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DISSEMINATION LEVEL		
PU	Public	**X**
PCA	Public with confidential annex	
CO	Confidential, only for members of the consortium (including Commission Services)	

EXECUTIVE SUMMARY

The work of SACRA develops into a number of different directions, ranging from basic research into new approaches and technologies for future communication systems, to application of technologies and techniques in existing architectures and systems. This also includes investigations into the business cases for these new technologies and approaches, as well as studies on the potential impact of the considered technologies and whether working on them actually does make sense from a business perspective.

There is, however, a range of issues that all this work has in common:

- the work needs to be disseminated to get a wider consensus about the applicability of the findings
- the techniques investigated need to find their way either directly into products, or into standards, to make sure that the communication systems that will use these techniques will be able to interoperate
- as SACRA addresses regulated communication systems, it needs to be made sure that the technologies researched, once they enter the market, may actually be used
- there is an economical incentive to pursue this research and in one way or another, the results obtained will need to be exploited to justify the work.

The SACRA project is following an integrated approach to these issues. In this direction, the present document provides an overview into the activities and plans for regulation, standardization, dissemination and exploitation that have already been achieved and are further expected to be accomplished throughout the remaining lifetime of the SACRA project.

More specifically, a detailed and multifaceted dissemination and exploitation process has been initiated, that is aiming to utilize various different tools in order to facilitate wide dissemination of the SACRA outcomes. The considered approach combines the publication of already emerged technical outcomes to appropriate international conferences, workshops and journals as well as to scheduled organization of SACRA workshops and training events. Interactions with other EU projects working on similar technical areas are also been pursued through the participation in European Commission concentration and cluster meetings. Furthermore, a strong on-line presence is maintained in order to guarantee the availability of up to date information about the main technical directions and key outcomes of the consortium. Finally, industrial level exploitation of the project outcomes is targeted through the submission of contributions in related standardization bodies.

TABLE OF CONTENTS

1 INTRODUCTION

One of the main goals of the SACRA project is to provide a rather holistic approach that surpasses the strict research bounds and further strives to place its outcomes in the wider, industry relevant community. To this direction, Work Package WP7 of the SACRA project focuses on the identification of opportunities for the promotion of SACRA outcomes to different interest groups and on the implementation of the resulting dissemination plan. The scientific community, the industry, various standardization groups and regulation authorities are identified as target groups.

Under this prism, the following issues have to be taken into account during the SACRA lifetime:

- the work needs to be disseminated to get a wider consensus about the applicability of the findings
- the techniques investigated need to find their way either directly into products, or into standards, to make sure that the communication systems that will use these techniques will be able to interoperate
- as SACRA deals with regulated communication systems, it needs to be made sure that the technologies researched, once they enter the market, may actually be used
- there is an economical incentive to pursue this research and in one way or another, the results obtained will need to be exploited to justify the work

Dissemination objectives of SACRA project include participation in international workshops and conferences, organization of workshops, scientific publications in international journals and various training activities. Another important goal of the consortium is to promote relevant SACRA outcomes into standardization bodies. Main standardization targets constitute the 3GPP Release 11+, the IEEE SCC41, and the ETSI RRS. All actions taken during the dissemination process aim to create strong awareness of scientific solutions proposed by SACRA and to facilitate their adoption by both society and industry.

The SACRA project has developed an integrated approach to these issues in accordance to the Technical Annex; this document provides an overview into the activities related to standardization, dissemination and exploitation taken place during the second year of the project, as well as plans that could be achieved throughout the remaining duration of the SACRA. More specifically, Deliverable 7.1 volume 2 provides an extensive presentation of the related achievements, and further elaborates on the dissemination and exploitation plans, which include participation in upcoming conferences and workshops, publications of SACRA outcomes to peer reviewed magazines and journals with high Impact Factors, project online presence through its website (http://ict-sacra.eu) and other dissemination related actions. More precisely, the structure of this deliverable is the following:

Section 2 provides a detailed description of the proposed dissemination plan, the identified dissemination opportunities and the way the consortium plans to further orchestrate and implement the specific actions. Moreover, open source activities are addressed.

Section 3 summarizes the dissemination outcomes achieved so far. Additionally, it presents metrics used to assess the impact of each dissemination opportunity such as the impact factor that determines the quality of a journal or the acceptance rate and the h-index that constitute criteria of the quality of a conference. In SACRA dissemination these metrics are used as indicators to target more impacting publications. Using these guidelines, already in its second year the SACRA project has published or submitted papers in events with high impact factors.

Section 4 outlines standardization and exploitation activities such as dissemination of project results to standardization bodies, regulation meetings and organization of training activities, as well as project liaisons.

Section 5 provides a detailed view of exploitation plans. More specifically, it presents various foreground types that consortium has achieved and the plans for future use.

Section 6 presents patents that have been filed under the SACRA Project.

Section 7 concludes the document with a brief summary.

2 DISSEMINATION PLAN

As described in SACRA Annex I ("Description of Work", 15.10.09), dissemination is considered as a key activity and, therefore, it is an essential element of the SACRA strategy to disseminate widely and with the maximal impact the project outcomes.

Towards this goal the consortium aims at designing, coordinating, implementing, and articulating dissemination and exploitations plans to create a strong awareness of SACRA at European level. The scope of this activity is twofold: to coordinate the output of results and technological solutions in European society and facilitate the adoption of SACRA outcomes by a large community of related business users, increasing its strategic importance.

2.1 DISSEMINATION PROCESS

The wide availability of results to a broader audience will be pursued targeting a number of different dissemination activities. High quality work items will be presented in highly ranked international conferences such as IEEE events (e.g., INFOCOM, ICC, VTC, and PIMRC). In addition, the publication of SACRA solutions to peer reviewed journals and magazines and special issues in the research areas of the project will be exploited, increasing awareness for the project work. Especially journals that are characterized by high Impact Factors will improve the visibility of the consortium, resulting also in increased number of citations, which are a major factor for determining the quality and impact of scientific work.

As previously referred, the dissemination of the exported SACRA results to the research as well as the standardization community is one of the key goals of the consortium. To achieve this, SACRA partners will follow a dissemination strategy which encompasses a number of different means, to achieve the highest possible impact. The strategy aims, once any relevant IPR is secured, at promoting the project results and ensuring project awareness within the European ICT and the global research community. The SACRA consortium will exploit various dissemination channels for the work items researched and technology solutions investigated.

2.1.1 Identification of dissemination opportunities

More specifically, the dissemination efforts will identify and include the following opportunities and activities:

- **SACRA online presence:** SACRA, since the beginning of the project, provides a web portal (http://ict-sacra.eu) for public dissemination of project information and results. This will include information about the project structure, scope, vision, challenges and objectives as well as all dissemination material of the project. Moreover, public project documents will be published on this home page for dissemination purpose. Additionally, SACRA project results will include the design of software. The software that is not restricted to project participants only, will also be placed on the project web site. Thus, people who are working in the same domain will be able to exploit these results. The homepage will also include a restricted section, which will be available only for the project partners and another restricted section for Commission services and reviewers.
- **Publications of high quality project results in International peer reviewed Journals, Magazines and book chapters:** Submission and publication of the technological concepts and results achieved by SACRA, in selected internationally acknowledged Journals and Magazines as well as special issues related to the end-to-end efficiency research areas. The editorship of book chapters related to the project research items will be also exploited as a means to externalise SACRA work and to document the advances w.r.t the state of the art SACRA achievements. The results will also be included in Thesis pursued by the Ph.D. students working in SACRA.

- **Contributions and participation at international conferences, workshops and summits:** This dissemination activity concerns the coordinated preparation, submission and presentation of papers in selected highly recognised international conferences and workshops (including IEEE events such as ICC, Globecom, and VTC). In addition, the participation to special sessions in large international mobile communications conferences and workshops will be pursued, fostering the promotion of project work and investigating the positioning of the project achievements in relation to new business opportunities and technological trends.
- **Organisation of SACRA workshops:** Facilitate targeted dissemination of project results and ensure high visibility of the SACRA work within the 7th Framework. This concerns both the potential organisation of SACRA public workshops, joined workshops. Such common workshops provide venues for interactive exchange of ideas. This will be supported with special brainstorming sessions tailored to specific research problems which will help shaping consensual concept development.
- **Open source software:** An additional means of dissemination will be to post selected software code resulting from the project as freely available on the web-page. Indeed, the different WPs include development of different software for cognitive radio applications. The software, which is not defined as restricted in this plan, will be placed on the web. Thus, others working in the same field will be able to use these results. This has the potential to significantly advance knowledge in this sector.
- **Participation and Contributions to European Commission concertation and cluster Meetings:** SACRA partners will actively participate and contribute to concertation and cluster meetings, fostering the aggregation of the project work in the unified framework of related European projects.
- **Training Course:** One of the last targeted dissemination is the inclusion of the SACRA Know-how as part of future graduate and postgraduate courses. Partner Universities will have the opportunity to enrich their courses.

2.1.2 Cascaded top-down and bottom-up dissemination orchestration

The dissemination of the SACRA outcomes to both the research and the standardisation community is one of the major goals of the consortium. Towards this goal the SACRA consortium aims at designing, orchestrating and implementing dissemination plans to create a strong awareness of the SACRA project at European level. Specifically, the SACRA consortium will apply a cascaded top-down and bottom-up dissemination strategy which encompasses a number of different means so as to achieve the highest possible impact of the project outcomes within the European ICT and the global research community.

The considered approach involves the identification of appropriate dissemination opportunities, using a combination of quality criteria (described in following Sections of this document) as a guideline in this process. Every partner can also provide feedback regarding other potential dissemination opportunities that can be included to the list. Following this process, discussions are taking place in order to investigate the possibility for joined publications between partners that work in the same or similar technical areas. The selected dissemination procedure targets both the wide dissemination of the projects outcomes in various conferences and workshops with a broad audience, as well as the selective publication of key outcomes in high quality journals, flagship IEEE conferences and book chapters.

3 DISSEMINATION IMPACT ASSESSMENT

In this section the dissemination impact assessment is presented. This includes the dissemination outcomes produced during the so far lifetime of the SACRA Project as well the description of impact assessment metrics, As described in the Technical Annex, publications in international peer-reviewed conferences is very important for the dissemination of the project results. The list of accepted and submitted papers includes some well known IEEE conferences with high impact factors (e.g. VTC and MELECON), as well as conferences that are crucial for achieving wide awareness of the project outcomes in the area of Cognitive Radio in particular, such as SDRF, Future Network & MobileSummit, and Crowncom.

3.1 IMPACT ASSESSMENT METRICS

3.1.1 Impact factor

As previously referred, one of the main goals of the SACRA project is to target Journals which are characterized by high Impact Factors (IF) in order to improve the visibility of the consortium, thus, resulting in increased number of citations, which are a major factor for determining the quality and impact of scientific work. The SACRA dissemination plan that is updated periodically with relevant dissemination opportunities includes information on such metrics or links to the related databases, so as to help the partners select the most appropriate journals and conferences.

The Impact factor [1] was devised by Eugene Garfield, the founder of the Institute for Scientific Information, now part of Thomson, a large worldwide US-based publisher. Impact factors are calculated each year by Thomson Scientific for those journals which it indexes, and the factors and indices are published in Journal Citation Reports.

The impact factor for a journal is calculated based on a three-year period. It can be viewed as an approximation of the average number of citations in a year, given to those papers in a journal that were published during the two preceding years. For example, the 2003 impact factor for a journal would be calculated as follows:

A = the number of times articles published in 2006-7 were cited in indexed journals during 2008

B = the number of "citable items" (usually articles, reviews, proceedings or notes; not editorials and letters-to-the-Editor) published in 2006-7

2008 impact factor = A/B

(Note that the 2008 impact factor was actually published in 2009, because it could not be calculated until all of the 2008 publications had been received.) A convenient way of thinking about it is that a journal that is cited once, on average, for each article published has an IF of 1 in the expression above.

The journal cited half-life: the median age of the articles that were cited in Journal Citation Reports each year. For example, if a journal's half-life in 2008 is 5, that means the citations from 2001-2008 are 50% of all the citations from that journal in 2008.

Immediacy index is a measure of how topical and urgent work published in a scientific journal is. Along with the better known impact factor measure, it is a calculated each year by the Institute for Scientific Information for those journals which it indexes; both impact factors and immediacy indices are published annually in the Journal Citation Reports.

The immediacy index is calculated based on the papers published in a journal in a single calendar year. For example, the 2009 immediacy index for a journal would be calculated as follows:

A = the number of times articles published in 2009 were cited in indexed journals during 2009

B = the number of articles, reviews, proceedings or notes published in 2009

2009 immediacy index = A/B

3.1.2 H-index

Conferences are also important dissemination targets, since they often attract a broad audience and have usually a short time interval between submission and publication, constituting them preferable choices for fast dissemination of project outcomes.

Common quality criteria for conferences include the acceptance rate (a low acceptance rate indicates strict selection between the submitted research works), as well as metrics related to the citations of the conference (h-index, g-index, etc). The h-index [2] of a conference is the largest number x of articles that have appeared in that conference and have been cited at least x times. It is a standard measure of the impact of research of individuals and equally valid for journals and conferences [3]. Like all metrics that are based on citations (g-index, etc), h-index favors established events that have published a significant number of high-quality papers (thus increasing the likelihood of papers that have gathered a significant number of citations). However, it might not be fair to evaluate events that have been established very recently (i.e. less than five years) using such a metric, since the papers appearing in such events did not had appropriate time to collect a significant number of citations. (For an event that takes place for the first time, all citation-based metrics are by definition zero). Finally, the accuracy of all metrics based on citation count is depending on the completeness and robustness of the corresponding databases, therefore a combination of metrics should be used whenever possible [4].

A list of upcoming conferences that have been identified as indicative potential targets of the SACRA consortium is presented below:

Conference Name	Loc.	Date	H-index	References & Citers
IEEE Radio and Wireless Symposium (RWS 2012) http://rawcon.org/index.html Paper Summary Due: 8 July, 2011 Final Manuscript Due : 30 October, 2011	Santa Clara, USA	15-19.01.2012	15	
International Conference on Cognitive Radio Oriented Wireless Networks and Communications (CrownCom 2012) http://www.crowncom.org/ Full paper submission deadline: 16.01.12 Acceptance Notification: Feb. 27th, 2012 Camera-ready Submission Due: March 23th, 2012	Stockholm, Sweden	18-20.06.12	4	
19th International Conference on Telecommunications (ICT 2012) http://www.ict2012.org/ Paper submission deadline: December 5, 2011 Notification of acceptance: January 31, 2012	Jounieh, Lebanon	23-25.04.12	12	

Camera ready version: February 17, 2012				
IEEE VTC Spring 2012 http://www.ieeevtc.org/vtc2012spring/ Submit papers for review by: 30 September 2011 Final paper due: 6 February 2012 Acceptance notice sent: 4 January 2012	Yokohama, Japan	6-9.05.12	88	
IEEE INFOCOM 2012 http://www.ieee-infocom.org/ Abstract due: Friday, July 22, 2011 Full paper due: Friday, July 29, 2011 Notification of acceptance: Monday, November 21, 2011	Orlando, USA	25-30.03.12	213	
The fourteenth International Mobility Conference (IMC14) http://www.imc14.com/page.php?1 Call for Abstracts: 1 February 2011 Close of Abstracts: 30 April 2011 Early Bird Registration Cut Off: 31 October 2011 Standard Registration Fee Applies: 1 November 2011	Palmerston North, New Zealand	13-17.02.12	3	
The Second International Conference on Advances in Cognitive Radio (COCORA 2012) http://www.iaria.org/conferences2012/COCORA12.html Submission (full paper): December 5,2011 Notification: January 23, 2012 Registration: February 7, 2012 Camera ready: February 7, 2012	Chamonix / Mont Blanc, France	29.04.2012-04.05.2012	14	
The Eighth Advanced International Conference on Telecommunications (AICT 2012) http://www.iaria.org/conferences2012/AICT12.html Submission (full paper): January 5, 2012 Notification: February 23, 2012 Registration: March 7, 2012 Camera ready: March 7, 2012	Stuttgart, Germany	27.05.2012-01.06.2012	16	

3.1.3 Acceptance rate

Acceptance rates are one of the key ways of measuring the quality of conferences [9]. More specifically, acceptance rate of a conference is the number of accepted papers divided by the number of the total submitted papers. It is clear that this metric does not rely on the number of citations as previous metrics did, but is calculated based on the percentage of the accepted works. Obviously, a low acceptance rate indicates that the conference accepts only a strict, small portion of submitted research works, which in turn, translates into higher quality papers. Therefore, SACRA will target conferences with a low acceptance in order to present the high quality of the conducted scientific work and, consequently, lead to a higher number of citations.

3.1.4 Holistic impact assessment

Successful accomplishment of the SACRA project results and well-targeted active exploitation and broad dissemination of the outcomes, evaluation of potential implications, and corresponding recommendations are required to prepare ground for the adoption of the SACRA vision. The process for the quantification of SACRA impact will be built upon the monitoring of different metrics: impact factor, h-index, acceptance rate and the availability of information about the progress of SACRA scientific research. SACRA will quantify and develop its impact with respect to these metrics:

Impact factor: SACRA partners aim at publishing their scientific work in journals with high impact factors, in order to promote its awareness. However, 2011 impact factors cannot be calculated until the end of the year, this is why we have to evaluate the importance of a journal with respect to 2010 impact factors. Especially Journals that are characterized by high Impact Factors will improve the visibility of the consortium, resulting also in increased number of citations.

H-index: H-index is a standard measure of the impact of research of individuals and equally valid for journals and conferences. This metric evaluates conferences and journals with respect to their citations. Considering this, SACRA partners target at publishing SACRA results in journals and conferences characterized by high h-index.

Acceptance rate: This metric shows whether the selection of papers published in a journal or conference is strict or not. A low acceptance rate indicates string selection among submitted research works and as a result accepted papers of high quality. Considering this, one of the main goals of dissemination plan is to publish and present SACRA scientific work to conferences and journals characterized by low acceptance rates.

The combination of these three metrics will help us choose conferences, journals and magazines that will facilitate the promotion and presentation of SACRA project results to a broader audience. Already during the first two year of the project, the SACRA publications take such criteria into consideration. Specifically, papers have been accepted or are under review in well known conferences with high impact factors (e.g. VTC and MELECON) as well as events that are of particular interest in the area of Cognitive Radios (e.g. SDRF and Crowncom). A few other parameters should also be considered:

Consultation and access to the SACRA website: The SACRA website will offer enhanced features in guest mode, relevant to SACRA objectives, technical approach, results and software that is not restricted to project participants only. Thus, people who are working in the same domain will be able to exploit these results.

Search for citations: A search for citations will be conducted, in parallel to search engines analysis. This process involves an analysis that shall be conducted systematically, in cooperation with numerous local documentation centers, which provide information on citations. Specifically, dissemination material coming from SACRA that will be used in this process includes publications in journals, conferences and books.

3.2 DISSEMINATION OUTCOMES

3.2.1 International Conferences:

Authors	Title	Conference Name	Status	Loc.	Date
A. Merentitis, A. Kaloxylos, M. Stamatelatos, N. Alonistioti	Optimal Periodic Radio Sensing and Low Energy Reasoning for Cognitive Devices	Mediterranean Electrotechnical Conference (MELECON)	Accepted	Valetta, Malta	25-28.04.10
R. Pacalet, J. Gonzalez	Full-reconfigurable interleaver Architecture for High-performance SDR applications	Wireless Innovation Conference and Exposition (SDR'10)	Accepted	Washington, DC, USA	30 Nov. - 3 Dec. 2010
B. Zayen, W. Guibene, A.Hayar	Performance comparison for low complexity blind sensing techniques in cognitive radio systems	CIP'10, 2nd International Workshop on Cognitive Information Processing	Accepted	Elba Island, Tuscany, Italy	June 14-16, 2010,
W. Guibene, A. Hayar, M. Turki	Distribution discontinuities detection using algebraic technique for spectrum sensing in cognitive radio networks	CrownCom 2010, 5th International Conference on Cognitive Radio Oriented Wireless Networks and Communications	Accepted	Cannes, France	9-11 Juin 2010,
H. Moussavinik, W. Guibene, A., Hayar	Centralized Collaborative Compressed Sensing of Wideband Spectrum for Cognitive Radios	ICUMT 2010, International Congress on Ultra Modern Telecommunications (Telecommunications)	Accepted	Moscow, Russia	18-20 October 2010
W. Guibene, A. Hayar	Joint Time-Frequency Spectrum Sensing for Cognitive Radio	COGART 2010 3rd International Workshop on Cognitive Radio and Advanced Spectrum Management	Accepted	Rome, Italy	November 08-10, 2010
I. Harjula, A. Hekkala, M. Matinmikko, M. Mustonen	Performance Evaluation of Spectrum Sensing Using Welch Periodogram for OFDM Signals	VTC Spring 2011	Accepted	Budapest, Hungary	B-18 ay 2011
B. Zayen A. Hayar G. Noubir	Utility/Pricing-based Resource Allocation for Cognitive Radio Systems	The 2nd International Conference on Multimedia Computing and Systems	Accepted	Ouarzazate Morrocco	07-09 April 2011
A. Hekkala, I. Harjula, D. Panaitopol, T. Rautio, R	Cooperative Spectrum Sensing Study Using Welch Periodogram	11th International Conference on Telecommunications (ConTEL)	Accepted	Graz, Austria	15-17 June 2011

Pacalet					
U. Salim and I. Ghauri	Mixed CSIT DL Channel: Gains with an Additional Receive Antenna	VTC Spring 2011	Accepted	Budapest, Hungary	15-18 May 2011
R. Ghaffar, U. Salim, I. Ghauri and R. Knopp	Mixed CSIT DL Channel: Gains with Interference Aware Receivers	European Wireless 2011	Accepted	Vienna, Austria	27-29 April 2011
U. Salim	Achievable Rate Regions for Cognitive Radio Gaussian Fading Channels with Partial CSIT	IEEE SPAWC 2011	Accepted	San Francisco, USA	26-29 June 2011
I. Harjula, A. Hekkala	Spectrum Sensing in Cognitive Femto Base Stations Using Welch Periodogram	the ICT-ACROPOLIS Network of Excellence Workshop on "Cognitive Radio and Networking: Challenges and Solutions Ahead", being held at IEEE PIMRC 2011	Accepted	Toronto, Canada	11-14 September 2011
B. Zayen A. Hayar	A Performance Study of Kullback-Leibler Distance-based Spectrum Sensing Algorithm	ICUMT'11, 3rd IEEE International Conference on Ultra Modern Telecommunications.	Accepted	Budapest, Hungary	05-07 October, 2011
B. Zayen A. Hayar	*On the Performance of Dimension Estimation-based Spectrum Sensing for Cognitive Radio*	*IEEE PIMRC'11, 22nd IEEE Symposium on Personal, Indoor, Mobile and Radio Communications,*	Accepted	*Toronto, Canada.*	*11-14 September, 2011*
R. R. Thomas B. Zayen R. Knopp B.T.J. Maharaj	*Multiband Time-of-Arrival Positioning Technique for Cognitive Radio Systems*	IEEE PIMRC'11, 22nd IEEE Symposium on Personal, Indoor, Mobile and Radio Communications,	Accepted	Toronto, Canada.	11-14 September, 2011
N. Milosevic, D. Panaitopol, A. Bagayoko	Wide-Band Cooperative Spectrum Sensing Method	CogART 2011	Accepted	Barcelona, Spain	26-29 October, 2011
D. Panaitopol, A. Bagayoko, N. Milosevic	Cooperative Spectrum Sensing Optimization under Different System Constraints	WCNC 2012	Submitted	Paris, France	1-4 April, 2012
A. Bagayoko, D. Panaitopol, P. Delahaye, C. Mouton	Spectrum Sensing Configuration Based on Detector Selection under Regulatory Constraints	WCNC 2012	Submitted	Paris, France	1-4 April, 2012
A. Jaschke, M. Schühler, R. Wansch	Digital Tunable LC Bandpass Filter	GeMIC 2012	Submitted	Illmenau, Germany	13-14th March, 2012
Guibene, Wael; Slock, Dirk T M	Spectrum sensing for cognitive radio exploiting spectral masks	CogART 2011, International Conference on Cognitive Radio and Advanced Spectrum	Accepted	Barcelona, Catalonia, Spain	October 26-29 October, 2011

		Management			
Guibene, Wael; Moussavinik, Hessam; Hayar, Aawatif	Combined compressive sampling and distribution discontinuities detection approach to wideband spectrum sensing for cognitive radios	ICUMT 2011, International Conference on Ultra Modern Telecommunications,	Accepted	Budapest, Hungary	October 5-7, 2011
Konstantinos Chatzikokolakis, Roi Arapoglou, Antreas Merentitis, Nancy Alonistioti	Fair Power Control in Cooperative Systems Based on Evolutionary Techniques	WCNC 2012	Submitted	Paris, France	1-4 April, 2012
Bassem Zayen, Atso Hekkala	Design and Implementation of Spectrum Sensing Techniques using OpenAirInterface Platform	Future Network and MobileSummit 2012	Submitted	Berlin, Germany	4 - 6 July 2012
V. T. Nguyen, F. Villain and Y. Le Guillou,	Cognitive Radio Systems: Overview and Challenges	*Invited paper at 3rd International Conference on Awareness Science and Technology*	Accepted	Dalian, China	Sep. 27-30, 2011
Chadi Jabbour, Hussein Fakhoury, Van Tam Nguyen and Patrick Loumeau	A Novel Design Methodology for Multiplierless filters	*IEEE International Conference on Electronics, Circuits, and Systems*	Accepted	Beirut, Lebanon	Dec. 11-14, 2011
Chadi Jabbour, Hasham Ahmed Khushk, Van Tam Nguyen and Patrick Loumeau	High-Pass or Low-Pass ΔΣ Modulators?	*IEEE International Conference on Electronics, Circuits, and Systems*	Accepted	Beirut, Lebanon	Dec. 11-14, 2011
Van Tam Nguyen, Hasham Ahmed Khushk, Chadi Jabbour and Patrick Loumeau	High Pass Filter Implementation Comparison in Unity STF High Pass ΔΣ Modulator	*IEEE International Conference on Electronics, Circuits, and Systems*	Accepted	Beirut, Lebanon	Dec. 11-14, 2011
L. Mouffok, AC. Lepage, J. Sarrazin, X. Begaud	A compact dual-band dual-port diversity antenna for LTE (700 MHz/2.5GHz)	*Advanced Electromagnetics Symposium*	Accepted	Paris, France	16-19 april 2012
Francesco Negro, Umer Salim, Irfan Ghauri, Dirk Slock	The Noisy MIMO Interference Channel with Distributed CSI Acquisition and Filter Computation	*Asilomar 2011, 45th Conference on Signals, Systems, and Computers*	Published	CA, USA	November 6-9, 2011
Rizwan Ghaffar, Pin-Han Ho, Umer Salim, Bin Wu	Femtocell Networks: Breaking the Complexity of Centralized Processing with Novel Dual-Stage Receivers	*WCNC 2012 Workshop on Broadband Femtocell Technologies - Broadband femtocell technologies*	Accepted	Paris, France	1-4 april 2012

3.2.2 Fora and Concertation Meetings

Authors	Title	Fora and Concertation Meetings	Loc.	Date
D. Merel	SACRA - Spectrum and Energy Efficiency through multi-band Cognitive Radio	Future Networks 5th FP7 Concertation Meeting	Brussels	Jan 27th, 2010
D. Merel	SACRA - Spectrum and Energy Efficiency through multi-band Cognitive Radio	RAS Workshop on Cognitive Radio	Brussels	Jan 28th, 2010
P. Spapis, S. Leveil, Ph. Delahaye	SACRA - Spectrum and Energy Efficiency through multi-band Cognitive Radio	ICT 2010 – Regulatory and Technological Requirements for Cognitive Radio	Brussels	Sept. 28th, 2010
S. Leveil	SACRA – Use Cases and Requirements	Future Networks 6th FP7 Concertation Meeting - RAS cluster meeting	Brussels	Oct 20th, 2010
W. Guibène		GDR ISIS workshop - *10 ans de Radio Intelligente : bilan et perspectives*	Paris	May 9th, 2011
P. Loumeau	*Etat de l'art des architectures des récepteurs, évolution vers plus de flexibilité*	GDR SoC-SiP workshop - *Les évolutions du Front-End RF pour la Radio Cognitive et la Radio opportuniste*	Paris	May 10th, 2011
V.Rekkas	ICT SACRA Green Radio and Energy Efficiency	Invited paper at the workshop on Green Radio at Wireless Innovation Forum European Conference	Brussels	June 22nd – 24th, 2011
S. Leveil	SACRA - Spectrum and Energy Efficiency through multi-band Cognitive Radio - Cognitive spectrum aggregation	Future Networks 8th FP7 Concertation Meeting - RAS cluster meeting	Brussels	Oct 6th, 2011
A. Jaschke	SACRA - Spectrum and Energy Efficiency through multi-band Cognitive Radio - Cognitive spectrum aggregation	COGEU Workshop - Can Europe make use of TV White Spaces?	Munich	Nov 10th, 2011

3.2.3 Scientific Journals

Authors	Title	Journal Name	Status
A. Hekkala, A. Kotelba, M. Lasanen, P. Järvensivu, A. Mämmelä	Novel Digital Compensation Approaches for Envelope Tracking Amplifiers	Wireless Personal Communications	Published online: 29 May 2010. In print: Volume 62 (2012), Number 1, pp. 55-77, DOI: 10.1007/s11277-010-0038-0.
B. Zayen A. Hayar G. Noubir	Game Theory-based Resource Management Strategy for Cognitive Radio Networks	Journal of Multimedia Tools and Applications	Will be published 2012

B. Zayen A. Hayar	Dimension Estimation-based Spectrum Sensing for Cognitive Radio	EURASIP Journal on Wireless Communications and Networking	Will be published soon
Wael Guibene Monia Turki Bassem Zayen Aawatif Hayar	Spectrum Sensing for Cognitive Radio Exploiting Spectrum Discontinuities Detection	EURASIP Journal on Wireless Communications and Networking	To be Published soon
Bassem Zayen Aawatif Hayar	Primary Outage-based Resource Allocation Strategies	Chapter book in "Cognitive Radio Systems", InTech, Ed. Samuel Cheng, ISBN 978-953-308-70-9	Will be published, January 2012
Umer Salim, Dirk Slock	Average minimum transmit power to achieve SINR targets: performance comparison of various user selection algorithms	EURASIP Journal on Wireless Communications and Networking 2011, 2011:127	Published
Umer Salim, David Gesbert, Dirk Slock	Combining Training and Quantized Feedback in Multi-Antenna Reciprocal Channels	IEEE Transactions on Signal Processing	Accepted for Publication- Will be published probably in 1st quarter of 2012.

3.2.4 Open source software and related activities

Software defined and cognitive radio systems rely on flexible RF front ends and digital baseband processors. The typical baseband processor for such applications is a complex mixture of hardware accelerators and micro-processors. The target baseband processor of the SACRA project comprises the ExpressMIMO platform developed by IT and EURE. Designing the software layers for this kind of platform is very challenging. WP5 activities aim at providing a software design framework for the specification, modeling, design and validation of the baseband software.

A software library named EMBB (ExpressMimo BaseBand) is currently designed by IT. EMBB is the basic building block on top of which SACRA baseband applications will be developed. The library is available in two different flavors, one synchronous and the other asynchronous. In the synchronous version, operations are sequential only and the high level of parallelism of the target hardware is underused. Apart this performance aspect, the function is accurately represented. This mode is mainly used for validation of the processing chain. In asynchronous mode operations can be parallelized and the programmer uses several extra time-related primitives to synchronize them. The primitives are exported by an underlying tiny operating system named MutekH (http://www.mutekh.org/) distributed under the GNU GPL license, version 2. The asynchronous mode is used for the final version of the application. EMBB is also available with two targets, a regular desktop PC (emulation) and the ExpressMIMO platform (actual final target). The same application runs unmodified on both. An asynchronous application will behave differently because the true parallelization on a desktop PC depends on the number of cores / processors while on ExpressMIMO it is directly related to the available processing units. All these features will ease the debugging and speedup the whole software design cycle. EMBB is distributed under the CeCILL license (http://www.cecill.info/index.en.html), a French equivalent of the GNU GPL.

Along EMBB, IT is developing a UML-based design framework in order to further improve and secure the software design tasks. This framework is based on TTool (http://labsoc.comelec.enst.fr/turtle/ttool.html), another open source tool developed and maintained

by IT and also distributed under the CeCILL license. A companion formal UML profile will allow designers to represent their baseband applications and the related performance requirements as UML diagrams. The main expected benefit is a higher level of abstraction (more low-level details will be hidden, like memory management and scheduling). IT will investigate ways to conduct formal static analysis, ultra-fast simulations and code generation of the embedded software, again based on the EMBB library. All these developments and the UML-based design framework will be released under the same CeCILL license.

Thanks to the chosen licenses the visibility of these outcomes of SACRA should increase. It is also expected that contributors, even not members of the SACRA consortium and even after the end of the project, will help improving the library and the toolkit. Porting them on different baseband processors could, for instance, be a very interesting extension.

3.2.5 Courses and Lectures

As indicated in the technical annex of the project, we hoped that knowledge gained during the SACRA project would enrich the curricula offered at the partner universities. SACRA results and know-how would be included as be part of future graduate and postgraduate courses. Event at this early stage, there is some interesting results concerning courses and lectures built in SACRA results in partner universities.

Institut Telecom opened a training session (continuous education, in-service training) on “opportunist and cognitive radio: challenges, constraints and perspectives” from September 28th to September 29th 2010. This section has attracted trainees from various players in the telecom industry.

Abstract of the session:

> *“The demand for seamless connectivity and the proliferation of standards, and the need for optimal management of the spectrum leads to the concept of cognitive radio where reconfiguration decisions are made based on the optimum conditions of connectivity and spectrum availability. The ultimate evolution of opportunistic radio is when the decision and intelligence are decentralized at the terminal. However, the deployment of these systems still raises many technical challenges. This course covers the deployment of the opportunistic radio terminals at: innovative approaches to managing the flexibility of the spectrum, the optimized design of front-end components, both in reception and transmission, and development of an embedded and powerful platform.”*

The session covered first the landscape of cognitive radio systems, spectrum access schemes classification; policy defined cognitive radio and standardization of cognitive radios. Then spectrum management models, dynamic spectrum allocation and usage scenarios were studied. Following the course is to study the antenna, in particular the design and choice of antenna and Smart Antenna. And then radio frequency transceivers for cognitive radio terminals are presented including CR requirements and bottlenecks and future directions. Strategies, algorithms for spectrum sensing in cognitive radio are also presented before the elements of modern Software Defined Radio Architectures - RF, Baseband DSP and Embedded Software.

The content of this course through SACRA project and others projects related to cognitive radio systems is going to be periodically enriched and will be open once every year.

In June 2011, an engineer – system architect from IMC (formerly Infineon Technologies France) came to give a two lectures on System in Package and System on Chip architecture for an UMTS WCDMA receiver at Telecom ParisTech / Institut Telecom. Another two lectures on RF transceiver architecture, design and challenges for cellular systems has been given by an former engineer –

system architect from DMCE (formerly DICE). These lectures have been given to Ph.D students and Ms.C students from Telecom ParisTech / Institut Telecom.

In June 2011, three professors from Telecom ParisTech / Institut Telecom gave a tutorial on cognitive and opportunistic radio at The 9th IEEE International NEWCAS Conference. This tutorial has three parts. In the first part, an overview of cognitive radio systems is presented, some big challenges are pointed out, especially how to split the intelligence between cognitive terminals and cognitive networks; how to distribute cognitions between layers; the difference between opportunistic spectrum use, dynamic spectrum access and smart, context aware radio. The regulation and standardization status of cognitive radio systems, promising applications are also highlighted. The research challenges including implementation challenges in cognitive radio systems are finally presented.

The second part is focused on the flexible RF receiver. The goal is to present the state of the art of the receiver architecture and evolution from RF sampling to Sigma Delta Receiver. There are a lot of solutions and this talk tries to classify them in terms of frequency plan, filtering techniques, continuous time or discrete time processing. The main topics are the agility and the power consumption.

The third part presents the new challenges in converter design due to cognitive radio requirements. Primarily, the challenges are caused by very large spectrum bandwidth (10 MHz up to 10 GHz) and no prior knowledge of interfering frequency bands. Therefore, wideband and high resolution converters are searched out with possibilities of reconfiguration to deal with the inherent trade-off between these two achievements. We will give an overview of the most promising ADC architectures for this goal: Pipeline, Parallel ADC, Sigma_Delta and the required high performance ADC.

University of Athens (UoA) has been offering a couple of courses on cognitive radio issues both in theoretical basis and in implementation/simulation perspective. More specifically, the undergraduate course “Software Development in Telecommunication systems” consists of an extensive implementation of network functions, protocols and applications. This approach aims to familiarize the planning phase at different network levels. More specifically, it includes planning for fixed and mobile networks and future Internet applications, mobile and wireless systems. Applications and implementation also concern cognitive and reconfigurable environments and mobile and wireless communications (e.g. J2ME, Android). Finally, the development will be extended by using Web programming techniques to manage mobile devices (in a pre-simulation environment).

In October 2011, an assignment was given for the implementation and extension of a simplified Cognitive Pilot Channel, for the efficient communication among network devices with the existing radio access network technologies. More specifically, the scenario, students were urged to implement, is the efficient communication of heterogeneous terminal devices with existing communication infrastructure. For this reason, a simplified CPC channel must be developed and used so as terminals get informed for the existing network state.

Furthermore, the postgraduate course “Advanced topics in wireless communication networks” has been offering a series of lectures in cognitive radio networks, since October 2010. Professor Nancy Alonistioti gives a series of introductory lectures in order to present cognitive radio issues. In addition, students are invited to search for topics and state of the art in order to make their own presentations. Indicatively, a series of topics covered are “Spectrum management framework in

cognitive radios", "Infrastructure for cognitive networks", "4G LTE analysis and challenges", "Reconfigurable hardware systems" and "Cloud RAN".

3.2.6 Exhibitions

Authors	Title	Fora and Concertation Meetings	Loc.	Date
S. Leveil, D. Nussbaum, B. Zayen	SACRA - Spectrum and Energy Efficiency through multi-band Cognitive Radio	Demonstration stand in the Exhibition at Future Network and MobileSummit 2011	Warsaw, Poland	June 2011 15th-17th,
C. Bonnet D. Camara R. Ghaddab L. Iacobelli F. KALTENBERGER R. KNOPP B. MERCIER N. NIKAEIN D. NUSSBAUM E. YILMAZ B. ZAYEN	Sensor Network aided Agile Spectrum Access through Low-Latency Multi-Band Communications	demonstration at IEEE DCOSS 2011	Barcelona, Spain	June 2011 27th-29th,

3.2.7 Workshops

Workshops will enable better understanding of the SACRA system outside of the consortium and trigger further development of algorithms and hardware technologies. In order to maximise dissemination and impact of the project, SACRA project is planning to organize a first Workshop on "Experimental platforms for 4G and beyond wireless systems". The workshop is envisioned to present the project achievements, key features and demonstrate its results and aims at providing a landscape of the most advanced Hardware and Software platforms for the experimentation of post 4G systems, in numerous fields such as Cognitive Radio, Green Radio, Software Defined Radio, new networks topologies. The workshop is also seen as a forum for both developers and users of the platforms to share their research results, and discuss problems and new developments. The technical focus of the workshop is the End-to-End wireless communication, from antenna design up to high layers in the protocol stacks. Several platforms will be demonstrated and real-time communications will be performed during the demonstration part of the Workshop.

The workshop will take place on the 23rd of February, 2012, in the "Centre International de Communication Avancée", 2229 Route des Crêtes, 06560, Valbonne, Provence-Alpes-Côte d'Azur, France. The Preliminary Program is presented below in Figure 1.

	Workshop Agenda Experimental platforms for 4G and beyond wireless systems	
09:30 - 10:00	Registration	
10:00 - 11:50	Presentations: session #1	
10:00 - 10:10	Welcome to the SACRA workshop 2012	Stéphanie Leveil (Thales Communications & Security)
10:10 - 10:30	SACRA modem presentation	Andreas Mayer (Danube Mobile Communications Engineering)
10:30 - 10:50	EMBB: a hardware/software architecture for Software Defined Radio baseband	Renaud Pacalet (Télécom ParisTech)
10:50 - 11:10	Presentation on SDR4all	Sylvain Azarian (Supélec)
11:10 - 11:30	CEA presentation (Magali/ARTIST 4G)	Fabien Clermidy (CEA-LETI)
11:30 - 11:50	FARAMIR presentation	Janne Riihijärvi (RWTH Aachen University)
12:00 - 13:30	Lunch at Oasis Restaurant of Mediagarden hotel (http://www.mediathel.com)	
13:40 - 15:20	Presentations: session #2	
13:40 - 14:00	COGEU: the low fares spectrum for 4G	Paulo Marques (Instituto de Telecomunicações)
14:00 - 14:20	HDCRAM Management for Cognitive Radio Real-Time Demos with USRP	Amor Nafkha (Supélec)
14:20 - 14:40	The CROWN FET project: Spatial Cognitive Radio	Dirk Slock (EURECOM)
14:40 - 15:00	C2POWER: Cooperative Algorithms towards Energy Savings: Evaluation and Business Models	Ayman Radwan (Instituto de Telecomunicações)
15:00 - 15:20	CONECT presentation	Raymond Knopp (EURECOM)
15:30 - 17:30	DEMONSTRATION SESSION and Networking	
	SACRA RF modem building blocks	SACRA
	SYMPA main prototyping results	SYMPA
	HDCRAM Management for Cognitive Radio Real-Time Demos with USRP	SUPELEC
	The COGEU TV white spaces database and spectrum broker	COGEU
		CROWN
		CEA-LETI
		SDR4ALL

Figure 1: Workshop Agenda

4 STANDARDIZATION

4.1 IDENTIFICATION OF RELATED STANDARDIZATION BODIES

SACRA consortium has currently selected ETSI RRS as initial target for the standardization of the project's outcomes, while monitoring the progress and roadmaps of other potential targets, namely IEEE P1900.4 and 3GPP. Hereafter, the following sections are describing the scope of these main standardization bodies and give a view on how SACRA project contributed and will continue to contribute.

4.1.1 Scope of IEEE SCC41 and potential SACRA contributions

IEEE Standards Coordinating Committee 41 (SCC41) is seeking proposals for standards projects in the areas of dynamic spectrum access, cognitive radio, interference management, coordination of wireless systems, advanced spectrum management, and policy languages for next generation radio systems. SCC41 is particularly interested in ideas that could be implemented in commercial products in the near to medium term.

IEEE 1900.4 WG was previously sponsored by SCC41 of IEEE Standards Association Standards Board (SASB). In December 2010, SCC41 was re-organised and renamed as DySPAN Standards Committee (DySPAN-SC) which is sponsored by the Communication Society (ComSoc) of IEEE and under the regulation of the IEEE SASB. However, this structure change doesn't affect actual activities of 1900.4 WG.

DySPAN WG4 is a working group aiming at defining "Architectural Building Blocks Enabling Network-Device Distributed Decision Making for Optimized Radio Resource Usage in Heterogeneous Wireless Access Networks". A standard, IEEE 1900.4-2009, has been published in February 2009. This standard defines the architectural building blocks, the interfaces, the information model and the procedures for optimized radio resource usage in heterogeneous wireless access networks. From April 2009, 1900.4 Working Group works on two projects:

- 1900.4a: Standard for Architectural Building Blocks Enabling Network-Device Distributed Decision Making for Optimized Radio Resource Usage in Heterogeneous Wireless Access Networks - Amendment: Architecture and Interfaces for Dynamic Spectrum Access Networks in White Space Frequency Bands. This standard amends the IEEE 1900.4 standard to enable mobile wireless access service in white space frequency bands without any limitation on used radio interface (physical and media access control layers, carrier frequency, etc) by defining additional components of the IEEE 1900.4 system. The P1900.4a system aims at enabling the coexistence of secondary systems operating in white spaces by providing the Base Stations (Cognitive Base Stations – CBSs – in the P1900.4a terminology) and the terminals with the following capabilities: spectrum sensing control, silent period management, white space classification and access to white space database.
- 1900.4.1: Standard for Interfaces and Protocols Enabling Distributed Decision Making for Optimized Radio Resource Usage in Heterogeneous Wireless Networks. This project aims at defining the protocols and the Service Access Points (SAPs) associated with the interfaces standardized in IEEE 1900.4-2009. Some of these protocols and SAPs are likely to be reused in the P1900.4a system.

The specification IEEE Std 1900.4a-2011 related 1900.4a project was published on 16th September. In terms of P1900.4.1 project, the work is continuing with the specification of I/F and protocols for optimized resource usage in heterogeneous networks. The consortium did not see any complementary effort for standardization in this remaining project because the subject is not addressed by SACRA project. The consortium may consider a follow-up of P1900.4a project to define the interface and protocols for the mobile wireless access use case in white space frequency bands. But in the other hand, although P1900.4a is a well advanced standard for WS operation, it does not seem to have raised enough interest in the industry and its market and future is unclear. P1900.4.1 work is still in progress but there was no contribution and there are no clear intentions from the floor. Finally, the partners involved in this group will review the situation later on in order to complement the effort of standardization if the viability of the group is recognized.

4.1.2 Scope of 3GPP Release 11+ and potential SACRA contributions

The 3rd Generation Partnership Project (3GPP) is a collaboration agreement that was established in December 1998. The collaboration agreement brings together a number of telecommunications standards bodies which are known as 'Organizational Partners'. The current Organizational Partners are ARIB, CCSA, ETSI, ATIS, TTA, and TTC.

The current scope of 3GPP is to produce globally applicable Technical Specifications and Technical Reports for a 4rd Generation Mobile System based on 3G core networks and the radio access technologies that they support. Concerning the current release 11, the work items can be found in the current work plan [7]. The status of Features being developed under the current work plan can be found in the summary presentation to the most recent TSG SA meeting and the overview of the 3GPP Release 11 is available on-line [8].

Related to the SACRA scenario, two work items related to carrier aggregation are recognized of interest by the SACRA consortium. The consortium reviewed the possible opportunities in 3GPP release 11, whose requirement phase (stage 1) has started in November 2010 andthis release is due to be “frozen” (essentially complete) in November 2012. Carrier Aggregation (CA) in LTE is a feature supported from Rel-10. In Carrier Aggregation (CA), two or more component carriers (CCs) are aggregated in order to support wider transmission bandwidths (up to 100MHz). CA is supported for both contiguous and non-contiguous CCs. In Release 11, the objectives of the first WI are to identify required performance measurements and KPIs to support CA management, specify required configurations for CA management, identify the use cases and requirements for SON functionality Self-establishment of eNodeB, and Self-healing in CA, identify the use cases and requirements for Energy Saving in CA and provide solution extensions. The objectives of second WI related to CA enhancement are to specify the support of the use of multiple timing advances in case of LTE uplink carrier aggregation and identify details for the enhancements methods in the related signalling for the use of LTE carrier aggregation to be specified through tradeoff analyses.

In terms of Release 12, there is no item related to carrier aggregation. In this current context, release 11 and 12 are frozen and didn’t contain any item related to the extension of CA concept with opportunist carrier component in the TV White space band. SACRA consortium didn’t see any forward to contribute to 3GPP for the lifetime of the project. Based on the review of ETSI RRS, ESTI RRS is an appropriate vehicle for the definition of CA enhancement in TVWS Band before any SI or WI will be created in the next release.

4.1.3 Scope of ETSI RRS and potential SACRA contributions

The European Telecommunications Standards Institute (ETSI) [5] produces globally-applicable standards for Information and Communications Technologies (ICT), including fixed, mobile, radio, converged, broadcast and internet technologies. ETSI is officially recognized by the European Union as a European Standards Organization. ETSI is a not-for-profit organization with more than 700 ETSI member organizations drawn from 62 countries across 5 continents world-wide.

ETSI RRS (Reconfigurable Radio Systems) is an ETSI Technical Committee (TC) working on standardizing Software Defined Radio and Cognitive Radio. TC RRS is responsible for standardization activities related to Reconfigurable Radio Systems encompassing both Software Defined Radio (SDR) and Cognitive Radio (CR). In this context, TC RRS is taking into account all the related requirements from relevant stakeholders, as well as the work done in other fora on the same subject in order to avoid overlapping activities in the overall standardization process in Software Defined Radio and Cognitive Radio.

ETSI RRS TC is composed of the following four Working Groups (WGs) [6], in which the technical discussions are organized and reports are produced (see Figure 2 below):

- **WG1** focuses on "**System Aspects**" and develops proposals from a system aspects point of view for a common framework in TC RRS with the aims to guarantee coherence among the different TC RRS WGs and to avoid overlapping and gaps between related activities.
- **WG2** focuses on SDR technology with a particular interest in "**Radio Equipment Architecture**" and proposes common reference architectures for SDR/CR radio equipments (mobile handset devices, radio base stations, etc.), related interfaces, etc.
- **WG3** focuses on "**Cognitive Management and Control**"; the group collects and defines the system functionalities for Reconfigurable Radio Systems which are related to the Spectrum Management and Joint Radio Resource Management across heterogeneous access technologies. Furthermore, the group has developed a Functional Architecture for the Management and Control for Reconfigurable Radio Systems as well as a report on the Cognitive Pilot Channel as an enabler to support the management of the RRS.
- **WG4** focuses on "**Public Safety**" and collects and defines the related RRS requirements from relevant stakeholders in the Public Safety and Defense domain. The group defines the system aspects for the applications of RRS in Public Safety and Defense.

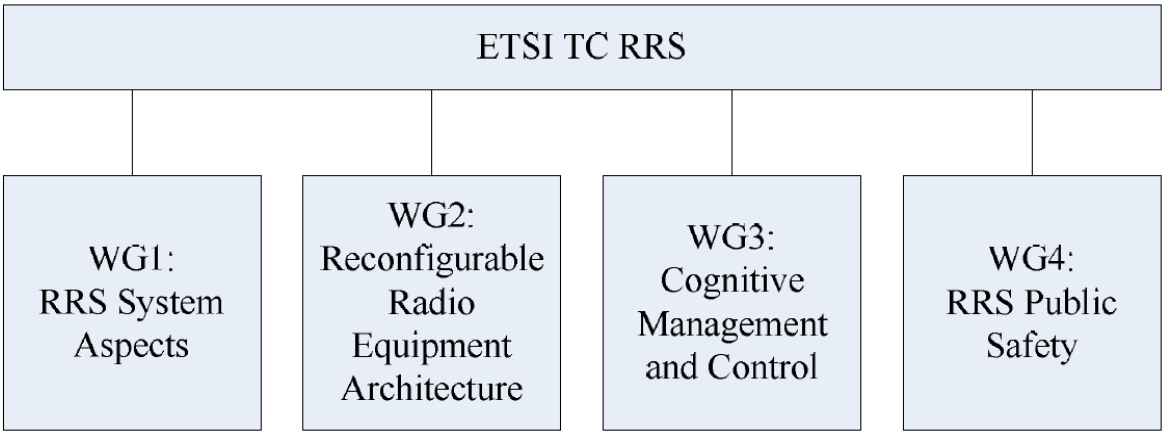

Figure 2: ETSI RRS structure.

Corresponding working items are active in the mentioned working groups, working on respective Technical Reports (TRs) and Technical Specifications (TS). In 2011, the following TRs are available as published deliverables of ETSI TC RRS:

- TR 102 839 “Multiradio Interface for SDR MD Architecture and Services”
- TR 103 064 “Business and cost considerations for RRS in Public Safety”
- TR 103 062 “Definition of refined Scenarios and Use Cases for Software Defined Radio (SDR) Reference Architecture for Mobile Device”
- TR 102 907 “Use Cases for Operation in White Space Frequency Bands”
- TR 103 063 “Use Cases for Reconfigurable Radio Systems operating in IMT bands and GSM bands for intra-operator scenarios”

ETSI RRS considers the introduction of Cognitive Radio Systems (CRS) as a whole based on a top-down approach. Recently, ETSI RRS has achieved major progress in the areas of TVWS usage, in particular with a focus on the adaptation of existing and/or evolving Radio Standards, such as 3GPP Long Term Evolution (3GPP LTE), to a possible operation in UHF White Space bands.

For the time being, ETSI RRS are working on several work items which are of interest for SACRA and in which SACRA consortium contributed:

- WI “Operation in White Space Frequency Bands”, producing TR102.907. The scope of the present document is to describe Use Cases for the operation of Reconfigurable Radio Systems within White Spaces in the UHF 470-790 MHz frequency band and gives an overview on methods for protecting the primary/incumbent users like TV broadcasts and wireless microphones.

SACRA partner already contributed to this technical specification. Various use cases have been included in the TR 102 907 “Operation in White Space Frequency Bands” classified in distance (e.g., short range, middle range and long range) and in applications (e.g., ad-hoc). As foreseen for SACRA system, carrier aggregation, known as the main feature of 4G systems which is being standardized in 3GPP as part of Release 10, could be extended to include the aggregation of the opportunistic UHF TV WS band to provide maximum flexibility in utilizing the scarce radio spectrum.
This report is finalized and approved by WG1 in the teleconference, June 22. It is also approved during the ETSI RRS#15 plenary meeting in September 2011.

- WI proposal on Feasibility study on Radio Frequency (RF) performances for secondary systems operating in UHF TV band White Spaces. The scope of WI proposal is the RF performance analysis for systems operating in TV WS. The three main aspects of this WI are to study:
  - Advanced sensing techniques for incumbent protection (for instance multi-node sensing solutions have not been considered yet by CEPT).
  - Sensing techniques that could be specific to the technology used in an area outside of Europe. ETSI addresses a global standard, thus it is relevant to investigate solutions for Asia, China and America which have different incumbent wireless technology.
  - RF Solutions for coexistence between secondary systems.

  In WP2 SACRA partners are considering advanced sensing techniques taking advantage of cooperation between several sensing nodes. These studies put SACRA partners in a position to contribute to this RRS Work item, disseminating the most promising cooperative sensing techniques and signal classification techniques for incumbent protection.

- WI on TS 102 946 “System Requirements for Operation in White Space Frequency Bands”

The scope of this technical specification is to define the system requirements for operation of secondary Reconfigurable Radio Systems within UHF TV band white spaces. The requirements are based from the use cases described in Technical Report 102 907 “Use cases for Operation in White Space Frequency Bands”. SACRA partner contributed to the definition of functional requirements for carrier aggregation in TVWS which fall into the Spectrum Management Requirements section of TS 102 946. In addition, requirements for LTE operation in TVWS are presented for the Radio Access Requirements Section.

As a next step, after having progressed with the work on use cases and requirements definition, ETSI RRS plans to create new work items on the definition of the architecture and protocols for Cognitive radio systems operating in TWS band and associated Cognitive Management and Control mechanism definition. It will bring new opportunities for SACRA partners to contribute based on WP1 and WP3 outcomes.

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4.2 PARTICIPATION TO STANDARDIZATION AND REGULATION MEETINGS

Authors	Title	Standardization Meetings	Loc.	Date
D. Nussbaum, S. Leveil	Presentation of “SACRA - Spectrum and Energy Efficiency through multi-band Cognitive Radio”	ETSI RRS#11	Sophia-Antipolis	Sept 7th-9th 2010
Philippe Delahaye	Contribution on Opportunistic Carrier Aggregation into TR 102.907: Carrier aggregation between Component Carriers from IMT and TV WS bands	ETSI RRS#12	Munich	Nov 22nd-25th 2010
Christian Mouton	SACRA Spectrum and Energy Efficiency through Multi-Band Cognitive Radio IEEE DYSPAN standards Committee – Working Group 6	kick-off meeting of new project (DySPAN P1900.6a)	Brussels	21 June 2011
Philippe Delahaye	Joint Contribution on definition of functional requirements for carrier aggregation in TVWS and requirements for LTE operation in TVWS for TS 102 946.	RRS1-RRS3-Conf call	Audio-conference	22 June 2011

Authors	Title	Regulator	Loc.	Date
Stéphanie Leveil	SACRA use cases and requirements	Agence Nationale des Fréquences (ANFR) - French Radio Spectrum Assignment Authorities	Maison-Alfort	November 2nd, 2010

5 EXPLOITATION PLANS

5.1 TYPE OF FOREGROUND

This chapter identifies the different types of foreground produced during the project implementation phases. It highlights the achievements that are of interest for a future use or reuse by the consortium members.

5.1.1 RRM techniques

Description of the CRRM

The overall CRRM system is composed of a hierarchy of algorithms, each contributing a key aspect in the complete cognitive radio resource management framework. The proposed CRRM algorithms cover a number of the SACRA target objectives.

A detailed description of these algorithms is provided in WP3, deliverable D3.2. A summarized list is given below:

- Sensing configuration
- Distributed primary users and secondary users spectrum access control and power setting based on a probability of outage criterion in terminals
- Secondary users cooperative power control in shared bands to optimize secondary users utility subject to primary user interference constraint
- Higher level application and flow partitioning algorithm that aims at partitioning flows across combined or aggregated bands located in the SACRA CRRM hierarchy.

Cooperative power control algorithms

The main research activities UoA concentrates on is the study, simulation and implementation of cooperative power control algorithm. The main idea of the cooperative power control algorithm is to fine tune power control levels for opportunistic users that have been granted access already. It relies on shared and exchanged experience instantaneous utility among these users to derive the best power settings. As the data gets shared and exchanged and delays as well as uncertainties in received data qualities are experienced, the cooperative power control algorithm introduced fuzzy logic features to handle these doubts and become robust to the unreliable utility reporting.

Furthermore, UoA has examined the integration of the algorithm to SACRA based use cases and scenarios. More specifically, simulation tests have taken place and network policies have been discovered and enforced to the cooperative power control algorithm. The performance of the algorithm was examined and interesting results and trade-offs were extracted.

5.1.2 Sensing and classification techniques

The main research activities are divided between sensing algorithms and classification algorithms. Sensing and classification is important in order to meet regulation requirements for WS operation and SU system constraints. In a fast changing environment, parameters such as fading, noise uncertainty, far away interferers, wrong noise estimation may result in a wrong detection result. SACRA has studied the sensing and classification techniques, defined the modules responsible for sensing control and studied their integration. Standardization experience also helped to extract useful parameters from DVBT, PMSE and LTE (3GPP) standards as well recommendation based on CEPT, Ofcom, 802.22 and FCC reports. With respect to these reports, SACRA developed algorithms that meet all these requirements.

In a matter of meeting SACRA's requirements for signal classification, two techniques were presented in D2.2.

The first proposed approach is operating in three steps. As a first step, the algorithm should locate the used sub-bands by locating their frequency edges. Then, the algorithm separates the different signals by some blind signal separation technique. Finally, the different signals are classified step using DVB-T signals cyclostationary properties.

The second proposed approach presents a less an LTE signal classification technique without quiet period. The objective of this study is to classify PUs detect while receiving and decoding LTE, but in this case the choice of the classification time will not affect the Quality of Service. These two techniques were then compared in order to help chosing the final algorithm to be implemented for final SACRA's demo.

Following SACRA target scenario, different spectrum sensing algorithms are developed, compared, and will be demonstrated through field trials performed in WP6. The studied algorithms have been or will be presented in WP2 deliverables. Recommendations about suitable sensing algorithms for different spectrum sensing tasks in SACRA are given.

5.1.3 Hardware technologies

One of the outcomes of WP4 is the design of dual band dual polarized antennas. Two directions are studied: the first one focuses on reducing the overall size whereas the second one offers better performances at the expense of the compactness. In any case, the challenge is to gather in a single element the dual band and dual polarization constraints. Moreover, the two considered bands (700-862 MHz) and (2.5-2.69 GHz) are widely spaced which makes difficult the design of the antenna. On the other hand, as the SACRA antennas are used in a MIMO context, a study of their diversity performances has also been performed. Thus, the studies conducted in the framework of SACRA will lead to innovative antennas which can be reused for other wideband applications.

Another outcome of WP4 is the design of a flexible antenna switch enabling, together with a dual uplink cellular transmitter, various TX MIMO investigations and demonstrations. TX MIMO and dual uplink investigations are not only important for the SACRA project, they are key features of upcoming cellular standards like LTE-A. Upcoming standards are targeting the capabilities of dual TX and all the advantages of MIMO systems to improve uplink performance for applications like cloud computing. WP4 is addressing these topics and results of the related demonstrator will lead to innovative future products, power and area efficient transmitter architectures

The baseband digital signal processor and its associated software libraries, operating system and software development kit are a major outcome of WP5 activities. The whole processor and its software environment are distributed under free software licences

5.2 USE OF FOREGROUND BY CONSORTIUM MEMBERS

The SACRA project has produced various types of foreground, among which reusable foreground for future activities in the wireless communications domain, and especially towards the development of future wireless devices. This chapter provides an overview of the plans for the use of foreground by each SACRA consortium member.

5.2.1 Industrial Members

5.2.1.1 THALES COMMUNICATIONS & SECURITY SA

SACRA foreground will be used by TCS for several purposes.

First the project foreground allows TCS to progress in its research activities in the field of cognitive radio, in particular from the specification of system requirements to the elaboration of a reference system architecture and to the definition of a cognitive radio terminal. Such terminals could be proposed in the future in the domain of Professional Mobile Radio (PMR). In this PMR market, TCS already proposes a product range of TETRA networks, called Digicom 25. TETRA is the European standard for PMR narrowband and wideband digital radio for professional usages (from public safety to railway networks). TCS is also promoting a broadband solution to complement Digicom 25, that is labelled TEMAX and is currently based on Wimax technology, but should also includes LTE technology in the near future.

Second, the study of digital pre-distortion techniques that is conducted in the scope of WP4 and WP5 shows the benefits of the proposed algorithms in terms of power consumption. The reduction of the non-linearities can also lead to a better frequency reuse, especially when introducing broadband solutions, and then contribute to a more efficient use of the resources in cognitive radio networks for PMR market.

This study of pre-distortion techniques was motivated by the need to evaluate the gains in terms of power consumption for two types of products: mobile terminals and high power equipments (such as base stations). The results of the on-going study show that the pre-distortion algorithms developed in SACRA provide significant gains for high power equipments, but the implementation of these techniques on mobile terminals could not be justified due to the complexity of the algorithms. These conclusions are considered in the development of narrowband/broadband products.

5.2.1.2 NEC TECHNOLOGIES (UK) LIMITED

The main use case of interest for NTUK is LTE communication in TVWS. In order to deal with this situation where classical sensing techniques cannot be used in all cases due to LTE constraints, NTUK studied classification algorithms which are necessary to discriminate between the primary user transmissions and (own) secondary user transmissions. SACRA further provided classification algorithms exemplified for LTE FDD DL. SACRA also showed that the performance of these algorithms copes with the FCC requirements, without employing more expensive Quiet Period techniques. So, project foreground in this area will allow NTUK to propose future LTE mobile equipment with sensing and classification techniques for operation in WS. More globally, the SACRA conclusion of the studies related to WS allows checking and revising the future specification of the mobile equipments which will have the capability to operate in White Spaces.

5.2.1.3 INTEL Mobile Communications, FRANCE

The main area of interest for IMC in SACRA is the investigation of novel receive algorithms which are required to make primary and secondary (cognitive) communications successful simultaneously. As the development of the sophisticated modems is the core business for IMC, this study will provide the know-how about the future sophisticated MIMO mobile receivers which have additional capabilities to cancel/strip the interference.

5.2.1.4 DMCE Danube Mobile Communications Engineering GmbH & Co KG

SACRA foreground related to modem architectures; cognitive radio and the exploitation of unlicensed frequency bands will found the basis for important, future RF cellular platform decisions. The efficient use of the highly expensive and limited frequency resource is a major task of all upcoming cellular standards and products and DMCE will have to cover all upcoming requirements. The SACRA project targets several efficiency topics from software, hardware to top level perspectives and many novel aspects investigated or developed within the SACRA project are directly related to modem features and software assisted hardware algorithms. Therefore any foreground developed might be important for upcoming cellular standards and products of DMCE. The significant mobile terminal performance gain possible due to the introduced digital pre distortion algorithm will be of interest for future product developments and architectures.

5.2.2 Academic Members

5.2.2.1 VALTION TEKNILLINEN TUTKIMUSKESKUS (VTT)

VTT is mainly participating to research activities and software development of studied algorithms. In algorithm point of view, VTT has studied single node and cooperative spectrum sensing methods for cognitive radios. In addition, software development and implementation considerations on the studied algorithms have been carried out. Several publications have been published in different international conferences.

5.2.2.2 Institut Telecom

On antenna design, IT has offered a PhD position in the framework of SACRA. This will contribute to the reinforcement of the research activities of the antenna design group. In this thesis, some designs methodologies for dual band dual polarized antenna will be proposed and could be reused for other applications. Publications are expected in international conferences as well as international journals.

The baseband digital signal processor and its companion software is actively used by IT as a way to promote and demonstrate the benefits of this type of flexible software / hardware combination for software defined and cognitive radio applications. It is used in lectures and tutorials. Scientific papers are based on it and on results obtained from implementation experiments on the processor. Finally, it is also a very valuable use case and design example for other research activities at IT, like, for instance, high level modelling and validation of complex embedded systems. IT will continue to maintain and enhance the processor and will use it in every future project dealing with wireless digital communications.

Other results obtained concerning sensing algorithms (WP2), network layer (WP3) and ADC design (WP4) are also used in lectures and tutorials. Several publications have been published,

some others will come in the future. The methodology developed in this project will be used for other applications or future projects.

5.2.2.3 FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V (IIS)

The main research objectives for the Fraunhofer IIS can be found in the antenna design and tunable band pass filter in WP4. Publications have been submitted in different conferences. Regarding to the digital tunable band pass filter a patent is submitted at the German patent office. Future work will profit from these researching results in further projects and other applications.

5.2.2.4 EURECOM

EURECOM is participating to research activities: spectrum sensing and classification techniques related to WP2, and resource management techniques related to WP3. EURECOM is participating also in implementation procedures related to WP5 and WP6 by designing and developing the final demonstration using EURECOM's OpenAirInterface platform. Several publications have been published in different selective conferences, books and journals.

5.2.2.5 NATIONAL AND KAPODISTRIAN UNIVERSITY OF ATHENS

The main purpose of UoA is the participation to research activities. Investigation of cognitive wireless communications and especially techniques for power control allocation for green communications are among the key points that characterize the role of UoA. For these reasons, concentrated investigation of power allocation policies has leaded to a series of publications in a number of international conferences.

6 PATENTS AND IPR

As captured by the project objectives SACRA aims at providing innovative concepts that could be published (see section 3) and patented. Towards this direction, SACRA partners have been working in the detailed description of solutions as regards the antenna, the RF and base band design as well as cognitive actuation techniques for dual-band resources management of the SACRA terminal.

During the development for the new SACRA terminal, described in Deliverable D4.2, the IIS could make a patent application with the title “Kognitives Funksystem und Verfahren für ein kognitives Funksystem” (“Cogntive Radio and Procedure for a cognitive radio system”). Examples of the patent claims are given:

A cognitive radio with a characteristic of:

- Filtering an incoming and/or outgoing signal with a tunable band pass filter.
- The center frequency of the incoming and/or outgoing signal can be adjusted digitally.

The patent has been written and has been submitted at the German patent office since 21.October.2011.

7 CONCLUSIONS

This deliverable has presented a snapshot of the regulation, standardization, dissemination and exploitation efforts within the SACRA project. Furthermore, the deliverable provides a detailed description of the dissemination strategy the SACRA consortium plans to follow in the remaining 12 months of the project, in order to achieve even wider promotion of SACRA outcomes and to convince the society and the industry to adopt the already introduced scientific solutions. The purpose of this dissemination plan is to make the high quality work items of SACRA available to a wider audience through many different dissemination activities.

It is worth mentioning, that during the first two years of the project, considerable outcomes have been achieved by SACRA, including both conference papers and journal publications. In terms of regulation, SACRA has presented its work and participated in working groups within the ETSI Reconfigurable Radio Systems (RRS). Additionally, significant open source software has been developed and is expected to be further evolved. Furthermore, in order to maximise dissemination and impact of the project, SACRA project is planning to organize a first Workshop on “Experimental platforms for 4G and beyond wireless systems” in February 2012. Last but not least, a patent was written and submitted at the German patent office, during the second year of the SACRA project.

The dissemination strategy adopted by SACRA, in compliance with the Technical Annex descriptions, facilitates the dissemination of SACRA work through its own website where users can find news about the evolution of project work and all the relative information. Such information include the submission and publication of the technological concepts and results achieved by the project in selected journals, magazines and international conferences, workshops, etc. Additionally, the consortium targets also the industry level dissemination, the interaction with worldwide forums and institutes and the promotion of project solutions to the identified standardization bodies and significant steps in this direction have already been achieved.

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