Related IST project:
Related EU IST FP6 projects: OASIS, Ambient Networks, ADHOCSYS, U-2010, SUPHICE, DAIDALOS, Akogrimo, ENABLE

Length of the workshop:
Full day workshop. The workshop will be open for the public and free of charge.

Title of the workshop:
Easy Wireless: Quality of Service and Service Continuity in Heterogeneous Wireless Networks

Name of the workshop coordinator:
Bjørn Rossow, Thales Norway AS

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Introduction to Easy Wireless workshop:
Easy Wireless (EW) is an ITEA project in the NOMADIC Technology Domain. The main goals for EW are to ensure Transparent Connectivity, seamless Service Continuity and to keep user experienced Quality of Service (QoS) at a certain level, during roaming in heterogeneous networks, and especially between all kinds of wireless networks. The user services to be supported could be for example video broadcasting, calls and streaming services, VoIP calls and high capacity data transmissions. The work includes issues such as: addressing, roaming, service continuity, QoS, measurements/monitoring and inter-working between heterogeneous networks. In addition, the project has studied these aspects in case the networks are mobile and unreliable, and the users are very mobile.

To achieve service continuity it is mandatory to study end-to-end QoS and resource management across different network technologies and across multiple paths. It is anticipated that transparent service continuity (with the same QoS) will not be possible in all cases and for all kind of services. To tackle such situations, enhanced features allowing adaptive service delivery taking into account the available networks capabilities has been defined in EW. Indeed, it is the user perceived QoS that ensures the acceptance of a service. In a wireless environment the management of QoS is particularly important. Therefore the EW project has studied the fundamental QoS mechanisms and the level of QoS that can be achieved for each of the technologies addressed. In addition, EW has defined an end-to-end architecture to allow the maintaining of QoS for multimedia data flows. Congestion problems are getting worse in the Internet where number of devices and access systems increase. Therefore, congestion control algorithms were studied in order to guarantee seamless connectivity.

Regarding service continuity for user roaming or when the network configuration changes considerably, the following technical topics have been addressed:

- Mechanisms to automatically adapt node configurations during roaming.
- Mechanisms to allow automatic service level negotiation during roaming.
- Architectures to minimize packet loss and duplication that may occur.
- Mechanisms to make the distribution of network topology information robust against transition phases.
- Methods for fast and time constrained re-configuration and adaptation in heterogeneous networks.

Networking is a complex problem that traditionally has been made tractable by splitting its functionality between different layers in a protocol stack. These architectures were defined decades ago, before the deployment of today's mobile devices and wireless networks. Mobility functions were not included in any layer. We took this into account when we proposed the architecture for QoS and service continuity in heterogeneous wired and wireless networks. Mobility support across different layers is required for detecting and joining new networks. A host must be able to determine what types of networks are available in a particular area (e.g., IEEE 802.11 and GPRS) and attach itself to one or more of these networks. The main disadvantages of regular mobility protocols (e.g. Mobile IP) are increased delays due to complex protocols and functionality. Examples of this are route optimisation for Mobile IP (e.g. triangle or quadrangle routes), and the SIP mobility support (e.g. the SIP handover procedure introduces latency for the signalling messages procedure and overhead for IP encapsulation). For mobility, one of the main ideas in EW is to transfer all the necessary information, referred to as context, to the new access router before the mobile node arrives. To

implement mobility at the transport layer, the host must be able to detect networks to which it moves, and obtain a new IP address in that network, through DHCP or a similar mechanism. Higher layer protocols, such as DNS and Dynamic DNS, help to maintain reachability for new connections.

Technologies addressed related to the development of Third Generation (3G) cellular systems, mainly UMTS and Wireless Local Area Networks (WLANs), especially of IEEE 802.11-based networks, has increased. The high penetration and communication speeds of WLANs has motivated the research on the possibility of integrating them into the cellular communication systems, constituting what is known as beyond third generation (B3G) or fourth generation (4G) systems. These technologies can be exploited in several application areas. In the EW project we have concentrated in three of these areas:

- Support of mobile domestic users or workers, that move between their home/office, equipped with an Ethernet LAN or an 802.11 WLAN and connected to the Internet by an ADSL line or other medium-speed data access technology, and outdoors, with GPRS/UMTS connectivity, and an option for a WiMAX system.
- Network support in WLAN-based public transportation systems, such as trains.
- In WLAN-based ad hoc networks (MANET) and mesh networks.

All concepts developed in the project have early on seen a transition into demonstrators in the form of simulations, software and hardware prototypes. The software developed by the 17 partners will be presented in the final demonstrators, and it will illustrate a practical use of the solutions in the specific use cases of the 3 main scenarios that the project has worked with. The project will also present an integrated demonstration incorporating several of the tools developed. Protocol augmentations and optimisations at different layers of the networking stack have been demonstrated, both for the purpose of QoS as for the continuity of service. On the network management aspects, network monitoring and QoS measurement tools have been developed. The purpose of these tools is to find out the current performance of the networks, and where the bottlenecks are. The tools will also be used to analyse the performance behaviour of the proposed QoS techniques, and will give feedback to QoS aware applications about the network conditions.

- The 3 main scenarios investigated in the EW project:
- *Train scenario*: The scenario for seamless wireless connectivity in public transport, and especially rail transport, is specific in the two-layer mobility:
    - The train moves along the track, while the passengers and crew move inside the train. The train changes access network to other infrastructure depending on availability. There are no single access points that can deliver connectivity in the whole train, therefore seamless roaming within the train is also supported.
    - The networking will also be heterogeneous, as trains move inside stations and depots, where high bandwidth is available (for example to upload video content). Passengers move from trains to the station and into another train.
- *Home and Office scenario*: In this scenario, the EW project has demonstrated how QoS aware applications can be very useful for the daily life. Especially, how to optimise the use of diverse network infrastructures, mainly when their cost is very different. One example is how a videoconference or VoIP session can continue despite the changing of access networks. To be able to enhance the QoS experienced by the mobile user for such applications, and end-to-end QoS architecture incorporating the QoS mechanisms in the core network, and real time QoS monitoring, has been defined. The demonstrations in the Home and Office scenario use access networks such as: LAN, WLAN and WCDMA/HSDPA network capabilities. The core network provides support for an access router and two other routers, which support DiffServ. The demonstration implements Mobile IP for supporting vertical handovers. The test network configuration is used for testing and measuring end-to-end QoS and vertical handovers between heterogeneous LAN, WLAN and WCDMA systems.
- *Emergency communication scenario*: The emergency scenario investigates a deployable, high-capacity communication system. Such a system is not meant to be a replacement for a low- capacity emergency system such as TETRA, but will be a complementary system providing high capacity functionality and services. The main benefits of a high capacity communication system based on ad hoc network technology are the high bandwidth supported, and that the network system is deployable. The latter means that the system does not depend on any pre-built infrastructure such as stationary base stations. The emergency personnel are bringing the communication network with them, and the infrastructure is built automatically and on-demand. We refer to this high capacity, deployable network as an ad hoc infrastructure. This infrastructure will consist of both smaller ad hoc access networks, gateways to external (home) networks for instance through

satellite communication (SatCom), stationary base stations or deployable base stations, stationary ad hoc backbone networks etc, or any subset of these networks. Other network technologies will also fit into this scenario.

Partners in the Easy Wireless project:
The partners in EW comes from Spain, Norway, Finland, Belgium and the Netherlands, and range from universities, research institutes, SMEs, to large telecom providers and industrial companies:
Netherlands: Thales Communication Netherlands, TNO, University of Twente, WMC.
Finland: VTT, Plenware, Nethawk.
Norway: Thales Norway, Applica, Baseline Communications, UniK-University Graduate Center
Spain: Telefonica I+D, Moviquity, University of Cantabria, Universidad Carlos III de Madrid.
Belgium: Televic, IBBT

Program for the Easy Wireless workshop

Budapest, July 5, 2007

The program for the EW workshop is divided into 4 sessions: 1) Tools, Methods, and Performance, 2) Service Continuity, 3) Quality of Service (QoS), and 4) Demonstrations. The first 3 sessions will have technical presentations from the research work in the project and invited presentations from related projects. After the workshop, the presentations and the abstracts will be published as the workshop proceedings.

Agenda 09:00 – 16:45
09:00 Introduction to Easy Wireless and the workshop, *Frederik Vermeulen*
09:10 Session 1 – Tools, Methods, and Performance, *Chair: Jarmo Prokkola*
- 09:10 1.1: QoS Provisioning in Mobile Ad-Hoc Networks,
  Hans van den Berg (TNO)
- 09:35 1.2: QoS Measurements Methods and Tools,
  Jarmo Prokkola (VTT)
- 10:00 1.3: Network Performance under Mobility in Ad Hoc Networks,
  Roland de Haan (U of Twente)

10:25 Break
10:40 Session 2 – Service Continuity, *Chair: Carlos García-Rubio*
- 10:40 2.1: Handover with mSCTP,
  Carlos García-Rubio (University Carlos III of Madrid)
- 11:05 2.2: Fast Handoff for Streaming Multimedia in WLAN,
  Bart Jooris (IBBT)
- 11:30 2.3: Cross Layer Routing in Ad Hoc Networks,
  Erlend Larsen (UNIK)
- 11:55 2.4: (Invited paper) Internet on Train – Architecture for Service Continuity,
  Ingrid Moerman (IBBT)

12:15 Lunch
13:15 Session 3 – Quality of Service (QoS), *Chair: Ingrid Moerman*
- 13:15 3.1: A Generic Architecture for End-to-End QoS in Heterogeneous Networks,
  Johnny Choque (University of Cantabria)
- 13:40 3.2: (Invited paper) A Pragmatic QoS Solution in Wireless Mesh Networks: The ADHOCSYS Approach,
  Luca Leschiutta (Politecnico di Torino)
- 14:05 3.3: Multi-Radio Multi-Channel Ad Hoc Networks,
  Jan Stemerdink (WMC)

14:30 Break
14:45 Session 4 – Demonstrations, *Chair: Erling Sandvik*
- 14:45 Introduction to Demonstrations Session,
  Erling Sandvik (Applica)
- 14:50 Storyline and Technical Demonstrations,
  Frederik Vermeulen (Televic)
- 15:45 Open floor for viewing the individual demonstrations,
  All

16:45 Workshop closing

Description of Sessions:

Session 1 – Tools, Methods, and Performance:

This session is dedicated to tools and methods, which relate to QoS and service continuity including performance characteristics. Measurement and monitoring tools related to the EW project play a major part in this session. The main focus is on QoS measurement/monitoring tools, but network measurement tools are included as well. QoS measurement tools measure the network path behaviour from the perspective of a certain application, while network measurement tools focus on the pure network performance. This session includes also tools and methods, which are used for achieving, maintaining, and controlling QoS, etc.

The main purpose of the measurement tools in EW is to monitor the operation of the networks, find bottlenecks, and to verify that how the proposed and developed QoS methods work in reality. The tools can be categorized to passive and active tools. Passive tools measure the existing network traffic, while active tools generate the measured traffic themselves. Further categorization can be made to real-time or non-real-time tools. The EW project has developed advanced tools for both passive and active monitoring of network traffic and associated QoS in different parts of the heterogeneous network, forming a multipoint measurement system. In addition, new innovative traffic control solutions have been developed.

Session Chair: Jarmo Prokkola (VTT)
Session Committee: UNIK – University Graduate Center, University of Twente

Session 2 – Service Continuity:

In this session, seamless service continuity solutions adopted in the EW project are presented. The 3GPP defines seamless service continuity as a handover between two wireless networks without user intervention and with minimal service disruptions (i.e., packet loss, etc.). Seamless service continuity across wireless networks is still an unsolved problem. Standards like UMA (Unlicensed Mobile Access) provide access to typical cellular (GSM/GPRS) services from WLAN/Bluetooth networks, but it does not guarantee the continuity of a previously established service (e.g., a videoconference or a video streaming) while transitioning from one network to the other.

In the EW project we concentrate on multimedia services continuity (video and audio streaming and conferencing) when transitioning between WLANs and GPRS/UMTS, There are several mobility management proposals with pros and cons, and with many open issues. Network layer solutions resulted in a complex architecture and heavy protocol, especially route optimization procedure suffers from a large overhead; moreover, as the registering procedure may take a long time, many packets will be lost. Transport layer solution is mainly targeted for client-server services, in which the client initiates the session with a fixed server; for supporting peer-to-peer services, they must be used along with an additional location management scheme. Application layer solutions are too specific to a certain application. 3.5 layer solutions need to make changes in the operating system kernel which means updating practically all applications that in some form use the Internet; in addition, a change of this magnitude has never before been attempted, and the architecture of the layers has remained the same for decades. However, we must point that approaches used in different layers often complement rather than exclude each other.

In the EW project we propose solutions for this problem in three different scenarios: the home/office, public transportation systems, and ad hoc and mesh networks. We integrate all these solutions in a common architecture, but at the same time fulfil the needs and peculiarities specific for each application area.

Chair: Carlos García-Rubio (University Carlos III of Madrid)
Committee: WMC, University of Twente

Session 3 – Quality of Service (QoS):

In this session, QoS solutions developed in the EW project will be presented. In the EW project, a number of protocols and mechanisms needed for end-to-end QoS provisioning for wireless multi-media communications over heterogeneous networks have been studied. Particular attention is paid to deployment of the QoS mechanisms in mobile ad hoc networks (MANETs). An end-to-end QoS

signalling mechanism has been proposed based on the work going on in the Next Step in Signalling (NSIS) Working Group within IETF. Enhancements/extensions of routing protocols in MANETs (such as cross-layer design, transmit power control, multicast and multi-path routing) haven been developed in order to improve network performance and to support QoS provisioning. IEEE 802.11 MAC layer mechanisms have been investigated, such as the QoS differentiating capabilities of IEEE 802.11E EDCA and the occurrence of performance bottlenecks that may occur in relay nodes due to radio resource sharing.

Chair: Ingrid Moerman (IBBT)
Committee: TNO, University of Cantabria

Session 4 – Demonstrations:

This session contains the different EW demonstrations showing mobility, service continuity and QoS in different scenarios, while monitoring the performance in real-time. The 3 scenarios are: (i) A train scenario, (ii) An emergency ad-hoc networking scenario, and (iii) A digital home and office scenario. The three scenarios will be connected together via a common story line.

(i) The train scenario will demonstrate session continuity and QoS for a passenger with a WLAN terminal: walking in and out of a train and through the train, while the train is connected to the infrastructure via 3G when moving between stations, and via WLAN when the train arrives a station. (ii) The emergency ad-hoc networking scenario will demonstrate QoS and mobility service continuity in the context of emergency ad-hoc networks. The demonstration story will follow a disaster. After discovery of the disaster a small network is formed which is then scaled to a larger network, which then becomes interconnected to the infrastructure. Continuous accurate QoS monitoring is performed during the operation. (iii) The digital home and office scenario will demonstrate seamless service continuity and end-to-end QoS across heterogeneous (WLAN/cellular) wireless networks with continuous real-time QoS monitoring. This can be used both in a home and an office setting.

Chair: Erling Sandvik (Applica)
Committee: NetHawk, Televic, Thales Norway, Thales Netherlands, Telefonica I+D