Program for Swe-CTW 2016

May 31st at 13.00 – June 2nd at 13.15

Mid Sweden University, Sundsvall

http://www.miun.se/en/stc-research-centre/events/sncnw-swe-ctw-2016

Tuesday, May 31st

12:30–13:00 Registration
13:00–13:15 Welcome
13:15–16:45 Tutorial - Challenges and Solutions for Networking in the Millimeter-wave Band
13:15–15:00 Tutorial 1, Part 1
15:00–15:30 Coffee break
15:30–16:45 Tutorial 1, Part 2

Wednesday, June 1st

10:00-17:00 SNCNW, https://www.miun.se/en/stc-research-centre/events/sncnw-swe-ctw-2016
09:00–09:50 Invited talks: Best IEEE VT/COM/IT Sweden Conference/Journal Papers, Part 1
09:50–10:00 Coffee break
10:00–11:00 Invited talks: Best IEEE VT/COM/IT Sweden Conference/Journal Papers, Part 2
11:00–12:00 Keynote (Swe-CTW and SNCNW)
12:00–13:30 Lunch
13:30–14:45 Invited talks: Best IEEE VT/COM/IT Sweden Conference/Journal Papers, Part 3
14:45–16:15 Coffee break and Poster Session 2
16:15–17:15 Invited talks: Best IEEE VT/COM/IT Sweden Conference/Journal Papers, Part 4
18:00–21:00 Social Event and Dinner; Announcement of Award Winners

Thursday, June 2nd

09:15–13:30 SNCNW, https://www.miun.se/en/stc-research-centre/events/sncnw-swe-ctw-2016
09:00–12:15 Tutorial 2 - Introduction to Factor Graphs and Message Passing
09:00–10:15 Tutorial 2, Part 1
10:15–10:30 Coffee break
10:30–12:15 Tutorial 2, Part 2
12:15–13:15 Lunch; Close of the workshop

Tutorial 1:

Challenges and Solutions for Networking in the Millimeter-wave Band

Carlo Fischione, *KTH, Dept. of Automatic Control*

Tuesday, May 31st: 13:15–15:00 Networking in the Millimeter-wave Band, Part 1
Tuesday, May 31st: 15:30–16:45 Networking in the Millimeter-wave Band, Part 2

Tutorial abstract: The tutorial will highlight the most prominent technical challenges of and possible approaches for networking in the millimeter-wave (mmwave) band. Communication at such high frequencies brings unique challenges, primarily due the high signal attenuation, which can only be overcome by the use of highly directional antennas. On the one hand side, this results in much less interference compared to omni-directional communication at lower frequencies, allowing for a high degree of spatial reuse and potentially simpler Medium Access Control Protocols (MAC) and interference management mechanisms. On the other hand, high directionality may cause deafness due to beam misalignments, whereas channels may appear and disappear over very short time intervals and cause sudden communication blockages, in particular for mobile devices. The tutorial specifically focuses on networking aspects of the MAC layer and above. It starts by an overview of mm-wave communication aspects and characteristics, and then delves into the most important network and protocol design aspects, ranging from beam-training and medium access to the impact on transport protocols and efficient network architectures.
Tutorial format: Three hours in total with one break of 30 minutes.

Bio of the speaker: Dr. Carlo Fischione is currently a tenured Associate Professor at KTH Royal Institute of Technology, Electrical Engineering and ACCESS Linnaeus Center, Stockholm, Sweden. He received the Ph.D. degree in Electrical and Information Engineering (3/3 years) in May 2005 from University of L'Aquila, Italy, and the Laurea degree in Electronic Engineering (Laurea, Summa cum Laude, 5/5 years) in April 2001 from the same University. He has held research positions at Massachusetts Institute of Technology, Cambridge, MA (2015, Visiting Professor); Harvard University, Cambridge, MA (2015, Associate); University of California at Berkeley, CA (2004-2005, Visiting Scholar, and 2007-2008, Research Associate); and Royal Institute of Technology, Stockholm, Sweden (2005-2007, Research Associate). His research interests include optimization with applications to wireless sensor networks, networked control systems, wireless networks, security and privacy. He has coauthored over 100 publications, including a book, book chapters, international journals and conferences, and international patents. He is Associated Editor of Elsevier Automatica, has chaired or served as a technical member of program committees of several international conferences and is serving as referee for technical journals. Meanwhile, he also has offered his advice as a consultant to numerous technology companies such as Berkeley Wireless Sensor Network Lab, Ericsson Research, Synopsys, and United Technology Research Center. He is co-founder and CTO of the sensor networks start-up companies Aukoti (Internet of Things indoor navigation) and MIND (ancient and modern musical instruments networked).

Tutorial 2:
Introduction to Factor Graphs and Message Passing

I. Naga V. Irukulpati

Chalmers University of Technology

Thursday, June 2nd: 09:00–10:15 Factor Graphs and Message Passing, Part 1
Thursday, June 2nd: 10:30–12:15 Factor Graphs and Message Passing, Part 2

Tutorial abstract: Graphical models such as factor graphs (FGs) allow a unified approach to a number of topics in coding, signal processing, machine learning, statistics, and statistical physics. An FG is generated based on a factorization of a function and the sum-product algorithm (SPA) is a message-passing algorithm on the FG with the aim of computing marginal posterior distributions. A wide variety of algorithms developed in artificial intelligence, signal processing, and digital communications can be derived as specific instances of the SPA, including the forward/backward algorithm, the Viterbi algorithm, the iterative turbo decoding algorithm, Pearl's belief propagation algorithm for Bayesian networks, the Kalman filter, and certain fast Fourier transform algorithms.

The presentation is mainly divided into 4 parts of FGs: WHAT is FG,WHY do we need FG, HOWto do message passing in FG, and finally WHERE was FG used in our research. These parts will cover basics about Bayesian inference, basics of FG and SPA, how the messages can be used to compute the marginal distributions. In the 4th part of the talk (WHERE part), an application of these concepts will be given with our proposed detector for fiber-optical communications, stochastic digital backpropagation, as a case study. FG and SPA have helped us to develop a near-optimal receiver and get closer to the fundamental performance limits of the fiber-optical channel. Depending on the audience background and interest, further details on this algorithm and further extensions will be delved into.

Bio of the speaker: Naga V. Irukulapati received the bachelors in technology (B.Tech) degree from Dhirubhai Ambani Institute of Information and Communication Technology (DA-IICT), India, in 2009, master studies in communication engineering program at Chalmers University of Technology in 2011 with 'Sensor fusion for vehicular networks' topic as his master thesis. Immediately following the graduation, he joined the Fiber-Optic Communications Research Center (FORCE) as a Ph.D. student in the communication systems group at Chalmers. His current research focus is on receiver design for coherent optical communications with emphasis on mitigation of nonlinear effects and specifically on the design on optimal receivers. During his PhD, he has been to ETH Zurich to visit Prof. Loeliger, to Coriant to work in a research lab, and to Scuola Superiore Sant' Anna, Pisa to work with Prof. Marco Secondini.

Invited talks: Best IEEE Sweden Conference/Journal Papers

Part 1

Wednesday, June 1st : 09:00–09:50

09:00-09:30 Antonios Pitarokoilis, Saif Khan Mohammed and Erik G. Larsson, "**Uplink Performance of Time-Reversal MRC in Massive MIMO Systems Subject to Phase Noise**," *IEEE Transactions on Wireless Communications*, vol. 14, no. 2, pp. 711-723, Feb. 2015.

09:30-09:50 Jesper Pedersen, Alexandre Graell i Amat, Iryna Andriyanova and Fredrik Brännström, "**Repair scheduling in wireless distributed storage with D2D communication**," *IEEE Information Theory Workshop*, Oct. 2015.

Part 2

Wednesday, June 1st : 10:00–11:00

10:00-10:30 Maksym A. Girnyk, Mikko Vehkaperä, and Lars K. Rasmussen, "**Large-system analysis of correlated MIMO multiple access channels with arbitrary signaling in the presence of interference**," *IEEE Transactions on Wireless Communications*, vol. 13, no. 4, pp. 2060–2073, April 2014.

10:30-11:00 Christian Häger, Alexandre Graell i Amat, Fredrik Brännström, Alex Alvarado, and Erik Agrell, "**Terminated and tailbiting spatially-coupled codes with optimized bit mappings for spectrally efficient fiber-optical systems**," *IEEE/OSA Journal of Lightwave Technology*, vol. 33, no. 7, pp. 1275-1285, Apr. 2015.

Part 3

Wednesday, June 1st : 13:30–14:50

13:30-14:00 Hossein Shokri-Ghadikolaei, Carlo Fischione, Gabor Fodor, Petar Popovski, and Michele Zorzi, "**Millimeter wave cellular networks: A MAC layer perspective**," *IEEE Transactions on Communications*, vol. 63, no. 10, pp. 3437-3458, Oct. 2015.

14:00-14:30 Jingya Li, Emil Björnson, Tommy Svensson, Thomas Eriksson, and Mérouane Debbah, "**Joint Precoding and Load Balancing Optimization for Energy-Efficient Heterogeneous Networks**," *IEEE Transactions on Wireless Communications*, vol. 14, no. 10, pp. 5810-5822, Oct. 2015.

14:30-14:50 Marcus Karlsson, Emil Björnson, and Erik G. Larsson, "**Broadcasting in Massive MIMO Using OSTBC with Reduced Dimension**," *IEEE Int. Symposium on Wireless Communication Systems*, Aug. 2015.

Part 4

Wednesday, June 1st : 16:15–17:15

16:15-16:35 Serveh Shalmashi, Emil Björnson, Marios Kountouris, Ki Won Sung, and Merouane Debbah, "**Energy Efficiency and Sum Rate when Massive MIMO meets Device-to-Device Communication**," *IEEE International Conference on Communication*, June 2015.

16:35-16:55 L. Srikar Muppirisett, Henk Wymeersch, Johnny Karout, and Gabor Fodor, "**Location-Aided Pilot Contamination Elimination for Massive MIMO Systems**," *IEEE Globecom*, Dec. 2015.

16:55-17:15 Sylvia T. Kouyoumdjieva and Gunnar Karlsson, "**Energy-Aware Opportunistic Mobile Data Offloading for Users in Urban Environments**," *IFIP Networking Conf.,* May 2015.

Poster Session

Wednesday, June 1st : 14:45–16:15

1. ***Mean Queuing Delay in LTE DRX***
   Hawar Ramazanali and Alexey Vinel;
   Halmstad University;
   Submitted to IEEE Wireless Communications Letters, April 2016.
   Abstract:
   Energy-efficiency is a crucial requirement for future 5G radio devices. Discontinuous Reception (DRX) is a mechanism for power saving in LTE/LTE-A standard. In this letter, a method is developed to compute the mean queuing delay induced by the DRX. In contrast to existing semi-Markovian models, an approach, which combines Markov chains and regenerative processes, is proposed.

2. ***Millimeter Wave Cellular Networks: A MAC Layer Perspective***
   Hossein Shokri Ghadikolaei and Carlo Fischione;
   KTH Royal Institute of Technology;
   Abstract:
   The millimeter-wave (mmWave) frequency band is seen as a key enabler of multi-gigabit wireless access in future cellular networks. In order to overcome the propagation challenges, mmWave systems use a large number of antenna elements both at the base station and at the user equipment, which leads to high directivity gains, fully directional communications, and possible noise-limited operations. The fundamental differences between mmWave networks and traditional ones challenge the classical design constraints, objectives, and available degrees of freedom. This poster addresses the implications that highly directional communication has on the design of an efficient medium access control (MAC) layer. The poster discusses key MAC layer issues, such as synchronization, random access, handover, channelization, interference management, scheduling, and association. This poster provides an integrated view on MAC layer issues for cellular networks, identifies new challenges and tradeoffs, and provides novel insights and solution approaches.

3. ***Distributed Optimization in Full-Duplex Networks***
   Jose Mairton B. da Silva Jr., Yuzhe Xu, Gabor Fodor, and Carlo Fischione;
   KTH Royal Institute of Technology;
   To be published at the IEEE ICC'16 - Workshop on Novel Medium Access and Resource Allocation for 5G Networks, May 2016.
   Abstract:
   Three-node full-duplex is a promising new transmission mode between a full-duplex capable wireless node and two other wireless nodes that use half-duplex transmission and reception respectively. Although three-node full-duplex transmissions can increase the spectral efficiency without requiring full-duplex capability of user devices, inter-node interference – in addition to the inherent self-interference – can severely degrade the performance. Therefore, the management of internode interference is becoming increasingly important. This work considers a cellular system in which a full-duplex capable base station serves a set of half-duplex capable users. The objective is to device channel assignment and power control algorithms that maximize the weighted sum of the uplink-downlink transmissions. To this end a distributed auction based channel assignment algorithm is proposed, in which the scheduled uplink users and the base station jointly determine

the set of downlink users for full-duplex transmission. Realistic system simulations indicate that the spectral efficiency can be up to 89% better than using half-duplex mode. Furthermore, when the self-interference cancelling level is high, the impact of the user-to-user interference is severe unless properly managed.

4. *LTE-based Water Monitoring Networks*

Rong Du, Carlo Fischione, and Ming Xiao;
KTH Royal Institute of Technology;
Published at *IEEE GLOBECOM 2014*.
Abstract:
We study two approaches to distributed compressed sensing for in-network data compression and signal reconstruction at a sink. Communication to the sink is considered to be bandwidth-constrained due to the large number of devices. By using distributed compressed sensing for compression of the data in the network, the communication cost (bandwidth usage) to the sink can be decreased at the expense of delay induced by the local communication. We investigate the relation between cost and delay given a certain reconstruction performance requirement when using basis pursuit denoising for reconstruction. Moreover, we analyze and compare the performance degradation due to erased packets sent to the sink.

5. *Finite Length Weight Enumerator Analysis of Braided Convolutional Codes*

Saeedeh Moloudi*, Michael Lentmaier*, and Alexandre Graell i Amat[§]
*Lund University; [§]Chalmers University of Technology
To be published at The International Symposium on Information Theory and Its Applications, Oct. 2016.
Abstract:
Braided convolutional codes (BCCs) are a class of spatially coupled turbo-like codes (SC-TCs) with excellent belief propagation (BP) thresholds. In this research we analyze the performance of BCCs in the finite block-length regime. We derive the average weight enumerator function (WEF) and compute the union bound on the performance for the uncoupled BCC ensemble. Our results suggest that the union bound is affected by poor distance properties of a small fraction of codes. By computing the union bound for the expurgated ensemble, we show that the floor improves substantially and very low error rates can be achieved for moderate permutation sizes. Based on the WEF, we also obtain a bound on the minimum distance, which indicates that it grows linearly with the permutation size. Finally, we show that the estimated floor for the uncoupled BCC ensemble is also valid for the coupled ensemble by proving that the minimum distance of the coupled ensemble is lower bounded by the minimum distance of the uncoupled ensemble.

6. *Detecting Communication Blackout in Industrial Wireless Sensor Networks*

Simone Grimaldi*, Mikael Gidlund*, Tomas Lennvally[§] and Filip Barac*;
*Mid Sweden University; [§]SICS;
To be published at IEEE World Conference on Factory Communication Systems.
Abstract:
Wireless communication in industrial wireless sensor networks (IWSNs) is affected by a series of compromising factors, such as multipath fading and attenuation (MFA) and interference. These phenomena can strongly decrease communication reliability and cause, under certain circumstances, complete isolation of a radio device, with potential severe consequences for the underlying industrial process. In this work we investigate the downsides of the mechanism used in the

WirelessHART standard for reporting communication outages and we propose an alternative method employing an ad hoc centralized blackout detection algorithm. The algorithm relies on end-to-end acknowledgement messages which are used as basis to build device-specific communication metrics for multihop communication with actuators and sensors. The proposed solution is fully compatible with WirelessHART and implements three criticality classes to address target applications with heterogeneous requirements. The performance of the algorithm is tested using the ns-2 network simulator and results show that communication blackouts are detected with delays in the order of 4-5 times the refresh rate of monitored nodes for the highest criticality class, while ensuring a reasonably low rate of false detections.

7. ***Sensing Throughput Optimization in Fading Cognitive Multiple Access Channels with Energy Harvesting Secondary Transmitters***

Sinchan Biswas, Amirpasha Shirazinia, and Subhrakanti Dey;
Uppsala University;
Abstract:
The paper investigates the problem of maximizing expected sum throughput in a fading multiple access cognitive radio network when secondary user (SU) transmitters have energy harvesting capability, and perform cooperative spectrum sensing. We formulate the problem as maximization of sum-capacity of the cognitive multiple access network over a finite time horizon subject to a time averaged interference constraint at the primary user (PU) and almost sure energy causality constraints at the SUs. The problem is a mixed integer nonlinear program with respect to two decision variables namely spectrum access decision and spectrum sensing decision, and the continuous variables sensing time and transmission power. In general, this problem is known to be NP hard. For optimization over these two decision variables, we use an exhaustive search policy when the length of the time horizon is small, and a heuristic policy for longer horizons. For given values of the decision variables, the problem simplifies into a joint optimization on SU transmission power and sensing time, which is non-convex in nature. We solve the resulting optimization problem as an alternating convex optimization problem for both non-causal and causal channel state information and harvested energy information patterns at the SU base station (SBS) or fusion center (FC). We present an analytic solution for the non-causal scenario with infinite battery capacity for a general finite horizon problem. We formulate the problem with causal information and finite battery capacity as a stochastic control problem and solve it using the technique of dynamic programming. Numerical results are presented to illustrate the performance of the various algorithms.

8. ***ISI and ICI in Transmit-windowed OFDM***

Tayebeh Taheri, Rickard Nilsson and Jaap van de Beek;
Luleå University of Technology;
Abstract:
Ever since its inception in 1980 the cyclic prefix (CP) has played a key role in orthogonal frequency division multiplexing (OFDM) systems, allowing standards and systems worldwide to manage dispersive channels with unprecedented elegance. At the expense of a slight reduction of spectral efficiency, intersymbol interference (ISI) and intercarrier interference (ICI) are avoided for relatively short channel lengths. Recently, with the prospect of a new disruptive change in an upcoming fifth generation of cellular systems, researchers are again challenging the OFDM modulation including its corner stone, the cyclic prefix. In particular recent research has shown focus on schemes that provide better reduction of out-of-band emissions than OFDM systems do (FBMC, FOFDM, OFDM spectral precoding, to name a few), and some of these schemes no longer include

a cyclic prefix. Transmit windowing is a classical means to reduce out-of-band emissions. Used for long in DSL systems, this technique is essentially also allowed in vendor-proprietary implementations of the current LTE standard. We generalize the results of conventional OFDM to windowed OFDM and give closed-form expressions for the ICI and ISI power in windowed OFDM. We show that for windowed OFDM systems, ISI and ICI power depend on window shape and unlike conventional OFDM systems, ISI and ICI power are in general not equal; only for a certain class of windows with a particular symmetry do the results of conventional OFDM extend to windowed OFDM. For other windows, including some of the well known, either the ISI or the ICI dominates. For instance the root-raised cosine window shape introduces up to 3dB more ISI than ICI. The results can be used to design an asymmetric window, which causes less distortion than current popular windows.

9. ***Channel Reservation for Dynamic Spectrum Access of Cognitive Radio Networks with Prioritized Traffic***

Thi My Chinh Chu*, Hans-Jürgen_Zepernick*, Hoc Phan[§];
[*]Blekinge Institute of Technology; [§]University of Reading, UK;
Submitted to *Elsevier International Journal of Electronic and Communications*.
Abstract:
This paper focuses on two tasks in underwater acoustic (UWA) communications, which includes channel modeling and performance analysis. To model the acoustic channel, we first implement a hardware system using FSK modulation/demodulation integrated circuits that are connected to a low frequency underwater transducer to measure real acoustic data. Channel profile is then derived from the measured data and an optimization algorithm widely used for channel modeling called the LP-norm method (LPNM). Subsequently, the close match of time and frequency correlation between reference and simulation models confirms correctness of our suggested modeling. Additionally, an OFDM system with several channel estimation techniques is investigated to analyze impacts of multipath UWA channel, Doppler effect and colored noise. Experimental results manifest superior improvements of the so-called sparse channel estimation over other traditional ones as least square or minimum mean square error. Besides, channel capacity under the influence of interference and colored noise is also investigated to select efficient bandwidth.

10. ***A Simplified Interference Model for Outdoor Millimeter Wave Networks***

Xiaolin Jiang, Hossein Shokri-Ghadikolaei, Carlo Fischione, and Zhibo Pang;
KTH Royal Institute of Technology;
Abstract:
Millimeter wave (mmWave) communication is a prominent technology in next generation wireless networks. The availability of tractable accurate interference models would greatly facilitate the design of these networks. The definition of tractable interference models in mmWave systems is difficult due to, among others, different channel models for the line-of-sight and non-line-of-sight situations and to different antenna gains at different angular directions. Assuming impenetrable obstacles and neglecting antenna sidelobes, while reducing the accuracy of the interference model, substantially enhance its mathematical tractability. In this paper, we investigate the accuracy of an interference model that assumes impenetrable obstacles and neglects the sidelobes. We quantify the error of such a model in terms of signal to noise plus interference ratio (SINR) distributions for the outdoor mmWave networks under different frequencies and antenna array settings. Moreover, we present the impact caused by the simplified interference model on the rate distribution. The results show that assuming impenetrable obstacle comes at almost no accuracy penalty. Neglecting antenna sidelobes is accurate only if proper scheduling is adopted.

The comprehensive discussions of this paper provide useful insights for the performance analysis and protocol design of outdoor mmWave networks.

11. *A new software framework for heterogeneous knowledge sharing in healthcare system*

Yang Guo, Yong Yao, and Guohua Bai;
Blekinge Institute of Technology;

Abstract:
Today's demand for healthcare is dramatically increasing as the factor of the aging population and expectations growing during the past few years. This leads to the need of substantial healthcare services with innovative technologies developed from both industry and academia. Designing an efficient healthcare system is however a sophisticated process due to different research issues with the requirement for the provision of high-quality healthcare services. Connected to this requirement, the focus of many studies done so far is widely laid on a well-known problem called knowledge sharing. In recent years, knowledge sharing raises as one of the most demanding applications with references to the dynamic inter-activity among different healthcare actors and the complex data structures involved in this application. Suitable solution approach to knowledge sharing can enhance the efficiency of healthcare delivery, and thus improving the quality of healthcare services. The corresponding development tasks can be accomplished by using different methodologies such as analytical approaches, simulation experiments and practical measurements on the real healthcare system. In our work, the problem of heterogeneous knowledge sharing in the healthcare system is considered. Here, the heterogeneous aspect is expressed in terms of different healthcare actors and the associated characterizations. To do this, we suggest a new software framework, which mainly consists of three components. The first component is about the ontology based activity theory, which is used to scientifically represent the healthcare actors together with their relationships and interactions. The second component refers to an overlay decision maker, which is responsible for dealing with the decision-making activities such as appointment scheduling. Its advantage is to jointly consider various healthcare parameters and different algorithms for decision-making purposes. Based on these two components, the third component provides the theoretical models to conduct the numerical analysis and performance evaluation on the particular healthcare service.

12. *Handling Event-Triggered Traffic of Safety and Closed-Loop Control Systems in WSANs*

Mehrzad Lavassani, Filip Barac, Mikael Gidlund, and Tingting Zhang;
Mid Sweden University;

Abstract:
This work investigates various methods to expand the deployment of Wireless Sensor-Actuator Networks (WSANs) to mission critical applications. We address the neglected open issues of hard deadline and deterministic delivery for event triggered traffic in safety and closed-loop regulatory systems. DeMAC algorithm is proposed by utilizing TDMA-based subslots in emergency access periods, group acknowledgement, alternative packet structure, and relay node. The proposed algorithm displayed promising results in comparison with contention-based methods, in improving delivery rate of critical data within the deadline, and lowering the worst-case delay.

13. *Outage Probability of a Cognitive Cooperative Relay Network with Multiple Primary Users Under Primary Outage Constraint*

Charles Kabiri*, Hans-Jürgen Zepernick[§] and Hung Tran[&];
University of Rwanda*, Blekinge Institute of Technology[§], Mälardalen Univesity[&];

Abstract:

In this paper, the impact of multiple primary user transmitters and multiple primary user receivers (PURxs) on the outage probability of a cognitive cooperative relay network (CCRN) with decode-and-forward relaying is studied. Specifically, power allocation policies for the secondary user transmitter and secondary relay are formulated, subject to the outage constraint at the PU-Rxs and the peak transmit power limit of the secondary transmitters. Given these power allocation policies, an expression for the outage probability of the CCRN is derived. Numerical examples are provided to illustrate the impact of system parameters on the outage probability of the CCRN.

14. ***Mobility Support in Wireless Sensor Networks***

Hossein Fotouhi;
Mälardalen University;

Abstract:

The need for mobility support is increasing in the Internet of Things (IoT) applications, where wireless sensor networks (WSNs) are the main building blocks of these applications. Employing low-power radios leads to unstable, unreliable and asymmetric wireless links, which in turn affects the quality of service. This problem is even more sever in WSNs with mobile nodes. In this context, we are aiming to provide reliability and timeliness in WSN applications with mobile nodes. Hand-off algorithms are the process of switching from one point of attachment to another. In this work, we designed two hand-off models, hard and soft hand-off models, where in hard hand-off algorithm, mobile node disconnects from one point and then searches for a new point, while in soft hand-off algorithm, mobile node finds the next point before disconnecting from the current point. The proposed hard handoff (smart- HOP) is based on a link quality parameter, where the relevant parameters have been fine-tuned with extensive experiments. We integrated smart-HOP within the RPL routing protocol (mRPL) in a simple, effective and backward compatible manner. The proposed soft hand-off algorithm (mRPL+) is an extension of mRPL algorithm, which enables a seamless parent switching within RPL routing. In order to enable soft hand-off, we activate a neighbor overhearing mechanism to eliminate the disconnected period for discovering possible parents. Simulation and experimental evaluations indicated that mRPL and mRPL+ are able to provide network connectivity and responsiveness by switching between parents in a short period of time while successfully delivering most of data packets. mRPL and mRPL+ are able to provide good reliability (≈ 100% packet delivery ratio) compared with RPL (delivering < 50% of data packets). The average hand-off delay in RPL is ≈ 3 s, while it reduces to 85 ms in mRPL and 4 ms in mRPL+.

Keynote Address

Wednesday, June 1st: 11:00–12:00 ***Patrik Fältström, Netnod***

Social Event and Workshop Dinner

Wedensday, June 1st: 18:00–21:00

Announcement of the Best IEEE VT/COM/IT Sweden Student Conference/Journal Paper 2016