# IEEE TCSIM Newsletter

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## Chair's Message

### - Prof. Kaushik Chowdhury

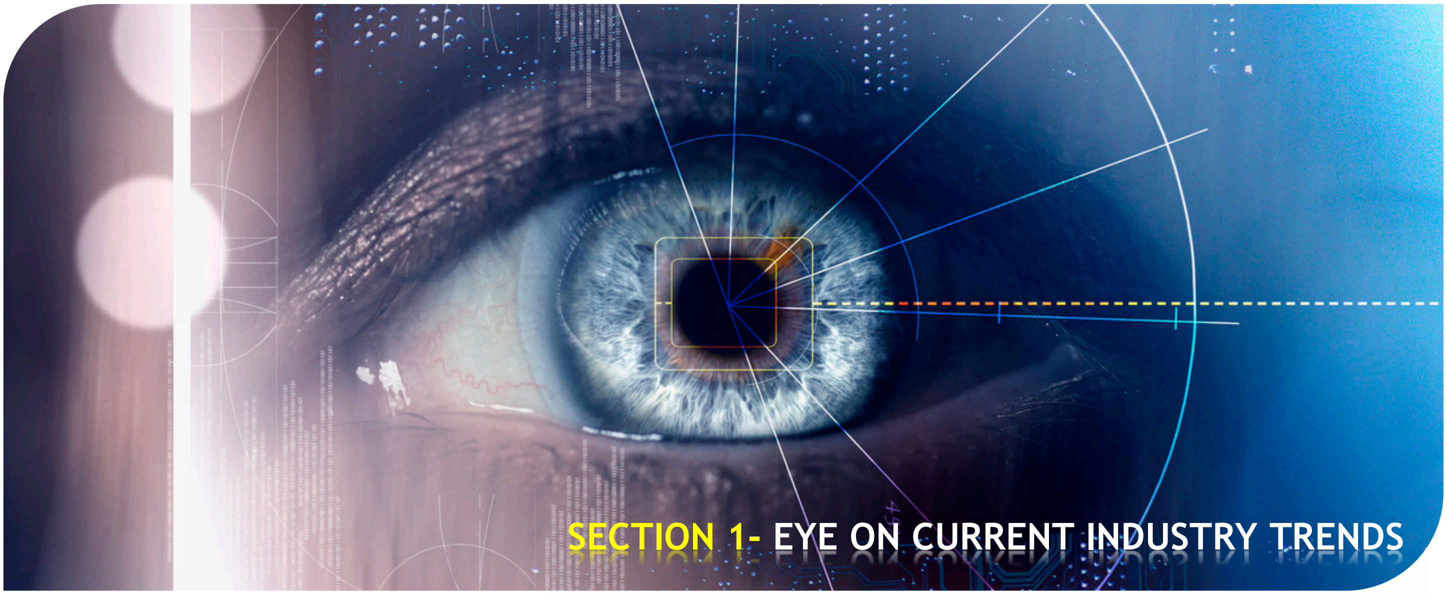
As the incoming Chair of TCSIM, I am honored to serve an active and vibrant community of professionals and students that have interest in using and advancing the state of the art of simulation-focused technologies. TCSIM, rooted in computing and simulation, serves a wide cross-section of disciplines, from large data-centers to communication systems to biological computing, and seeks active participation from members with such rich and diverse interests.

We have an exciting new look, starting with the TCSIM website and the newsletter. We will continue to build on our traditional activities in publishing quarterly newsletter that highlights the most significant advances in the area, organizes special issues and endorses conferences that fall within the TC's scope, as well as encourages student authors through best paper awards and travel grants. I would like to welcome Dr. Natalizio and Di Felice from Europe as incoming Vice-Chairs and co-editors of the newsletter, and also appreciate Dr. El-Said for his leadership in revamping the TC's website.

My sincere thanks to my predecessor: Dr. Cavalcanti, who provided inspired leadership of the TC over the past several years, and is still actively involved in the executive leadership of the TC. My deep appreciation also to Vice Chairs: Dr. Ghosh and Dr. Mazza who played crucial roles in reaching out to interest groups in networking and systems biology, and have now stepped down to pursue other opportunities.

Finally, I encourage you to read more and discover TCSIM, join our mailing lists, contribute to our newsletters and grow the simulation community!

## In this issue:




Simulation has been increasingly used in difficult and challenging scenarios, in which real world data is hard to obtain, or experiments may not be safely conducted. In this containing series, we will place a spotlight on some of the ways and recent research through which computer simulations are aiding systems design and solving some of the practical problems facing the world today. This issue covers the following areas:

## Verizon is going to test 5G in 2016

Verizon and its partners committed to the 5G trials last month during Verizon's Inaugural 5G Technology Forum and have established teams to ensure that the pace of innovation is aggressive. "We feel a tremendous sense of urgency to push forward on 5G," said Roger Gurnani, EVP and chief information and technology architect at Verizon in a prepared statement. [Link]

## Purdue Univ launches a new tool to reduce smartphone battery drain

The first large-scale study of smartphones in everyday use by consumers has revealed that apps drain 28.9 percent of battery power while the screen is off. To address the problem, researchers have created a software tool that reduces the energy drain by about 16 percent. Researchers at Purdue University, Intel Corp. and startup company Mobile Enerlytics studied the use of 2,000 Samsung Galaxy S3 and S4 phones served by 191 mobile operators in 61 countries. "This was the first large-scale study of smartphone energy drain 'in the wild,' or in everyday use by consumers," said Y. Charlie Hu, a Purdue professor of electrical and computer engineering. [Link]

## Telecom Experts Plot a Path to 5G

In October, the International Telecommunication Union (ITU) will try to give 5G a definition. The ITU's IMT-2020 Focus Group reviewed more than 60 research proposals and will pitch the first 5G network blueprint. The draft lays out major gaps in the 5G wire-line network infrastructure, such as software and high-level network architecture, according to Peter Ashwood-Smith, chairman of the focus group. It will suggest potential technology improvements and a timeline for when each component of 5G needs to be ready before deployment, he says. [Link]

## GSMA Launches Low Power WAN Initiative for IoT

The GSMA has announced that it has established the 'Mobile IoT Initiative', a new project backed by 26 of the world's leading mobile operators, OEMs, chipset, module and infrastructure companies, designed to address the use of Low Power Wide Area (LPWA) solutions in licensed spectrum. The new group will work to accelerate the commercial availability of mobile IoT technology by facilitating demonstrations, proofs of concept and trials of a selection of complementary LPWA licensed spectrum technologies. It will also provide analysis and feedback to assist 3GPP in standardising the technologies. [Link]

# SECTION 2- MEETING SIMULATION PEOPLE

**Dear Christoph, can you give us a little background about yourself?**

I studied Computer Science (Informatik) at the University of Erlangen, Germany, focusing first on computer networks and communication systems in general, later self-organizing and mobile ad hoc networks in particular, and still later diving into the newly evolving field of vehicular networking. I was awarded a Ph.D. (Dr.-Ing.) degree with distinction for my work on heterogeneous vehicular networks and their simulation in 2011. I briefly stayed at Carnegie Mellon University (CMU), the University of California, Los Angeles (UCLA), then at the University of Innsbruck until most recently joining the University of Paderborn as an Assistant Professor (AkadR a.Z.) in 2014.

In my spare time I serve on the editorial board of ACM/Springer Wireless Networks and co-organize conferences on wireless mobile and ad hoc networks, most recently the Vehicular Networking Conference (VNC). To foster research in this field, I am actively engaged in community building, as co-founder of a successful regional workshop series (FG-IVC), giving tutorial lectures at conferences, or participating in panel discussions, most recently at the technical plenary of the 93rd IETF meeting. I created a master level class on vehicular networking held at three universities and also authored "Vehicular Networking", a first textbook on the subject published in late 2014 by Cambridge University Press.

I teach classes on network simulation and embedded systems in general and I am happy to see my research contributing to the state of the art in modeling and designing wireless and ad hoc networks over the years, but applications in vehicular networking are currently among my main interests.

**One of your main research interests is vehicular networking. Can you please tell us more about it?**

Modern vehicles are no less than

Continued…

## INTERVIEW WITH Dr. SOMMER

In this issue, we meet with Dr. Christoph Sommer, one of the most active researchers in the field of vehicular networking and related simulation issues.

Dr. Christoph Sommer is with the Department of Computer Science, Distributed Embedded Systems Group, University of Paderborn and can be contacted at: sommer@ccs-labs.org

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mobile sensor platforms. Aside from a speedometer and GPS, they are equipped with anything and everything from one or more Radar and Lidar sensors to near/far infrared sensing and computer vision. Vehicular networking deals with the challenges and opportunities that arise from, quite simply, exchanging this data in and between vehicles.

Among the challenges that this brings about are coping with the limited bandwidth offered by each of potentially multiple available technologies and exploiting extremely short communication opportunities in highly dynamic and very heterogeneous networks. In all this, the security of data is as much a concern as the privacy and the safety of drivers and their passengers. Even taken in isolation, each is an interesting research field. Taken together, they make up the exciting field of vehicular networking that I am happy to be a part of.

Almost without exception, vehicular networks need to operate either at extremely large scale, under safety critical conditions, or using technology that is still in the concept phase. This makes computer simulation a vital tool to investigate novel approaches and designs.

**You are well-known in the research community on vehicular networks for being one of the creator/developer of the Veins framework. Can you please tell us more about Veins, and its current extensions?**

I created Veins out of necessity for my master's thesis, some ten years ago. What I wanted to do was to build on an existing full-featured, yet easy to learn network simulator, extending it with custom models for vehicular networking and coupling it with an established road traffic simulator. I wished for all of them to be Open Source – in my view a core necessity, so that I would be able to publish not just results, not just models, but the full tool chain allowing anyone to reproduce (then build upon) my results. At the time, such a framework was simply not available, so I set out to create it.

"… Modern vehicles are no less than mobile sensor platforms …"

*- Dr. Sommer*

Over the years, I was happy to see people around the world adopt Veins as the foundation for their research – but also to see them work on Veins itself: from extending it with new models of different granularity levels, to cross-validating results with their own measurements.

This open approach to science has proved to be hugely beneficial to everyone involved. Wherever Veins is extended to the point where it strays too far from being a generic Open Source vehicular network simulation framework, researchers simply fork it. One fork I am aware of is Artery, which provides a toolkit to evaluate Advanced Driver Assistance Systems (ADAS) applications running on top of the European standard vehicular networking protocol stack. Another fork I know of is Plexe, which provides a toolkit for investigating approaches to Cooperative Adaptive Cruise Control (CACC), also known as platooning. Now, some ten years later, and with hundreds of papers relying on the predictions of computer simulations run on it, Veins has become the core of an active community and one of the foundations of modern research in the field of vehicular networking.

**Several simulation tools are available for vehicular networks. What do you think is still missing for a realistic and accurate**

Continued…

**modeling of the vehicular scenarios?**

In my view, a pillar of scientific progress is the ability to build upon others' work. One aspect of this is being able to compare new approaches with the current state of the art. Today, it is good practice to share not just results, but also the full source code of underlying computer simulations, so one might not expect this to be a problem. What is still missing, however, is a smallest common denominator in terms of mobility.

Despite all its drawbacks, Mobile Ad Hoc Networks (MANETs) had this as the Random Waypoint (RWP) mobility model – unfortunately this model does not translate to vehicular networks, where an accurate representation of realistic road traffic is key to accurately predicting system performance. There are some publicly available data sets of vehicle movement, both those derived from computer simulations and recorded in real life. Yet, many systems exist in a feedback loop with road traffic: network traffic is just as much dependent on vehicles' behavior as it impacts how vehicles behave.

However, while data on the road topology of cities is easy to obtain (e.g., from the OpenStreetMap project), simulations are notoriously hard to calibrate to realistic traffic demand: at what time instant which vehicle drives from where to where or how demand actuated traffic lights react to traffic flow, to give just two examples, often needs to be derived from scarce data that can often not be freely shared with other researchers.

This has led to a situation where, today, we have a plethora of free-to-share well-validated simulation models of network components at hand, but no commonly agreed upon (and freely available) demand models to measure performance against.

**'Connected vehicle' is a hot research topic. In your opinion, which are the most relevant applications of this technology? Do you think there will a market for them?**

One of the most relevant applications is safety, such as in the shape of an intersection assistance system. Because vehicular networking can serve to cross-check and validate sensor readings beyond the limits of local sensors, regulatory bodies worldwide look to their introduction as a way of further improving traffic safety. Dedicated frequency bands have been reserved for vehicular networking in the U.S., Europe, and Japan. Further, the U.S. government has conducted an investigation into the potential safety benefits and has recently announced plans to prepare rulemaking to make vehicular networking equipment mandatory – and it is very likely that other governments will follow.

As a second example, truck manufacturers are looking to a different application: platooning, where a string of trucks autonomously follow their respective leader at very close distances – both to increase the safety (through computer control), the fuel efficiency (through close following distances), and the speed (through obviating the need for breaks) of long haul trucking. Some manufacturers have already announced autonomously driving trucks for their next model generations, some announced that they will take full responsibility for any defects in such a system and laws and regulations in many countries have already been updated to allow such systems on the streets.

The market potential of both sample applications is massive: in the first case for equipping each new vehicle with such a mandatory system, in the second case for retrofitting existing vehicles with a system that can save companies both time and fuel – and, once deployed on the road, even more visionary applications can easily be imagined.

**Thank you very much Christoph.**

# Best Student Paper Awardee at IEEE CORAL 2015 (sponsored by TCSIM): A Wideband Spectrum Sensing Scheme for LTE-A Signals

## SECTION 3- ELECTRONICS NOTES ON SIMULATION


**Trung Thanh Nguyen, Theo Kreul, and Thomas Kaiser**
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*Abstract—Spectrum sensing plays a vital role in the context of cognitive radio (CR) to be aware of surrounding radio-environments. For multiple channels in a wideband spectrum, the sensing tasks are more challenging than those in the case of single channels. In this paper, we investigate on wideband sensing for long-term evolution Advanced (LTE-A) signals. We propose a wideband spectrum sensing scheme for detection and classification of LTE-A signals. The scheme is able to detect the desired signals and classify the cell-identities of the signals in sub-channels in parallel. To validate the scheme in realistic scenarios, we simulate secondary LTE-A transmissions with practical configuration parameters. The simulation results show that the detection and classification performances for multiple channels in the wideband spectrum are closed to those for single channels. It proves the effectiveness of the proposed scheme. Therefore, the scheme can be feasibly implemented in LTE-A systems to obtain CR abilities.*

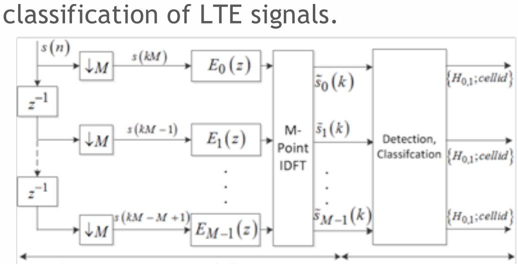

### I. INTRODUCTION

The demand of high data rates in mobile communications is increasing rapidly. Standard organizers and industry preventatives attempt to propose new technologies for the improvement of the data rates. To meet defined requirements of the 4G networks from International Telecommunication Union (ITU), in 2011 3GPP published Release 10 for LTE-A which is the most prominent candidate for the network. Currently, 4G LTE frequency bands 1 to 25 and 33 to 43 are already defined and planned by regulators. These bands are allocated at the frequency of 800 MHz to 3.4 GHz. Thus, the frequency bands are more crowded. Additionally, while the coverage areas of LTE-A networks have been increasing, concepts of 5G also have been initially discussed. However, 5G systems would require further spectrum bands to increase the system capacity. It will result in that spectrum scarcity for mobile communications is intensively demanded. Nevertheless, the spectrum efficiency in frequency bands is under-utilized. For example, spectrum occupancy is only about 13.6% for the frequency range from 30 MHz to 30 GHz in cities such as Dublin, Chicago and New York [1]. Therefore, mobile networks such as LTE-A can utilize white spaces in current spectrum bands for secondary transmissions. The total spectrum efficiency will be improved. Motivated by utilizing white spaces, LTE-A networks enhanced with CR functions are designed and developed. The test-bed as in [2], e.g., aims to obtain TV white spaces for LTE transmissions. In this scenario, new challenging tasks need to be handled including the procedure of initial-cell-search for secondary user-equipments (UEs) and a co-ordination among the secondary networks. Secondary UEs and base-stations have to detect transmitted LTE-A signals [3] and to identify the transmitting base-stations. In the literature reviews, the detection of LTE signals which is based on the primary synchronization signal (PSS) was proposed by Yang Wen in [4].

This previous work considers the detection in single channels with the implicit assumption that the LTE-A signals are perfectly extracted from a certain frequency band. The approach of spectrum sensing for multiple channels with filter bank spectral estimators was proposed by Farhang-Boroujeny in [5]. In this paper, we propose a spectrum sensing scheme which has some enhancements compared to the previous works. Firstly, the proposed scheme can handle a sensing task simultaneously for sub-band LTE signals transmitted in multiple channels. The sub-band signals are extracted by a polyphase implementation of filter-bank with a flexible design of the prototype filter. Additionally, the sensing task is not only to detect the LTE signals but also classify them.

### II. A PROPOSED SCHEME FOR WIDEBAND SENSING

Fig. 1.The proposed scheme for detection and classification of LTE signals.




We propose a sensing scheme for detection and classification of LTE-A signals in wideband spectrums as shown in Figure.

There are two stages of the scheme. The first stage is to subtract sub-band signals from the input signals by polyphase implementation of a filter bank. Then, the second stage is to detect and classify LTE-A signals.

### A. Stage 1: Implementation of filter bank

At this stage, the input signals are analyzed by a bank of filters which is realizations of a prototype filter. Each sub-band signals are extracted as:

$$\tilde{s}_m(k) = \sum_{l=0}^{M-1}\left[s(kM-l)\otimes h(kM+l)\right]W_M^{ml} \quad (1)$$

where $k$, $m$, $M$, $h$, and $W_M^{ml}$ denote the indices of received samples of sub-band signals, and the sub-band indices, the number of sub-bands, impulse responses of the prototype filter, and the inverse discrete Fourier transform, respectively. The prototype filter is a kind of low-pass filter (LPF) and can be implemented by a finite impulse response (FIR) type 1. To reduce the number of multiplication at this stage, we can design this LPF with the pass-band equal to the bandwidth of the synchronization signals instead of the whole effective bandwidth of LTE-A signals. Therefore, the transition-band can be increased; and the length of the prototype filter is shortened.

### B. Stage 2: Detection and Classification

#### 1) PSS-based detection

The cross-correlation between the received signals with the pre-defined feature sequences of PSS is given by the following form

$$c_i(t) = \frac{\left|\int_0^{T_p}\tilde{s}_m(t+\tau)p_i^*(\tau)d\tau\right|^2}{\int_0^{T_p}\left|\tilde{s}_m(\tau)\right|^2 d\tau\int_0^{T_p}\left|p_i^*(\tau)\right|^2 d\tau} \quad \text{i=0,1,2,} \quad (2)$$

A summation of PSS-based peaks was calculated with each sector-identity. The maximum value in is selected as a statistic test of detection. As in (1), the statistic test does not need the knowledge of noise power. Therefore, this PSS-based detection does not depend on noise uncertainty [6], which causes significant degradation for other detectors such as energy-based detector.

The sector-identity is also determined by $NID2 = arg\max_i\{T_{PSS_i}\}$ when the LTE-A signals are detected.

#### 2) Cell-ID Classification

Cell-ID will be classified when a presence of desired signals is detected. In LTE frames, the secondary synchronization signal (SSS) is located at the symbol which precedes the detected PSS. Each candidate of sector-group is selected by:

$$T_{SSS_i} = \max\{z_{i1}, z_{i2}\} \quad \text{i=0,1,167} \quad (3)$$

where $z_{i1}$, and $z_{i2}$ are the cross-correlation of the pre-defined feature sequences of SSS in the 0$^{th}$ and 10$^{th}$ slots with the extracted signals, respectively.

Then, the sector-group is determined by:

$$NID1 = arg\max_i\{T_{SSS_i} \quad (4)$$

Therefore, the detected signals can be classified with a Cell-ID which is comprised of $NID1$ and $NID2$.

## III. METHODOLOGY OF EVALUATION

To verify the scheme, we model secondary LTE-A transmissions in the ultra-high frequency. The secondary signals are allocated at the center of TV channels with a bandwidth less than that of the primary signals. Secondary UEs have to detect the secondary transmission, and to obtain Cell-IDs for the procedures of network attachments. Considering on a hardware simplification in realistic systems, we adjust the FFT length to 2048, which is configured only for 20 MHz-bandwidth LTE-A signals as in [3]. The sequences of PSS and SSS are pre-generated with the FFT length. Thanks to the TU-Wien Simulator [7], LTE-A signals are generated and scaled to particular SNR values. The generated signals are randomly up-converted onto different TV channels. The computation of performances is carried out by the Monte-Carlo method. The sensing performances for single channels, in which sub-band signals are extracted perfectly, are considered as benchmarks in comparison with those of the proposed scheme.

## IV. EVALUATION RESULTS

In simulations, a LTE-A system is modeled to transmit the signals in 8 MHz-bandwidth TV channels with the frequency from 470 MHz to 790 MHz. There are totally 40 TV channels in this range. The proposed scheme is designed to perform sensing tasks for a wideband spectrum of 8 sub-channels with a prototype filter of Blackman windows. Main parameters for LTE-A transmissions are presented as in TABLE I.

**TABLE 1**. Configuration Parameters for LTE-A signals

| Parameters | Values |
|---|---|
| Bandwidth | 5 MHz |
| Number of effective subcarriers | 300 |
| FFT length | 2048 |
| Sampling rate | 30.72 MHz |
| Multiplexing type | FDD mode |
| Channel model | ITU Pedestrian A (PedA) |

Figure 2. Peaks based on PSS and SSS cross-correlation at SNR of -6 dB.

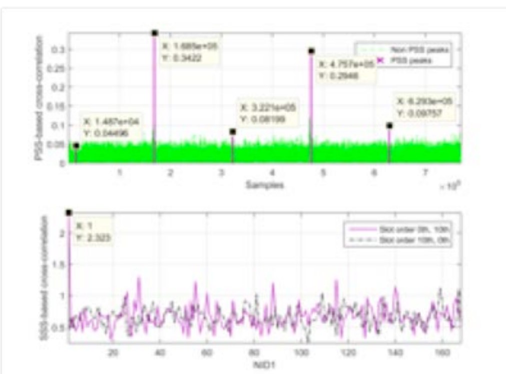



Fig. 2 shows snapshots of peaks based on the cross-correlation between pre-defined sequences with PSS and SSS signals at SNR of -6 dB. PSS-based peaks appear periodically in a half of LTE-A frame. The presence of LTE-A signals is detected by comparing the highest summation with a threshold. Then, the sector-identity can be identified corresponding to the highest summation with different pre-defined PSS sequences. The SSS-based peaks are categorized by two groups due to the slot order 0th or 10th, which conveys the SSS signal. The highest peak helps to identify the sector-group of the detected signals.

## V. CONCLUSIONS

In this paper, we proposed the spectrum sensing scheme for LTE-A signals in wideband spectrums. This scheme is based on an implementation of filter-bank realization to subtract sub-band signals from a wideband spectrum. The detection and classification of LTE-A signals are also carried out by the scheme. Our scheme is effective in realistic scenarios: multi-path fading channels, noise-uncertainty tolerance, and practical configuration parameters. The performances of our scheme are close to these of single channels. CR-enhanced LTE-A systems can be implemented with this scheme to handle sensing tasks effectively in wideband spectrums.

## ACKNOWLEDGMENT

This work was presented in our paper "Multi-Channel Spectrum Sensing Scheme with Filter-Bank Realization for LTE Signals," in COgnitive Radio Applications and aLgorithms (IEEE CORAL 2015), Boston, USA, Jun. 2015. It was supported in part by Federal Ministry of Education and Research (BMBF) of Germany under Project kogLTE/kogModul (FKZ16BU1213), and in part by the European Commission under Project ABSOLUTE (FP7-ICT-2011-8-318632). We also thank Dr. Hanwen Cao, our ex-colleague in the institute, for his contributions on this work.

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# SECTION 4. REPORT FROM SPONSORED EVENTS

**Third IEEE International Workshop on Emerging COgnitive Radio Applications and aLgorithms (IEEE CORAL 2015)**

IEEE CORAL is a young yet successful workshop which holds in conjunction with the World of Wireless and Mobile conference (WOWMOM). The objective of this workshop is to bring together practitioners and researchers from both academia and industry to discuss the recent advances in both the methodological, simulative and algorithmic aspects and the novel applications of cognitive radio technologies.

The Third CORAL workshop edition was held in Boston, on 14 June 2015, and it repeated the success of previous two events, with an outstanding number of paper submissions, and a good number of attendees. Based on the reviews performed by the PC members, **ten papers** were selected to be included in the final program. The workshop was opened by a Keynote speech held by **Prof. Alexander Wyglinski** on the topic of cognitive radio applications on vehicular systems. The **IEEE TCSIM** sponsored the Best Paper Award (BPA) and Best Student Paper Award (BSPA), which were assigned respectively to:

- *(BPA) Daiki Cho and Shusuke Narieda, for the paper A Weighted Diversity Combining Technique for Cyclostationarity Detection Based Spectrum Sensing in Cognitive Radio Networks*
- (BSPA) Trung Thanh Nguyen, Hanwen Cao, Theo Kreul, and Thomas Kaiser, for the paper A Multi-Channel Spectrum Sensing Scheme with Filter Bank Realization for LTE Signals

# SECTION 5. UPCOMING EVENTS AND CFPs

The IEEE TCSIM Newsletters will publish short technical papers. The submissions should emphasize modeling, design, and analysis of computational methods for simulations and its applications in various areas, including, but not limited to, computer science, engineering, communications, and simulation applications. The submissions are invited covering, but not limited to, the following topics:

- Simulation algorithm design, implementation, and analysis
- Simulation complexity in computing
- Parallel and distributed simulation
- Design and usage of simulation tools
- Real-time simulation monitoring
- Simulation tools for communications and networks
- Simulation of computer systems and applications
- Agent-based simulation tools focus on the use of agents in engineering, human and social dynamics, military applications
- Systems and process simulation
- Simulation of ubiquitous networking and computing
- Simulation of transportation systems
- Automotive simulation applications
- Building and energy management simulations
- Machine learning
- Virtual reality systems
- Knowledge and data systems
- Systems optimization
- Web-based simulation and applications
- Department of Defense Architecture Framework (DoDAF)-based network simulations
- DoDAF-based vulnerability assessment

**Submission**

All papers must be submitted to marco.difelice3@unibo.it in four pages or fewer, including all figures, tables, and references. A manuscript submitted for publication should be original work that should not have been previously published and should not be under consideration for publication elsewhere. If an author uses charts, photographs, or other graphics from previously printed material, he/she is responsible for obtaining written permission from the publisher to use the material in his/her manuscript. The maximal number of figures and tables are five, and the number of reference is limited to ten. Submissions exceeding this length will be returned without review. Papers should use 7.875in x 10.75 in (20cm x 27.30cm) trim size and the IEEE transactions two-column format in 10-pt. font. Please submit electronically in PDF file, and ensure that the submitted file can be viewed in Acrobat Reader 8.0. No hard copy is necessary. A standard IEEE copyright release will also be required before full acceptance. All papers must include the authors' affiliation and e-mail addresses of all authors. All papers will be fully refereed for accuracy, technical content, and relevance. Contact Dr. Marco Di Felice at marco.difelice3@unibo.it with any questions concerning the paper submission and review process, or questions regarding the relevance of a paper to the IEEE TCSIM Newsletters.

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