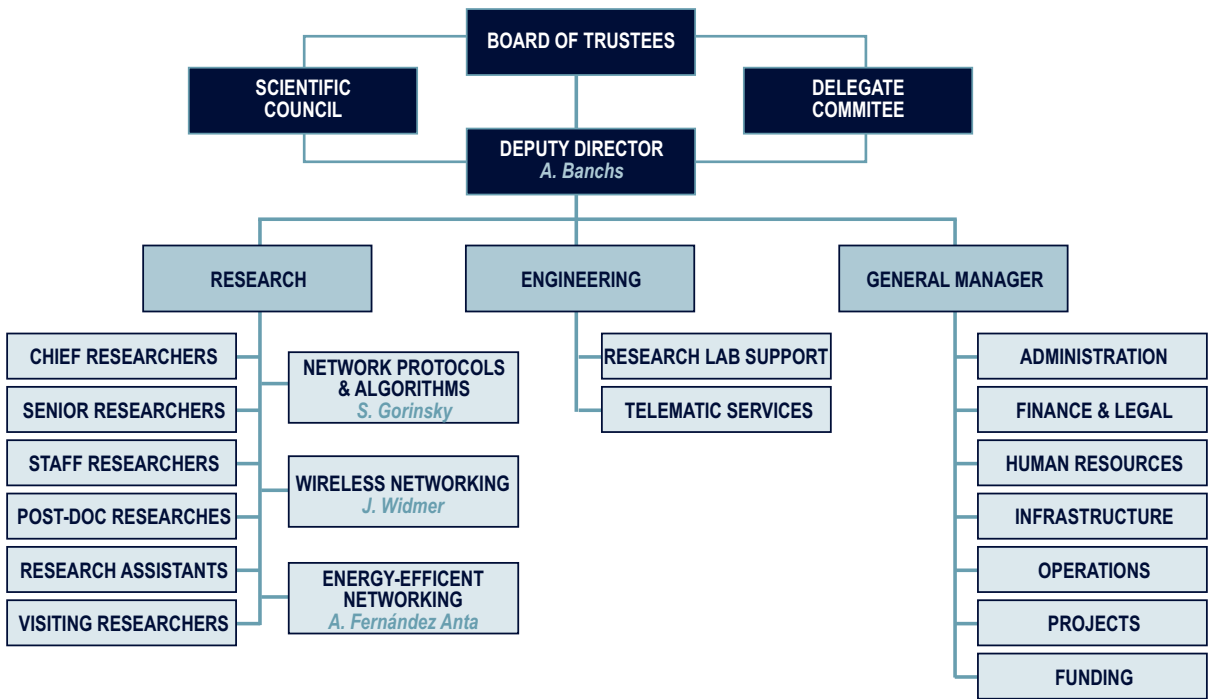
Avenida del Mar Mediterráneo, 22

28918 Leganés, Madrid

Spain

9.2. Governing bodies & organizational structure

9.2.1. Organizational structure



9.2.2. Board of Trustees

The Board of Trustees of Institute IMDEA Networks is its highest organ of governance, representation and administration. In accordance with the Institute's statutes, the Board of Trustees is composed of Ex Officio Members representing the Regional Government of Madrid and Elective Members who are recognized leaders in the scientific matters of the Institute. The Deputy Director and General Manager of the Institute also participate in the Board of Trustees. The Board is presently composed of the following members:

Ex Officio Trustees | Elective Trustees – Prestigious Scientists | Elective Trustees – Companies | Elective Trustees – Company Experts | Elective Trustees – Institutional Trustees: Universities | Elective Trustees

President: Prof. Dr. Ralf Steinmetz **Vice-President:** Excma. Sra. D^a. Lucía Figar de Lacalle

EX OFFICIO TRUSTEES

Excma. Sra. D^a. Lucía Figar de Lacalle
Regional Government Secretary for Education, Department of Education, Regional Government of Madrid (Madrid, Spain)

Ilmo. Sr. D. Jon Juaristi Linacero
Director General of Universities and Research, Department of Education, Regional Government of Madrid (Madrid, Spain)

Ilmo. Sr. D. Salvador Victoria Bolívar
Vice Counsel of the Senior Vice Presidency and Secretary General of the Governing Council, Vice Council of the Senior Vice Presidency and Secretariat General of the Governing Council, Regional Government of Madrid (Madrid, Spain)

Ilmo. Sr. D. José María Rotellar García
Director General of Economy, Statistics and Technological Innovation, Department of Economy and Treasury, Regional Government of Madrid (Madrid, Spain)

Sr. D. José de la Sota Ríos
General Manager, madri+d Foundation for Knowledge, (Madrid, Spain)

ELECTIVE TRUSTEES - PRESTIGIOUS SCIENTISTS

Prof. Dr. Ralf Steinmetz
Professor and Head of Multimedia Communications Laboratory, Technische Universität Darmstadt (Darmstadt, Germany)

Prof. Dr. Hari Balakrishnan
Professor, Massachusetts Institute of Technology (Massachusetts, USA)

Prof. Dr. Jim Kurose
Interim Dean and Distinguished University Professor, University of Massachusetts at Amherst (Massachusetts, USA)

Dr. Huw Oliver
Independent computer and network security specialist, University of Bristol and the Civil Aviation Authority (former Technical Director, European Research Consortium, Hewlett-Packard Laboratories) (Bristol, United Kingdom)

Prof. Dr. Ioannis Stavrakakis
Professor, National and Kapodistrian University of Athens (Athens, Greece)

ELECTIVE TRUSTEES - COMPANIES

**Telefónica I+D (Madrid, Spain)**

Designated Representative: Mr. Carlos Francisco Domingo Soriano, Chief Executive Officer

**Hewlett-Packard (Madrid, Spain)**

Designated Representative: Mr. José Antonio de Paz Martínez, President

**BBVA (Madrid, Spain)**

Designated Representative: Ms. Beatriz A. Lara Bartolomé, Director of Strategy and Innovation in Technology and Operations

**SATEC (Madrid, Spain)**

Designated Representative: Mr. Luis Alberto Rodríguez-Ovejero Alonso, President

**Teldat (Madrid, Spain)**

Designated Representative: Mr. Antonio García Marcos, President

ELECTIVE TRUSTEES - COMPANY EXPERTS

**Dr. Juan Mulet Meliá**

Director General, COTEC Foundation for Technological Innovation (Madrid, Spain)

**Carlos Nieva Martínez**

Director of Operations, Ericsson (Madrid, Spain)

ELECTIVE TRUSTEES - INSTITUTIONAL TRUSTEES: UNIVERSITIES

Universidad Carlos III de Madrid (Madrid, Spain)

Designated Representative: Prof. Dr. D. Carlos Balaguer Bernaldo de Quirós, Vice-Rector of Research

**Universidad Autónoma de Madrid (Madrid, Spain)**

Designated Representative: Prof. Dr. D. Roberto Moriyón Salomón, Professor of Languages and Information Systems, Higher Polytechnic School (Escuela Politécnica Superior)

**Universidad Nacional de Educación a Distancia (Madrid, Spain)**

Designated Representative: Prof. Dra. D^a. Felisa Verdejo Mailló, Director of the Department of Languages and Information Systems

**Universidad Politécnica de Madrid (Madrid, Spain)**

Designated Representative: Prof. Dr. D. Juan Quemada Vives, Higher Technical School of Telecommunications Engineering (Escuela Técnica Superior de Ingenieros de Telecomunicación)



ELECTIVE TRUSTEES - INSTITUTIONAL TRUSTEES: DEVELOPMENT AGENCIES

IMADE - Instituto Madrileño de Desarrollo (Madrid, Spain)

Designated Representative: Sr. D. Aurelio García de Sola y Arriaga, General Manager



9.2.3. Scientific Council

The Scientific Council is a very important organ of IMDEA Networks, advising us on all aspects of the Institute's scientific activities. Among many other things, the Council proposes the incorporation and renewal of Scientific Expert members of the Board of Trustees; reviews and approves scientific appointments, and generally provides support to the Deputy Director in determining scientific research strategy and policies.

The Institute's Scientific Council is composed of internationally-prestigious researchers in the field of Telematics and Internet technologies. The Institute is greatly strengthened by the participation of these eminent scientists. The current members of our Scientific Council are:



Prof. Dr. Hari BALAKRISHNAN
Professor at Massachusetts
Institute of Technology.
Massachusetts. USA

PhD: University of California, Berkeley. Berkeley. USA

Research: Networked computer systems, spanning overlay and peer-to-peer networks, network protocols and architecture, wireless and sensor networks, and distributed data management



M.Sc. Gonzalo CAMARILLO
Head of the Advanced
Signaling Research Laboratory
- Nomadic Laboratory,
Ericsson Finland. Suomi.
Finland

M.Sc.: Universidad Politécnica de Madrid (Madrid, Spain) Tekniska Högskolan, (Royal Institute of Technology). Stockholm. Sweden

Research: Signaling; Multimedia applications; Transport protocols; Network security.



Prof. Dr. Jon CROWCROFT
Marconi Professor at
University of Cambridge.
Cambridge. UK

PhD: University College London. London. UK

Research: QoS sensitive routing, scheduling and signaling protocols.



Prof. Dr. Gustavo DE VECIANA
Professor of Electrical and
Computer Engineering, The
University of Texas at Austin.
USA

PhD: University of California, Berkeley. USA

Research: Analysis and Design of Wireless and Wireline Telecommunication Networks; Architectures and Protocols to Support Sensing and Pervasive Computing; Applied Probability, Queueing and Information Theory



Prof. Dr. Edward KNIGHTLY

Professor of Electrical and Computer Engineering at Rice University in Houston, Texas. Houston. USA

PhD: Columbia University of University of California at Berkeley. Berkeley. USA

Research: Wireless Networks and Protocols; Wireless Access for Developing Regions; Dynamic Spectrum Access Networks



Prof. Dr. Jim KUROSE

Interim Dean and Distinguished University Professor at University of Massachusetts, Amherst. Massachusetts. USA

PhD: Columbia University of New York City. New York. USA

Research: Network protocols and architecture; Network measurement; Sensor Networks; Multimedia communication; Modeling and performance evaluation.



Dr. Huw OLIVER

Independent Computer & Network Security Professional University of Bristol and the Civil Aviation Authority (former Technical Director, European Research Consortium, Hewlett-Packard Laboratories). Bristol. UK

PhD: University College Aberystwyth. Aberystwyth. UK

Research: Computer & Network Security; Wireless OSS; Wireline Core and Access Networks.



Dr. Pablo RODRIGUEZ RODRIGUEZ

Research Director, Telefonica R&D. Spain; Director, Barcelona Telefonica R&D Lab. Spain; Adjunct Faculty Professor, Department of Computer Science, Columbia University of New York City. USA

Research: Networking; Distributed Systems; Information Theory; Wireless and Mobile; Network Economics; Social Networks

Prof. Dr. Ioannis STAVRAKAKIS

Full Professor at National and Kapodistrian University of Athens. Athens. Greece

PhD: University of Virginia. Charlottesville. USA

Research: Resource allocation protocols and traffic management for communication networks, with recent emphasis on peer-to-peer, wireless, ad hoc and autonomic networking.

Prof. Dr. Ralf STEINMETZ

President of Board of Trustees IMDEA Networks, Managing Director of Multimedia Communications Lab (KOM) and Professor at Technische Universität Darmstadt. Darmstadt. Germany

PhD: Technische Universität Darmstadt. Darmstadt. Germany

Research: Networked multimedia issues with the vision of «seamless multimedia communications»; i.e. network dependability and security (e.g. gateways, firewalls); quality of service (e.g. network engineering);

content distribution networks (e.g. streaming); context aware communications (e.g. peer-to-peer mechanisms); media semantics (e.g. ontology enrichment, metadata).



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