Wireless Networking & Embedded Systems (WING)

Introduction and Research Projects

Denmark

Aalborg university

Population January 1995
Total: 5,215,718. Men: 2,573,324. Women: 2,642,394. The population is distributed over 2.4 million households.
Aalborg University

Aalborg university was founded in 1974 and now has 12,000 students. Approximately 800 of these are from abroad;

Under the Faculty of Engineering and Science the Electronic Engineering Education has approximately 650 students for the B.Sc. E.E. and M.Sc. E.E. degrees. Yearly turnout of candidates: 100;

Since 1996 AAU has offered engineering programmes conducted in English to obtain the International M.Sc. E.E. degree:

- Mobile Communications;
- Digital Communications;
- Acoustics;
- Multimedia Communication;
- RF Technology

Convergence is the key challenge
### WING: Research Scope

#### Future Vision
- Cooperative Networks
- Cognitive Radio
- Mobile Applications
- Content encoding/Multiple Description Coding
- Header Compression

#### Access Technology
- OFDM systems
- Multiple antenna systems
- Link adaptation
- Transceiver design and optimization

#### IP based Networks
- Resource Management/Discovery & Quality of Service
- Multi-channel MAC protocols
- End-to-end dependability & resilience
- IP Mobility Support & Ad-hoc routing
- Localization and location based network optimisation
- IP-based multimedia subsystems (IMS)
- Enhanced Methodology of Analysis
  - Analytic Models & Simulation Techniques
  - Traffic and Queueing Models

#### Embedded Systems
- Computational models
- Heterogeneous distributed Simulation
- HW/SW Co-design
- Low-power software
- Reconfigurable HW Platforms

#### Security and Sensor Networks
- Adaptive security mechanisms
- Communication protocols for sensor networks

### WING: Current Projects & Activities

#### External Collaborations:
- **Highly DEpendable ip-based NETworks and Services, HIDENETS, (EU STREP), 01/06-12/08**
- **My Adaptive Global NETwork, MAGNET (EU IP), 01/04-05/08**
- **WWI New Radio, WINNER (EU IP), 01/04-12/07**
- **Joint Advanced Development Enabling 4G, JADE (Samsung), 01/04 – 12/06**
- **Enhanced Mobility Support in IMS based networks (Siemens) 03/04-09/06**
- **Wireless Access Networks, Devices & Applications, WANDA (Danish Gov. & local industries), 08/04-08/07**
- **Center for Network and Service Convergence, CNTK (Danish Gov. & local industries), 12/02-10/06**
- **Efficient Broadcast and Multicast in next generation wireless networks (Ericsson Telebit), 10/05-9/08**
- **Center for embedded Software Systems, CISS, (Danish Gov. & local industries), 04/03-04/06**
- **Creating Ubiquitous Intelligent Sensing Environments, CRUISE (EU, NoE), 01/06-12/07**

#### Teaching:
- Courses in Semesters 4-9 (Lines/Specialisations: Data-Engineering, Communication Networks, Mobile Communications, Distributed Real-Time Systems, Network Planning & Management)
- PhD Courses
- External Courses – ELITE, Life-long learning
- Master Projects & Semester Projects

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PACWOMAN

PACWOMAN: Power Aware Communications for Wireless OptiMized personal Area Networks

WING involvement:
- WPAN/CAN architecture + System definition
- Adaptive/QoS aware MAC protocols for different PHY technologies
- Link-layer enhancement (protocol boosters)
- Mobility models
- Evaluation of ad-hoc routing protocols in PAN-like scenarios
- Clustering and cluster-head selection
- Provisioning of end-to-end security

My Personal Adaptive Global Network -- MAGNET

Extension of PAN concept to Personal Networks
- Logical networks, defined by appropriate security associations
- Potential huge geographical/topological span
- Consisting of ad-hoc and infrastructure networks
- User centric definition

WING involvement
- Network aspects (WP2): architecture, service discovery, naming
- Air interface/MAC (WP3): cross-layer optimization
- Security (WP4)
- Platforms (WP5)

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Highly available IP-based networks and services

Started April 2001, in cooperation with Siemens ICM N

- Fault-tolerant Session Control in 3GPP IMS
  - Distributed Redundancy
  - Cluster Approach

Performance Evaluation & Modeling

- Prototype Implementation & Analytic Models

Example: PhD Thesis
Evaluation of Server Selection Policies (Analytic & Simulation)

HIDENETS --
Highly DEpendable ip-based NETworks and Services

Goal:
Develop and analyze end-to-end resilience solutions
- for scalable distributed applications and mobility aware services
- in ubiquitous communication scenarios
  Example use-case: car2car communication with server-based infrastructure
- assuming highly dynamic, unreliable communication infrastructures

Planned results are
- architectural and design solutions, tools for development and analysis
- for end-to-end system level resilience and dependability
  based on standard off-the-shelf components
  in wireless communication networks and infrastructures
Center for Network and Service Convergence (CNTK)

**Duration:** 01/2003 -- 10/2006  
**Partners**  
- Universities/Research Institutes:  
  Aalborg University, Dept. of Comm. Techn. (SMC & WING)  
  Danish Technical University, COM center  
  Danish Technological Institute  
- Industrial Partners:  
  Ericsson Telebit, Sonofon, Nettest  

**Objective**  
- Develop networking concepts, performance models/tools and user-interfaces for provisioning of Quality of Service in future multi-service networks with heterogeneous wired and wireless access  
- taking into account  
  - User perception of quality  
  - future applications and requirements

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Wireless Access Networks, Devices & Applications (WANDA)

**Duration:** 02/2004 -- 10/2007  
**Partners**  
- Universities/Research Institutes:  
  Aalborg University/CTIF (RISC & WING)  
  Danish Technological Institute  
- Industrial Partners:  
  BLIP Systems  
  Texas Instruments  
  RF Micro Devices  
  Siemens ICM MP  

**Objectives (WING part)**  
- Development and Evaluation of methods to obtain device locations  
- Architectures & Protocols for mixed wired/wireless NWs (mixed ad-hoc/infrastructure)  
- Protocol optimization based on location information

**Example:**  
Accuracy of positioning in Bluetooth

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Evaluation Approaches: Experimental System

Recent Student Projects:
- Wireless TCP
- WLAN Performance
- Security Concept
- Vertical Handover performance
- QoS for Gaming Applications

WLAN (802.11)
Wired access (Ethernet)
Cellular access (GPRS)
Bluetooth AP (802.15)
Bluetooth (802.15)
WLAN AP
WLAN AP
WLAN AP
WLAN AP
Switch
Server (e.g. Video application)

Soon to come: W-CDMA

Additional experimental networks
- Service Availability (RSerPool, RTP)
- Bluetooth multi-hop access network (WANDA)
- MAGNET testbed (service discovery, naming)
- Header Compression
- OFDM

Analytic approaches
- Stochastic availability models
- Queueing models with ‘realistic’ traffic models (matrix-analytic approaches)
- Multi-hop MAC performance models (WLAN)
- Wireless TCP models
  [Advanced Simulation techniques, Importance Sampling]

... In close cooperation with Mathematics department at AAU and Arhus University as well as Network Planning Group within CTIF
Teaching: AAU specifics

AAU’s approach: Problem Based Learning
  – Large semester projects (ca. 60% of students’ working hours)
  – Teamwork (4-7 students)
  – Related to specific semester topic (e.g. Network management, dynamic channels etc.)

Project Examples
  – See previous slide (dealing with experimental investigations)

Simulation Projects
  • Radio Resource Management in GPRS Networks (TBF Assignment, Scheduling)
  • Evaluation of ad-hoc routing protocols
  • Buffer management strategies for video streaming
  • Adaptive Header Compression for VoIP over Bluetooth
  • Traffic Modeling for GPRS Networks

... frequently performed in cooperation with industry