1 Research Group on Computer Networks and Distributed Systems

1.1 Personnel

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* with financial support from a third party

1.2 Overview

The research group for Computer Networks and Distributed Systems (Rechnernetze und Verteilte Systeme, RVS) has been active since 1998 in several areas of computer communications and distributed systems.

Multimedia Communications The Internet is increasingly being used for multimedia data transfer (audio, video, data). We are investigating how services with high demands on the quality and reliability of communication systems and networks can be supported. Overlay networks and peer-to-peer systems are becoming more important for new Internet services, in particular to support communication within user groups. We are focusing on the design, development, and evaluation of methods to construct overlay networks supporting the quality-of-service requirements of distributed applications and using network resources efficiently.

Wireless and Mobile Communication Decentralized system architectures and self-organization are fundamental concepts of future wireless and mobile communication systems. These concepts are particularly important in application scenarios such as sensor networks, mobile ad hoc networks and wireless mesh networks. There is an urgent need for research on routing and transport protocols as well as on security and management mechanisms. In sensor networks, limited energy, computing and memory resources as well as limited reliability require special forms of distributed data processing and management.

Security in Distributed Systems The Internet simplifies access to distributed resources and services such as web services, e-learning contents, computer grids or sensor nodes. Traditional techniques for authentication and authorization are not very user-friendly and barely scalable. We investigate, design, implement, and evaluate novel schemes for efficient and secure authentication and authorization.

Distance Learning In all our lectures, we are using distance learning elements that are based on standard components but also on developments resulting from recent research projects. We are developing new methods and tools to support learners and teachers in e-learning environments. In particular, we aim to support practical experiments.

1.3 Research Projects

Middleware design for embedded networked devices

Data gathering, either for event recognition or for monitoring applications is the primary intention for sensor network deployments. In many cases, data is acquired periodically and autonomously, and simply logged onto secondary storage (e.g. flash memory) either for delayed offline analysis or for on demand burst transfer. Moreover, operational data such as connectivity information, node and network state is typically kept as well. Naturally, measurement and/or connectivity logging comes at a cost. Memory space is limited. Finding a good representative model for the data and providing clever coding of information, thus data compression, may be a means to use the available memory space to its best. In this project, we explored the design space for data compression for wireless mesh and sensor networks by profiling common, publicly available algorithms. Several goals such as low overhead in terms of utilized memory and compression time as well as a decent compression ratio have to be well balanced in order to find a simple, yet effective compression scheme. We evaluated different compression algorithms how they may be simply deployed on such nodes without any previous changes to their implementations. We can conclude from our research that there is not the one, outstanding algorithm which suits all desires. Rather, the choice has to be made according to the primary goals of the application and the restrictions posed by the utilized wireless node platform. When optimizing for speed, MiniLZO should be the choice unless resource restrictions regarding RAM memory exist. If a good compression ratio is mandatory, yet execution time and memory restriction may be disregarded, a higher order arithmetic coding algorithm is an appropriate candidate. LZW variants score well in most categories; especially the simple LZW implementation with 12bit symbols offers a solid performance in all categories. The attained values for SLZW, a LZW variant for sensor networks, were disappointing. The reasons for its failure can be accounted to the structure of the data, hindering all proposed optimizations to come to their full potential.

Research staff: Kirsten Dolfus, Torsten Braun

Financial support: Swiss National Foundation Project No. PAERP2-128767 and Swiss Association for Research in Information Technology (SARIT) supporting an ERCIM Fellowship

Efficient and Robust Overlay Networks (ERON)

The goal of the ERON (Efficient and Robust Overlay Networks) project was to develop an efficient and robust peer-to-peer message routing protocol on top of the Internet protocol. Almost all existing peer-to-peer (P2P) protocols build an overlay network using the Internet as the underlying network. Most of such protocols completely disregard the topology of the underlying network when choosing peering neighbours and making routing decisions for messages. This has the consequence that the length of the paths taken by messages through the underlying network is not optimal.

For constructing a topology aware overlay network we developed a novel protocol for building overlay networks - a distributed fisheye view. Similar to round trip time (RTT) prediction approaches, we consider end systems to be embedded in a virtual metric space. Unlike other approaches, we use only the distances (measured RTTs) to build an RTT proximity aware overlay network. Therefore, we are able to construct a fisheye view without performing the embedding. Simultaneously, we are still able to guarantee the geographical diversity of the neighbors. Once built, the fisheye views on the end systems are continuously refined as information about new potential neighbors becomes available. This makes our overlay network adaptive to changes in the network topology. To evaluate our approach, we compared it with an existing topology aware overlay network construction approach - binning. We based this comparison on RTT measurements obtained using the King RTT measurement method and from the Planet Lab all-site-ping experiment. Our evaluation shows that the overlay network built using our approach outperforms binning in terms of relative RTT stretch. We also show that for an increasing number of neighbors the performance of our approach converges towards an optimal solution.

Further, we developed NetICE9, a novel landmark-less method for embedding RTTs into virtual spaces. NetICE9 is inspired by VIVALDI, the most commonly used landmark-less approach. VIVALDI chooses its neighbors randomly and optimizes only towards one neighbor at a time. With NetICE9, we propose a solution to those drawbacks. NetICE9 significantly improves both the stability of the simulation and the precision of how RTTs are embedded into a virtual space. Our evaluation based on RTTs measured in the Internet show that NetICE9 outperforms VIVALDI in terms of stability and precision of RTT prediction. NetICE9 improves RTT prediction also compared to Global Network Positioning (GNP).

We also investigated possible applications of embedding of end systems in a virtual space. Our goal was to introduce an efficient geographic routing protocol in an overlay network. The main issue of every routing protocol is to find a path in the overlay network between source and destination end systems. For the case, when end systems have positions in a Euclidean space, we could use geographic routing protocols such as greedy routing. The problem of greedy routing is that it can fail, if it reaches the so called local minimum of the overlay network. The local minimum is an end system within the overlay network which is surrounded by a non-convex gap. In such a case, greedy routing fails, since it is unable to make progress towards the destination of the message. In mobile ad-hoc networks such situations cannot be avoided, since end systems have limited transmission range and are dealt with by using a backup routing strategy. In an overlay network on top of the fixed Internet, where every pair of end systems can communicate directly, it is possible to avoid such situations. With the nearest neighbour convex set (NNCS), we introduced one such overlay network building strategy. By being able to construct and maintain NNCS on every end system, we obtain an overlay network, in which greedy routing is always successful. Using NNCS and combining it with fisheye overlay, we are able to obtain a very efficient unicast routing protocol within the overlay network. Another use of NNCS is building topology aware multicast trees. Such a tree is constructed by forwarding multicast messages along the reverse of the unicast paths towards the position of the sender. Based on such a multicast flooding scheme, we also defined a service discovery protocol. This service discovery protocol is able to flood all end systems (within the given diameter) with a query message. This flooding mechanism can be used in order to find different services in the vicinity of the querying end system. Such a service can be the nearest copy of a file or the nearest end systems providing computing services such as storage or CPU time. We also used the NNCS overlay network in order to simplify the task of finding QoS paths. Finding a QoS path in an overlay network implies finding at least one path consisting of end systems from the overlay network, where required QoS parameters such as RTT, bandwidth, jitter etc. are fulfilled. In general, finding such paths involves flooding the whole overlay network with messages, which try finding all possible routes. In our approach we reduce the number of peers involved by limiting the flooding to the ellipsoid within the virtual space. This ellipsoid is defined by positions of the source and the destination end systems as well as the required RTT. By doing so, we can significantly reduce the number of messages and load of the overlay network.

Research staff: Dragan Milic, Torsten Braun

Financial support: Swiss National Foundation Project No. 200021-109270/1

Wireless Sensor Network Testbeds (WISEBED)

The *WISEBED* project (http://www.wisebed.eu) started in June 2008. It aims to provide a multi-level infrastructure of interconnected testbeds of large-scale wireless sensor networks for research purposes, pursuing an interdisciplinary approach that integrates the aspects of hardware, software, algorithms, and data. In the *WISEBED* project, researchers are investigating new theoretical approaches on algorithms, mechanisms and protocols. The project's main aim is to make the distributed laboratories available to the European scientific community, so that other research groups can take advantage of a federated testbed infrastructure. Our research group is involved as task leaders in several work packages.
Within WP1 (*Hardware Installation*) we installed a persistent testbed of 20 TelosB and 5 MSB430 sensor nodes, using a wired backbone of mesh nodes for code distribution and retrieval of debug/trace data. The sensor/mesh network spans over 5 floors of the building Neubrückstrasse 10 in Bern. The TelosB and MSB430 sensor nodes are attached via USB cables to the mesh nodes, which also form the power supply. Using this reliable backbone infrastructure, all nodes can be reset, rebooted and reprogrammed remotely within a short time.
Within WP2 (*Testbed operation, access, and management*) we have designed and implemented the *Testbed Management Architecture for Wireless Sensor Networks (TARWIS)*, a generic experiment and testbed management system for wireless sensor network testbeds. TARWIS has been integrated into the testbed federation and is to-date already the management system of various testbeds of the WISEBED project partners, as e.g. University of Lancaster and Technical University of Delft. Three major releases of the software have been published between July 2009 and July 2010, each with additional functionality. The current version is TARWIS 3.0. TARWIS consists of a server and GUI component. The TARWIS server prepares and controls the experiment execution steps and connects to the individual sensor nodes. The system is independent of the type and the operating system of the sensor nodes, but relies on a set of APIs to access the sensor nodes and obtain experiment data.
Real-world environmental data is of major importance when it comes to real-world evaluation of protocol mechanisms. With yet no existing standard for real-world experimental data, the WISEBED project has devel-

oped the WiseML language, a XML-based XSD Schema that offers a uniform description of experiment trace data. Within WP4, we have been integrating WiseML into the TARWIS system. Every experiment data is described in WiseML and can be downloaded from the web-based GUI interface.
Within WP3, we have implementated the OLSR routing protocol and the Diffie-Hellman Key-Exchange algorithm for the Shawn simulator. We are working on implementations of DYMO routing and Eschenauer-Gligor key management algorithms.

Research staff: Philipp Hurni, Markus Anwander, Gerald Wagenknecht, Zhongliang Zhao, Christoph Knecht, Thomas Staub, Torsten Braun

Financial support: EU project ICT-2008-224460

Traffic Adaptivity in Wireless Sensor Networks (TRAWSN)

Energy efficiency is a major concern in the design of Wireless Sensor Networks (WSNs) and their communication protocols. As the radio transceiver typically accounts for a major portion of a WSN node's power consumption, researchers have proposed Energy-Efficient Medium Access (E^2-MAC) protocols that switch the radio transceiver off for a major part of the time. Today's E^2-MAC protocols are able to deliver little amounts of data with a low energy footprint, but introduce severe restrictions with respect to throughput and latency. Regrettably, they yet fail to adapt to varying traffic loads and changing requirements of the imposed traffic load.
Strong restrictions with respect to throughput and latency may be tolerable in networks with low quality of service requirements. However, many event-based scenarios require reasonable quality of service during short periods of intense activity, and a high energy-efficiency and lower quality of service during long periods of inactivity. Such scenarios can be found, e.g., in monitoring systems for the healthcare system, in disaster-aid-systems, but also in the broad area of environmental monitoring. Once an event has been triggered, e.g., a patient's pulse monitor registering anomalies in a hospital or geriatric clinic, the MAC protocol's primary objective should shift towards delivering good quality of service (high throughput, low delay) rather than saving energy. In such scenarios, today's existing E^2-MAC protocols do not provide reasonable flexibility, as most of them were designed under the assumption of very sparse low-rate traffic.
We intend to bridge this gap with the TRAWSN project, which started in

October 2009. Within TRAWSN, we have developed MaxMAC, an energy-efficient MAC protocol for sensor networks designed for WSN scenarios with varying traffic conditions. While MaxMAC operates similarly as existing E^2-MAC protocols in low traffic situations, it is able to maximally adapt to changes in the network traffic load at run-time. Taking advantage of design principles for E^2-MAC protocols developed over the last couple of years, the protocol introduces novel run-time adaptation techniques to effectively allocate the costly radio transceiver truly in an *on demand* manner. The protocol reaches the throughput and latency of energy-unconstrained CSMA in situations of high-traffic, yet exhibiting a high energy-efficiency in periods of sparse traffic.
We have published novel simulation-based results of the MaxMAC protocol in Europe's most selective conference on WSNs in spring 2010, and have since then been working on a real-world prototype implementation of MaxMAC.

Research staff: Philipp Hurni, Torsten Braun

Financial support: Swiss National Foundation Project No. 200021-126718/1

Wireless Mesh Networks for Interconnection of Remote Sites to Fixed Broadband Networks

This technology transfer project aimed to evaluate the usefulness and feasibility of wireless mesh networks (WMNs) in meteorological and environmental monitoring applications. We identified application and usage scenarios for WMNs and investigated whether and how the used hardware and software components are appropriate for the intended application scenarios and whether the application requirements such as bandwidth, delay, reliability, recovery times etc. can be met. Potential weaknesses and bottlenecks have to be identified.
The project was carried out with three industry/application partners with different interests in the project. MeteoSwiss, the operator of the meteorological network of Switzerland, has approximately 130 weather stations with environmental sensing equipment deployed all over Switzerland. WMNs are a possibility to interconnect weather stations or even some sensors with an own broadband network. WMNs would allow SWITCH, the provider of the Swiss national research and education network, to extend the geographic coverage of their fiber network and to offer broad-

band services to remote locations that are not close to the fiber network. PCEngines provided us with their mesh nodes and expect to extend their business with the achieved results.

We investigated whether wireless mesh networks (WMNs) are appropriate for connecting sensor networks or other devices deployed in remote areas, where no fixed network access is available, to a fixed broadband network. To support a variety of application scenarios, the WMN must meet reliability requirements and high bandwidth over distances of several 10 km, e.g., by using directional radio transmission.

During the project we deployed a WMN based on IEEE 802.11a/h (5 GHz) in the area of Neuchâtel and Payerne. A weather station at Payerne has been connected to the fibre backbone with an access point at Neuchâtel. A camera sensor has been made accessible over a wireless mesh access network to the Internet by two redundant paths in order to provide robustness and reliability. The network consisted of six nodes, of which the four intermediate nodes were solar-powered. One end point of the wireless mesh access network was mounted on the roof of the University of Neuchâtel. It acted as gateway to the fibre backbone. The other end point was mounted on the roof of SwissMeteo at Payerne and operated as gateway to the sensor network with an IP capable camera and another mesh node. Intermediate nodes equipped with solar equipment (panels, chargers, and batteries) were placed on the hills in the area to interconnect Payerne with the fiber network in Neuchâtel.

Our evaluations showed that our setup can provide a network service for transmitting weather data. The network stability can be further improved, e.g. by replacing or extending the used routing daemon to avoid route fluctuations, replacing the MadWiFi wireless driver with its successor driver, and additional self-healing mechanisms.

With the experiences gained from the deployment, we are now able to easily dimension further outdoor wireless mesh networks (approved equipment, possible distances, planning and setup time).

Research staff: Thomas Staub, Markus Anwander, Marc Brogle, Paul Kim Goode, Kirsten Dolfus, Torsten Braun

Financial support: Swiss Commission for Technology and Innovation under grant number 9795.1 PFES-ES and the industry partners (SwissMeteo, SWITCH, and PCEngines)

Wireless Mesh Networks

Besides the technology transfer project, there are further activities in the area of WMNs such as extensions of the framework for administration and deployment of WMNs (ADAM), finalization of a WMN virtualization framework (VirtualMesh), an '"easy-to-install" temporary network for video communication (OViS), and using wireless mesh technology for unmanned aerial vehicles.

Administration and Deployment of Adhoc Mesh networks (ADAM) provides mechansims for fault-tolerant and safe deployment and configuration of WMNs as well as a build system for cross-compilation of tailored embedded Linux distribution with a very small footprint for the mesh nodes. ADAM has been extended to support OpenMesh Mini nodes. We updated the software with newer Linux kernels and the new wireless driver architecture. In addition, we collaborated with the VTT Technical Research Centre of Finland to integrate their passive QoS measurement tool QoSMeT into ADAM.

VirtualMesh is an emulation framework for WMNs and provides new testing facilities during the development of architectures and protocols for WMNs. It virtualizes a complete wireless mesh network by using host virtualization (XEN) for the mesh nodes and redirecting their wireless network traffic to a network simulator. Traffic interception and handling within the simulator is transparent for upper layers. Therefore, the final application software can be tested in various scenarios with the help of the simulation model. Our latest modifications of VirtualMesh include the support for multi-channel communication.

On-site Video System (OViS) reduces the number of costly visits of engineers on construction sites by providing an easily deployable temporary video communication infrastructure. At the time of electrical installations, electrians may face unknown problems or plan deviations, which require consultations with a remote engineer. Unfortunately, in-building communication networks, as well as electrical installations, are set up very lately in the building construction process. In addition, communication over cellular mobile networks is often not possible inside buildings, especially in basements. To support telepresence of the engineer, a temporary communication network has to be deployed. Our approach is to use a WMN. We developed a first prototype of OViS, which provides an '"easy-to-install"' temporary communication network. The user is guided through the deployment process and the network is automatically configured by OViS. We are currently enhancing this system to support multi-channel communication.

Finally, we started the development of an airborne communication network. A WMN is automatically deployed using *unmanned aerial vehicules (UAVs)*. They provide communication facilities in case of natural disasters such as floodings or earthquakes. The UAVs with the wireless mesh nodes position themselves automatically to enable communication between two distant communication peer (airborne relay) or to cover a defined area (airborne mesh). For our prototype network, we connected small wireless mesh nodes to quadrocopters by a serial interface and implemented an API to steer and coordinate the UAVs over the IEEE 802.11g-based WMN. Our research focus is on automatic deployment, replacement and routing. The prototype will be further used in the ORMAN project.

Research staff: Thomas Staub, Paul Kim Goode, Reto Gantenbein, Stefan Ott, Simon Morgenthaler, Markus Anwander, Torsten Braun

Opportunistic Routing for highly Mobile Ad-hoc Networks (ORMAN)

The ORMAN project started in April 2010 and aims to investigate, develop and evaluate novel routing and forwarding schemes based on opportunistic routing schemes. Existing mobile ad-hoc networks protocols are not appropriate for the highly mobile node application scenario such as unmanned aerial vehicles (UAVs) ad hoc networks, because a packet source is unable to calculate a complete route to the destination. Opportunistic routing protocols do not calculate an end-to-end communication path, forwarding choice is performed on a hop-by-hop basis. Therefore, an opportunistic routing scheme seems to be a possible solution for the highly mobile application scenario. We aim to develop a geographic opportunistic routing protocol exploiting the multi-channel capabilities to reduce interference and maximize throughput. In order to maintain a basic connectivity required to apply the routing protocol, we aim to develop an appropriate topology control protocol that not only achieves connectivity but also minimizes interference. Besides the simulation work, real implementations using unmanned aerial vehicles and interconnected test-beds has to be performed in order to prove feasibility of the developed concepts.
In the past months, we mainly worked on the implementation of multi-channel support for the latest Linux kernel version, since the mesh node we are using is loaded with the latest Linux OS kernel version and currently the only available multi-channel support is for older kernels. In the

next couple of months, we plan to develop and evaluate the topology control protocol and the multi-channel opportunistic routing protocol in the network simulator OMNET++. The purpose of the simulation is to provide a proof-of-concept and to investigate scalability issues. Before we use the routing protocol in a real UAV test-bed, we plan to do the emulation first, with the purpose of testing the real implementation in a safe environment. Simulation and emulation are used for evaluating scalability in larger scenarios, while the real test-bed can be used for proof-of-concept evaluation and investigating forwarding via a smaller set of nodes.

Research staff: Zhongliang Zhao, Torsten Braun

Financial support: Swiss National Foundation Project No. 200021-130211/1

Testbed for Mobile and Internet Communications

Our research group maintains its own comprehensive and heterogeneous testbed network for various purposes. The testbed is used to build networks of experimental routers and end systems in order to be able to evaluate the behavior of new networking protocols and architectures in realistic environments. The testbed also forms a productive network of Linux PCs and provides the storage capacity and CPU power for many of our research group's projects. The ERON project for example used the available CPU power to compute embeddings of network distances into Euclidean space. An educational laboratory network for students' training is also connected and has been extended by the OSLab project. Our research group also takes part in PlanetLab (http://planet-lab.org) and GpENI (https://wiki.ittc.ku.edu/gpeni/). PlanetLab is an open platform for developing, deploying, and accessing planetary-scale services. For this purpose we are hosting three PlanetLab nodes in our testbed network. GpENI is a distributed set of sites, interconnected at layer 2 (or layer 2 tunnels) to enable experimentation at layers 3 and higher. For this purpose we are hosting three GpENI nodes, two GpENI routers and one GpENI controller node in our testbed network. We have installed several Cisco routers terminating several L2TP connections in order to provide a major European GpENI concentrator point (https://wiki.ittc.ku.edu/gpeni/Image:GpENI-Euro-topo.png). Our research group owns a number of sensor nodes: Embedded Sensor Board (ESB), Modular Sensor Board (MSB), tmote SKY nodes, BTnodes, TelosB nodes, and micaZ nodes. A testbed consisting of multiple mesh nodes (17 x PCEngines WRAP, 10 x Meraki Mini, 6 x PCEngines ALIX) has been deployed throughout the building and work environment of the research group. In this testbed, multi-channel communication, multi-path routing and the management framework ADAM have been evaluated. The testbed is currently used by several student projects.

Research staff: All members of the RVS research group

1.4 Ph.D. Theses

- Marc Brogle: IP Multicast using Quality of Service enabled Overlay Networks, May, 2010
- Dragan Milic: Error Resilient and Robust Overlay Networks, May, 2010

1.5 Master and Diploma Theses

- Luca Bettosini: Quality of Service for Overlay Multicast Content Addressable Network (CAN), August, 2009
- Peter Siska: A Framework for the Evaluation of Flow-Based Traffic Monitoring Systems, March, 2010
- Dominic Papritz: MCFTP (Multicast File Transfer Protocol): Simulation and Comparison with BitTorrent, May, 2010
- Reto Gantenbein: VirtualMesh: An Emulation Framework for Wireless Mesh Networks in OMNeT++, June, 2010

1.6 Bachelor Theses and Computer Science Projects

- Sebastian Barthlomé: OM-QOS: Quality of Service for Overlay Multicast applied to the NICE Protocol, August, 2009
- Roger Strähl: Benutzung Statistischer Eigenschaften von RTT-Messungen zur Eingliederung von Netzwerken in Virtuelle Räume, September, 2009

- Ulrich Bürgi: REPOM: Reputation Based Overlay Multicast, December, 2009
- Simon Morgenthaler: Management Extensions for Wireless Mesh and Wireless Sensor Networks, March, 2010
- Christine Müller: Implementation of a Multichannel Multiradio Prototype on Embedded Linux, May, 2010
- Cyrill Schluep: Porting Contiki to the BTnode Sensor Node Platform, June, 2010

1.7 Further Activities

Memberships

- Chair of ERCIM working group on eMobility (Torsten Braun)
- Secretary General of ERCIM working group on eMobility (Marc Brogle)
- Erweitertes Leitungsgremium Fachgruppe "Kommunikation und Verteilte Systeme", Gesellschaft für Informatik (Torsten Braun)
- Integration Coordination Board and Steering Committee of EU IST project Wisebed (Torsten Braun)
- SWITCH Stiftungsrat (Torsten Braun)
- SWITCH Stiftungsratsausschuss (Torsten Braun)
- SWITCH AAI Advisory Committee (Thomas Staub)
- Kuratorium Fritz-Kutter-Fonds (Torsten Braun)
- Expert for Diploma Exams at Fachhochschule Bern (Torsten Braun)
- Management committee member of the COST Action IC 0804 Energy-Efficiency In Large Scale Distributed Systems (Torsten Braun)
- Management committee member of the COST Action IC 0906 Wireless Networking for Moving Objects (WiNeMO) (Torsten Braun)

Editorial Boards

Torsten Braun

- Editorial Board of Elsevier's Computer Communications Journal
- Editorial Board of Elsevier's Computer Networks Journal
- Editorial Board of Informatik Spektrum, Springer-Verlag
- Editorial Board of Journal of Internet Engineering (Editor in Chief)

Conference Chairs

- TPC Chair of 1st International Conference on Energy-Efficient Computing and Networking, April 13-15, 2010, Universität Passau, Germany (Torsten Braun)
- General Chair of 4th ERCIM Workshop on eMobility, May 31, 2010, Lulea University of Technology, Lulea, Sweden (Torsten Braun)

Conference Program Committees

Torsten Braun

- 35th EUROMICRO Conference on Software Engineering and Advanced Applications (SEAA), Patras, Greece, August 27-29, 2009
- 9th International Conference on Next Generation Wired/Wireless Networking NEW2AN 2009, St. Petersburg, Russia, September 15-18, 2009.
- 12th Asia-Pacific Network Operations and Management Symposium, APNOMS 2009, Jeju Island, South Korea, September 23, 2009
- 3rd IEEE International Workshop on Enabling Technologies and Standards for Wireless Mesh Networking, MeshTech'09, Macau SAR, P.R. China, October 12, 2009
- International Conference on Ultra Modern Telecommunications, St. Petersburg, Russia, October 12-14, 2009
- 34th IEEE Conference on Local Computer Networks (LCN), Zürich, October 20-23, 2009

- 4th Fachgespräch Future Internet, GI/ITG-Fachgruppe ”Kommunikation und Verteilte Systeme” (KuVS), Zürich , November 9-10, 2009
- 1st International Conference on Multimedia Information NEtworking and Security, MINES 2009, Wuhan, China, November 18-20, 2009
- 5th IEEE Broadband Wireless Access Workshop, co-located with IEEE GLOBECOM 2009, Honolulu, Hawai, USA, November 30, 2009
- IEEE Global Communications Conference 2010 (IEEE GLOBECOM 2010), Honoulu, USA, November 30 - December 4, 2009
- 5th ACM International Conference on emerging Networking EXperiments and Technologies, ACM CoNEXT 2009, Rome, Italy, December 1-4, 2009
- 7th European Conference on Wireless Sensor Networks, EWSN 2010, Coimbra, Portugal, February 17-19, 2010
- 3rd International Workshop on OMNeT++, Torremolinos, Malaga. Spain, March 19, 2010
- IEEE Wireless Communications & Networking Conference (WCNC), Sydney, Australia, April 18-21, 2010
- 3rd IFIP/IEEE International Workshop on Bandwidth on Demand and Federation Economics (BoD 2010), Osaka, Japan, April 23, 2010
- 9th IFIP International Conferences on Networking, Madras, Chennai, India, May 10-14, 2010
- IEEE International Communications Conference (ICC 2010), Cape Town, South Africa, May 23-27, 2010
- 12th IFIP/IEEE International Symposium on Integrated Network Management, Dublin, Ireland, May 23-27, 2010
- 8th International Conference on Wired/Wireless Internet Communications (WWIC), Lulea, Sweden, June 1-3, 2010
- 5th Fachgespräch Future Internet, GI/ITG-Fachgruppe ”Kommunikation und Verteilte Systeme” (KuVS), Stuttgart, June 9, 2010
- 18th IEEE International Workshop on Quality of Service (IWQoS 2010), Tsinghua University, Beijing, China, June 16-18, 2010

- 4th International Conference on Autonomous Infrastructure, Management and Security (AIMS 2010), Zürich, Switzerland, June 21-25, 2010
- 3rd International Workshop on Sensor Networks (SN 2010), in conjunction with IEEE ICDCS 2010, Genoa, Italy, June 21-25, 2010
- 2nd International Workshop on Communication Technologies for Vehicles (Nets4Cars 2010), Northumbria University, Newcastle, UK, July 21-23, 2010
- 3rd Workshop on Economic Traffic Management (ETM), Amsterdam, The Netherlands, September 6, 2010

Ph.D. Jury Memberships

Torsten Braun

- Ph.D. Thesis, Thomas Bocek, Universiät Zürich
- Ph.D. Thesis, Carolin Latze, Universität Freiburg
- Ph.D. Thesis, Steffen Ortmann, Brandenburgische Technische Universität Cottbus, Germany

Reviewing Activities

Torsten Braun

- The Croucher Foundation
- European Commission Framework Programme 7
- Hasler Foundation
- Belgian agency for Innovation by Science and Technology
- Research Council of Norway
- Swiss National Science Foundation
- Qatar National Research Fund
- Indian Institute of Technology Madras

- Universita di Pisa
- ACM Transactions on Multimedia Computing Communications
- IEEE Network Magazine
- IEEE Journal on Selected Areas in Communications
- IEEE Transactions on Aerospace and Electronic Systems
- IEEE Transactions on Mobile Computing
- IEEE Transactions on Network and Service Management
- IEEE Transactions on Parallel and Distributed Systems
- IEEE Transactions on Vehicular Technology
- VLSI Journal, Elsevier
- Journal of Network and Computer Applications, Elsevier
- Adhoc Networks, Elsevier
- Telecommunication Systems Journal
- International Journal of Network Management, Wiley

Invited Talks and Tutorials

- Torsten Braun: Interconnecting Sensors via Wireless Mesh Networks to the Internet, 25th Nordunet Conference, Copenhagen, Denmark, September 16, 2010
- Torsten Braun, Philipp Hurni: A Testbed Management Architecture for Wireless Sensor Networks (TARWIS), University of Karlsruhe, Germany, October 5, 2009
- Torsten Braun: Energie-effiziente und adaptive Medienzugriffsprotokolle für drahtlose Sensornetze, Kolloquium Telekommunikationsnetze, TU München, Germany, November 2, 2009
- Torsten Braun: Vom ARPANET zum Internet of Things, Computer Science in Education, PH Bern, November 16, 2009

- Thomas Staub: Telematiknetze, Kaderkurs Telematik, Bundesamt für Bevölkerungsschutz, Schwarzenburg, Switzerland, November 24, 2009
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