3   Research Group on Communication and Distributed Systems

3.1   Personnel

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* with financial support from a third party

3.2   Overview

The research group "Communication and Distributed Systems" has been investigating how multimedia applications and cloud computing services with high demands on the quality, reliability and energy efficiency can be supported by mobile communication systems and networks. Moreover, we are investigating localization mechanisms for wireless devices and new Future Internet paradigms such as Information-Centric Networking.

3.3   Research Projects

Mobile Cloud Networking

Mobile Cloud Networking (MCN) is a EU FP7 large-scale Integrating Project (IP) funded by the European Commission, and launched in November 2012 for a period of 36 months. In total 19 partners from industry and academia perform research on MCN.

The project is primarily motivated by an ongoing transformation that drives the convergence between the mobile communication and cloud computing industry, enabled by the Internet. These observations led to a number of objectives to be investigated, implemented and evaluated over the course of the project. The top-most objectives of the MCN project are to: a) extend the concept of cloud computing beyond data centres towards the mobile end-user, b) to design an 3GPP-compliant Mobile Cloud Networking architecture that exploits and supports cloud computing, c) to enable a novel business actor, the MCN provider, and d) to deliver and exploit the concept of an end-to-end MCN for novel applications and services. The key research and innovation issues that the MCN project is expected to tackle are the following: a) how to virtualise the Radio Access Networks (RAN), b) how to design a cross-domain Infrastructure-as-a-Service (IaaS) control plane, c) how to upgrade virtualisation and cloud computing middleware to support highly demanding, real-time network applications and services, d) how to design, deploy and operate mobile communication software components to attain and fully benefit from cloud computing attributes, e) how to ensure QoE with advanced content and service migration mechanisms for mobile cloud users and f) how to support multiple cross-domain aspects that must service a multitude of business actors and stakeholders.

The CDS group is involved in the following technical work packages (WP): WP3 on Mobile Cloud Infrastructural Foundations, WP4 on Mobile Network Cloud, and WP5 on Mobile Platform. Besides, the CDS group is leading

WP7 on Dissemination, Exploitation, Standardisation activities.

The scope of work within WP3 of the project is to offer a comprehensive testing framework for the LTE radio access network (RAN). In particular, the framework should allow the virtualisation of base stations (running a base station in the cloud) and the development of novel algorithms for the RAN such as load balancing which can exploit the advantages of virtualisation in order to improve mobility management and service delivery. In its current phase the task has delivered initial evaluations on the computational needs of LTE base stations and how running the network functions in the cloud can influence the execution time. Moreover, for the management of a virtualised RAN, an architectural model was designed, consisting of entities for communication with the end users as well as orchestration of the virtual, computational and networking resources. Implementation work on the architecture was initiated and testing is currently being done. In order to align with the general MCN architecture we were actively involved in activities within WP2.

The scope of WP4 is to develop a novel Mobile Core Cloud concept in support of the on-demand and dynamic deployment of mobile core networks in a cloud computing environment. In the second project year, the research activities of WP4 mainly cover two areas: shared memory and storage distribution; Mobility and Bandwidth as a service (MOBaaS).

In the context of MCN, where the goal is pushing most of the operator's network components into the cloud, a critical issue is the placement of the virtual components and the physical storage, taking into consideration user mobility. Moving virtualised network components close to the user reduces communication delays, thus improving the quality perceived by the user. Furthermore, it reduces the communication overhead on the network. Keeping the mobility information in a single centralized location (e.g. Mobility Management Entity) far from the user and the corresponding network components reduces the overall efficiency. On the other hand, splitting the storage into many locations close to the users raises data consistency issues. To solve this problem we rely on using shared memories for "local" communications, and on distributed shared storage (e.g. Ceph) for remote virtual instances. Ceph promises good robustness and consistency properties, relying on duplications of storage in random locations, and on direct communications between "peers". However, the random distribution of storage is to be made deterministic, depending on the user location. Controlling Ceph's storage in order to increase the overall network efficiency and user satisfaction is an issue we are currently investigating.

Mobility and Bandwidth as a service (MOBaaS) is a MCN service that generates prediction information to be used by any MCN defined services

in order to generate triggers needed for self-adaptation procedures, e.g., optimal run-time configuration, scale-out and scale-in of service instance components, or optimal network function placement. MOBaaS is defined to predict information regarding: (1) the movement of individual end-users (estimated location of an individual end-user in a future moment in time); (2) the traffic that these individual end-users will be generating at a certain location in a future moment in time; (3) bandwidth available in a certain location in a future moment in time. In order to make some predictions, MOBaaS needs certain inputs to learn the behaviors of end-users. Monitoring as a service (MaaS) will provide, in a periodic way, this information to MOBaaS, such that MOBaaS does not need to communicate with different MCN services. All the end-user relevant services will provide necessary information to MaaS, which will be aggregated and forwarded to MOBaaS. Since MOBaas is a supporting MCN service, it does not need a specific service manager (SM), instead a specific service orchestrator (SO) will be needed to initialize the virtual machine (VM) with a running prediction algorithm. In order to work in parallel with other MCN supporting services, such as MaaS, certain types of user data have to be used as inputs to the prediction algorithms. To achieve this, mobility trace data will be a used.

A key contribution of WP5 is to design and implement the follow-me cloud concept, which aims to provide cloud services and data to the mobile user as close as possible to minimize delays and improve performance. After the architecture design being successfully specified in the first year of the project, implementation of the first prototype has started. Significant contributions were made to the cloud orchestration framework, the Follow-Me Cloud concept development and the Information-Centric Networking integration into legacy and cloudified mobile networks. Such work has proven to be key in minimizing content access time and network load, while not creating relevant extra load on the cloud computing infrastructure. The work also contributed to other work packages in the project, namely to the performance evaluation carried out within Task "Real-time Performance of Infrastructure Resource Management Frameworks" and to end-to-end evaluations performed in Task "Experimentation and Evaluation".

As the project entered its second year, work on WP6 Integration has also started. In particular, definition of all interfaces and the interdependence of MCN services on each other is established. To allow for smooth integration and demonstration, common functional tests are defined, based on which performance evaluation and troubleshooting can be done.

Research staff: Andre Gomes, Zhongliang Zhao, Islam Alyafawi, Zan Li, Denis Lima do Rosario, Desislava Dimitrova, Imad Aad, Torsten Braun,

Almerima Jamakovic-Kapic

Swiss Academic Compute Cloud

The Swiss Academic Compute Cloud project (SwissACC) sustains the cloud-related activities of the AAA/SWITCH-e-Infrastructure for e-Science program and bridges the activities that are expected to become relevant for the upcoming SUK-Program 2013-2016 Wissenschaftliche Information: Zugang, Verarbeitung und Speicherung. The A^4-Mesh contribution to the SwissACC project includes a feasibility study on the A^4-Mesh integration into the Swiss Academic Compute Cloud to become a platform for storage and processing of the collected sensor data. Besides this main goal, the A^4-Mesh contribution implemented a solution provided by the feasibility study for a) storing experimentation data on a distributed computing and/or data storage infrastructure, such as Grid and/or Cloud and b) using SwissACC as a processing platform for the collected sensor data to be fed into the hydrology modelling and simulation system to make the environmental research process more efficient.

Research staff: Almerima Jamakovic-Kapic, Teodor Macicas, Torsten Braun

Integral Indoor 3D Guidance and Access-Control System

The central idea of the project in technical terms is to develop a software defined radio (SDR) system that is able to intercept GSM traffic from both base stations and mobile devices, independently of a subscriber, in order to enable localisation algorithms based on the time difference of arrival (TDOA). The main challenge in this aspect is to capture transmissions on the uplink (from mobile devices) and to be able to identify and localise the devices: Most, if not all software, available today deals with active participation of the phone in the communication to process the GSM signal and network operators take special measures to protect the identity of their users, which aggravates the problem.

In the first year of the project the focus was on gathering all specifications necessary for the development of the GSM sensor as well as dealing with device synchronisation (needed for time localisation) and GSM signal capturing (first done for the downlink). In the final, second year of the project we extended the first version of the GSM sensor from the first year to intercept also uplink GSM signals. The sensor was used to test the capturing of uplink GSM messages for localisation. Our experimentation showed that, in line with GSM standards, there are only few signalling procedures that carry uplink messages with unprotected user identity, i.e., messages that can be used by a passive system to position the device. During the testing process we also came across other interesting research challenges such as impact of user diversity and power distributions. In order to overcome these challenges we carefully determined evaluation scenarios that will allow us to test the accuracy of the system in terms of localisation error. Both, positioning algorithms using signal strength and propagation time were developed and evaluated. As main achievements of the project we identify: (i) a novel algorithm that allows highly precise evaluation of the time synchronisation between two devices, which was applied for GPS as an example; (ii) evaluation of the feasibility of GSM time localisation outdoors (successful) and indoors (challenging); (iii) the development of new positioning approach, namely, positioning through time-fingerprinting; and (iv) adapting proximity algorithms for power-based localisation that deliver few meters accuracy indoors.

We are using the USRP N110 and E110 equipment from Ettus Research as SDR platform. An embedded Linux system built with the Administration and Deployment Adhoc Mesh (ADAM) framework, developed at the University of Bern, has been ported to the N210 devices. On top of that the GNUradio software package was integrated and several other modules, borrowed from the Airprobe project, were incorporated into it for processing and interpretation of the GSM signals. The current version of the system is able to capture GSM signals on both uplink and downlink, attach high accuracy timestamps and interpret the messages, allowing us to derive valuable positioning information.

Enhanced Mobile Communication with Content-Centric Networks

Opportunistic networking defines communication in challenged networks, where connectivity and contact durations between devices are unpredictable and intermittent. Content-centric communication can support opportunistic networking. In this project, we focus our work on Content-Centric Networking (CCN) using IEEE 802.11 wireless networks. The main topics of this project are divided into three areas: memory management, energy efficient operation and content discovery/delivery.

We have implemented a communication scheme based on broadcast and unicast communication. Since connectivity between devices is unknown in opportunistic networks, discovery can only be performed via broadcast. If an answer is received, the content source can be addressed directly via unicast. Forwarding strategies switch back to broadcast if content sources disappear and are not reachable anymore via unicast. Evaluations have shown that adaptive unicast transmissions can significantly reduce the number of transmitted duplicates and decrease the required time for content retrieval. If multiple concurrent unicast flows are identified, a content source can switch back to broadcast.

To discover namespaces, we combined Regular Interest Discovery (RID) and Enumeration Request Discovery (ERD) discovery to increase discovery efficiency exploiting the advantages of both approaches. Content names in a content object cannot be changed without resigning the content. To support flexible location-based discovery, we have also designed and implemented an alias mapping approach that locally maps temporary names to unique static names. After an alias discovery, content retrieval is performed using the unique content name enabling the identification of identical content for duplicate suppression and caching.

If a requester never meets a suitable content source, Interests need to be forwarded. We investigated multi-hop forwarding based on overhearing and improved multi-hop forwarding by limiting Interest forwarding. We have also implemented algorithms to dynamically adapt Interest lifetimes based on current round trip times between requesters and content source. This enables faster retransmissions in case of collisions resulting in higher throughput. If connectivity to other nodes is intermittent, multi-hop forwarding does not work because CCN requires symmetric content retrieval, i.e., content is returned on the same path back to the requesters. Therefore, we implemented and evaluated agent-based content retrieval on Android smart phones and in hybrid emulation environments. Evaluations have shown that it is advantageous even in case of continuous connectivity but

different link capacities.

Caching can be extended to persistent storage on repositories. To avoid memory depletion, old content needs to be deleted. We designed and implemented an automatic storage replacement strategy for CCN repositories based on content popularity and age.

Research staff: Carlos Anastasiades, Tobias Schmid, Jürg Weber, Alexander Striffeler, Wafaa El Maudni El Alami, Arun Sittampalam, Lukas Diener, Rene Gadow, Lukas von Rotz, Nina Mujkanovic, Torsten Braun

Network Coding Based Multimedia Streaming in Content Centric Networks

Information Centric Networking architectures (ICN) have recently gained significant attention in the research community, as they promise to revolutionize the way data is exchanged in the Internet. They move from the traditional paradigm of Internet communication using IP addresses towards using names as addresses. This is motivated by the fact that when users browse the Internet, they care only about the data content and not where the content is stored. On the contrary, the IP model of communication focuses on where the data is located. Several problems are associated with the current IP network architecture like usability, performance, security and resilience to mobility. To cope with some of these limitations, content distribution networks (CDN) and peer-to-peer architectures have been proposed. These methods mainly deal with the scalability issue and attempt to exploit better the available network resources. CDN and P2P could be seen as a first step towards ICN. Network coding has been presented a decade ago as an efficient technique for heterogeneous both wired and wireless overlay networks to increase the throughput, decrease the delay, enhance resilience, remove the need for coordination between the network nodes etc. There are two major classes of network coding algorithms namely Linear Network Coding (LNC) and Random Linear Network Coding (RLNC). Both methods operate in finite fields. LNC decides about the coding operations centrally, although there are some decentralized designs, whereas RLNC randomly performs operations in finite fields and has only a small performance penalty compared to LNC when operations are in large finite fields. Network coding is interesting for multimedia

communication. The challenge with multimedia is that data is often scalable and data delivery should respect the tight decoding deadlines.

In this project, we envisage the design of novel network coding methods that will promote the use of ICN. We will build our techniques on the Content Centric Networking (CCNx) implementation, since it has many advantages like hierarchical prefixes and being open source. Some abstract ideas regarding the use of network coding in CCN have been very recently discussed. It mainly provides some examples motivating the appropriateness of network coding for the ICN framework, rather than specific solutions. In our perspective, specific problems should be resolved prior to employing such technologies. Specifically, open challenges are: what kind of prefixes should be used, security issues, where to cache information, how one can deal with multiple concurrent sessions accessing the network, could data correlation be exploited? The target of our project is twofold: (a) design network coding techniques that will improve the perceived quality of services and (b) propose an architecture for CCN appropriate for network coding enabled systems. We will focus on multimedia streaming applications, as it is the main source of data traffic in today's Internet. We will further target on the employment of our methods in social networks deployed when users want to share multimedia data. We believe that the ICN paradigm fits well into the framework of multimedia communication over social networks as users can take advantage of multiple interfaces to acquire the multimedia data faster and exploit efficiently the cached data as typically many users seek for the same multimedia data. We are convinced that the employment of network coding in CCN will accelerate the data delivery, improve multimedia quality, enable better the available resources, and revolutionize the caching strategies in CCN framework by considering data importance.

To validate the performance of our proposal, we will use NS-3 Direct Code Execution (DCE), which allows to run the CCNx implementation into a simulated network environment. Thus, we will be able to compare the performance of current version of CCNx with that of our proposed network coding enabled CCNx.

Research staff: Eirina Bourtsoulatze, Jonnahtan Saltarin, Torsten Braun

Wireless Networking for Moving Objects

The Future Internet will incorporate a large number of autonomous wireless objects moving with diverse patterns and speeds while communicating via several radio interfaces. Examples of such objects may include humans, cars or unmanned aerial vehicles, with every object acting as a networking device generating, relaying and/or absorbing data. The Future Internet will require global interoperability among objects/devices. To overcome current shortcomings, a number of research challenges have to be addressed in the area of networking, including protocol engineering, development of applications and services, as well as realistic use-cases. The COST Action IC0906 coordinated research efforts of national and international projects in the area of Wireless Networking for Moving Objects (WiNeMO).

In a joint research activity with University of Coimbra (Portugal) we have further developed mechanisms for energy saving in IEEE 802.11 wireless local area networks. In particular, we have identified the problem of congestion when multiple mobile stations are requesting buffered packets from an access point. A solution to address this problem has been developed, which consists of using time slots allocated to individual stations to request and receive the buffered packets. The initial solution has been developed during the Short-Term Scientific Mission of Torsten Braun at University of Coimbra.

Research staff: Torsten Braun, Carlos Anastasiades

Financial support: European Science Foundation, COST Action IC0906

Algorithms, Architectures and Platforms for Enhanced Living Environments (AAPELE)

Ambient Assisted Living (AAL) is an area of research based on Information and Communication Technologies (ICT), medical research, and sociological research. AAL is based on the notion that technology and science can provide improvements in the quality of life for people in their homes, and that it can reduce the financial burden on the budgets of European healthcare providers. The concept of Enhanced Living Environments (ELE) refers to the AAL area that is more related with the Information and Communication Technologies. To design, plan, deploy and operate, an

AAL system often comprehends the integration of several scientific areas. The Architectures, Algorithms and Platforms for Enhanced Living Environments (AAPELE) COST Action addresses the issues of defining software, hardware and service architectures and on studying and creating more efficient algorithms and protocols for AAL. Related CDS research activities include localization of wireless devices as well as activity detection of mobile users.

Research staff: Torsten Braun, Islam Alyafawi, Zan Li

Financial support: European Science Foundation, COST Action IC1303

Service-Centric Networking

Content-centric network (CCN) is a new and promising networking paradigm. CCN aims at moving from the host-to-host communication style to a new paradigm that focuses on content as the building block of the future Internet architecture. However, CCN does not consider the concept of services in its architecture. We believe that services, rather than content, should be the center of focus in future network architectures. This is due to the fact that content is just a subset of services and what applies to services can easily apply to content, but not the other way around.

Service-centric network (SCN) is a new networking paradigm where services are at the heart of its architecture. SCN is an object-oriented architecture where services and contents are considered as objects. Our research aims at building the SCN architecture based on CCN with extensions regarding service naming, name resolution, service routing, and service management.

We built the NextServe framework to support the publication, invocation, and orchestration of services over CCN. The naming scheme of NextServe allows services to be invoked by name. Also service results can be cached within the CCN network improving the response time significantly.

Authentication and trust in the service are another crucial topic in SCN. Legacy authentication methods can be applied to ICN without any major issues: the owner of a content signs using his private key, and publishes both content and signature, to be used by the receiver to verify that no alterations have been made on the way.

In SCN, the content is to be "serviced" by any service point that is not necessarily trusted, thus invalidating the signature of the original content.

We are investigating authentication techniques that can be used by a receiver to validate contents even after being changed by intermediate service points, without necessarily involving the owner of the original content.

Research staff: Dima Mansour, Torsten Braun, Imad Aad

Adaptive Network Coding for Video Communications

During the Hasler funded project "Adaptive Network Coding for Video Communications", our research has focused on: (a) the design of methods that make the optimal coding and scheduling decisions for adaptive video streaming systems and (b) the design of an interactive free-viewpoint video streaming scheme that uses Prioritized Randomized Network Coding (PRNC).

Specifically, we dealt with the problem of jointly determining the optimal Priority Random Linear Coding (PRLC) and the scheduling decisions when the receivers can obtain layered data directly from multiple servers. The layered data is protected by means of PRLC in order to respect the unequal levels of data importance. Differently from the state-of-the-art Random Linear Coding (RLC) approaches where data blocks are transmitted sequentially, the data from multiple data blocks is jointly considered. Markov Decision Processes (MDP) are used to formulate the problem. Large performance gains are observed over methods treating the data blocks sequentially. Reinforcement learning approaches such as Q-learning are studied in order to cope with MDPs' overwhelming computational complexity that renders them inappropriate for practical settings. The presented Q-learning and MDP solutions are examined in an illustrative example for scalable video transmission.

Moreover, we investigated the design of an optimized delivery strategy based on PRNC for free viewpoint streaming over overlay networks. We consider that the images are captured by an array of cameras that acquire a scene of interest from different perspectives and that any intermediate viewpoint not included in the camera array can be virtually synthesized by the decoder, at a quality that depends on the distance between the virtual view and the camera views available at decoder. Since in overlay networks the bandwidth is limited, the delivery of all the views is not possible. We first introduce the layered Quality of Experience (QoE) concept and then

we organize the cameras (views) in layered subsets. These subsets are then delivered to clients through a PRNC streaming scheme, which deals with the network and clients heterogeneity and effectively exploits the resources of the overlay network.

Research staff: Nikolaos Thomos

Financial support: Hasler Foundation

Enterprise Integration of WSNs and IoT-devices

The aim of the project is to investigate new methodologies to enable interoperability between wireless sensor networks (in general various heterogeneous Internet of Thing devices (IoT) devices) and enterprise IT systems. The project assumes that the lower layers of a typical IoT/WSN protocol stack is mature and concentrates on application layer protocols, service-based integration of devices and (semantic) data content abstraction. We implemented a novel semantic overlay for IoT protocols, based on a semantic service description language (Linked USDL). It supports modeling IoT/WSN specific details, including technical interface descriptions, data representation (input/output) as well as different communication patterns. For enterprise IT systems that do not support a specific application layer protocol the semantic descriptions enable algorithmic solutions for automatic conversion between technical interfaces and automatic creation of further technical interfaces. The semantic representation of services and things support seamless integration of various heterogeneous devices and abstracts the things monitored by a WSN away from the actual sensing devices. Furthermore, we investigate to use of emerging enterprise-level protocols and the impact of scaling towards the needs of IoT-devices.
Evaluation results show that the performance of the platform is very promising and the overhead imposed by the semantic overlay is reasonable compared to alternatives such as WSDL. OData, as one example of an enterprise-level protocol has been studied and its feasibility on an IoT-device level has been demonstrated. Furthermore, an empirical study on the challenges and opportunities of semantics in IoT has been conducted.

Research staff: Matthias Thoma, Torsten Braun

Financial support: SAP (Switzerland) Inc.

Scaling of Distributed Applications in Cloud Computing Environments

Cloud computing enables provisioning and distribution of highly scalable services in a reliable, on-demand and sustainable manner. Our project's aim is to model and test different virtual machine (VM) scaling policies based on both Service Level Agreements (SLAs) and application-level monitoring information. We assume that the management system will control enterprise distributed applications, which are able to scale horizontally by increasing the number of VMs allocated to running the application's services. We employ SLAs for describing the performance invariants of the distributed application and then we use the SLAs as input to the management system for scaling the number of application's VMs under varying workload conditions. We consider different SLA scaling policies, both reactive and predictive. Reactive scaling simply responds to changes in the SLA compliance level (e.g. ratio of the current value of a application metric and its maximum allowed value) by changing the number of VMs allocated to a service until the SLA ratio returns to a safe value (e.g. between 0.6 and 0.9). We also developed a SLA scaling mechanism using results from queueing theory, by controlling the number of allocated VMs based on the relation between the concurrent number of requests executed by the service and the average execution time obtained at that concurrency level. We are currently extending these mechanisms to incorporate a prediction component. We are investigating the usage of both regression and non-linear mechanisms for forecasting the values of near-future workload. The project also explores modelling of distributed applications by characterising application performance under different workload patterns. We built a statistical model of the distributed application's performance by profiling the execution times of atomic operations and inter-service network round-trip times. These statistical models are then used for constructing a simulation model of the target application in CloudSim cloud simulator. We have extended CloudSim to support simulation of multiple cloud tenants (isolated applications with different SLA contracts), accurate time-shared CPU scheduling of concurrent tasks and multiple SLA-based VM scaling managers.

We have evaluated the accuracy of workload modelling in CloudSim by comparing the execution results in both a real distributed small-scale testbed and then by replicating the same workload in our extended simulator. The outcomes of evaluating the reactive and predictive scaling mechanisms are encouraging and seem to validate using them as reliable means of scaling cloud systems.

Research staff: Alexandru-Florian Antonescu, Torsten Braun

Financial support: SAP (Switzerland) Inc.

Testbed for Mobile and Internet Communications

Our research group maintains its own comprehensive and heterogeneous network testbeds for various purposes. A wired testbed is used to build networks of experimental routers and end systems 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. An educational laboratory network for students' training is also connected and has been used for teaching in the Bachelor program. 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. Moreover, we have installed three Cisco routers. Each of them is terminating a L2TP connections to provide a major European GpENI concentrator point. We are connected to the University of Kansas, the ETH Zürich and the University of Zürich.

Moreover, we deployed two powerful servers for offering virtual machines/networks in a fast and user-friendly way, one running Xen (http://xenserver.org/) and the other running OpenStack (http://www.openstack.org/). Virtualization alleviates the overhead of buying, setting up and managing virtual machines/networks, offering the users/researchers efficient and easy ways of running their experiments while reducing the financial costs and saving time, on a network that is not a simulation one.

Our research group also runs wireless testbeds. The 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. Some of these nodes are operated as part of the Wisebed infrastrucuture. Another testbed consisting of multiple wireless 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 Ph.D. theses and student projects.

Research staff: All members of the CDS research group

3.4   Ph.D. Theses

- Zhongliang Zhao "Context-aware Adaptive Opportunistic Routing in Mobile Ad-hoc and Sensor Networks", June 26, 2014

- Denis Lima do Rosario "Cross-Layer Optimizations for Multimedia Distribution over Wireless Multimedia Sensor Networks and Flying Ad-Hoc Networks with Quality-of-Experience Support", joint-supervision PhD Degree of Federal University of Para, Belem, Brazil, and University of Bern, July 16, 2014

3.5   Master's Thesis

- Wafaa El Maudni El Alami: An Agent-based Content-centric Networking Application for Data Retrieval, September 2013

3.6   Bachelor's Theses

- Simon Alexander Hirsbrunner: Indoor Localisation In Wi-Fi Networks Using An Improved Centroid Approach, July 2014

- Arian Uruqi: Content Discovery and Retrieval Application for Mobile Content-centric Networks, March 2014

- Adrian Hänni: Ipad / Iphone App as a Front-End for Prototype of a Highly Adaptive and Mobile Communication Network Using Unmanned Aerial Vehicles (UAVs), February 2014

- Marcel Stolz: OviS Wizard. A User-Friendly Mesh Network Deployment App for iOS, December 2013

- Daniel Moser: Human Mobilty Models for Indoors, August 2013

3.7   Awards

- Best Paper Award, 7th IFIP Wireless and Mobile Networking Conference for Zan Li, Desislava Dimitrova, David Hawes and Torsten Braun for the paper entitled "TDOA for Narrow-band Signal with Low Sampling Rate and Imperfect Synchronization", May 2014

- Best Paper Award, ARMS-CC-2014 Workshop for Florian Antonescu and Torsten Braun for the the paper entitled "Simulation of Multi-Tenant Scalable Cloud-Distributed Enterprise Information Systems", July 2014

- Support for young researchers grant (Nachwuchsförderung) by the University of Bern for Islam Alyafawi, for the ICC14 conference, Sydney, Australia. June 2014.

3.8   Further Activities

Memberships

Torsten Braun

- Chair of ERCIM working group on eMobility

- Erweitertes Leitungsgremium Fachgruppe "Kommunikation und Verteilte Systeme"', Gesellschaft für Informatik

- SWITCH Stiftungsrat

- SWITCH Stiftungsratsausschuss

- Vice President of SWITCH foundation

- Kuratorium Fritz-Kutter-Fonds

- Expert for Diploma Exams at Fachhochschule Bern

- Expert for Matura Exams at Gymnasium Kirchenfeld, Bern

- Management committee member of COST Action IC 0906 Wireless Networking for Moving Objects (WiNeMO)

- Management committee member of COST Action IC 1303 Algorithms, Architectures and Platforms for Enhanced Living Environments (AAPELE)

- External Advisory Board Member of Space Internetworking Center (SPICE) at Democritus University of Thrace, Greece

- Board Member (Gesellschafter) of VGU Private Virtual Global University, Berlin, Germany

Editorial Boards

Torsten Braun

- Editorial Board Member of Informatik Spektrum, Springer

- Editorial Board Member of Journal of Internet Engineering (Editor in Chief)

- Editorial Board Member of Telecommunication Systems, Springer

Conference Chairs

Torsten Braun

- Wired/Wireless Internet Communications 2014, Steering committee, Paris, France,May 26-28, 2014

- International Symposium on Quality of Service 2014, Steering committee, Hongkong, May 27-28, 2014

- 7th IFIP Wireless and Mobile Networking, Vilamoura, Keynote Chair, Portugal, May 20-22, 2014

- European Conference on Networks and Communications, Workshop Chair, Mobile Cloud Infrastructures and Services, Bologna, Italy, June 23-26, 2014

Conference Program Committees

Torsten Braun

- ICCCN International Workshop on Sensor Networks, Nassau, Bahmas, July 30 - August 2, 2013

- ACM SIGCOMM 2013 Workshop on Future Human-Centric Multimedia Networking, Hongkong, China, August 16, 2013

- International Conference on Next Generation Wired/Wireless Advanced Networking, St Petersburg, Russia, August 27-29, 2013

- IEEE Vehicular Technology Conference, VTC 2013 Fall, Las Vegas, USA, September 2-5, 2013

- IEEE International Conference on Network and Service Management 2013, Zürich, Switzerland, October 14-18, 2013

- IEEE Local Computer Networks, Sydney, Australia, October 21-24, 2013

- IEEE Globecom Workshop Wireless Networking and Control for Unmanned Autonomous Vehicles, Atlanta, USA, December 9, 2013

- IEEE Globecom 2013, Atlanta, USA, December 9-13, 2013

- 6th International Workshop on Multiple Access Communications, Vilnius, Lithuania, 16-17 December 2013

- Ninth International Conference on Wireless Communication and Sensor Networks (WCSN-2013), Allahabad, India, December 16-19, 2013

- IEEE Symposium on Network Cloud Computing and Applications, Rome, February 5-7, 2014

- Communication Technologies for Vehicles, Offenburg, Germany, May 6-7, 2014

- IEEE International Symposium on Quality of Service, Hongkong, China, May 26-27, 2014

- Wired/Wireless Internet Communications, Paris, France, May 26-28, 2014

- IFIP Networking Conference, Trondheim, Norway, June 2-4, 2014

- IEEE International Conference on Communications, Sydney, June 10-14, 2014

- EUCNC Workshop Mobile Cloud Infrastructures and Services (MCIS), Bologna, Italy, June 23, 2014

Desislava Dimitrova

- 6th International Workshop on Multiple Access Communications, Vilnius, Lithuania, December 16-17, 2013

- AIMS 2014 - PhD Workshop, Brno, Czech Republic, June 30 - July 3, 2014

Ph.D. Jury Memberships

Torsten Braun

- Thomas Bohnert, University of Coimbra (Portugal), October 24, 2013

- Laurynas Riliskis, Lulea University of Technology (Sweden), February 10, 2014

Imad Aad

- Antonio Sapuppo, Aalborg University (Denmark), September 10, 2013

Project and Person Reviewing Activities

Torsten Braun

- Project Reviewer for 7th Framework Programme of the European Community for research, technological development and demonstration activities

- Swiss National Science Foundation

- Academy of Finland

- Research Council of Norway

- TU Hamburg Harburg, Germany

- University of Bremen, Germany

- University of Potsdam, Germany

- Karlsruhe institute of Technology, Germany

- IMDEA Networks Institute, Spain

- Flemish Agency for Innovation by Science and Technology (IWT), Belgium

Journal Article Reviewing Activities

Torsten Braun

- Journal of Communications and Networks
- Journal of Zhejiang University Science C (Computer & Electronics)

Desislava Dimitrova

- IEEE Wireless Communications Magazine
- Elsevier Computer Communications
- Elsevier Computer Networks
- Elsevier Performance Evaluation
- International Journal of Distributed Sensor Networks
- Springer Wireless Networks

Almerima Jamakovic-Kapic

- Oxford Journal of Complex Networks
- Elsevier Computer Networks

Eirina Bourtsoulatze

- ACM/IEEE Transactions on Networking
- IEEE Communications Letters

Imad Aad

- Elsevier Computer Networks Journal
- IEEE Transactions on Wireless Communications
- Telecommunication Systems Journal

Zhongliang Zhao

- IEEE Journal of Transactions on Mobile Computing
- Elsevier Journal of Ad Hoc Networks

Carlos Anastasiades

- IEEE Network Magazine

Invited Talks and Tutorials

Torsten Braun

- Telematiknetze, Kaderkurs Telematik, Bundesamt für Bevölkerungsschutz, Schwarzenburg, Switzerland, September 3, 2103

- Content-Centric Networking in Opportunistic Networks, 8th Technical and MC Meeting, COST Action IC 0906, Ohrid, Macedonia, September 24-25, 2013

- Software-Defined Service-centric Networking, SWITCH SDN Workshop, Zürich, Switzerland, October 30, 2013

- Information-Centric and Software-Defined Networking, ICT LEIT in H2020 Info Day and International Brokerage Event, Koc University, Istanbul, Turkey, December 6, 2013

- Passive Localization of Wireless Devices, Workshop on Network Data Storage, Access, and Analysis, Zürich, Switzerland, March 31, 2014

- Localization using Distributed Radio Sensors based on Software-Defined Radios, University of Coimbra - CISUC, Coimbra, Portugal, April 22, 2014

- Routing Protocols for and Deployment of Flying Ad-hoc NETworks, Keynote, 6th International Workshop on Communication Technologies for Vehicles, Offenburg, Germany, May 7, 2014

- Content-Centric Networking in Opportunistic and Delay-Tolerant Networks, Final Event of Space Internetworking Center 2014, Xanthi, Greece, June 10, 2014

- Internet of Things, iCIS Summer Workshop, Coimbra, Portugal, June 24, 2014

- Future Internet, iCIS Summer Workshop, Coimbra, Portugal, June 24, 2014

Organized Events

- Doctoral Workshop on Distributed Systems, for Ph.D. students from Universities of Bern, Neuchâtel and University of Applied Sciences Fribourg, Kandersteg, Switzerland, June 3-5, 2014

3.9 Publications

Publications submitted in the academic year 2013/2014 and appearing in the following academic year are not listed.

Book Chapters

- Anastasiades, Carlos; Braun, Torsten; Siris, Vasilios (2014). *"Information-Centric Networking in Mobile and Opportunistic Networks"*. In: Wireless Networking for Moving Objects. Springer Lecture Notes in Computer Science, Vol. 8611. ISBN: 978-3-319-10833-9

- Jamakovic, Almerima; Bohnert, Thomas Michael; Karagiannis, Georgios (2013). *"Mobile Cloud Networking: Mobile Network, Compute, and Storage as One Service On-Demand"*. In : Galis, Alex; Gavras, Anastasius (eds.) The Future Internet. Lecture Notes in Computer Science: Vol. 7858 (pp. 356-358). Springer Berlin Heidelberg. DOI: 10.1007/978-3-642-38082-2_33.

Reviewed Journal Papers

- Bilogrevic, I; Jadliwala, M.; Joneja, V.; Kalkan, K.; Hubaux, J.; Aad, Imad Rafic (2014). *"Privacy-Preserving Optimal Meeting Location Determination on Mobile Devices"*. In: IEEE Transactions on Information Forensics and Security, 9(7), pp. 1141-1156. 01.07.2014. DOI: 10.1109/TIFS.2014.2318435

- Lima do Rosario, Denis; Zhao, Zhongliang; Braun, Torsten; Cerqueira, Eduardo (2014). *"A Cross-Layer QoE-Based Approach for Event-Based Multi-Tier Wireless Multimedia Sensor Networks"*. In: International Journal of Adaptive, Resilient and Autonomic Systems (IJARAS), 5(1), 1-18. IGI. DOI: 10.4018/ijaras.2014010101

- Bernardo, Vitor; Pascoal Curado, Marilia; Braun, Torsten (2014). *"An IEEE 802.11 energy efficient mechanism for continuous media applications"*. In: Sustainable Computing: Informatics and Systems, 4(2), 106 - 117. Elsevier. 13.04.2014. DOI: 10.1016/j.suscom.2014.04.001

- Bourtsoulatze, Eirina; Thomos, Nikolaos; Frossard, P. (2014). *"Decoding Delay Minimization in Inter-Session Network Coding"*. In: IEEE Transactions on Communications, 62(6), pp. 1944-1957. IEEE. 18.06.2014. DOI: 10.1109/TCOMM.2014.2318701

- Bourtsoulatze, Eirina; Thomos, Nikolaos; Frossard, P. (2014). *"Distributed Rate Allocation in Inter-Session Network Coding"*. In: IEEE Transactions on Multimedia, PP(99), p. 1. 03.06.2014. DOI: 10.1109/TMM.2014.2328320

- Aguiar, Elisangela; Riker, Andr; Cerqueira, Eduardo; Abelm, Antnio; Mu, Mu; Braun, Torsten; Pascoal Curado, Marilia; Zeadally, Sherali (2014). *"A real-time video quality estimator for emerging wireless multimedia systems"*. In: Wireless Networks, pp. 1-18. Springer. 06.03.2014. DOI: 10.1007/s11276-014-0709-y

- Faical, Bruno S.; Costa, Fausto G.; Pessin, Gustavo; Ueyama, J; Freitas, Heitor; Colombo, Alexandre; Fini, Pedro H.; Villas, Leandro; Osrio, Fernando S.; Vargas, Patricia A.; Braun, Torsten (2014). *"The use of unmanned aerial vehicles and wireless sensor networks for spraying pesticides"*. In: Journal of Systems Architecture, 60(4), 393 - 404. Elsevier. 29.01.2014. DOI: 10.1016/j.sysarc.2014.01.004

- Filho, Geraldo P R; Ueyama, J; Villas, Leandro A; Pinto, Alex R; Gonalves, Vincius P; Pessin, Gustavo; Pazzi, Richard W; Braun, Torsten (2014). *"NodePM: A Remote Monitoring Alert System for Energy Consumption Using Probabilistic Techniques"*. In: SENSORS, 14(1), pp. 848-867. 06.01.2014. DOI: 10.3390/s140100848

- Lima do Rosario, Denis; Zhao, Zhongliang; Santos, Aldri; Braun, Torsten; Cerqueira, Eduardo (2014). *"A Beaconless Opportunistic Routing Based on a Cross-Layer Approach for Efficient Video Dissemination in Mobile Multimedia IoT Applications"*. In: Computer communications, 45, pp. 21-31. Elsevier. DOI: 10.1016/j.comcom.2014.04.002

- Riera, Jordi Ferrer; Tzanakaki, Anna; Antonescu, Alexandru-Florian; Anastasopoulos, Markos; Garca-Espn, Joan A.; Escalona, Eduard; Peng, Shuping; Landi, Giada; Bernini, Giacomo; Belter, Bartosz; Parniewicz, Damian; Hesselbach, Xavier; Figuerola, Sergi; Simeonidou, Dimitra (2014). *"Virtual Infrastructures as a Service enabling Converged Optical Networks and Data Centres"*. In: Optical Switching and Networking. ISSN 1573-4277. Elsevier. DOI: 10.1016/j.osn.2014.05.017

- Thomos, Nikolaos; Pulikkoonattu, Rethnakaran; Frossard, Pascal (2013). *"Growth Codes: Intermediate Performance Analysis and Application to Video"*. In: IEEE Transactions on Communications, 61(11), pp. 4710-4721. 28.11.2013. DOI: 10.1109/TCOMM.2013.092813.120865

- Pessin, Gustavo; Osrio, Fernando S.; Souza, Jefferson R.; Ueyama, J; Costa, Fausto G.; Wolf, Denis F.; Dimitrova, Desislava; Braun, Torsten; Vargas, Patricia A. (2013). *"Investigation on the evolution of an indoor robotic localization system based on wireless networks"*. In: Applied Artificial Intelligence, 27(8), pp. 743-758. 16.09.2013. DOI: 10.1080/08839514.2013.823328

- Goleva, Rossitza; Atamian, Dimitar; Mirtchev, Seferin; Dimitrova, Desislava; Grigorova, Lyubina (2013). *"3G network traffic sources measurement and analysis"*. In: Transactions on Emerging Telecommunications Technologies. 04.09.2013. DOI: 10.1002/ett.2703

- Laurila, Juha K.; Gatica-Perez, Daniel; Aad, Imad; Blom, Jan; Bornet, Olivier; Do, Trinh Minh Tri; Dousse, Olivier; Eberle, Julien; Miettinen, Markus (2013). *"From big smartphone data to worldwide research: The Mobile Data Challenge"*. In: Pervasive and Mobile Computing, 9(6), 752 - 771. Elsevier. 21.08.2014. DOI: 10.1016/j.pmcj.2013.07.014

Reviewed Conference Papers

- Antonescu, Alexandru-Florian; Braun, Torsten (2014). *"SLA-Driven Simulation of Multi-Tenant Scalable Cloud-Distributed Enterprise Information Systems"*. In: Workshop on Adaptive Resource Management and Scheduling for Cloud Computing (ARMS-CC 2014), held in conjunction with PODC 2014. Paris, France. 15.07.2014.

- Dimitrova, Desislava Cvetanova; Alyafawi, Islam Fayez Abd; Ferreira, Lucio Studer.; Gomes, Andre; Nikaein, N.; Georgiev, A.; Pizzinat, A. (2014). *"Challenges ahead of RAN virtualization in LTE"*. In: MCIS workshop, collocated with EuCNC 2014. Bologna, Italy. 23.06.2014.

- Ferreira, Lucio Studer; Pichon, Dominique; Hatefi, Atoosa; Gomes, Andre; Dimitrova, Desislava Cvetanova; Braun, Torsten; Karagiannis, Georgios; Karimzadeh, Morteza; Branco, Monica; Correia, Luis M. (2014). *"An Architecture to offer Cloud-Based Radio Access Network as a Service"*. In: European Conference on Networks and Communications 2014 (EuCNC 2014). Bologna, Italy. 23-26.06.2014.

- Karagiannis, Georgios; Jamakovic, Almerima; Briggs, K.; Karimzadeh, Morteza; Parada, Corici, M.J.; Taleb, T.; Edmonds, A.; Bohnert ,T.M. (2014). *"Mobility and Bandwidth Prediction in Virtualized LTE Systems: Architecture and Challenges"*. In: European Conference on Networks and Communications 2014 (EuCNC 2014). Bologna, Italy. 23-26.06.2014.

- Lima do Rosario, Denis; Zhao, Zhongliang; Braun, Torsten; Cerqueira, Eduardo; Santos, Aldri; Alyafawi, Islam Fayez Abd (2014). *"Opportunistic Routing for Multi-flow Video Dissemination over Flying Ad-Hoc Networks"*. In: 15th IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM 2014). Sydney, Australia. 16-19.06.2014. ISBN: 978-1-4799-4786-7

- Alyafawi, Islam Fayez Abd; Dimitrova, Desislava Cvetanova; Braun, Torsten (2014). *"Real-Time Passive Capturing of the GSM Radio"*. In: IEEE ICC 2014 - Signal Processing for Communications Symposium. Sydney, Australia. 10-14.06.2014. ISBN: 978-1-4799-2003-7

- Anastasiades, Carlos; Braun, Torsten; El Maudni El Alami, Wafaa (2014). *"Agent-based Content Retrieval for Opportunistic Content-Centric Networks"*. In: Proc. of the 12th International Conference on Wired & Wireless Internet Communications (WWIC 2014). Paris, France, 26-28.05.2014. Lecture Notes in Computer Science. ISSN 0302-9743, Volume 8458. Springer.

- Mansour, Dima; Braun, Torsten; Anastasiades, Carlos (2014). *"NextServe Framework: Supporting Services Over Content-Centric Networking"*. In: Proc. of the 12th International Conference on Wired & Wireless Internet Communications (WWIC 2014). Paris, France.

26-28.05.2014. Lecture Notes in Computer Science. ISSN 0302-9743, Volume 8458. Springer.

- Li, Zan; Dimitrova, Desislava Cvetanova; Hawes Raluy, David; Braun, Torsten (2014). *"TDOA for Narrow-band Signal with Low Sampling Rate and Imperfect Synchronization"*. In: 7th IFIP Wireless and Mobile Networking Conference (WMNC 2014). Vilamoura, Algarve, Portugal. 20-22.05.2014. ISBN: 978-1-4799-3060-9

- Zhao, Zhongliang; Braun, Torsten; Rosrio, Denis; Cerqueira, Eduardo (2014). *"CAOR: Context-aware Adaptive Opportunistic Routing in Mobile Ad-hoc Networks"*. In: 7th IFIP Wireless and Mobile Networking Conference (WMNC 2014). Vilamoura, Algarve, Portugal. 20.-22.05.2014. ISBN: 978-1-4799-3060-9

- Antonescu, Alexandru-Florian; Braun, Torsten (2014). *"Improving Management of Distributed Services Using Correlations and Predictions in SLA-Driven Cloud Computing Systems"*. In: IEEE/IFIP Network Operations and Management Symposium (NOMS 2014). Krakow, Poland. 5-9.05.2014. DOI: 10.1109/NOMS.2014.6838320

- Karagiannis, Georgios; Jamakovic, Almerima; Edmonds, Andy; Parada, Carlos; Metsch, Thijs; Pichon, Dominique; Corici, Marius; Ruffino, Simone; Gomes, Andre; Secondo Crosta, Paolo; Bohnert, Thomas Michael (2014). *"Mobile Cloud Networking: Virtualisation of Cellular Networks"*. In: Proceedings of 21st International Conference on Telecommunications (ICT 2014). Lisbon, Portugal. 05.-07.05.2014. DOI: 10.1109/ICT.2014.6845149

- Furquim, Gustavo; Neto, Filipe; Pessin, Gustavo; Ueyama, Jo; de Albuquerque, Joao P.; Clara, Maria; Mendiondo, Eduardo M.; de Souza, Vladimir C.B.; de Souza, Paulo; Dimitrova, Desislava Cvetanova; Braun, Torsten (2014). *"Combining Wireless Sensor Networks and Machine Learning for Flash Flood Nowcasting"*. In: 28th International Conference on Advanced Information Networking and Applications Workshops (WAINA). Victoria, BC, Canada. 13-16.05.2014. DOI: 10.1109/WAINA.2014.21

- Thoma, Matthias; Braun, Torsten; Magerkurth, Carsten; Antonescu, Alexandru-Florian (2014). *"Managing Things and Services with Semantics: A Survey"*. In: IEEE/IFIP Network Operations and Management Symposium (NOMS 2014). Krakow, Poland. 5-9.05.2014. DOI: 10.1109/NOMS.2014.6838366

- Anastasiades, Carlos; Schmid, Tobias; Weber, Jürg; Braun, Torsten (2014). *"Opportunistic Content-Centric Data Transmission During Short Network Contacts"*. In: IEEE Wireless Communications and Networking Conference (WCNC 2014). Istanbul, Turkey. 6-9.04.2014. ISBN: 978-1-4799-3083-8

- Zhao, Zhongliang; Lima do Rosario, Denis; Braun, Torsten; Cerqueira, Eduardo (2014). *"Context-aware Opportunistic Routing in Mobile Ad-hoc Networks Incorporating Node Mobility"*. In: IEEE Wireless Communications and Networking Conference (WCNC 2014). Istanbul, Turkey. 6-9.04.2014. ISBN: 978-1-4799-3083-8

- Thoma, Matthias; Braun, Torsten; Magerkurth, Carsten (2014). *"Enterprise Integration of Smart Objects using Semantic Service Descriptions"*. In: IEEE Wireless Communication and Networking Conference (WCNC 2014). Istanbul, Turkey. 6-9.04.2014. ISBN: 978-1-4799-3083-8

- Thoma, Matthias; Kakantousis, Theofilos; Braun, Torsten (2014). *"REST-based sensor networks with OData"*. In: 11th IEEE/IFIP Annual Conference on Wireless On-demand Network Systems and Services (WONS). Obergurgl, Austria. 2-4.04.2014. DOI: 10.1109/WONS.2014.6814719

- Antonescu, Alexandru-Florian; Oprescu, Ana-Maria; Demchenko, Yuri; de Laat, Cees; Braun, Torsten (2013).*"Dynamic Optimization of SLA-Based Services Scaling Rules"*. In: 5th IEEE International Conference on Cloud Computing Technology and Science (CloudCom). Bristol, UK. 2-5.12.2013. IEEE. DOI: 10.1109/CloudCom.2013.44

- Oprescu, Ana-Maria; Antonescu, Alexandru-Florian; Demchenko, Yuri; Laat, Cees de (2013).*"ICOMF: Towards a Multi-cloud Ecosystem for Dynamic Resource Composition and Scaling"*. In : 5th IEEE International Conference on Cloud Computing Technology and Science (CloudCom). Bristol, UK. 2-5.12.2013. IEEE. DOI: 10.1109/CloudCom.2013.14

- Vinhas, Adriano; Bernardo, Vitor; Pascoal Curado, Marilia; Braun, Torsten (2013). *"Performance Analysis and Comparison between Legacy-PSM and U-APSD"*. In: 13th Portuguese Conference on Computer Networks (CRC 2013). Leiria, Portugal. November 14 - 15, 2013. Instituto Politécnico de Leiria. ISBN 978-972-8793-62-3

- Li, Zan; Dimitrova, Desislava C.; Braun, Torsten; Rosario, Denis (2013). *Highly accurate evaluation of GPS synchronization for TDOA localization.* In: Wireless Days (WD) 2013 IFIP, Valencia, Spain. 13-15.11.2014. IEEE. DOI: 10.1109/WD.2013.6686489

- Rosario, Denis; Zhao, Zhongliang; Braun, Torsten; Cerqueira, Eduardo; Santos, Aldri; Li, Zan (2013). *"Assessment of a robust opportunistic routing for video transmission in dynamic topologies"*. In: Wireless Days (WD), 2013 IFIP. Valencia, Spain. 13-15.11.2013. IEEE. DOI: 10.1109/WD.2013.6686464

- Thoma, Matthias; Sperner, Klaus; Braun, Torsten; Magerkurth, Carsten (2013). *"Integration of WSNs into enterprise systems based on semantic physical business entities"*. In: Wireless Days (WD), 2013 IFIP. Valencia, Spain. 13-15.11.2013. IEEE. DOI: 10.1109/WD.2013.6686525

- Biswas, Debmalya; Aad, Imad; Perrucci, Gian Paolo (2013). *"Privacy Panel: Usable and Quantifiable Mobile Privacy"*. In: Availability, Reliability and Security (ARES), 2013 Eight International Conference on (pp. 218-223). 2-6.09.2013. Regensburg, Germany. DOI: 10.1109/ARES.2013.29

- Toni, L.; Thomos, Nikolaos; Frossard, P. (2013). *"Interactive free viewpoint video streaming using prioritized network coding"*. In: 2013 IEEE 15th International Workshop on Multimedia Signal Processing (MMSP). Pula, Croatia. 30.09.2013-02.10.2013. DOI: 10.1109/MMSP.2013.6659330

- Kunszt, Peter; Maffioletti, Sergio; Flanders, Dean; Eurich, Markus; Bohnert, Thomas; Edmonds, Andrew; Stockinger, Heinz; Haug, Sigve; Jamakovic, Almerima; Flury, Placi; Leinen, Simon; Schiller, Eryk (2013). *"Towards a Swiss National Research Infrastructure"*. In: The first international workshop FedICI 2013: Federative and Interoperable Cloud Infrastructures. Aachen, Germany. 26.08.2013. Lecture Notes in Computer Science. Volume 8374. Springer. DOI: 10.1007/978-3-642-54420-0_16

Tutorials

- Cerqueira, Eduardo; Santos, A.; Lima do Rosario, Denis; Braun, Torsten; Gerla, M. (2014). *"Multimedia Human-Centric Networking: Concepts, Technologies and Trends"*. In: Tutorials of the 32th

Brazilian Symposium on Computer Networks and Distributed Systems (SBRC 2014). ISSN: 2177-4978

Technical Reports

- Hugues Mercier, Torsten Braun, Pascal Felber, Peter Kropf, Pierre Kuonen (2014). *"2014 Doctoral Workshop on Distributed Systems"*, Technical Report IAM-14-001, Kandersteg, Switzerland, July 2014