Cognitive Radio Experimentation World

Project Deliverable D8.2
Second Promotion and Dissemination Status Report

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Lead beneficiary:	IBBT
Authors:	Danny Finn (TCD), Stefan Bouckaert (IBBT), Ingrid Moerman (IBBT), Christoph Heller (EADS), Alejandro Sanchez (TCS), Peter Van Wesemael (imec), Jan Hauer (TUB), Nicola Michailow (TUD), Miha Smolnikar (JSI)
Reviewers:	Somsaï Thao (TCS), Mihael Mohorcic (JSI)
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Abstract: This deliverable compiles all the promotion and dissemination activity accomplished within the scope of WP8 during the second year of the project. These activities include scientific presentations, general presentations and demonstrations. The document also provides details on the strategy for the announcement of the second CREW open call for experimenters.

Keywords: dissemination, presentations, publications, demonstrations, network testbeds, federation, wireless networks, cognitive radio, cognitive network, benchmarking

REVISION HISTORY

Version	Date	Author	Description
0.0	03/07/2012	Alejandro SANCHEZ (TCS), Somsai THAO	Initial draft from CREW documents template
0.1	14/09/2012	Stefan Bouckaert (from input ALL)	Assembling of all information based on the collected input from templates
2.2	19/09/2012	Mihael Mohorcic (JSI)	Review
3.0	26/09/2012	Ingrid Moerman	Final editing

Executive Summary

This deliverable presents an overview of the CREW dissemination activities in year 2 of the project. Dissemination activities that are related to standardization or regulation are included in a separate deliverable, D8.3. In addition, the deliverable summarizes the promotion strategy that was followed for the second CREW open call.

List of Acronyms and Abbreviations

BSN	Body Sensor Networks
CN	Cognitive Networking
CR	Cognitive Radio
CREW	Cognitive Radio Experimentation World
DSA	Dynamic Spectrum Access
FER	Frame Error Rate
FIA	Future Internet Assembly
FIRE	Future Internet Research & Experimentation
ICT	Information and Communication Technologies
IEEE	Institute of Electrical and Electronics Engineers
Iris	Implementing Radio in Software
ISM	Industrial Scientific Medical
OC2	(CREW) Open Call 2
OFDM	Orthogonal Frequency Division Multiplexing
OMF	cOntrol and Management Framework
OOB	Out-Of-Band
RF	Radio Frequency
RFIC	Radio Frequency Integrated Circuit
SDR	Software Defined Radio
TWIST	TKN Wireless Indoor Sensor Network Testbed
USRP	Universal Software Radio Peripheral
VESNA	VErsatile platform for Sensor Network Applications
WPx	(CREW) Work Package x

Table of contents

1 Introduction

1.1 Scope

This document provides an overview of all WP8 promotion and dissemination activities. It compiles all the publications and dissemination activities that were undertaken by core members of the CREW consortium. The CREW dissemination activities that are led by partners that joined CREW as a result of the first open call are not included in this deliverable in order to avoid duplication: the dissemination activities of these partners will be included in a separate deliverable authored by the open call partners.

The content is offered in a slightly different way than was the case in D8.1: scientific publications are mostly linked to a presentation, a poster, or a demonstration. While in D8.1 these linked activities were mentioned multiple times (under the same reference) in different categories, in this deliverable they only appear under the "publication" category; where applicable, it is indicated whether a presentation or demonstration was linked to this publication.

In addition to this dissemination work belonging to activities 8.1.1 "Demonstrations" and 8.1.3 "Dissemination" of task 8.1, the document also provides an overview of the dissemination efforts for the second CREW open call (OC2) to date.

1.2 Document purpose and intended audience

D8.2 is a public deliverable, primarily targeting the European Commission staff as a report of external activities towards dissemination and external reaching of the project. It can help in measuring the impact of the project on the scientific community.

Moreover, it can provide good insights on the major outstanding contents to anyone interested in the CREW project.

2 Scientific publications

1 Van Wesemael, P., S. Pollin, M. Desmet, and A. Dejonghe, "Interference Robust SDR FE receiver", *IEEE Symposia on New Frontiers in Dynamic Spectrum Access Networks (DySPAN - demo track)*, Bellevue, USA, 10/2012.

Publication & demonstration
Abstract: Research on Dynamic Spectrum Access (DSA) has focused to a large extent on the reliable detection of signals at very low power levels, possibly even under the noise floor. However, many of those channels that are detected to be free are adjacent to used channels, with possibly very large power levels. As a result, the true DSA problem is not only reliable detection of free bands, but also robust operation next to used bands. In this demo we demonstrate an SDR RFIC which is robust against out-of-band interference. This robustness is achieved by improving the linearity of the SDR receiver significantly. The need for robustness is demonstrated in real time by showing the received constellation diagram of an 802.11af-like OFDM signal in the presence of a large out-of-band interferer. The wanted and interfering signal are received simultaneously by two generations of SDR RFIC's, showing both the performance degradation caused by interference from adjacent bands and the improvement enabled by the robust receiver.

2 Tallon, J., J. Kibilda, T. K. Forde, L. A. DaSilva, and L. Doyle, "Receiver-driven Handover between Independent Networks", *IEEE Symposia on New Frontiers in Dynamic Spectrum Access Networks (DySPAN – demo track)*, Bellevue, USA, 10/2012.

Publication & demonstration
Abstract: The purpose of this demonstration is to show handover with continuous service between two independent base-station entities belonging to different operators. The handover occurs without any link layer connection between the base-stations and without prior knowledge of base-station operating frequencies or channelization on the part of the receiver. To achieve this, the system employs a receiver-driven approach to the handover.

3 Heller, C., C. Bluemm, S. Bouckaert, W. Liu, I. Moerman, P. Van Wesemael, S. Pollin, T. Solc, and Z. Padrah, "Spectrum Sensing for Cognitive Wireless Applications Inside Aircraft Cabins", *Digital Avionics Systems Conference*, Williamsburg, VA, IEEE, 10/2012.

Publication & presentation
Abstract: Wireless intra-aircraft communication is expected to be the enabler for more flexible avionic systems and the reduction of weight and cost in system installations. An alternative to the usage of a dedicated frequency band for wireless intra-aircraft avionics could be the usage of a virtually unregulated ISM band. Cognitive radio techniques could be used to increase system robustness in the likely case of interferences in this kind of frequency bands. A cognitive wireless cabin management system is discussed as a use-case for the validation of this approach. Using the mobile cognitive radio testbed of the FP7 project CREW, spectrum sensing experiments are carried out in a realistic aircraft cabin environment as a baseline for the development of suitable cognitive protocols and to record interference scenarios for the further system design.

4 Smolnikar, M., T. Šolc, Z. Padrah, M. Vučnik, and M. Mohorčič, "Eksperimentalno senzorsko omrežje LOG-a-TEC za razvoj in testiranje principov kognitivnega radia (en. Experimental sensor network LOG-a-TEC for the development and testing of cognitive radio principles)", *19. Seminar Radijske komunikacije (SRK 2012)*, Ljubljana, Slovenia, 09/2012. [in slovene]

Publication & presentation
Abstract: An outdoor sensor network based testbed LOG-a-TEC is one of the 5 testbeds federated in the FP7 project CREW, made available for the experimenting in the area of cognitive radio and cognitive networks. In this contribution we describe: the overall setup of the LOG-a-TEC testbed; its basic building block wireless sensor network platform VESNA, which was extended to support spectrum sensing in the ISM and UHF frequency bands; the basic experimental scenarios, supported by the LOG-a-TEC testbed; and some examples of possible experiments.

5 Padrah, Z., D. Denkovski, L. Gavrilovska, and M. Mohorčič, "Integrating the low-cost low complexity VESNA spectrum sensor into a heterogeneous spectrum sensing platform", *3rd COST IC0902 Workshop*, Ohrid, Macedonia, 09/2011.

Extended abstract & presentation
Abstract: Spectrum sensing is one of the essential functions of a cognitive radio system. Using multiple devices of different types for spectrum sensing can increase the accuracy of the sensing. In this paper we present the integration of the VESNA spectrum sensing platform into a heterogeneous sensing system. A sensing experiment has been carried out with the integrated system and based on the collected data the correct functioning of the integrated system is verified.

6 Van Wesemael, P., W. Liu, M. Chwalisz, J. Tallon, D. Finn, Z. Padrah, S. Pollin, S. Bouckaert, I. Moerman, and D. Willkomm, "Robust distributed sensing with heterogeneous devices", *Future Network & Mobile Summit*, 07/2012.

Publication & presentation
Abstract: In the ISM band multiple wireless technologies compete for a limited amount of spectrum, leading to interference and performance degradation. Reliable information on the spectrum occupation enables more optimal usage and can improve co-existence in the ISM band. In this paper, we study the robustness of the information obtained about the propagation environment when sensing with multiple, heterogeneous devices, at multiple diverse locations. More specifically, we look into the impact on the path loss estimation depending on the type, number and the location of the sensing devices. The analysis in this paper is done based on indoor measurements in the ISM band. Based on the presented measurements and analysis we conclude that analysis based on only one device type or in specific locations can lead to suboptimal or even incorrect estimation results.

7 Bouckaert, S., P. Becue, B. Vermeulen, B. Jooris, I. Moerman, and P. Demeester, "Federating wired and wireless test facilities through Emulab and OMF: the iLab.t use case", *Tridentcom*, Thessaloniki, Greece, 06/2012.

Publication & presentation
Abstract: The IBBT iLab.t technology centre provides computing hardware, software tools and measurement equipment to support researchers and developers in building their ICT solutions, and in measuring the performance of these solutions. Among other things, the iLab.t hosts several generic Emulab-based wired test environments called the Virtual Walls, and two wireless test environments which are grouped under the name w-iLab.t. Until very recently, these wired and wireless test facilities each had their own history: they were deployed and maintained by a different group of people, were operated using different tools, and each had their own community of experimenters.

This paper provides insight on the origin and evolution of the Virtual Wall and w-iLab.t facilities. It explains how these facilities were federated, by using the best parts of both the OMF and Emulab frameworks. It discusses the benefits of our local federation as well as our future federation plans.

8 Bouckaert, S., B. Jooris, P. Becue, I. Moerman, and P. Demeester, "The IBBT w-iLab.t: a Large-scale Generic Experimentation Facility For Heterogeneous Wireless Networks", *Infinity Workshop at Tridentcom 2012*, Thessaloniki, Greece, 06/2012.

Publication & presentation
Abstract: The w-iLab.t is a large-scale generic wireless experimentation facility. Over 260 wireless nodes are installed at two different locations. Every single wireless node is equipped with multiple wireless technologies, namely IEEE~802.15.4, Wi-Fi a/b/g(/n), and on some devices also Bluetooth. Additionally, w-iLab.t provides access to software defined radio platforms and also uses them to characterize the wireless environment during an experiment. The w-iLab.t flexibility and its tools enable experimenters to design and schedule a wide range of wireless experiments, and to collect and process results in a user-friendly way.

9 Hauer, J. - H., and D. Willkomm, "An Empirical Study of Urban 2.4 GHz RF Noise from the Perspective of a Body Sensor Network", *International Conference on Wearable and Implantable Body Sensor Networks (BSN2012)*, London, UK, 05/2012.

Publication & presentation
Abstract: In the 2.4 GHz ISM band RF interference is becoming an ever-increasing problem. While there have been several attempts to mitigate the impact of RF interference on (body) sensor networks, e.g. via frequency hopping, it is often unclear how these solutions perform in different interference environments and when they are actually useful. This is not least due to a lack of knowledge about the characteristics of environmental 2.4 GHz RF noise as perceived by a BSN in realistic scenarios. Such knowledge would, for example, help to better understand the communication challenges in a BSN and derive design decisions for interference mitigation techniques. Our work targets this under explored area: we present the results from an urban measurement campaign, in which a mobile BSN collected about half a billion RF noise samples in various urban environments (park, campus, residential area, shopping street, urban transportation system). Our setup captured the entire 2.4 GHz band, on five different body positions simultaneously. Among other things, our results indicate that WLAN was the dominating source of 2.4 GHz RF noise, significant spectrum activity was typically detected during about 5% of the time, but there is a large variation among the scenarios, and, to detect the presence of RF interference the body position is of no of major importance, however, the difference in interference power measured at two different body positions is not negligible.

10 Liu, W., L. Bienstman, B. Jooris, O. Yaron, and I. Moerman, "FPGA-based Wireless Link Emulator for Wireless Sensor Network", *Tridentcom*, Thessaloniki, Greece, 05/2012.

Publication & demonstration
Abstract: Wireless sensor testbeds lack the flexibility for topology control and the accuracy for interference generation. Once the testbed is set up, the topology becomes fixed. Due to the nature of the wireless environment, experimenters often suffer from unpredictable background interference, while at the same time, find it hard to get accurate and repeatable interference sources. The wireless link emulator addresses these issues by replacing the uncontrollable wireless link by a well-controlled and programmable hardwired medium. A radio interface is then made to behave according to the link configuration, thus offering flexibility for both topology and interference control. This paper describes the implementation of the wireless link emulator based on a number of low-cost Xilinx FPGA's. The system is verified experimentally and compared to existing emulation systems.

11 Padrah, Z., Šolc, T., and Mohorčič, M., "VESNA based platform for spectrum sensing in ISM bands", *4th International Postgraduate School Students Conference (IPSSC)*, Ljubljana, Slovenia, 05/2012.

Publication & Poster
Abstract: The radio spectrum used by wireless communication systems is becoming increasingly crowded. One approach to overcome this problem is to perform real-time dynamic spectrum assignment. To this end, it is necessary to collect information about the radio spectrum, also called spectrum sensing. In this paper a framework is presented which can be used for collecting information about radio spectrum usage. This framework is based on the low-cost and versatile VESNA sensor platform. A spectrum sensing experiment has been performed in the 2.4 GHz to demonstrate the capabilities of the framework.

12 Bouckaert, S., P. Van Wesemael, J. Vanhie-Van Gerwen, B. Jooris, L. Hollevoet, S. Pollin, I. Moerman, and P. Demeester, *Distributed Spectrum Sensing in a Cognitive Networking Testbed*, vol. 6994, Berlin, Heidelberg, Springer Berlin Heidelberg, pp. 325 - 326, 10/2011.

Publication & demonstration
Abstract: The field of experimentally supported research in wireless networks has received increasing attention from the international research community. Multiple well-established wireless networks such as TWIST, w-iLab.t, Motelab, or Orbit have now been in use for multiple years, and many of these testbeds are now also putting effort in federating their facilities. One of these federations, the CREW (Cognitive Radio Experimentation World) federation (www.crew-project.eu), is bringing together the hardware, software, and expertise from multiple European wireless testbeds, with the aim of facilitating experimental research in the field of cognitive radio, cognitive networking and advanced spectrum sensing.

13 Liu, W., O. Yaron, I. Moerman, S. Bouckaert, B. Jooris, and P. Demeester, "Real-time wide-band spectrum sensing for cognitive radio", *2011 18th IEEE Symposium on Communications and Vehicular Technology in the Benelux (SCVT)*, Ghent, Belgium, IEEE, pp. 1 - 6, 10/2011.

Publication & presentation
Abstract: Cognitive radio has received considerable amount of attention as a promising technique to provide dynamic spectrum allocation. Wide-band spectrum sensing is the corner stone for cognitive radio to be functional. Most existing commercial sensing solutions lack either the required flexibility or speed. Software-defined radio (SDR) on the other hand offers very high flexibility and therefore becomes a common platform for CR implementation. Among various SDR platforms, the universal software-defined radio peripheral (USRP) gained broad popularity. This paper presents a real-time wide-band-capable spectrum sensing solution based on USRP. The concept of energy detection and the methodology for wide-band sensing are explained. Finally, the performance of the proposed sensing solution is verified and compared with another popular commercial sensing solution, Airmagnet.

14 Fortuna, C., Mihelin, M., Z. Padrah, and O. Holland, "A Common Data Format for Spectrum Sensing Information", *2nd COST IC0902 Workshop*, Castelldefels, Spain, 10/2011.

Extended abstract & presentation
Abstract: This contribution suggests a format for spectrum sensing information compatible with the IEEE 1900.6 Standard, and also serving the requirements for representation, communication, and utilization of spectrum sensing information within the CREW federation. The IEEE 1900.6 standard does not specify experiment description, nor the specific data format for storage, but mainly focuses on interfaces between Sensors and Cognitive Engines/Data Archives.

15 Mohorčič, M., C. Fortuna, M. Smolnikar, "Heterogeneous ISM/TVWS Bands Cognitive Radio Testbed: Extending the CREW federation", *2nd COST IC0902 Workshop*, Castelldefels, 10/2011.

Extended abstract & presentation
Abstract: CREW project decided to extend the federation of four CR testbeds with a complementary large-scale outdoor testbed based on low-cost, low-complexity sensor node platform VESNA for testing CR systems using the geo-location and database approach. This testbed will consist of a fixed heterogeneous outdoor sensor network deployed on the public lighting infrastructure in a mixed rural/built-up environment for coordinated low-cost basic (using VESNA platform) and advanced (using USRP software radios) spectrum sensing in the ISM and TV frequency bands.

3 Other presentations

Some of the presentations below are presentations on invitation, not linked to any peer-reviewed publication. Nevertheless, these presentations contributed to the dissemination of the CREW project and are therefore important to list. These presentations are also often used to announce open calls.

Still other presentations below are a result of a peer-reviewed extended abstract (without "official" publication).

16 Smolnikar, M., "LOG-a-TEC: An experimental sensor network testbed for spectrum sensing and cognitive radio", *8th Technical Meeting of WUN Cognitive Communications Consortium*, Paris, France, 08/2012.

Presentation
Abstract: This presentation discusses the outdoor LOG-a-TEC testbed based on wireless sensor network in the light of CREW project, where it represents one of the five federated testbeds for experimentally driven research on spectrum sensing, cognitive radio and cognitive networking.

17 DaSilva, L., "CREW: Shape-Shifting Wireless Networks: The Role of TV Spectrum in Future Network Architectures", *Future Network & Mobile Summit 2012*, Berlin, Germany, 07/2012.

Invited presentation; no abstract available

18 Liu, W., S. Pollin, P. Van Wesemael, D. Finn, C. Heller, M. Chwalisz, D. Willkomm, N. Michailow, Z. Padrah, I. Moerman, and S. Bouckaert, "A Set of Methodologies for Heterogeneous Spectrum Sensing", *SDR'12-WinnComm-Europe conference*, Brussels, Belgium, 06/2012.

Presentation
Abstract: Cognitive radio has received tremendous amount of attention in the academic world. As a key enabler for cognitive radio, the spectrum sensing technology faces many challenges. The real-life wireless communication often happens in a heterogeneous environment, hence, how to combine sensing results obtained with heterogeneous devices is one of the biggest challenges. In order to have a valid heterogeneous sensing system, many issues need to be, such as the calibration among heterogeneous devices, post processing for the obtained data in different formats, what is the most efficient way for combining data, and many other aspects. In this work we present a set of methodologies that have been derived in the scope of the CREW project to deal with some common issues encountered for heterogeneous sensing. The FP7 project CREW (www.crew-project.eu) targets the

development of a federated testbed for cognitive radio systems by physically and virtually interconnecting radio equipment of the individual project partners. By combining the spectrum sensing devices from each project partner, we are able to form a sensing platform with many popular heterogeneous devices. These devices include dedicated integrated sensing hardware (imec sensing engine), USRP software-defined radios (SDRs), small, low power sensor nodes (TelosB), off-the-shelf, low cost USB spectrum analyzers (WiSpy) as well as high cost, high precision spectrum analyzers. The presentation will start with a series of heterogeneous and distributed sensing experiments that we performed as background information. The aim of those experiments was originally to compare the performance of different sensing devices. However, during those experiments we have gradually formed a system to properly process distributed data and calibrate heterogeneous devices. The derived methodologies are covered next. The main focuses here are the measurement we performed to compensate for the hardware heterogeneity, and the common data format we derived to overcome the software difference. Finally we also propose some principles we adopted to detect outliers in the heterogeneous distributed sensing experiment. This work is not about analyzing results from any particular heterogeneous sensing experiment, but rather to learn from all the experiments from a methodology point of view. It can serve as a reference for future work in heterogeneous sensing.

19 Smolnikar, M., "Experimentally Driven Research on Wireless Sensor Networks", *Panel: Open Innovation in IoT for Business, Academia and Society, 25th International Conference eCollaboration: Overcoming Boundaries Through Multi-Channel Interaction*, Bled, Slovenia, 06/2012.

Panel presentation
Abstract: As an invited panellist Miha Smolnikar gave a presentation on using the wireless sensor networks for experimentally driven research in the areas of communication protocol development and testing, cognitive radio and networking, Internet of Things and smart cities. As an example, the characteristics of existing LOG-a-TEC testbed and possibilities for its expansion were discussed.

20 DaSilva, L., "The CREW project: experimental validation of cognitive radio, cognitive networking and spectrum sensing concepts", *CREW workshop at the Future internet week*, Aalborg, Denmark, 05/ 2012.

Presentation
Abstract: The main target of FP7-CREW is to establish an open federated test platform, which facilitates experimentally-driven research on advanced spectrum sensing, cognitive radio and cognitive networking strategies in view of horizontal and vertical spectrum sharing in licensed and unlicensed bands. In the opening talk, the relevance of experimentation for the field of CR/CN en spectrum sensing is discussed. In addition, the audience will learn how CREW can help them in executing CR, CN and sensing experiments.

21 DaSilva, L., and I. Moerman, "Opportunities for cooperation on cognitive radio / cognitive networking”, *FIRE Thematic pre-FIA Workshop 4: Brazil-EU cooperation in ICT Research and Development*, Aalborg, Denmark, 05/2012.

Presentation & video
Comments: During this workshop, the CREW project was briefly introduced. More importantly, a view on possible EU-Brazil collaboration topics was presented. Video: http://webcast.ec.europa.eu/eutv/portal/ism/_v_fl_300_en/player/index_player.html?id=14975 &pId=14963.

22 Moerman, I., "Metrics and measurement tools for assessing the channel condition in a wireless experimentation environment", *FIRE Thematic pre-FIA Workshop 2: Workshop on Measurement and Measurement Tools*, Aalborg, Denmark, 05/2012.

Presentation
Abstract: Novel wireless solutions, in particular new cognitive radio and networking concepts, require a rigorous experimental validation prior to uptake in wireless standards and commercial products. Wireless experimentation is very challenging, as experiments may be impaired by unwanted/uncontrolled interfering signals in the wireless environment. Within CREW a benchmarking methodology is developed to support the experimenter in getting more reliable and comparable results when executing their experiments. In this talk we will focus on a method for measuring the channel occupation during a wireless experiment. First we will explain how we can measure and score the channel condition in a wireless experimentation environment. Next we will show that the metrics for the channel condition can be used at the same time (1) to validate the performance of cognitive wireless solutions in ISM bands and (2) to improve the efficiency of wireless experiments.

23 Smolnikar, M., "Sensor Networks as Infrastructure for the Internet of Things", *Living bits and things 2011*, Ljubljana, Slovenia, 11/2011.

Presentation
Abstract: The Internet of Things (IoT) paradigm is widely recognized as the next big revolution of the Internet. One of the fundamental technologies that will enable the interactions with and among “things” are wireless sensor networks (WSN), which are yet evolving from dedicated, homogeneous and small-scale solutions to heterogeneous, self-configurable and large-scale networks of shared resources. The aim of the first part of the talk is to present and discuss WSN technologies, requirements for the design of a WSN node hardware and software, and the role of WSN gateways. This framework presents the basis for the design of VESNA platform, which will be discussed in the second part of the talk. It is a high performance WSN platform with modular structure, long-life autonomy and flexible radio. Its wireless interface spans over several industrial, scientific and medical frequency bands and supports multiple communication technologies. Various sensors as well as actuators can be connected via digital and analog peripherals, making the platform adaptable to diverse application requirements. The final part of the talk provides a short overview of SensorLab projects and discusses the experiences gained in the setups of testbeds and real-life deployments, the largest being LOG-a-TEC for the need of CREW project.

4 Demonstrations

The “scientific publication” section of this document already indicated that several demonstrations were given as a result of the acceptance of a peer-reviewed publication. In this section, additional CREW demonstrations –those that are not attached to peer-reviewed publications– are listed:

24 Selim, A., and J. Kibilda, "Real-time Interference Reduction for OFDM Systems", *Future Network & Mobile Summit 2012*, Berlin, Germany, 07/2012.

Demonstration
Abstract: One of the main challenges in Dynamic Spectrum Access (DSA) networks is how to effectively utilize the available spectrum holes ensuring that no harmful interference is created to the primary systems and among secondary users. Within the proposed experiment we focus our attention on the problem of adjacent channel interference that may arise in OFDM-based systems due to the out-of-band (OOB) emissions. In practical systems the problem is typically resolved with the standardized frequency domain guard bands, which,

however, reduce the spectral efficiency of the system. Alternatively, the system transmitters may perform spectrum shaping (interference reduction) which reduces the OOB emissions considerably. This is mostly achieved at the cost of high computational complexity which makes it infeasible for real-time operations. However, within our experiment we show that spectrum shaping can be done in real-time using our two novel spectrum shaping techniques. The whole demonstration presents a DSA system consisting of a cognitive femtocell node, which realizes a cognitive control channel operation, and two transmitter-receiver pairs, which perform either data or video transmissions. The setup allows us to observe a negative effect of the interference caused by adjacent channel operation, i.e. high frame error rate (FER) experienced by the receivers. The presented DSA system is able to react upon the high FER by performing dynamic reconfiguration based either on secondary user reallocation (i.e. guard band insertion) or spectrum shaping with any of the two proposed techniques. Effectively, the demonstration will show that both reallocation and spectrum shaping can eliminate the interference, while our proposed real-time spectrum shaping techniques outperform user reallocation in terms of spectrum utilization. The demonstration will be performed as a remote experiment based on a flexible cognitive radio platform located in TCD testbed and operated through the CREW federated platform portal. The hardware components of the platform include four Quad core working stations, each connected to the Universal Software Radio Peripheral (USRP) and corresponding XCVR2450 daughterboard. The USRPs serve as a radio frontend for reconfigurable radio software engine, known as Iris (Implementing Radio in Software). Iris virtualizes functional blocks for signal operations, allowing to dynamically manage and reconfigure them during system run-time. In the course of our demonstration we will utilize Iris to alter carrier frequency and signal structure (i.e. by performing spectrum shaping) in real-time. The experiment will be monitored with a remotely accessed spectrum analyzer.

25 Vučnik, M., and M. Mohorčič, "LOG-a-TEC: Cognitive Radio Networking Testbed", *Future Network & Mobile Summit 2012*, Berlin, Germany, 07/2012.

Demonstration & Poster
Comment: Demonstration of spectrum sensing in UHF and ISM bands using the VESNA Platform as well as demonstration of remote access to the testbed via JSI portal were given.

26 Chwalisz, M., C. Fortuna, and M. Vučnik, "Wireless experimentation of cognitive radio networking solutions", *Hands-on-FIRE! Demo session* organized at the *Future Internet Assembly (FIA)* in Aalborg, Denmark, 05/2012.

Demonstrations & Posters
Info and abstracts: the Hands-on-FIRE demo session showed a wide range of FIRE projects performing live demonstrations to the audience. From CREW side, two demonstrations were presented:

- Mobile experiments in a cognitive radio testbed: In this demo we showed how a subset of the testbed infrastructure provided by the CREW (Cognitive Radio Experimentation World) project can be accessed remotely to conduct experiments in the field of cognitive radio. We used the TWIST testbed located at Technical University Berlin (TUB), Germany, to build an RF noise environment map for the department building. In the experiment a mobile robot, located at the Berlin island of the CREW platform, was equipped with a sensing agent that continously measured 2.4GHz RF noise. The path of the robot was controlled remotely (from Aalborg) and the measured data was visualized in realtime. In addition, a signal generator at TUB premises was also controlled remotely to emit RF noise in different parts of the spectrum, enabling a repeatable wireless environment.
- Capabilities of new Slovenian island: In this demo we showed VESNA - the platform that is underlying the new testbed of the CREW federation located in Slovenia. We showed the VESNA hardware and software modules, their spectrum sensing

capabilities, extensions, remote over the air reconfiguration and reprogramming. More specifically, VESNA is composed of four modules SNC (Sensor Node Core), SNR (sensor node radio), SNP (sensor node power) and SNE (sensor node expansion). The four modules can be layered in a sandwich for applications and we showed the layering for spectrum sensing applications. Spectrum sensing capabilities were demoed in ISM bands. Finally, the over the air re-programming protocol was also demoed, supporting remote experiment configuration and execution.

5 Workshops & Tutorials

27 Bouckaert, S., I. Moerman, S. Pollin, and A. Alonso, "Using CREW: a federated platform for experimentally-supported research on cognitive networks and spectrum sensing", *Tutorial 1.2 at the SDR'12-WinnComm-Europe conference*, Brussels, Belgium, 07/2012.

Tutorial

Abstract: The aim of the FP7-Call5 project CREW (Cognitive Radio Experimentation World) is to create an open federated testbed for the evaluation of cognitive radio and cognitive networking strategies. Experiments can be executed at 5 CREW test sites across Europe, located in Belgium, Germany (x2), Ireland and Slovenia, offering a diverse set of wireless technologies including heterogeneous ISM, heterogeneous licensed cellular, wireless sensor, and heterogeneous outdoor wireless networks. Since the start of the project in October 2010, the baseline testbeds of the testbed owners in the consortium have been extended with advanced sensing hardware developed by other partners in the consortium. Additionally, federation functionality such as a benchmarking framework allowing the comparison of different cognitive solutions, a common data format to store and share the experiments and experimental results, and mix-and-match interfaces that can be used to combine cognitive components from different partners were developed. Finally, a portal website was created (www.crew-project.eu/portal), which offers a single point of entry to experimenters, and provides information on the different facilities in the CREW testbed and how to access them. Early 2012, three additional partners joined the CREW project for the duration of one year after being selected as part of an open call for experimenters, to execute their experiments on top of the CREW testbed offered by the eight core partners of the consortium. While the former partners are using the current CREW testbed for the execution of their experiment, the other partners plan to improve the functionality offered by the federation in the coming months.

Tutorial program

1. In the first part of the tutorial, an overview of the federated CREW facility will be given, and the goal and use of selected CREW federation functionalities such as the common data format or the benchmarking framework will be explained. [Presenter: I. Moerman, IBBT. Duration: 30']

The second and most important part will illustrate how the CREW facility can be used to evaluate cognitive radio/networking solutions, by presenting three concrete use cases that have been investigated using the CREW federation:

2. The CREW federation houses a broad range of spectrum sensing equipment, from off-the-shelf sensor nodes such as WiSpy devices, to specialised sensing engines that are custom-built by partners of the consortium. We demonstrate the technical background behind, the advantages of, and the experimentation possibilities enabled by integrating advanced sensing components in a cognitive networking testbed. [Presenter: S. Pollin, imec. Duration: 20']
3. In past experiments performed by the CREW consortium, a common data format and benchmarking methodologies have been used to compare the different sensing devices

that are present in the CREW consortium. Through this example, it will be explained to the audience how the benchmarking and common data aspects of the CREW federation contribute to making fair comparison of different cognitive solutions a possibility. Additionally, the results of the sensing device comparison experiment are briefly presented. [Presenter: S. Bouckaert, IBBT. Duration: 20']

4. Testimonial from an open call partner. Tecnalia is one of the three partners that was accepted as part of the first open call for experimenters. In this talk, it will be discussed how CREW will be used to carry out an experiment focussing on the assessment of benefits of optimized linear collaborative multiband spectrum sensing in cognitive radio networks. [Presenter: A. Alonso Muñoz, TECNALIA-Telecom. Duration: 20']
5. Before finishing with a Q&A, in a final part of the tutorial, we will show how the audience can learn more about the CREW federation and/or access the federated testbed, by demonstrating the use of the federated portal. Furthermore, we will share preliminary information on the second open call, which allows selected experimenters to become part of the CREW project and to get funded for executing their cognitive radio and cognitive networking experiments. [Presenter: I. Moerman, IBBT. Duration: 30']

For the audience of the conference, this tutorial provides the opportunity to learn about the CREW project and about the existing possibilities of experimental research related to cognitive radio and cognitive networks in general. For the members of the CREW consortium, it is an interesting opportunity to meet the cognitive radio and cognitive networking experimenter community, whose comments and questions will help to shape the future of the CREW federation in a demand-driven way.

28 Moerman, I., *FIRE workshop 1: Experimental validation of cognitive radio/cognitive networking solutions, Future Internet Week*, Aalborg, Denmark, 05/2012.

Workshop

During the FIRE week in Aalborg, CREW organized a workshop on Experimental validation of cognitive radio/cognitive networking solutions. The workshop took place on Wednesday, May 9 2012. In addition to various external speakers, the afternoon part of the session was used to present four CREW tutorials to the public:

- Chwalisz, M., "The Twist testbed", *CREW tutorial, Future Internet Week*, Aalborg, Denmark, 05/2012.
- Bouckaert, S., "The w-iLab.t testbed", *CREW tutorial, Future Internet Week*, Aalborg, Denmark, 05/2012.
- Fortuna, C., and M. Vučnik, "LOG-a-TEC testbed: Cognitive Radio Networking Experimentation Using the VESNA Platform", *CREW tutorial, Future Internet Week*, Aalborg, Denmark, 05/2012.
- Forde, T. K., "The Iris Software Defined Radio Testbed", *CREW tutorial, Future Internet Week*, Aalborg, Denmark, 05/2012.

6 Open Calls

6.1 Networking at events and presentations

During several of the presentations and workshops mentioned above, the second CREW open call was promoted by adding open call slides to the slide deck. Especially during tutorials and workshops, but by extension whenever there was a possibility and a relevant target audience during other events and meetings (not necessarily linked to CREW), the CREW second open call was also discussed and/or promoted.

In addition to these planned and opportunistic promotion opportunities mentioned above, a dedicated announcement session for the second CREW open call was organized at the Future Network and Mobile Summit in Berlin, Germany, July 4 2012. During this event, details on the second open call were shared. The presentation and the relevant documentation (Guide for applicants, Open call announcement document) are available from the open call website, http://www.crew-project.eu/opencallinfo.

During the same event in Berlin, there was also a CREW booth from July 4 to July 6 2012. At this booth, participants of the conference could not only take a look at the demonstrations: the opportunity was also offered to talk with members of the CREW consortium about the open call.

6.2 Additional ways of promoting the open call

- **CREW website:** the old open call pages were archived, and a new open call section was added to the website.
- **CREW mailing list:** People expressing their interest in the open call during events and conferences are encouraged to subscribe to the CREW mailing list. The open call events are promoted on the CREW mailing list. From the website statistics, it can be seen that this leads to a significant increase of traffic to the website, as can be observed in Figure 1. There are clear peaks in the first half of July, which is right after the mailing related to the announcement of the open call and the announcement session on the Future Network and Mobile Summit in Berlin. There are also clear peal in September presumably due to the preparartion of open call proposals.
- **Advertisements:** as required by the European commission, advertisements were published in three national newspapers, and in a journal (see Figure 2 and Figure 3).
    - **Journal:** IEEE Communications Magazine, August 2012
    - **Newspaper 1:** De Tijd / L'Echo (Belgium): Saturday August 18, 2012
    - **Newspaper 2:** Tagesspiegel (Germany): Sunday August 19, 2012
    - **Newspaper 3:** DELO (Slovenia): Thursday August 23, 2012
- **Dresden Mobile Newsletter:** In the quarterly newsletter of the Technical University Dresden of June 30th, 2012, an entire page is devoted to CREW and more specifically, to the second open call.

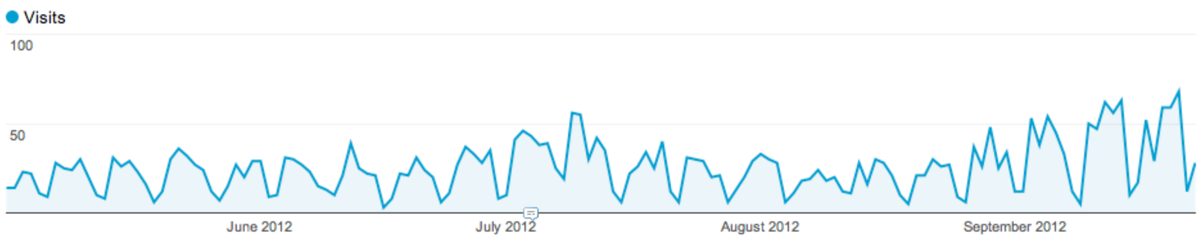

Figure 1: Visits to CREW website from 1 May 2012 until 23 September 2012

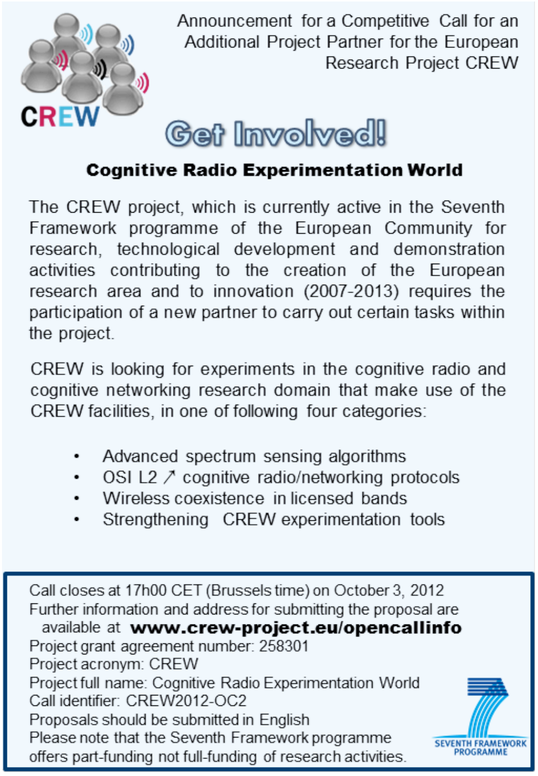

Figure 2: OC2 advertisement, as used for publication in IEEE Communications Magazine.

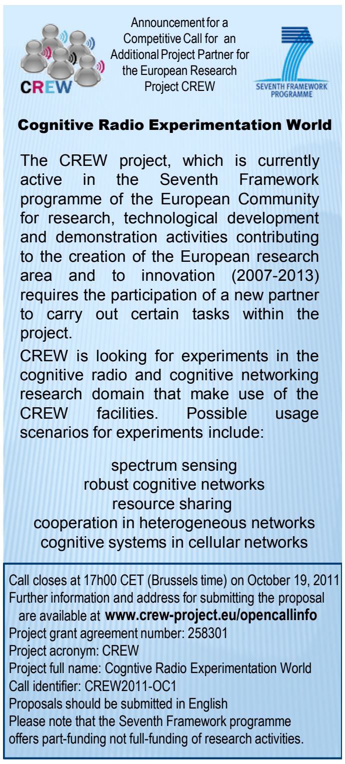

Figure 3: OC2 advertisement, as published in newspapers De Tijd / L'Echo (Belgium, left) and DELO (Slovenia, right).

7 Conclusion

From the list of events and publications above, it can be seen that CREW continued its dissemination activities during the second year. As last year, the open call was launched in a sufficiently early stage, advertisements were published, and the website was updated as to reflect the actual state of the CREW federation.