FP7 ICT-1-1.1: The Network of the Future

EU-MESH: Enhanced, Ubiquitous, and Dependable Broadband Access using MESH Networks

D7.2: EU-MESH Publicity Pack

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Summary

Deliverable 7.1 “EU-MESH Publicity Pack” contains publicity material that has been produced by the project in its first six months. In addition to the Appendix of this overview report, the publicity material is available from the project’s website (www.eu-mesh.eu).
1. Public releases

The following two press releases have been issued for the project, and are available in Appendix 1.


2. Articles in online news

The following three articles related to the project have been published in online news sites. They are available in Appendix 2.

- “EU-MESH project launched”, TotalTelecom, 23 January 2008
- “Europe in a Mesh”, Unstrung News Feed, 23 January 2008

3. Public articles

The following two public articles about the project have been published or are to appear. Both are available in Appendix 3.


4. Project presentation

The general project presentation given at the 1st Concentration Meeting, 11, 12/3/2008, Brussels. The same presentation is also used to introduce the project to various visitors of the EU-MESH partner organizations. The presentation is available in Appendix 4.

5. Project factsheet

The project factsheet is available in Appendix 5.
6. **Poster**

The project has produced one research poster, which is available in Appendix 6.

7. **Public website**

Screenshots of the EU-MESH website ([www.eu-mesh.eu](http://www.eu-mesh.eu)) are available in Appendix 7.
Appendix 1 – Press Releases
European Commission funded EU-MESH project launched

Jan 22, 2006

Having its kick-off meeting this week in Berlin, nine European organisations are beginning collaboration on "The Network of the Future through the EU-MESH (Enhanced, Ubiquitous, and Decentralised broadband access using Mesh Networks) project. The goal of EU-MESH to develop, evaluate, and trial a system of software modules for building dependable multi-radio, multi-channel mesh networks with QoS support that provide ubiquitous and ultra-high speed broadband access. The system will be based on a wireless access infrastructure that uses a wireless mesh network to aggregate the capacity from both subscriber broadband access lines and provider fixed broadband links to form a virtual capacity pool, and provide access to this capacity pool for both stationary and mobile users. It will support low operation and management costs through novel configuration and management procedures that achieve efficient usage of both the wireless spectrum and fixed broadband access lines. This will increase the competitiveness of existing providers, lower the barrier for small enterprises to enter the mobile broadband access market, and enable innovative services.

The 30-month collaborative project has a 4.55 M€ budget, of which 3.06 M€ will be contributed by the European Commission.

The organisations collaborating on the EU-MESH project include: (i) Foundation for Research and Technology - Hellas (FORTH) - Greece, Coordinator. (ii) Consiglio Nazionale delle Ricerche (CNR) - Italy, (iii) Technische Universitaet Berlin (TUB) - Germany, (iv) Scuola Universitaria Professionale della Svizzera Italiana (SUPSI) - Switzerland, (v) Budapest University of Technology and Economics (BME) - Hungary, (vi) Forschungszentrum Juelich GmbH - Germany, (vii) Télécoms Communications S.A., France, and (viii) Ocone-France, and (ix) Prometry France Sp. Z O.O. (Prometry) - Poland.

Current mesh systems do not achieve efficient resource utilization, have sub-optimal channel and power control that prohibits large-scale deployment, and lack a comprehensive security solution combining proactive and reactive mechanisms.

To address the above, EU-MESH’s objectives are to develop algorithms that combine channel access with power and channel control to reduce interference, QoS and opportunistic routing algorithms to support scalable end-to-end QoS and efficient usage of the virtual capacity pool, location-aware automated (re-)configuration procedures that adapt to varying network conditions to provide robust connectivity, lightweight application layer procedures for seamless mobility over heterogeneous and multi-operator mesh networks, and intrusion detection and mitigation mechanisms that exploit cross-layer monitoring. In addition, an external advisory committee that includes experts from both industry and academia will provide an external global viewpoint.

The system will be assessed through metropolitan scale trials, from the perspective of a pure wireless network operator and a wired/wireless telecommunication operator.

For more information on the EU-MESH project and its participants, please see http://www.eu-mesh.eu.

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This press release contains forward-looking statements within the meaning of Section 27A of the Securities Act of 1933 and Section 21E of the Securities Exchange Act of 1934. All statements, other than statements of historical facts, including statements regarding our strategy, future operations, financial position, future revenues, projected costs, prospects, plans and objectives of management, may be deemed to be forward-looking statements. The words "anticipates," "believes," "estimates," "expects," "intends," "may," "plans," "projects," "will," "would" and similar expressions or negative variations thereof are intended to identify forward-looking statements, although not all forward-looking statements contain these identifying words. We may not actually achieve the plans, intentions or expectations disclosed in our forward-looking statements and you should not place undue reliance on our forward-looking statements. There are a number of important factors that could cause actual results or events to differ materially from those set forth in the forward-looking statements we make, and investors and others are therefore cautioned that a variety of factors, including certain risks, may affect our business and cause actual results to differ materially from those set forth in the forward-looking statements. The Company is subject to the risks and uncertainties described in its filings with the Securities and Exchange Commission, including its Annual Report on Form 10-K for the year ended 31 December, 2006 and Form 10-Q for the first quarter ended 1 April 2007. You should read those factors as being applicable to all related forward-looking statements whenever they appear in this press release. We do not assume any obligation to update any forward-looking statements.

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News Release
For Immediate Release

European Commission Funded EU-Mesh Project Launched

Nine European Organizations Begin Collaboration on the Wireless Access Network of the Future

Berlin, Germany (PRWeb) January 18, 2008 – Having its kick off meeting this week in Berlin, nine European organizations are beginning collaboration on ‘The Network of the Future’ through the EU-MESH (‘Enhanced, Ubiquitous, and Dependable Broadband Access using MESH Networks’) project. The goal of EU-MESH to develop, evaluate, and trial a system of software modules for building dependable multi-radio, multi-channel mesh networks with QoS support that provide ubiquitous and ultra-high speed broadband access. The system will be based on a converged infrastructure that uses a wireless mesh network to aggregate the capacity from both subscriber broadband access lines and provider fixed broadband links to form a virtual capacity pool, and provide access to this capacity pool for both stationary and mobile users. It will support low operation and management costs, through novel configuration and management procedures that achieve efficient usage of both the wireless spectrum and fixed broadband access lines. This will increase the competitiveness of existing providers, lower the barrier for small enterprises to enter the mobile broadband access market, and enable innovative services.

The 30 month collaborative project has a 4.55 MEuro budget, of which 3.06 MEuro will be contributed by the European Commission.


Current mesh systems do not achieve efficient resource utilization, have sub-optimal channel and power control that prohibits large-scale deployment, and lack a comprehensive security solution combining proactive and reactive mechanisms.

To address the above, EU-MESH’s objectives are to develop algorithms that combine channel access with power and channel control to reduce interference, QoS and opportunistic routing algorithms to support scalable end-to-end QoS and efficient usage of the virtual capacity pool, location-aware automated (re-)configuration procedures that adapt to varying network conditions to provide robust connectivity, lightweight application layer procedures for seamless mobility over heterogeneous and multi-operator mesh networks, secure routing and handover in single and multi-operator mesh networks, and intrusion detection and mitigation mechanisms that exploit cross-layer monitoring. In addition, an external advisory committee that includes experts from both industry and academia will provide an external global viewpoint.
The system will be assessed through metropolitan scale trials, from the perspective of a pure wireless network operator and a wired/wireless telecom operator.

For more information on the EU-MESH project and its participants, please see http://www.eu-mesh.eu/.

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Appendix 2 – Articles in online news

(M2 PressWIRE Via Thomson Dialog NewsEdge)

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Having its kick off meeting this week in Berlin, nine European organizations are beginning collaboration on The Network of the Future through the EU-MESH (Enhanced, Ubiquitous, and Dependable Broadband Access using MESH Networks') project.

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Current mesh systems do not achieve efficient resource utilization, have sub-optimal channel and power control that prohibits large-scale deployment, and lack a comprehensive security solution combining proactive and reactive mechanisms.

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The system will be assessed through metropolitan scale trials, from the perspective of a pure wireless network operator and a wired/wireless telecom operator.

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EU-MESH project launched
Proximetry
23 January 2008
Nine European Organizations Begin Collaboration on the Wireless Access Network of the Future

January 23, 2008 – Having its kick off meeting this week in Berlin, nine European organizations are beginning collaboration on 'The Network of the Future' through the EU-MESH ('Enhanced, Ubiquitous, and Dependable Broadband Access using MESH Networks') project.

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Or contact Dr. Walter Buga, CTO of Proximetry one of the organizations collaborating on the EU-MESH project, on +1 916 201 2220 or WBuga@proximetry.com

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Europe in a Mesh

BERLIN -- Having its kick off meeting this week in Berlin, nine European organizations are beginning collaboration on 'The Network of the Future' through the EU-MESH ('Enhanced, Ubiquitous, and Dependable Broadband Access using MESH Networks') project. The goal of EU-MESH to develop, evaluate, and trial a system of software modules for building dependable multi-radio, multi-channel mesh networks with QoS support that provide ubiquitous and ultra-high speed broadband access.

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European Commission
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The fault-tolerant search algorithm that was developed based on these findings has been integrated into the new versions of the Contentum content management product, and may also be used for further collaboration in European projects related to data repositories. In addition, and along with the list of the most common character substitutions, the analysis and the algorithm may provide a good basis in the future for building a robust search index for digital repositories comprising digitized documents.

Enhanced, Ubiquitous and Dependable Broadband Access using MESH Networks

by Vasilios Siris, Ioannis G. Askoxylakis, Marco Conti and Raffaele Bruno

The reduction of network deployment and operation costs and the integration of wireless access networks with fixed broadband access technology are crucial to allowing small and medium-scale enterprises to enter the high-growth potential mobile broadband access market, and for the introduction of innovative services that require pervasive broadband access.

This is the focus of the thirty-month EC-funded project EU-MESH (Enhanced, Ubiquitous and Dependable Broadband Access using MESH Networks), which commenced in January 2008 and is targeting the objective 'Network of the Future' of ICT's 'Pervasive and Trusted Network and Service Infrastructures' challenge.

EU-MESH's goal is to develop, evaluate and trial a system of software modules for building dependable multi-radio multi-channel mesh networks with QoS support that provide ubiquitous and ultra-high-speed broadband access. The system will be based on a converged infrastructure that uses a wireless mesh network to aggregate the capacity from both subscriber broadband access lines and provider fixed broadband links to form a virtual capacity pool, and will provide access to this capacity pool for both stationary and mobile users. It will support low operation and management costs, through novel configuration and management procedures that achieve efficient usage of both the wireless spectrum and fixed broadband access lines. This will increase the competitiveness of existing providers, lower the barrier for small enterprises to enter the mobile broadband access market, and enable innovative services.

Existing mesh systems are based on non-standard solutions, do not achieve efficient resource utilization, have sub-optimal channel and power control that prohibits large-scale deployment, and
lack a comprehensive security solution combining proactive and reactive mechanisms.

To address the above, EU-MESH’s objectives are to develop:

• algorithms that combine channel access with power and channel control to reduce interference
• QoS and opportunistic routing algorithms to support scalable end-to-end QoS and efficient resource usage
• location-aware automated (re-)configuration procedures that adapt to varying network conditions to provide robust connectivity
• lightweight application layer procedures for seamless mobility over heterogeneous and multi-operator mesh networks, and
• secure routing, communications and handover in multi-operator mesh networks, and intrusion detection and mitigation mechanisms that exploit cross-layer monitoring.

The system will be assessed through local experiments and metropolitan-scale trials, from the perspective of a pure wireless network operator and a wired/wireless telecom provider.

The primary goal of WEIRD is to establish four cutting-edge research WiMAX testbeds (see Figure 1), which employ both IEEE 802.16d (Portugal and Romania) and 802.16e (Italy and Finland) and interconnect them via GEANT2. In addition to the use of WiMAX as a backhaul and wireless local loop solution, the project considers three specific deployment scenarios: volcano monitoring, telemedicine and fire prevention.

Moreover, WEIRD proposes an architecture that is compliant with recent work by the relevant standardization bodies, such as IEEE 802.16, IETF 16ng and the WiMAX Forum. For example, in order to guarantee full interoperability among different WiMAX vendors, the WiMAX Network Reference Model (NRM) is used as a foundation, and the Next Steps in Signalling (NSIS) framework is used for Quality of Service reservations. Applications employing the Session Initiation Protocol (SIP) enjoy additional services from the WEIRD system. Legacy applications are supported, and the IEEE 802.21 Media Independent Handover standard has also been considered and integrated into the WEIRD architecture. This allows multi-access nodes to take advantage of the WEIRD architecture and optimize seamless handovers between WiMAX (and other) access networks. Furthermore, in order to allow for independence from the particulars of WiMAX vendor equipment, an abstraction layer has been defined that separates the lower-layer specific functionalities from the upper-layer ones. In order to

Establishing the First European Research WiMAX Testbeds

by Kostas Pentikousis, Marilia Curado, Pedro Miguel Neves and Marcos Katz

The WEIRD (WiMAX Extension to Isolated Research Data Networks) project is unique in the European R&D scene: by the end of May 2008, WEIRD will deliver not one but four WiMAX testbeds, all interconnected via GEANT2, the pan-European research and education network. By combining theoretical methods with empirical research and prototype development, the project identifies and addresses the needs arising from a variety of scenarios, ranging from environmental monitoring to telemedicine. WiMAX has been much touted (and criticized) during the last years. The WEIRD testbeds are instrumental in separating hype from reality.

In recent years, increasing attention has been paid to the IEEE 802.16 family of wireless local and metropolitan area network (LAN/MAN) standards and its potential to change the field of telecommunications operations and business models. Along with the WiMAX Forum extensions that define an end-to-end architecture, this wireless LAN/MAN technology emerges as a potent proposal for building next-generation wireless networks. According to some projections, 1.3 billion people could have access to WiMAX networks by 2012. Despite the buzz however, there is very little data on what can actually be done with WiMAX, in practice, today. In fact, the current WiMAX-related literature is based primarily on analysis and simulation, making use of the general properties of systems employing Orthogonal Frequency Division Multiple Access (OFDMA), and for the most part drawing on specifics from vendor-provided data.

The WEIRD project involves the following European organizations participating in the EU-MESH project:

- FORTH-ICS (Coordinator, Greece), National Research Council - CNR (Italy), Technical University of Berlin (Germany), University of Applied Science of Ticino - SUPSI (Switzerland), Budapest University of Technology and Economics - BME (Hungary), Proximetry (Poland), Forthnet (Greece), Thales Communications (France), and Ozone (France).

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http://www.eu-mesh.eu/
Securing wireless MESH Networks

By Ioannis G. Askoxylakis, Levente Buttyan, Vasilios Siris, and Apostolos Traganitis

Reduction of network deployment and operation costs and integration of wireless access networks with fixed broadband access technologies is a key enabler for small and medium scale enterprises to enter the high growth potential mobile broadband access market, and introduce innovative services that require pervasive broadband access. Mesh Networks represent an emerging wireless networking technology that promises wider coverage than traditional wireless LANs and higher data rates combined with lower deployment costs than 3G mobile networks. This is the focus of the 30-month EC funded project EU-MESH (Enhanced, Ubiquitous, and Dependable Broadband Access using MESH Networks), FP7 ICT-215320, which started January 2008, and targets the objective “Network of the Future” of ICT’s “Pervasive and Trusted Network and Service Infrastructures” challenge.

In order to turn the tremendous business potential represented by mesh networking into real profit, one needs to solve a number of technical problems related to the design and operation of mesh networks. Security, among others, is a fundamental technical problem and a key factor for the design of such decentralized communication systems.

EU-MESH system overview

EU-MESH's goal is to develop, evaluate, and trial a system of software modules for building dependable multi-radio multi-channel mesh networks with QoS support that provide ubiquitous and ultra-high speed broadband access. The system is based on a converged infrastructure that uses a wireless mesh network to aggregate the capacity from both subscriber broadband access lines and provider fixed broadband links to form a virtual capacity pool, and provide access to this capacity pool for both stationary and mobile users. It supports low operation and management costs, through novel...
configuration and management procedures that achieve efficient usage of both the wireless spectrum and fixed broadband access lines. This will increase the competitiveness of existing providers, lower the barrier for small enterprises to enter the mobile broadband access market, and enable innovative services.

Existing mesh systems are based on non-standard solutions, do not achieve efficient resource utilization, have sub-optimal channel and power control that prohibits large-scale deployment, and lack a comprehensive security solution combining proactive and reactive mechanisms.

To address the above, EU-MESH’s objectives are to develop
- algorithms that combine channel access with power and channel control to reduce interference,
- QoS and opportunistic routing algorithms to support scalable end-to-end QoS and efficient resource usage,
- location-aware automated (re-) configuration procedures that adapt to varying network conditions to provide robust connectivity,
- lightweight application layer procedures for seamless mobility over heterogeneous and multi-operator mesh networks, and
- secure routing, communications, and handover in multi-operator mesh networks, and intrusion detection and mitigation mechanisms that exploit cross-layer monitoring.

The system will be assessed through local experiments and metropolitan scale trials, from the perspective of a pure wireless network operator and a wired/wireless telecom provider.

**Securing wireless mesh networks: the EU-MESH approach**

Security is a key factor for the design of decentralized wireless communication networks like mesh networks. EU-MESH addresses security by two complementary approaches: The proactive approach that aims at preventing attacks and relies on cryptographic algorithms, and the reactive approach that aims at detecting intrusions, and reacting to them by reconfiguration of the mesh infrastructure.

In this direction, EU-MESH aims to design and implement a comprehensive security architecture that combines proactive and reactive security mechanisms, takes into account cross-layer considerations and multi-operator environments, and jointly incorporates QoS and security requirements right from the design phase. EU-MESH jointly investigates QoS-aware secure routing and novel re-authentication mechanisms that enable secure and fast handoffs between different operators. EU-MESH investigates intrusion detection in multi-radio multi-channel mesh networks by utilizing detectors at different locations and follows a cross-layer approach that combines detectors, variables and algorithms at different layers, while balancing the detection overhead. It also investigates mitigation procedures that combine multiple control mechanisms, such as channel switching, alternative route selection, power/rate control, and traffic filtering, in order to minimize the range, degree, and duration of QoS disruptions.
More specifically, the EU-MESH security architecture aims at satisfying the following main security requirements:

**Authentication of mesh clients and access control.**
In order to prevent unauthorized access to services, mesh clients must be authenticated, and access control rules must be enforced in the system. Ideally, access control enforcement should take place at the access points so that unauthorized access attempts are denied as early as possible without affecting the rest of the network. In addition, authentication needs to support end-user mobility and QoS-aware applications, and it must work in a multi-operator environment. Supporting user mobility and QoS-aware applications means that re-authentication of mesh clients and access authorizations during hand-over should be fast enough not to disrupt QoS aware application sessions, such as a VoIP call. In addition, the multi-operator environment means that such handovers may occur between access points belonging to different administrative domains.

**Protection of wireless links.**
Wireless communications between mesh clients and mesh routers, as well as among mesh routers and gateways must be protected against various attacks, such as eavesdropping, spoofing, replay, and traffic analysis. This protection can be realized in an end-to-end or in a link-by-link manner. However, in order to identify and remove fake, modified, or replayed messages as early as possible, and in this way, avoid wasting bandwidth, message integrity and authenticity should be provided ideally in a link-by-link manner. Traffic analysis must be prevented as much as possible in order to prevent unauthorized access to meta-data of the customers, and hence, to ensure some degree of privacy. Link-by link encryption of messages can help in this matter, as it can hide end-to-end addressing information. In addition, dummy traffic can be maintained by neighbouring mesh routers on idle links in order to prevent the identification of communication profiles.

**Increasing the robustness of the networking mechanisms.**
An easy way to mount stealth DoS attacks against a network is to manipulate its basic mechanisms such as the routing protocol, the medium access control scheme, the topology control and channel assignment mechanisms, etc. For this reason, it is important to increase the robustness of these basic networking mechanisms. In particular, securing the routing protocol seems to be the most important requirement in this category, because interfering with the routing protocol may affect the entire network, whereas attacks on lower layers (e.g., on medium access control and channel assignment) seem to have a localized effect.

In general, QoS-aware routing protocols provide three functions: (1) proactive dissemination of routing information (e.g., link quality metrics) and local route computation, or on-demand route discovery (depending on the type of the protocol), (2) resource reservation on selected routes (for the purpose of QoS guarantees), and (3) recovery from errors during the data forwarding phase. Routing information dissemination and route discovery requires the authentication and integrity protection of routing control messages, in order to prevent their manipulation by external adversaries. In addition, in some protocols, special attention must be paid to the protection of non-traceable mutable information (e.g., the cumulative routing metric values) in routing control messages against misbehaving mesh routers. Resource
reservation messages also need to be authenticated in order to avoid resource blocking DoS attacks. Similarly, it must be guaranteed that resources do not stay reserved forever. Finally, error recovery procedures should not be exploitable by attacks aiming at the disruption of communication or increasing the message overhead in the network.

**Intrusion and misbehaviour detection and recovery.**

Due to the fact that operators may also misbehave and mesh routers could be physically tampered with by external attackers, we must assume that some fraction of the mesh routers may exhibit arbitrary Byzantine behaviour. It is more or less impossible to identify such misbehaving nodes by cryptographic means. Similarly, cryptographic solutions are ineffective against jamming attacks. Therefore, besides the proactive security measures that we have described above, one must also consider the application of some reactive measures aiming at the detection and recovery from attacks based on intrusion and misbehaviour. As misbehaviour can happen at any layer of the communication stack, misbehaviour detection should be implemented in all layers; moreover, various misbehaviour detection modules can be combined in a cross layer approach to increase the effectiveness of the detection. Misbehaviour detection and recovery requires that the nodes can monitor the activity of each other (at least to some extent), that they can identify suspicious activities, and that they can make counteractions (e.g., they can exclude misbehaving nodes from the network). This also means that some level of cooperation must take place between the nodes.

The 9 European Organizations participating in the EU-MESH project are the following: Institute of Computer Science, Foundation for Research and Technology – Hellas, FORTH (Coordinator, Greece), National Research Council - CNR (Italy), Technical Universities Berlin - TUB (Germany), University of Applied Science of Ticino - SUPSI (Switzerland), Budapest University of Technology and Economics - BME (Hungary), Proximetry (Poland), Forthnet (Greece), Thales Communications (France), and Ozone (France).

Further information about the project is available at: [www.eu-mesh.eu](http://www.eu-mesh.eu)

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Appendix 4 – Project Presentations
Observations

- Fixed/wired broadband access limited by single broadband subscriber line
  - isolated, unevenly utilized ⇒ unused communication resources
- Separate wired and wireless access networks
  - isolated wireless hotspots with non-uniform coverage
  - city-wide/community wireless meshes with few Internet gateways
- Wireless multi-hop mesh technology is key for providing ubiquitous broadband access
- Existing mesh products lack significant features
  - based on proprietary solutions
  - sub-optimal channel and power control
  - assume few fixed Internet gateways
  - no comprehensive security
Our vision for enhanced, ubiquitous, and dependable broadband access

Aggregate capacity from subscriber & provider links to form virtual capacity pool

Multi-radio MESH network for dependable access to virtual capacity pool
Our vision for enhanced, ubiquitous, and dependable broadband access

Enhanced security & scalable end-to-end QoS in single & multi-operator environments

Scalable converged architecture supporting flexible business models and innovative apps

Wireless technology to provide ubiquitous broadband access with mobility support

Objectives and key issues

- Develop, evaluate, and trial a system of software modules for building wireless multi-radio multi-channel mesh networks that
  - support scalable end-to-end QoS while efficiently utilize wireless spectrum and control interference
  - enable fast deployment and reduce management complexity and cost, while providing dynamic and reliable connectivity
  - support enhanced proactive & reactive security, and seamless mobility based on cross-layer monitoring in single and multi-operator environments
  - seamlessly integrate mesh networks with fixed technologies to provide pervasive ultra-high capacity broadband access to both stationary and mobile users, through a converged infrastructure

- Implement and evaluate system in two existing metropolitan scale deployments (Paris and Heraklion)

Jointly consider QoS, mobility, and security
Contact and partners

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  Institute of Computer Science, FORTH
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- Website: www.eu-mesh.eu
- 9 partners from 7 EU member states:
EU-MESH will develop, evaluate, and trial a system of software modules for building dependable multi-radio mesh networks with QoS support that provide ubiquitous and ultra-high speed broadband access.

**Main Objectives**

EU-MESH’s goal is to develop, evaluate, and trial a system of software modules for building dependable multi-radio multi-channel mesh networks with QoS support that provide ubiquitous and ultra-high speed broadband access.

The system will be based on a converged infrastructure that uses a wireless mesh network to aggregate capacity from both subscriber broadband access lines and provider fixed broadband links to form a virtual capacity pool, and provide access to this capacity pool for both stationary and mobile users. It will support low operational and management costs, through novel configuration and management procedures that achieve efficient usage of both the wireless spectrum and fixed broadband access lines. This will increase the competitiveness of existing providers, lower the barrier for small and medium enterprises to enter the mobile broadband access market, and enable innovative services.

Existing mesh systems are based on non-standard solutions, do not achieve efficient resource utilization, have sub-optimal channel and power control that prohibits large-scale deployment, and lack a comprehensive security solution combining proactive and reactive mechanisms.

To address the above, EU-MESH’s objectives are to develop

- algorithms that combine channel access with power and channel control to reduce interference,
- QoS and opportunistic routing algorithms to support scalable end-to-end QoS and efficient resource usage,
- location-aware automated (re-)configuration procedures that adapt to varying network conditions to provide robust connectivity,
- lightweight application layer procedures for seamless mobility over heterogeneous and multi-operator mesh networks, and
- secure routing, communications, and handover in multi-operator mesh networks, and intrusion detection and mitigation mechanisms that exploit cross-layer monitoring.

The system will be assessed through local experiments and metropolitan scale trials, from the perspective of a pure wireless network operator and a wired/wireless telecom provider.
Technical Approach
EU-MESH’s approach includes cross-layer control and monitoring, and joint consideration of QoS, mobility, and security requirements at the architecture design phase.

The work plan involves four phases: identification of requirements; architecture design; research and development activities for mesh configuration and link control, resource management, QoS routing, mobility, and security; integration; and finally experiments and trials. The specific work packages and their approach are as follows:

- **WP1 Project Management and Assessment.**
- **WP2 Requirements and Architecture:** Definition of user and application requirements, and architecture of the EU-MESH system. The architecture will follow a cross-layer design principle, and will be the basis for the work in WP3-5.
- **WP3 Mesh Configuration and Link Control:** Procedures for automated configuration and management, cross-layer wireless network monitoring, and efficient topology control.
- **WP4 Resource, QoS, and Mobility Management:** Models and algorithms for efficient resource management based on cross-mechanism optimization, QoS routing metrics and opportunistic routing algorithms, and mobility support.
- **WP5 Security:** Combined proactive (secure routing and handoffs) and reactive security based on cross-layer monitoring for ensuring high dependability and availability.
- **WP6 Experiments and Trials:** Integration of software modules, definition and execution of experiments and trials, assessment of results.
- **WP7 Dissemination, Standardization, and Exploitation.**

Key Issues
Key issues addressed by the EU-MESH project include the following:

- Cross-layer architecture design that integrates requirements for QoS, mobility, and security.
- Investigate combined impact of various control mechanisms, such as channel access, power control, channel assignment, and routing on the overall performance of a mesh network.
- Support seamless mobility over heterogeneous and multi-operator mesh networks.
- Integrate proactive and reactive security procedures in single and multi-operator mesh networks.
- Assess the developed system from the perspective of a pure wireless network operator and a wired/wireless telecom operator.

Expected Impact
EU-MESH will achieve the following expected impact:

- Align work and contribute to IEEE and ITU-T standards related to the integration of mesh networks with heterogeneous fixed access technologies, in order to provide ubiquitous broadband access to both fixed and mobile users.
- Develop a scalable converged infrastructure that supports flexible network and service models, which can in turn contribute to new business models.
- Lower the barrier for small/medium size providers to enter the high growth potential mobile broadband access market, through reduced deployment costs and time while exploiting underused communication resources, and enable the introduction of innovative services that require pervasive broadband access.
Appendix 6 – Project Poster
EU-MESH: Enhanced, Ubiquitous, and Dependable Broadband Access using MESH Networks
http://www.eu-mesh.eu

At a Glance

- **Project Coordinator:** Vasilios A. Siris
  Institute of Computer Science, FORTH
- **Duration:** 01/2008-06/2010
- **Funding:** 7th Framework Programme, ICT
- **Total cost:** € 4,55 m
- **EC Contribution:** € 3,06 m
- **Contract number:** INFSO-ICT-215320
- **9 partners** from 7 EU member states:

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Vision for Enhanced, Ubiquitous, and Dependable Broadband Access

- Aggregate capacity from subscriber & provider links to form a virtual capacity pool
- Use a multi-radio MESH network for providing access to the virtual capacity pool for both fixed and mobile users

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Key Issues

- Converged infrastructure integrating wireless mesh networks with fixed/wired networks
- Scalable end-to-end QoS while efficiently utilizing wireless spectrum and wired links
- Fast deployment and reduced management costs
- Enhanced proactive and reactive security in single and multi-operator environments
- Seamless mobility across heterogeneous networks

**EU-MESH will jointly consider QoS, mobility, and security**

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Objectives and Approach

**EU-MESH will develop**

- algorithms that combine channel access with power and channel control to reduce interference,
- QoS and opportunistic routing to support scalable end-to-end QoS and efficient resource usage,
- location-aware automated configuration procedures to provide robust connectivity,
- lightweight application layer procedures for seamless mobility over heterogeneous and multi-operator mesh networks,
- secure routing, communications, and handover in multi-operator mesh networks and intrusion detection mechanisms that exploit cross-layer monitoring

**EU-MESH will assess** the developed system through experiments and metropolitan scale trials in
- Ozone’s production network in Paris and
- FORTH-ICS’ experimental mesh network in Heraklion

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FORTH-ICS’ experimental metropolitan mesh network:
- 60 Km² coverage
- 14 nodes, 6 core multi-radio mesh nodes
- 1.6-5 Km wireless links
- 19-26 dBi panel antennas
- 3 fixed network gateways
Appendix 7 - Website of EU-MESH project

1. Welcome page

2. Participants page
3. Description

a. Summary

EU-MESH goal is to develop, evaluate, and standardize a system of software modules for building dependable multiaccess multi-hop wireless networks with QoS support that provide multi-hop wireless networks with QoS support that provide multi-hop wireless networks with QoS support that provide...
c. Work Packages

4. Dissemination

a. Publicity
b. Public Deliverables

c. Publications
5. News and Information

6. Internal Wiki
7. Contact

EU-MESH: Enhanced, Ubiquitous, and Dependable Broadband Access using MESH Networks

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