

Centre for Informatics and Systems of the  
University of Coimbra



## CISUC: Communications and Telematics Group

### **CISUC Workshop**

CISUC's Research Strategy for the Next Decade

Quinta da Lágrimas, Coimbra

September 17<sup>th</sup>, 2012

**Fernando Boavida**

## Outline

- ▣ Scientific contributions (in the last 5 years)
- ▣ Core competences
- ▣ Main research questions (for the next decade)
- ▣ Organisation of activities
- ▣ Plan to attract resources

## Scientific contributions (1/5)

- Signalling and routing for the multi-service Internet
  - Signalling mechanisms for WiMAX access networks in all-IP environments (WEIRD)
  - Scalable routing mechanisms for disaster scenarios (MORFEU)
  - Clustering schemes for multi-hop communication (MORFEU)
  - Routing metrics and algorithms for wireless mesh networks (UBIQUIMESH)
  - Routing mechanisms for user provided networks (UCR)

## Scientific contributions (2/5)

- WSN solutions for critical scenarios
  - Algorithms and protocols to support reliability in wireless sensor networks (GINSENG)
  - Mobility support in critical scenarios (GINSENG)
  - Design of security mechanisms for resource-constrained sensing applications (GINSENG)
  - Management methods for Wireless Sensor and Actuator Networks (GINSENG)
  - Integration and interoperability of sensor networks with other environments (i-Locator)
  - Location of people and goods in industrial environments (i-Locator)
  - Use cases in the area of Wireless Sensor Networks as input for Data Processing activities (PULSE)

## Scientific contributions (3/5)

- Mobility and multi-homing architectures
  - Mobility mechanisms for seamless mobility in heterogeneous access technology scenarios (WEIRD)
  - Mechanisms for multi-homing in mobile environments (CoFiMoM)
  - Client-based network mobility solutions and tools (CoFiMoM)

## Scientific contributions (4/5)

- Virtualised and cloud-sourced environments
  - Mechanisms for resiliency in cloud scenarios (TRONE)
  - Management architecture for P2P service overlay networks (CONTENT)
  - Management solutions for virtualised and cloud-based environments (S3P, Virtuoso)

## Scientific contributions (5/5)

- Security solutions for critical infrastructures
  - Service Monitoring for Critical Infrastructures (MICIE, CockpitCI)
  - Intrusion Detection Mechanisms for SCADA-based Industrial Control Networks (CockpitCI)
  - Trust and reputation mechanisms for exchanging security information between interdependent critical infrastructures (MICIE, CockpitCI)
  - Distributed Security Management Platforms for DSL and GPON access networks (S3P)

## Core competences

- ▣ Networking technologies and protocols
- ▣ Routing and forwarding
- ▣ Ad Hoc and mesh networks
- ▣ Wireless sensor and actuator networks
- ▣ Mobility and multi-homing
- ▣ Quality of service / quality of experience
- ▣ Networks and systems management
- ▣ Security and privacy

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## Research questions (overview)

- Focused on and aligned with Horizon 2020 priorities
  - Future and Emerging Technologies collaborative research
  - Research and innovation with industry, particularly SMEs
  - Address societal challenges, spanning different fields
- Societal challenges
  - Inclusive, innovative and secure societies
  - Health, demographic change and wellbeing
  - Smart, green and integrated systems
  - Secure, clean and efficient use of resources

## Research questions (1/7)

- Convergence and interoperability of dynamic heterogeneous fixed and mobile network technologies
  - Is cross-layer the best way to achieve the convergence and interoperability of dynamic heterogeneous fixed and mobile network technologies?
  - Will the so-called “Internet of the Future” paradigm and clean-slate architectures replace the Internet of today?
  - Will the end-to-end communication paradigm play an important role? How will the global networks integrate the partially connected devices?
  - How can current and future standards efficiently support mobility in heterogeneous environments? This is more critical for devices with limited computational capability, lack of storage, unstable and slow communication links, and energy constraints.
  - How is it possible to reduce adjacent and co-channel interferences in these IoT environments with many traffic sources? How to increase spectral efficiency and to provide radically new and more efficient wireless access methods?

## Research questions (2/7)

- Resilient, trustworthy, and energy-efficient Internet architectures
  - What is the best way to address resilience in Internet architectures? Can resilience be tackled orthogonally to functional components or it must result from the integration of layered / component based solutions?
  - What are the main trade-offs when building/evolving an energy-aware Internet? Is the end-user willing to compromise his quality of experience to save energy? Will the providers accept the flexibility of user-controlled operations for energy efficiency?
  - Will cognitive networking be a plus or a minus within the context of an energy-efficient Internet?

## Research questions (3/7)

- Network management and operation frameworks (incl. mobility, virtualization, self-management and distributed management)
  - How can we support real-time activity detection in the Internet of the Future? How to maintain activity detection in real time, even when facing network handoffs, communication failure and heterogeneous environments?
  - What are the new challenges concerning post-deployment IoT diagnostic tools, regarding scope, flexibility, generality and security?
  - Can mobility be efficiently tackled at the IP layer? What is the best approach to mobility: network-based or client-based?
  - How can we further extend the reach of virtualization and cloud-sourced paradigms to the access networks (mobile, GPON, DSL, including physical infrastructure) and home/SOHO networks?

## Research questions (4/7)

- Novel protection approaches for critical infrastructures
  - How can we handle the growing interdependencies between heterogeneous critical Infrastructures and the associated cascade vulnerabilities?
  - How can we improve intrusion detection systems for specialized critical infrastructures?
  - In the event of successful attacks, how can critical Infrastructures minimize their impact on the provided services (avoiding service disruption and or service degradation)?

## Research questions (5/7)

- Cloud computing infrastructures
  - How can we make cloud computing infrastructures more resilient to all kinds of attacks?
  - Is the cloud an opportunity to attackers?
  - How can we further extend the reach of virtualisation and cloud-sourced paradigms to the access networks (mobile, GPON, DSL, including physical infrastructure) and home/SOHO networks?
  - Can mobility and multi-homing approaches aid in the virtualisation of servers in the cloud?

## Research questions (6/7)

- Internet of things
  - As the number of wireless devices increases and more technologies become a part of everyone's life, which mechanisms are needed to avoid/minimize the impact of interference?
  - What kind of people-centric applications can we develop using recent and future technologies?
  - How can we enrich virtual worlds with real world information?
  - How to adapt traditional communication stacks and standards to support content-centric networks, where users access the network for finding relevant content and possibly modifying it?

## Research questions (7/7)

- Security, privacy and trust
  - How can we secure spontaneous wireless networks with unknown receivers (thereby unsuitable for typical cryptographic schemes) using physical-layer mechanisms?
  - How can we enforce cooperation of devices for security in such distributed environment?
  - How can we provide cloud computing with a security framework that inspires trust on its clients with respect to the protection of their data in the cloud?
  - Can we use the mobility of individuals and the resulting sparse and time-limited social network interactions as a means to increase their privacy?



## Organisation of activities (1/2)

- Clear leadership and coordination of research activities
- Fundamental research carried out in the scope of PhD work
  - Actively working with and mentoring of Ph.D. students
- Cooperation
  - R&D projects
  - NoEs
  - COST actions
  - Researcher exchanges
  - Sabbatical leaves

## Organisation of activities (2/2)

- ▣ Active transmission of know-how among successive generations of students
- ▣ Use of specialised test-beds
- ▣ Close interaction with MSc and PhD course work
- ▣ Group workshops and regular meetings, which foster the sense of community inside the group
- ▣ Invited seminars
- ▣ Team building activities (e.g., Descida do Rio)

## Plan to attract resources (1/3)

- Increase visibility
  - Increase the number of journal and high-impact publications
  - Participation in editorial boards of international journals
  - Organization of conferences
  - Projects reviewing
  - Open source contributions
- International cooperation
  - Joint projects
  - Joint publications
  - Joint PhD supervision

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## Plan to attract resources (2/3)

- Submission of project proposals to competitive calls
  - FP7
  - Horizon 2020
  - QREN
  - FCT
- Projects with industry (national and international)
- Application to international research grants
  - E.g., CNPQ “Ciência sem Fronteiras” (science without frontiers) from Brazil

## Plan to attract resources (3/3)

- Offering of student grants, in the scope of financed projects
- Early involvement of students in research activities
- Use, maintain and increase the LCT “contact network”
  - Former students
  - Former project contacts
  - Personal contacts

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## Backup slides

- Main publications per scientific contribution

## Signalling mechanisms for WiMAX access networks in all-IP environments (WEIRD)

- “Novel WiMAX Scenarios for Future Broadband Wireless Access Networks”, in WiMAX Evolution – Emerging Technologies and Applications, Marcos Katz, Frank Fitzek, (Eds.), ISBN 9780470696804, Wiley 2009.
- “WiMAX Extension to Isolated Research Data networks: the WEIRD System”, in Mobile WiMAX, Kwang-Cheng Chen (Ed.), J. Roberto B. de Marca, Wiley, 2008.
- “VoIP over WiMAX: Quality of Experience Evaluation”, in Proceedings of the IEEE Workshop on multimedia Applications over Wireless Networks (MediaWiN 2009), Sousse, Tunisie, 5 July, 2009.
- “QoS management and control for an all-IP WiMAX network architecture: Design, implementation and evaluation”, Journal of Mobile Information Systems, Vol.4/N.4, 2008, pp. 253-271, IOS Press (ISSN: 1574-017x).
- “The Cost of Using IEEE 802.16d Dynamic Channel Configuration”, in Proceedings of IEEE International Conference on Communications (ICC 2008), Beijing, China, 19-23 May, 2008.
- “Experimental Evaluation of Multimedia Services in WiMAX”, 4th International Mobile Multimedia Communications Conference Mobimedia, Oulu Finland, 7-9 July, 2008.



## Scalable routing mechanisms for disaster scenarios (MORFEU)

- "Onto Scalable Ad-hoc Networks: Deferred Routing", Computer Communications, Elsevier, Available online 8 May 2012, ISSN 0140-3664, 2012.
- "Link Quality Estimation in Wireless Multi-hop Networks Using Kernel Based Methods", Computer Networks, Elsevier, 2012.
- "DASH, Deferred Aggregated routing for Scalable ad-Hoc networks", IFIP / IEEE Wireless Days conference, Veneza, Itália, October 2010.
- "Inside-out OLSR Scalability Analysis", in Proceedings of the 8th International Conference on Ad-Hoc Networks and Wireless (AdHocNow 2009), Murcia, Spain, 16-19 September, 2009.
- "NODRoP, Nature Optimized Deferred Routing Protocol", in Proceedings of the 28th Annual Joint Conference of the IEEE Computer and Communications Societies - Student Workshop (INFOCOM 2009), Rio de Janeiro, Brasil, 19-25 April, 2009.

## Clustering schemes for multi-hop communication (MORFEU)

- “Clustering for Indoor and Dense MANETs”, 12th Conference on Next Generation Wired/Wireless Advanced Networking (New2AN 2012), St Petersburg, Russia, August 27-29, 2012.
- “Smart and Balanced Clustering for MANETs”, 10th International Conference on Adhoc Networks and Wireless (Adhoc-Now 2011), 18-20 July, Paderborn, Germany.
- “A Novel Stable and Low-maintenance Clustering Scheme”, in Proceedings of the ACM 25th Symposium On Applied Computing (ACM SAC), Sierre, Switzerland, 22-26 March, 2010.

## Routing metrics and algorithms for wireless mesh networks (UBIQUIMESH)

- “Cross-layer Routing Metrics for Mesh Networks: Current Status and Research Directions”, Computer Communications, Elsevier, vol.34, pp.681 n° 703, 2011.
- “The Impact of Interference-Aware Routing Metrics on Video Streaming in Wireless Mesh Networks”, ADHOC NETWORKS, Elsevier, vol.9, pp.652 - 661, 2011.
- “Tendencies and Challenges of the Routing in Wireless Mesh Networks: Metrics using Cross-layer and Quality of Experience”, Tutorial at IEEE Latin American Conference on Communications 2010 (Latincom), Bogotá – September 2010.

## Routing mechanisms for user provided networks (UCR)

- “On the use of DTN Routing and Incentives for UPN”, submitted to Computer Networks, 2012.
- “Time Message System for Delay Tolerant Networks”, 2nd Baltic Congress on Future Internet Communications, Vilnius, Lithuania, April 25-27, 2012.

## Algorithms and protocols to support reliability in wireless sensor networks (GINSENG)

- “Performance Control in Wireless Sensor Networks”, IEEE SECON 2009, June 2009.
- “A taxonomy of Wireless Sensor Networks with QoS”, Fourth IFIP International Conference on New Technologies, Mobility and Security (NTMS'2011) - New Technologies, February 2011.
- “WSN Evaluation in Industrial Environments - First results and lessons learned”, Proceedings of 3rd International Workshop on Performance Control in Wireless Sensor Networks in conjunction with 7th IEEE International Conference on Distributed Computing in Sensor Systems (IEEE DCOSS '11).
- “A framework for Wireless Sensor Networks performance monitoring”, First IEEE WoWMoM Workshop on the Internet of Things: Smart Objects and Services, June 2012.

## Mobility support in critical scenarios (GINSENG)

- “Management of Mobility in Wireless Sensor Networks”, IEEE International Symposium on a World of Wireless Mobile and Multimedia Networks, WoWMoM 2008.
- “A new Approach for Multi-Sink Environments in WSNs”, 11th IFIP/IEEE International Symposium on Integrated Network Management” (IM 2009), June 2009
- “GINSENG - Performance Control in Wireless Sensor Networks”, Fourth Workshop on Real-World Wireless Sensor Networks 2010 (REALWSN10).
- “A Proposal for Proxy-based Mobility in WSNs”, Elsevier Computer Communication, ISSN: 0140-3664, September 2012.
- “Mobile IP-based Protocol for Wireless Personal Area Networks in Critical Environments”, Wireless Personal Communications, Special Issue on Advances in Mobile IPv6 and Network-based Localized Mobility Management, Wireless Personal Communications, Springer 2011.
- “Mobility in WSNs for Critical Applications - Issues and feasibility”, 16th IEEE Symposium on Computers and Communications (ISCC'11), June 2011

## Design of security mechanisms for resource-constrained sensing applications (GINSENG)

- “Why is IPSec a viable option for Wireless Sensor Networks”, 4th IEEE International Workshop on Wireless and Sensor Networks Security, 2008.
- “Enabling network-layer security on IPv6 Wireless Sensor Networks”, IEEE Globecom 2010 - Ad-hoc and Sensor Networking Symposium, December 2010.
- “A secure interconnection model for IPv6 enabled Wireless Sensor Networks”, IFIP Wireless Days 2010, October 2010.

## Management methods for Wireless Sensor and Actuator Networks (GINSENG)

- “Diagnostic Tools for Wireless Sensor Networks - A Comparative Survey”, Springer’s Journal of Network and Systems Management, Manuscript No. JONS-460R1, May 2012.
- “A Framework for Cognitive Radio Wireless Sensor Networks”, The IEEE Symposium on Computers and Communications (ISCC 2012), July 2012
- “Hermes: A versatile platform for wireless embedded systems”, IEEE International Symposium on a World of Wireless Mobile and Multimedia Networks (WoWMoM 2012), June 2012



Integration and interoperability of sensor networks with other environments (i-Locator)  
Location of people and goods in industrial environments (i-Locator)

- "A Web Service-based framework model for people-centric sensing applications applied to Social Networking", Sensors (ISSN 1424-8220), Special Issue "Microprocessors and System-on-Chip", pp. 1688-1701, March 2012
- "An Adaptive Model for Exposing WSN as a Service platform", INForum 2012, September 2012

## Use Cases in the area of Wireless Sensor Networks as input for Data Processing activities (PULSE)

- “A Framework for Integrating WSNs and External Environments”, 2010 Management and Control of Production Logistics, September 2010.
- “Characteristics of channels of IEEE 802.15.4 compliant sensor networks”, Wireless Personal Communications, Springer, ISSN: 0929-6212, August 2011.

## Mobility mechanisms for seamless mobility in heterogeneous access technology scenarios (WEIRD)

- “Advanced Cross-Layer Mobility Mechanisms in a Heterogeneous WLAN Scenario”, in Cross Layer Designs in WLAN Systems, Nizar Zorba, Charalambos Skianis and Christos Verikoukis, (Eds.), ISBN: 9781848768109, Troubador Publishing Ltd, Leicester, UK. 2011.
- “Mobility Management Architecture for WiMAX Networks”, in WiMAX Architecture, Ramjee Prasad, (Ed.), Springer, 2009.
- “Mobility Management for NGN WiMAX: Specification and Implementation”, in Proceedings of the 10th IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM 2009), Kos, Greece, 15-19 June, 2009.

## Mechanisms for multi-homing in mobile environments (CoFiMoM)

- “Multihoming Management for Future Networks”, in Mobile Network and Applications (MONET), Vol. 16, N. 4, 2011, pages 505-517.
- “A study of multimedia application performance over Multiple Care-of Addresses in Mobile IPv6”, proceedings of ISCC 2011 - 16th IEEE Symposium on Computers and Communications, ISCC 2011, Kerkyra, Corfu, Greece, June 28 - July 1, 2011.

## Client-based network mobility solutions and tools (CoFiMoM)

- “mobSim – A Network Mobility Simulation Tool for Very Large-Scale Scenarios”, proceedings of NTMS 2011 - 4th IFIP International Conference on New Technologies, Mobility and Security, Paris, France, 7-10 February 2011.
- “A Comparative Study of Network Mobility Paradigms”, proceedings of WWIC 2011 – 9th International Conference on Wired/Wireless Internet Communications, Vilanova i la Geltrú, Catalonia, Spain, June 13-17, 2011.
- “Some Results on Network Mobility Stress Testing”, Proceedings of BCFIC 2012 – 2nd Baltic Conference on Future Internet Communications, Vilnius, Lithuania, 25-27 April 2012.

## Mechanisms for resiliency in cloud scenarios (TRONE)

- “TRONE: Trustworthy and Resilient Operations in a Network Environment”, The Second International Workshop on Dependability of Clouds, Data Centers and Virtual Machine Technology (DCDV 2012), Boston, MA, USA, June 25, 2012.
- “Multihoming Management for Future Networks”, Mobile Networks and Applications, Volume 16, Number 4, 505-517, 2011.

## Management architecture for P2P service overlay networks (CONTENT)

- "An Approach to Peer Selection in Service Overlays", Proceedings of CNSM 2011 – 7th International Conference on Network and Service Management, Paris, France, 24-28 October, 2011.
- "On the Dimensioning of an Aggregation Service for P2P Service Overlay Networks", proceedings of AIMS 2011 – 5th International Conference on Autonomous Infrastructure, Management and Security, Nancy France, June 13-17, 2011.
- "Performance Evaluation of Service Searching using Aggregation in Peer-to-Peer Service Overlay Networks", proceedings of IM 2011 - 12th IFIP/IEEE International Symposium on Integrated Network Management, Dublin, Ireland, 23-27 May 2011.
- "An Aggregation Scheme for the Optimisation of Service Search in Peer-to-Peer Overlays", in Proceedings of CNSM 2010 - 6th International Conference on Network and Service Management, IEEE Communications Society, Niágara Falls, Canada, 25-29 October 2010.
- "OMAN - A Management Architecture for P2P Service Overlay Networks", in Proceedings of AIMS 2010 - 4th International Conference on Autonomous Infrastructure, Management and Security, University of Zurich, Switzerland, 21-25 June 2010.

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## Management solutions for virtualised and cloud-based environments (S3P, Virtuoso)

- "A Framework for Internet Media Services Delivery to the Home Environment", Springer's Journal of Network and Systems Management (accepted 2012, in press)
- "Using UPnP-CWMP Integration for Operator-assisted Management of Domestic LANs", IEEE Consumer Communications and Networking Conference (CCNC 2012), pp. 73-78, IEEE Press, January 2012.
- "Outsourced management of home and SOHO desktops", 7<sup>th</sup> Int. Conf. on Network and Services Management (CNSM 2011), IEEE Press, October 2011.
- "How to Provision and Manage Off-the-Shelf SIP Phones in Domestic and SOHO Environments", 36<sup>th</sup> Annual IEEE Conf. on Local Computer Networks (LCN 2011), October 2011.
- "Integration of PXE-based Desktop Solutions into Broadband Access Networks", 6<sup>th</sup> Int. Conf. on Network and Services Management (CNSM 2010), IEEE Press, October 2010.
- "CWMP Extensions for Enhanced Management of Domestic Network Services", 35<sup>th</sup> Annual IEEE Conf. on Local Computer Networks (LCN 2010), October 2010.
- "How to Cooperatively Improve Broadband Security", Proc. of the 8<sup>th</sup> European Conf. on Information Warfare and Security (ECIW09), July 2009.



## Security, trust and reputation mechanisms (MICIE, CockpitCI)

- "Design and implementation of a mediation system enabling secure communication among Critical Infrastructures", Int. Journal of Critical Infrastructure Protection, Vol. 5, Issue 2, pp. 86-97, Elsevier, July 2012.
- "Trust and reputation management for critical infrastructure protection", International Journal of Electronic Security and Digital Forensics, pp. 187-203, Vol. 3, No. 3, 2010.
- "An Alerting System for Interdependent Critical Infrastructures". 9th European Conf. on Information Warfare and Security (ECIW 2010), July 2010.
- "Trust and Reputation Management for Critical Infrastructure Protection", in Proc. of the 6th Int. Conf. on Global Security, Safety and Sustainability (ICG3S 2010), September 2010.
- "Trust and Reputation for Information Exchange in Critical Infrastructures", 5th Int. Conf. on Critical Information Infrastructure Security (CRITIS 2010), September 2010.
- "Assurance and trust indicators to evaluate accuracy of on-line risk in critical infrastructures", 6th Int. Conf. on Critical Information Infrastructure Security (CRITIS 2011), September 2011.
- "Trust based interdependency weighting for on-line risk monitoring in interdependent critical infrastructures", 6th Int. Conf. on Risks and Security of Internet and Systems (CRISIS 2011), September 2011.
- "Cloud Computing and Security". 11th European Conf. on Information Warfare and Security (ECIW 2012), July 2012.

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