UEB/CominLabs Chair Report

GREAT: Green Cognitive Radio for Energy-Aware Wireless Communication Technologies Evolution

Honggang ZHANG

International Chair of Excellence - CominLabs
Université Européenne de Bretagne (UEB) & Supélec
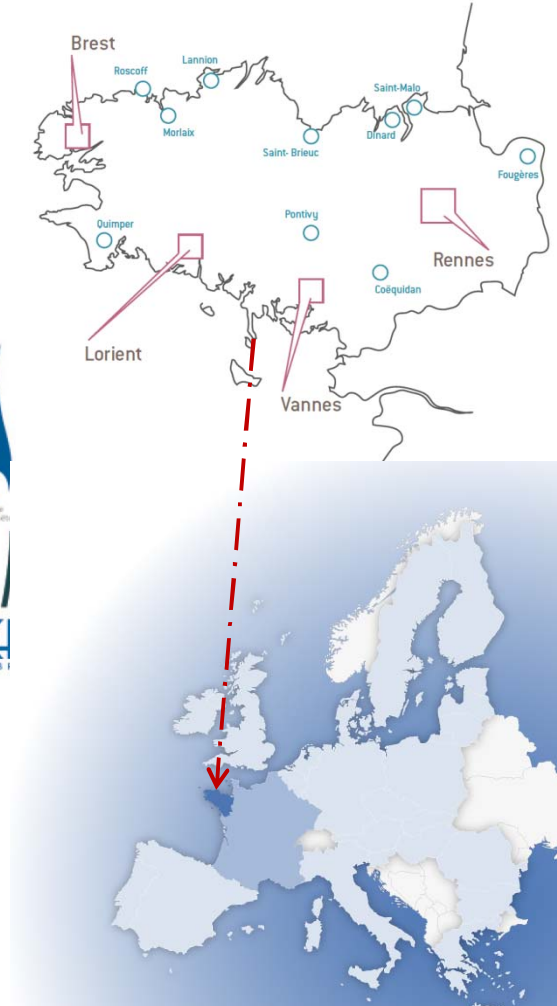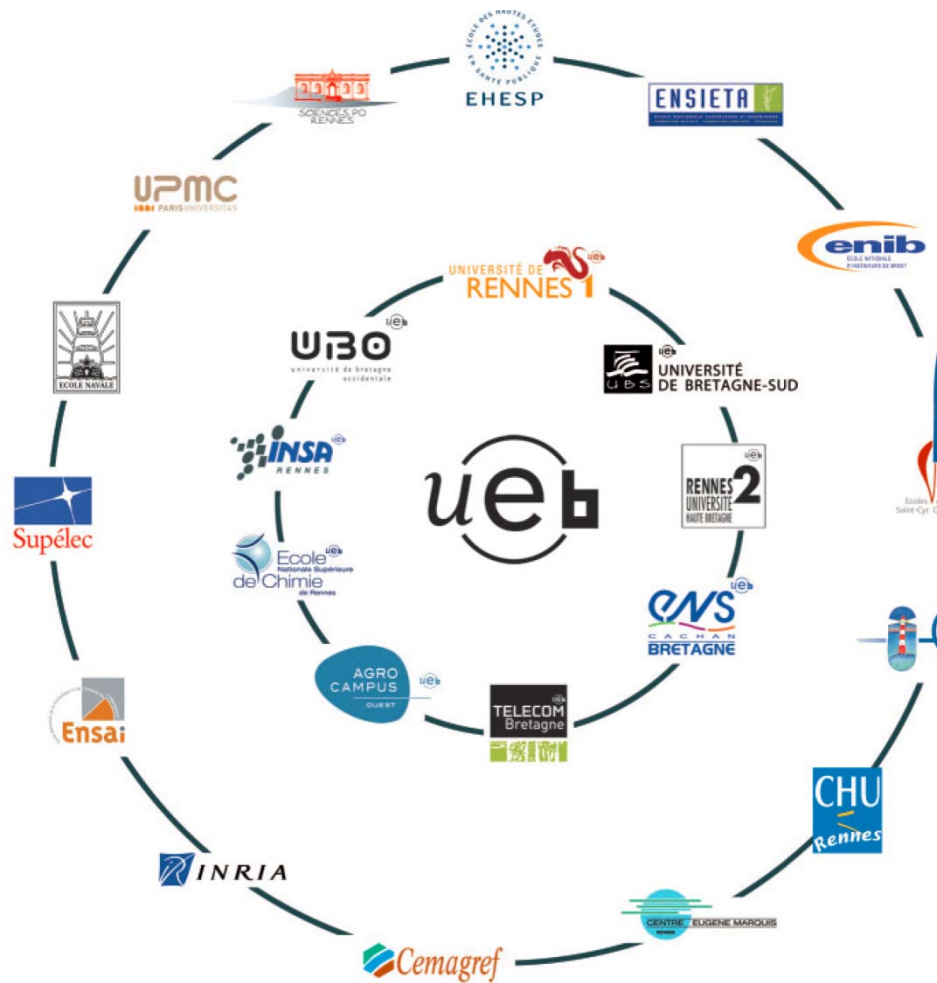
November 30, 2014
Rennes, France

Acknowledgement

ACKNOWLEDGEMENT:

GREAT (*G*reen Cognitive *R*adio for *E*nergy-*A*ware wireless communication *T*echnologies evolution) Project
5G Challenges: Paradigm Change from Coverage- & Capacity-Driven to Energy-Efficiency Driven Era (Sustainable Green Communications Evolution for 5G by 2020)
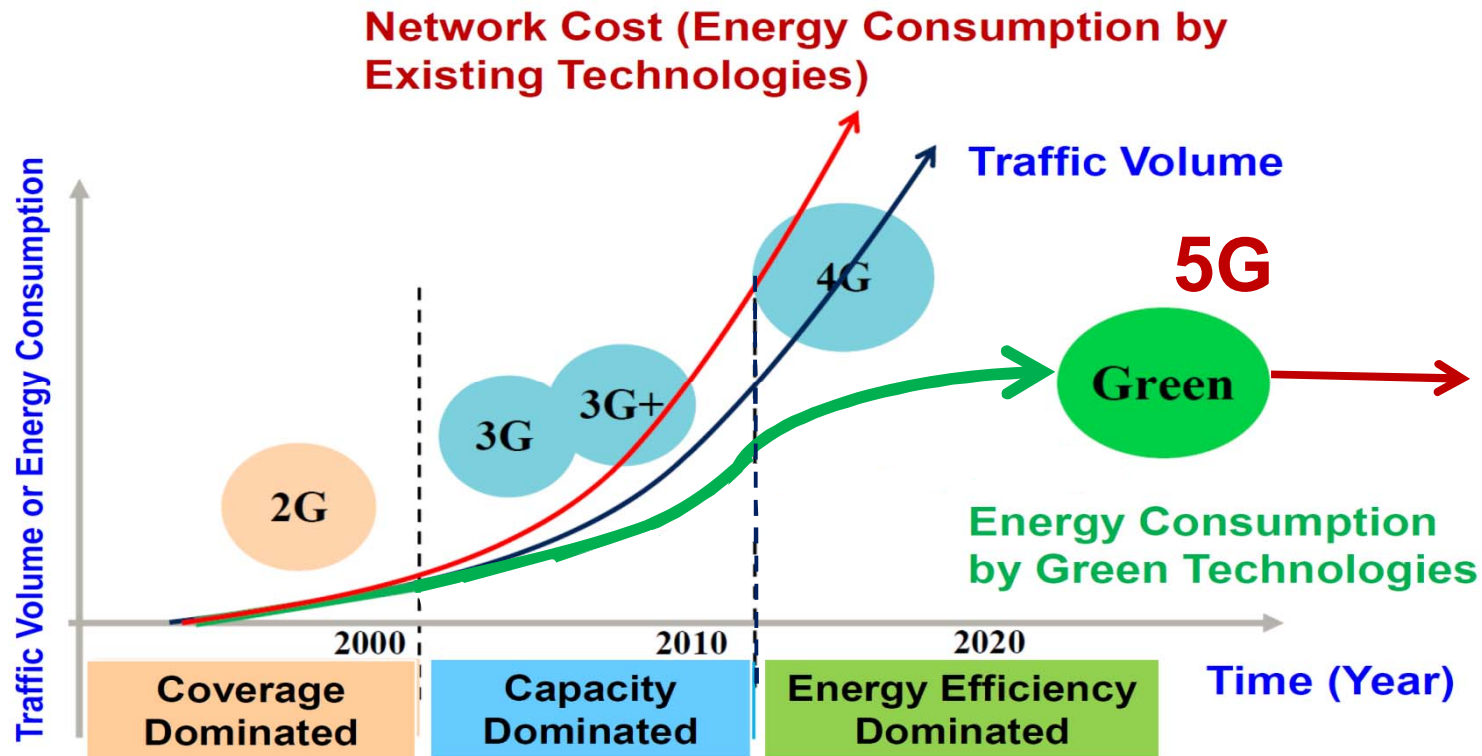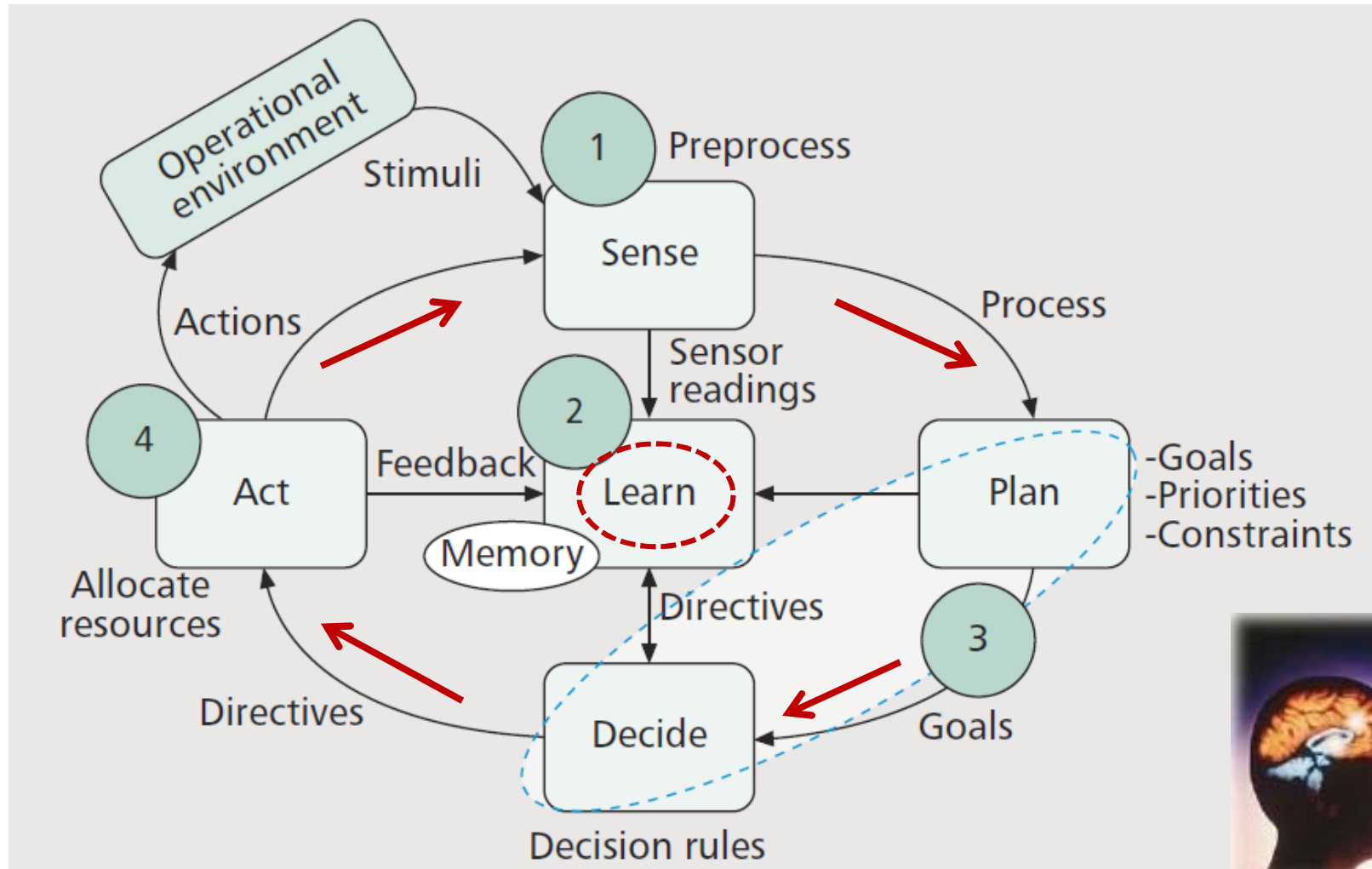
Source: Gurkan Gur and Fatih Alagoz, "Green Wireless Communications via Cognitive Dimension: An Overview", IEEE Network, March 2011.

Mobile Stations

Radio access and core network

Mobile Network 20%

Base Stations 80%

User Terminals 10%

Network 90%

GREAT Project in a Nutshell

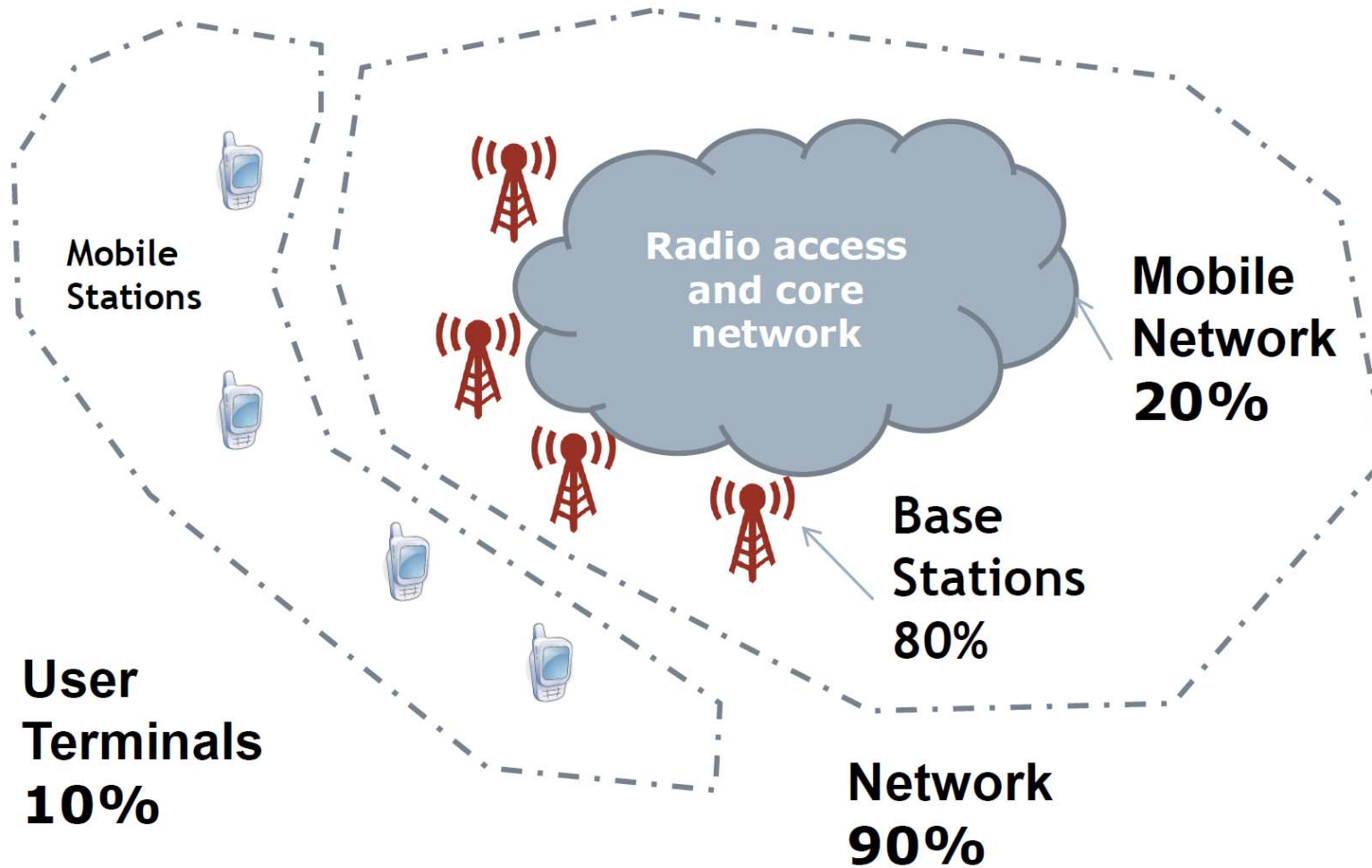|	
Project Title	**GREAT (G**reen Cognitive **R**adio for **E**nergy-**A**ware wireless communication **T**echnologies evolution)
Work Plan Structure	**The research program is organized into 4 main tasks:** **Task 1**- Decision making functions; **Task 2** - Application to energy efficiency; **Task 3** - Application to spectrum efficiency; **Task 4** - Implementation & demonstration
Project Duration	**24 months (01/12/2012 - 30/11/2014)**
Research Area	**New challenging frontiers in future wireless communications and networking (e.g. 5G & H2020)**
Key Words	**Cognitive radio, cognitive networks, green radio, green communications, green cognitive radio, energy efficiency, energy consumption, spectrum efficiency, machine learning, reinforcement learning, decision making, adaptive waveform**

The main objective of this **GREAT** project is to establish a number of disruptive theoretical foundations and to realize some demonstrations as proof-of-concept, in order to validate the advantage, efficiency and feasibility of the proposed **Green Cognitive Radio** approach, for achieving the **energy-spectrum harmonized era** of future radio communications systems (**5G**).
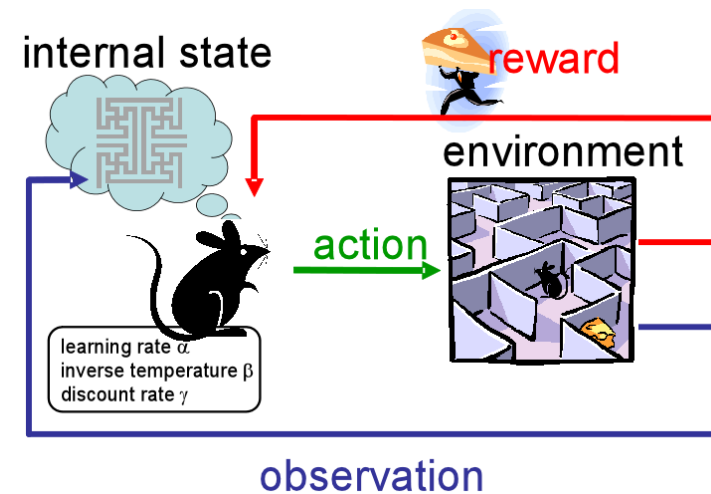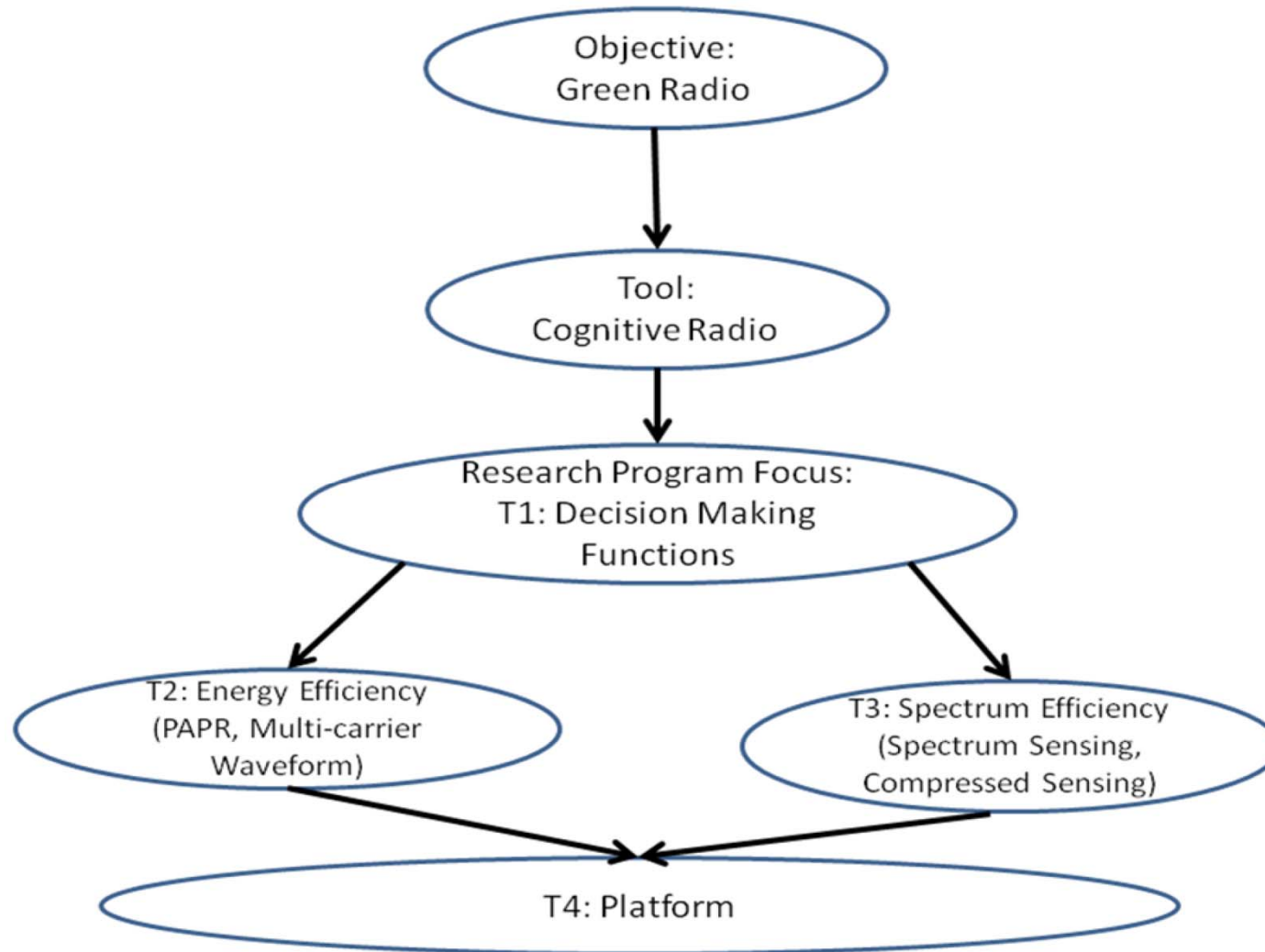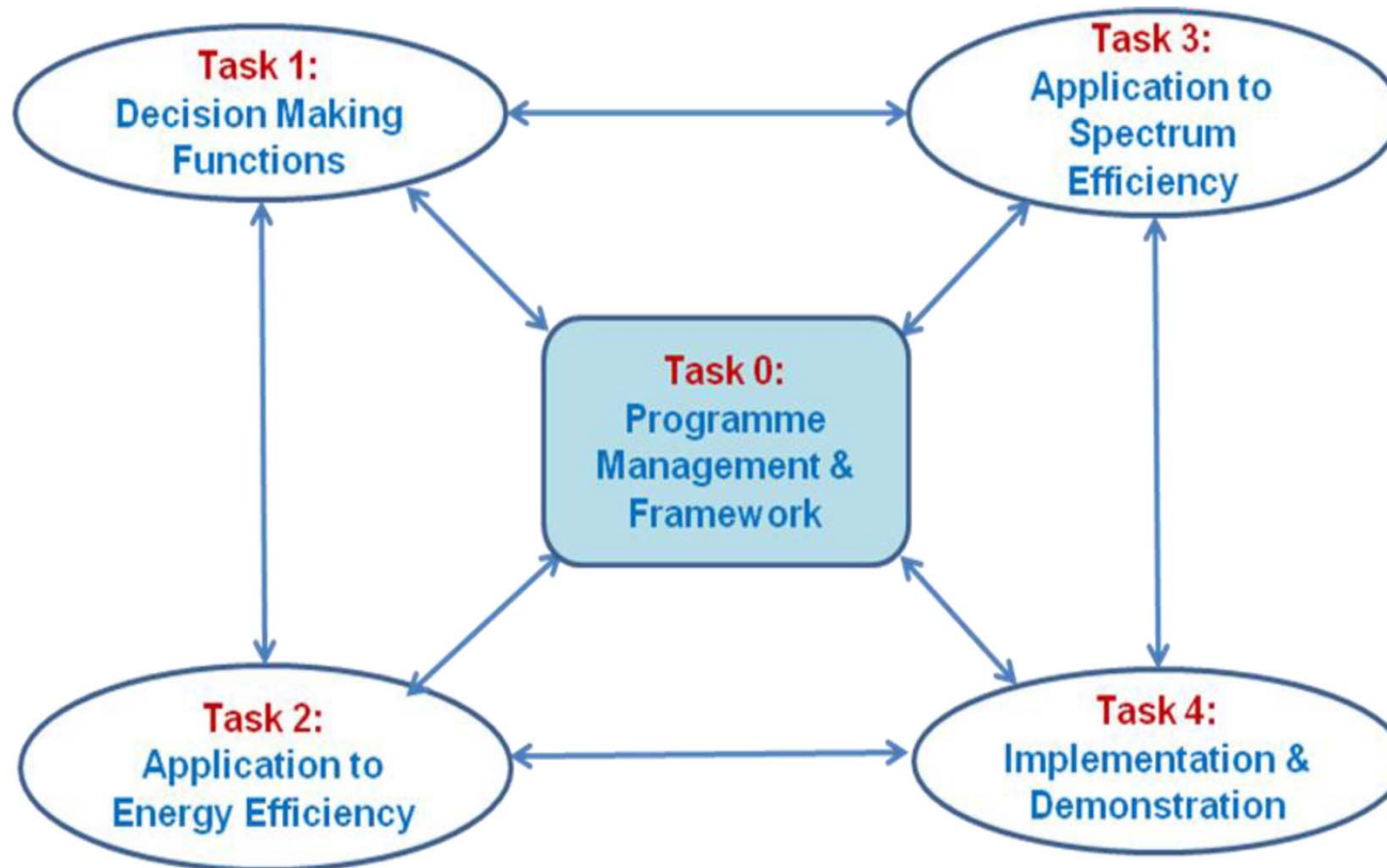
Name	Position	Roles in GREAT Project
Jacques Palicot	Professor (Supélec)	All tasks
Honggang Zhang	UEB/CominLabs Chair Professor	All tasks
Sumit Darak	Post-Doc Research Fellow (UEB/CominLabs)	Task 1, 2, 3
Hadi Noureddine	Post-Doc Research Fellow (UEB/CominLabs)	Task 2, 3, 4
Malek Naoues	Post-Doc Research Fellow (UEB/CominLabs)	Tasks 2, 4
Christophe Moy	Professor (Supélec)	Task 1, 2, 3, 4
Yves Louet	Professor (Supélec)	Task 0, 2, 3, 4
Daniel Le Guennec	Professor (Supélec)	Task 2, 3
Carlos Faouzi Bader	A/Professor (Supélec)	Task 2, 3, 4
Amor Nafkha	A/Professor (Supélec)	Task 4

Task 1: Decision Making Functions

In this task, which is at the heart of this research program, several approaches will be investigated such as reinforcement learning & transfer learnng, statistical intelligent signal processing and distributed nodes collaboration based on Swarm Intelligence. Output of this task will be used by Tasks 2 and 3.

Task 2: Application to Energy Efficiency

This task is fundamental in the program because it is concerned with the power consumption reduction at the signal waveform level. Power consumption reduction and energy efficiency are the core part to deal with green communications requirement. Specially, a number of strategies using the waveform adaptation functionalities of Cognitive Radio to reduce the transmit power consumption will be thoroughly investigated, which relies on advanced learning and decision making function under green constraint. Accordingly, a series of novel adaptive multicarrier waveforms (e.g. OFDM or FBMC), which can make HPA (high power amplifier) running at high efficiency level, will be designed. Output of this task will be used by Task 4.
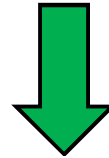
Task 3: Application to Spectrum Efficiency

Efficient strategies will be proposed in Task 3 to increase opportunistic spectrum utilization and reach a good balance of spectrum- and energy-efficiency, which includes: 1) new spectrum sensing and accessing methods based on Compressed Sensing   2) output of this task will be used by Task 4.

Task 4: Implementation & Demonstration

The aim of Task 4 within the program is the development, testing, and demonstration of the Green Cognitive Radio concept, algorithms and solutions studied in the Task 2 and Task 3. These algorithms and solutions will be implemented in software simulators as well as in reconfigurable hardware testbed.
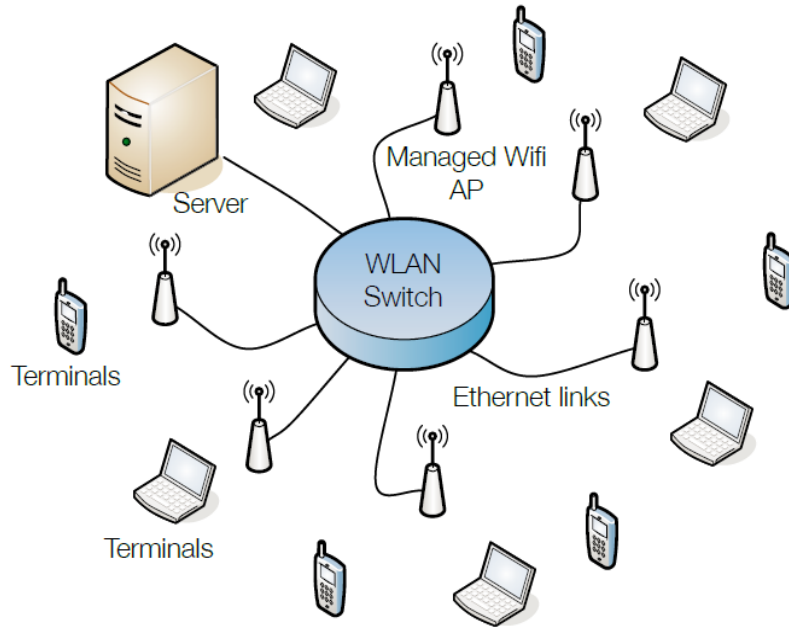
WiFi-Based Platform for Energy Saving in Wireless Networks (Demonstration Platform Architecture)

Energy Saving Approach Realizing Sleeping Mode (AP/BS Switching on-off) Based on Clustering and Clusters Detection by Applying the Indoor Location Algorithm on the WiFi-based Platform
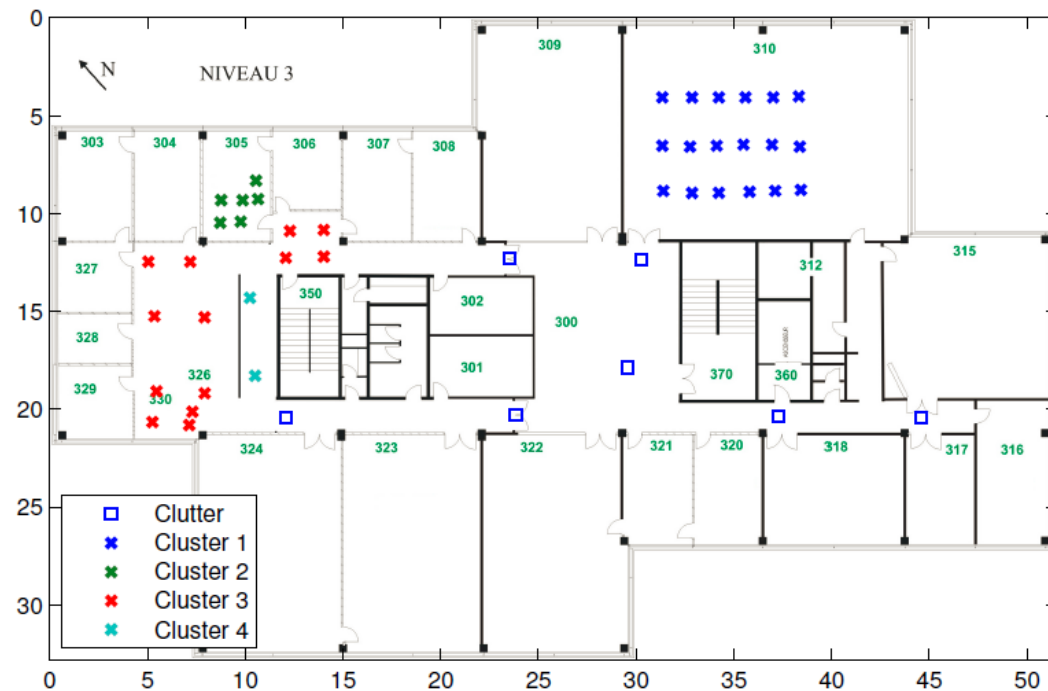
➢ **In summary, have finished and submitted <u>20</u> journal papers and <u>29</u> international conference papers, among which <u>17</u> journals papers and <u>29</u> conference papers have been published or accepted.**

Task 1: Decision Making Functions

Task 1 Output (Published & Accepted Journal Papers):

1. Rongpeng Li, Zhifeng Zhao, Xianfu Chen, Jacques Palicot, and <u>Honggang Zhang</u>, "TACT: A Transfer Actor-Critic Learning Framework for Energy Saving in Cellular Radio Access Networks," *IEEE Trans. on Wireless Communications*, April 2014.

2. Rongpeng Li, Zhifeng Zhao, Xuan Zhou, Jacques Palicot, and <u>Honggang Zhang</u>, "The Predictability Analysis of Cellular Networks Traffic: From Entropy Theory to Networking Practice," *IEEE Communications Magazine*, June 2014.

3. Jacques Palicot, <u>Honggang Zhang</u>, and Christophe Moy, "On the Road towards Green Radio," *URSI Radio Science Bulletin*, December 2013. (Invited Article)

4. Jacques Palicot, Steve McLaughlin, <u>Honggang Zhang</u>, and H. Vincent Poor, "Special Issue on Green Radio," *EURASIP Journal on Wireless Communications & Networking*, Feb. 2013. (IEEE Best Readings in Green Communications, Top 100 Highly Accessed Article in EURASIP Journal)

5. Xianfu Chen, Jinsong Wu, Yueming Cai, <u>Honggang Zhang</u>, and To Chen, "Energy-Efficiency Oriented Traffic Offloading: A Brief Survey for Wireless Networks and A Learning Approach for Heterogeneous Cellular Networks," *IEEE JSAC*, 2015.

Task 2: Application to Energy Efficiency

Task 2 Output (Published & Accepted Journal Papers):

6. Sumit Darak, A. P. Vinod, E. M-K. Lai, Jacques Palicot, and Honggang Zhang, "Linear Phase VDF Design with Unabridged Bandwidth Control over the Nyquist Band," *IEEE Transactions on Circuits and Systems II*, June 2014.

7. Sumit Darak, Jacques Palicot, Honggang Zhang, A. P. Vinod, and Christophe Moy, "Reconfigurable Filter Bank with Complete Control over Subband Bandwidths for Multistandard Wireless Communication Receivers," *IEEE Transactions on Very Large Scale Integration (VLSI) Systems*, September 2014.

8. Sumit Darak, Sumedh Dhabu, Christophe Moy, Honggang Zhang, Jacques Palicot, and Vinod Prasad, "Low Complexity and Efficient Dynamic Spectrum Learning and Tunable Bandwidth Access for Heterogeneous Decentralized Cognitive Radio Networks," *Digital Signal Processing (Elsevier)*, 2015. (In Press)

9. Tao Chen, Honggang Zhang, Xianfu Chen, and Olav Tirkkonen, "SoftMobile: Control Evolution for Future Heterogeneous Mobile Networks," *IEEE Wireles Communications*, December 2014.

10. Xuan Zhou, Zhifeng Zhao, Rongpeng Li, Yifan Zhou, Tao Chen, Zhisheng Niu, and Honggang Zhang, "Towards 5G: When Explosive Bursts Meet Soft Cloud," *IEEE Network*, November 2014.

11. Xuan Zhou, Zhifeng Zhao, Rongpeng Li, Yifan Zhou, Jacques Palicot, and Honggang Zhang, "Understanding the Nature of Social Mobile Instant Messaging in Cellular Networks," *IEEE Communications Letters,* Feb. 2014. (Top 2 Most Frequently Downloaded Documents in IEEE Communications Letters, Feb. 2014)

12. Xuan Zhou, Zhifeng Zhao, Rongpeng Li, Yifan Zhou, Jacques Palicot, and Honggang Zhang, "Human Mobility Patterns in Cellular Networks," *IEEE Communications Letters*, October 2013. (Top 11 Most Frequently Downloaded Documents in IEEE Communications Letters, November 2013)

Task 3: **Application to Spectrum Efficiency**

<u>Task 3 Output </u>(Published & Accepted Journal Papers):

13. Xianfu Chen, <u>Honggang Zhang</u>, A. B. MacKenzie, and M. Matinmikko, "Predicting Spectrum Occupancies Using a Non-stationary Hidden Markov Model," *IEEE Wireless Communications Letters*, August 2014.

14. Xianfu Chen, <u>Honggang Zhang</u>, Marko Hoyhtya, Mika Lasanen, and Jacques Palicot, "Reciprocally Opportunistic Spectrum Access," *European Transactions on Emerging Telecommunications Technologies (ETT),* DOI: 10.1002/ett.2810, March 2014.

15. Rongpeng Li, Zhifeng Zhao, Yuan Zhang, Jacques Palicot*,* and <u>Honggang Zhang</u>, "Adaptive Multi-Task Compressive Sensing for Localization in Wireless LANs," *IET Communications*, July 2014. (Top 5 Most Frequently Downloaded Documents in IET Communications, September 2014)

16. Xin Tao, Zhifeng Zhao, Rongpeng Li, Jacques Palicot, and <u>Honggang Zhang</u>, "Downlink Interference Minimization in Cooperative Cognitive LTE-Femtocell Networks," *EURASIP Journal on Wireless Communications & Networking*, July 2013. (Top 100 Highly Accessed Article in EURASIP Journal in 2013)

17. Dongheon Lee, Sheng Zhou, Xuan Zhou, Xiaofeng Zhong, Zhisheng Niu, and <u>Honggang Zhang</u>, "Spatial Modeling of the Traffic Density in Cellular Networks," *IEEE Wireless Communications*, March 2014.

Task 4: Implementation & Demonstration

Demonstration Platform Architecture
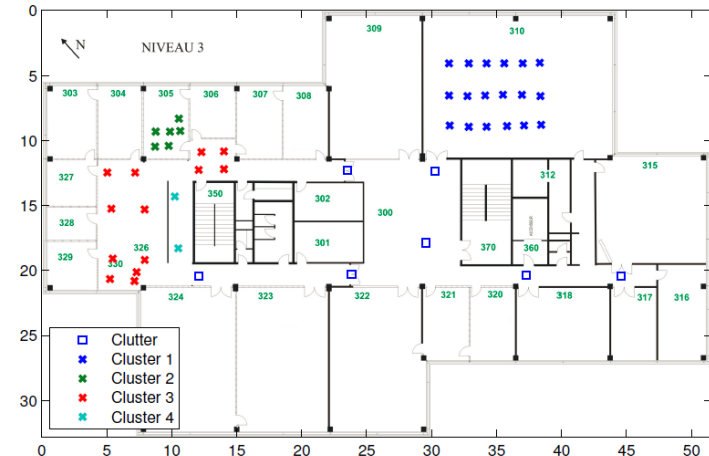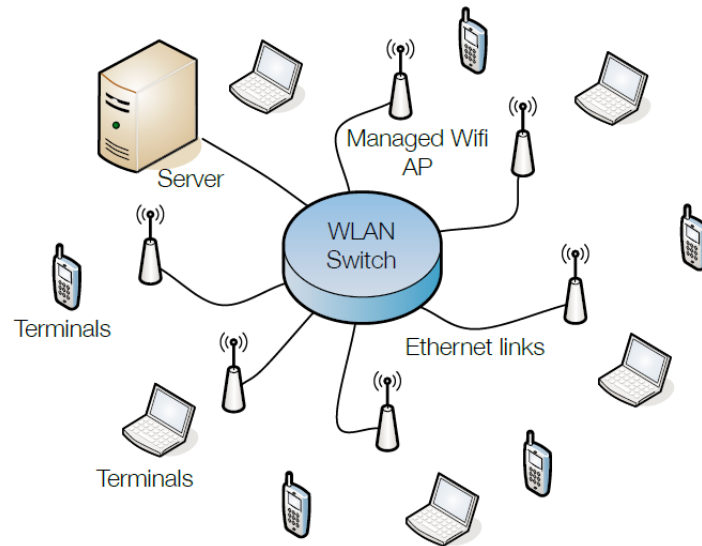
Task 4 Output:

1. Malek Naoues, Hadi Noureddine, Quentin Bodinier, Jacques Palicot, and Honggang Zhang, "WiFi-Based Platform for Energy Saving in Wireless Networks," *IEEE Online-GreenComm 2014*, November 2014. (**Accepted for Demonstration Session**)

2. Hadi Noureddine, Malek Naoues, Honggang Zhang, and Jacques Palicot "Devices Clustering: A Context Information for Cognitive 5G Networks," *IEEE Communications Magazine* (Feature Topic Issue on Emerging Applications, Services and Engineering for Cognitive Cellular Systems), 2014. (**Submitted**)
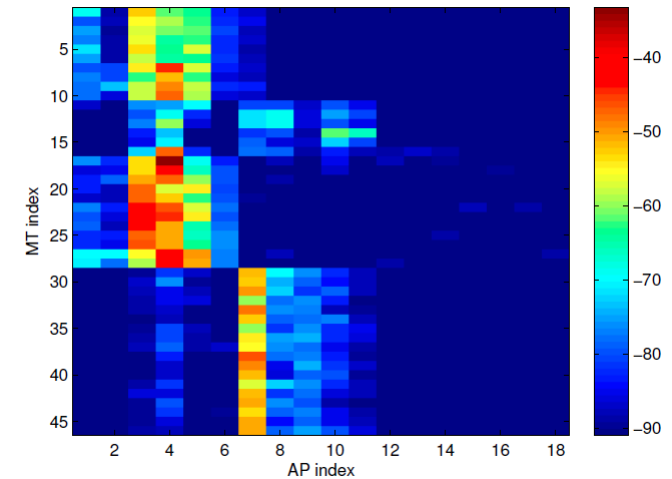
Output: (28 Published International Conference Papers in Total)

1. Xianfu Chen, <u>Honggang Zhang</u>, Tao Chen, and Jacques Palicot, "Combined learning for resource allocation in autonomous heterogeneous cellular networks," *Proc. IEEE PIMRC*, London, UK, Sep. 2013.

2. Xianfu Chen, <u>Honggang Zhang</u>, and Mika Lasanen, "Combined learning for energy efficiency in heterogeneous cellular networks," *Proc. IEEE PIMRC Workshop*, London, UK, Sep. 2013.

3. Xianfu Chen, Tao Chen, Wei Cheng, and <u>Honggang Zhang</u>, "Reciprocity inspired learning for opportunistic spectrum access in cognitive radio networks," *Proc. CROWNCOM*, Washington DC, USA, July 2013. (invited paper)

4. Xianfu Chen, <u>Honggang Zhang</u>, Tao Chen, and Mika Lasanen, "Improving energy efficiency in green femtocell networks: A hierarchical reinforcement learning framework," *Proc. IEEE ICC*, Budapest, Hungary, Jun. 2013.

5. Xianfu Chen, Zhifeng Zhao, David Grace, and <u>Honggang Zhang</u>, "Reciprocal learning for cognitive medium access," *Proc. IEEE WCNC*, Shanghai, China, Apr. 2013.

6. Sumit Darak, <u>Honggang Zhang</u>, Jacques Palicot, and A. P. Vinod, "Efficient Spectrum Sensing For Green Cognitive Radio Using Low Complexity Reconfigurable Fast Filter Bank," *Proc. The 2013 International Conference on Advanced Technologies for Communications* (ATC'13 Special Section on Green Communications), Vietnam, October 2013. (Invited Paper)

7. Babar Aziz, Amor Nafkha, Jacques Palicot, and <u>Honggang Zhang</u>, "Blind Wireless Standard Identification for Green Radio Communications," *Proc. The 2013 International Conference on Advanced Technologies for Communications* (ATC'13 Special Section on Green Communications), Vietnam, October 2013.

8. Ziad Khalaf, Jacques Palicot, Amor Nafkha, and <u>Honggang Zhang</u>, "Blind Free Band Detector Based on the Sparsity of the Cyclic Autocorrelation Function," *Proc. 21st European Signal Processing Conference 2013 (EUSIPCO 2013)*, September 2013.

Output: (Published International Conference Papers)

9. Huanyu Yang, Zhifeng Zhao, and Honggang Zhang, "Hard Combining Based Energy Efficient Spectrum Sensing in Cognitive Radio Network," *Proc. of IEEE Globecom 2013*, Atlanta, USA, Dec. 2013.

10. Yun Li, Honggang Zhang, and Tohru Asami, "On the Cooperation between Cognitive Radio Users and Femtocell Networks for Cooperative Spectrum Sensing and Self-Organization," *Proc. IEEE WCNC 2013*, Shanghai, April 2013.

11. Xin Tao, Zhifeng Zhao, Rongpeng Li, Jacques Palicot, and Honggang Zhang, "Downlink Interference Minimization in Cognitive LTE-Femtocell Networks," *Proc. of IEEE ICCC 2013*, Xi'an, China, Aug. 2013.

12. Xin Tao, Zhifeng Zhao, and Honggang Zhang, "Location Information Based Interference Control for Cognitive Radio Network in TV White Spaces," *Proc. of IEEE WCNC 2013*, Shanghai, China, Apr. 2013.

13. Jianxiong Jin, Zhifeng Zhao, Rongpeng Li, and Honggang Zhang, "Compressive Sensing Based Overhead Reduction Scheme in Multi-antenna Downlink Management," *Proc. 2013 International Conference on Wireless Communications and Signal Processing (WCSP 2013)*, Hangzhou, China, Oct. 2013.

14. Manman Dang, Zhifeng Zhao, and Honggang Zhang, "Detection of Primary User Emulation Attacks Based on Compressive Sensing in Cognitive Radio Networks," *Proc. 2013 International Conference on Wireless Communications and Signal Processing (WCSP 2013)*, Hangzhou, China, Oct. 2013.

15. Yian Zhou, Zhifeng Zhao, Qianlan Ying, Rongpeng Li, Xuan Zhou, and Honggang Zhang, "Two-tier Spatial Modeling of Base Stations in Cellular Networks," *Proc. of IEEE PIMRC 2014*, Washington DC, USA, September 2014.

16. Xuan Zhou, Zhifeng Zhao, Rongpeng Li, Yifan Zhou，and Honggang Zhang, "Service-oriented Cross-layer Management for Software-defined Cellular Networks," *Proc. of IEEE PIMRC 2014*, Washington DC, USA, September 2014.

Output: (Published International Conference Papers)

17. Gang Wang, Zhifeng Zhao, Jialiang Peng, Rongpeng Li, and Honggang Zhang, "An Approximate Algorithm of Configurating Controllers in Multi-domain SDN Architecture," *Proc. ChinaCom 2014*, Maoming, China, Aug. 2014.

18. Qianlan Ying, Zhifeng Zhao, Yifan Zhou, Rongpeng Li, Xuan Zhou and Honggang Zhang, "Characterizing Spatial Patterns of Base Stations in Cellular Networks," *Proc. IEEE ICCC 2014*, Shanghai, China, Oct. 2014.

19. Liang Xie, Zhifeng Zhao, Yifan Zhou, Gang Wang, Qianlan Ying, and Honggang Zhang, "An Adaptive Scheme for Data Forwarding in Software Defined Network," *Proc. WCSP 2014*, Hefei, China, October 2014.

20. Jianchao Zheng, Yueming Cai, Xianfu Chen, Ronggpeng Li, and Honggang Zhang, "A Game-Theoretic Approach for Optimal Base Station Sleeping in Green Cellular Networks," *Proc. WCSP 2014*, Hefei, China, October 2014.

21. Clément Robert, Christophe Moy, and Honggang Zhang, "Opportunistic Spectrum Access Learning Proof of Concept," SDR-WinnComm 2014, Schaumburg, IL, USA, March 2014.

22. Hadi Noureddine, Honggang Zhang, and Jacques Palicot, "Mobile Terminals Clustering for Green Radio Applications," *Proc. IEEE CCS 2014*, Germany, August 2014.

23. Hadi Noureddine, Honggang Zhang, and Jacques Palicot, "RSS-Based Clustering of Mobile Terminals for Localization in Wireless Networks," *Proc. IEEE ISWCS 2014*, Barcelona, August 2014.

24. Sumit Darak, Honggang Zhang, Jacques Palicot, and Christophe Moy, "Efficient Decentralized Dynamic Spectrum Learning and Access Policy for Multi-standard Multi-user Cognitive Radio Networks," *Proc. IEEE ISWCS 2014*, Barcelona, August 2014.

25. Sumit Darak, Xiguang Wu, Jacques Palicot, and Honggang Zhang, "Linear Phase Filter Bank Design with Unabridged Control over Bandwidth and Center Frequency of Subbands," *Proc. URSI GASS 2014*, Beijing, China, August 2014.

Output: (Published International Conference Papers)

26. Rongpeng Li, Zhifeng Zhao, Xianfu Chen, Yves Louët, and Honggang Zhang, "Intelligent base station management in greener traffic-aware cellular networks," *Proc. URSI GASS 2014*, Beijing, China, August 2014.

27. Xiguang Wu, Sumit, Darak, Pierre Leray, Jacques Palicot, and Honggang Zhang, "Reconfiguration Management on FPGA Platform for Cognitive Radio," *Proc. URSI GASS 2014*, Beijing, China, August 2014. (URSI GASS 2014 Travel Grant Award)

28. Sumit Darak, Christophe Moy, Honggang Zhang, and Jacques Palicot, "Dynamic Spectrum Access with Tunable Bandwidth for Multi-standard Cognitive Radio Receivers," *Proc. 37th International Conference on Telecommunications and Signal Processing (TSP)*, Berlin, Germany, June 2014.

Output : (1 Published National Conference Paper)

1. Ziad Khalaf, Jacques Palicot, Amor Nafkha, and Honggang Zhang, "Un détecteur aveugle de signaux de télécomunications base sur la parcimonie de la fonction d'autocorrélation cyclique," Actes du 24e Colloque GRETSI, 2013

Appendix: (Submitted Journal Papers)

1. Hadi Noureddine, Malek Naoues, Honggang Zhang, and Jacques Palicot "Devices Clustering: A Context Information for Cognitive 5G Networks," *IEEE Communications Magazine* (Feature Topic Issue on Emerging Applications, Services and Engineering for Cognitive Cellular Systems), 2014.

2. Y. Zhou, Z. Zhao, Q. Ying, Rongpeng Li, Xuan Zhou, Xianfu Chen, and Honggang Zhang, "Large-scale Spatial Distribution Identification of Base Stations in Cellular Networks," *IEEE Trans. Mobile Computing*, 2014. (Under Review)

3. Jianchao Zheng, Yueming Cai, Xianfu Chen, Rongpeng Li, and Honggang Zhang, "Optimal Base Station Sleeping in Green Cellular Networks: A Distributed Cooperative Framework Based on Game Theory," *IEEE Trans. Wireless Commun.*, 2014. (Under Second Round of Review)

Next G-WiN 2014
3rd International Workshop On
Next Generation Green Wireless Networks

October 1-3, 2014
Supélec, Rennes, France

- ➤ **General Co-Chairs (together with Prof. Jacques Palicot), Next-GWiN 2014** (The 3rd International Workshop on Next Generation Green Wireless Networks, **Rennes**, France)

- ➤ Totally, **135** registers from **20** countries around the world. All the feedbacks were very positive and praiseful.

- ➤ **The European Commission scientific leader, Mr. Pertti Jauhiainen, gave an Opening Keynote on how the European "Horizon 2020" will coin the "landscape" of future ICT innovation and evolution.**

- ➤ **3** industrial key-leaders from Alcatel-Lucent, Ericsson, and Bell Labs(GreenTouch), Dr. **Didier Bourse**, Dr. **Afif Osseiran**, and Dr. **Thierry Klein**, gave Keynote on how the 5G technologies (5G PPP) and energy challenges will be investigated.

- ➤ **Up to 17 scientific leaders, Prof. Luis Muñoz, Prof. Hanna Bogucka, Prof. Luiz DaSilva, Prof. Mérouane Debbah, Prof. Eryk Dutkiewicz, Prof. Damien Ernst, Prof. David Grace, Prof. Aawatif Hayar, Mr. Erik Luther, Prof. Michela Meo, Dr. Alain AM Mourad, Dr. Christine Morin, Prof. Loutfi Nuaymi, Dr. Sumei Sun, Prof. Sofie Pollin, Dr. Ahmed Zeddam, and Prof. H. Zhang, gave various invited talks.**

CALL FOR PARTICIPATION
3rd International Workshop on
Next Generation Green Wireless Networks
1-3 October 2014
Rennes, France

General Co-Chairs
Honggang Zhang, UEB/Supélec, France/ Zhejiang Univ., China
Jacques Palicot, Supélec/IETR, France
TPC Co-Chairs
Mérouane Debbah, Huawei, France
Aawatif Hayar, GREENTIC/ENSEM, Univ. Hassan II Casablanca, Morocco
Keynote Co-Chairs
Luiz DaSilva, Trinity College, Ireland/ Virginia Tech, USA
Christophe Moy, Supélec/IETR, France
Members
Faouzi Bader, Supélec/IETR, France
Hanna Bogucka, Poznan Univ. of Technology, Poland
Alberto Conte, Alcatel-Lucent Bell Labs, France
Maria-Gabriella Di Benedetto, Sapienza Univ. of Rome, Italy
Mischa Dohler, King's College London, UK
Eryk Dutkiewicz, Macquarie Univ., Australia
David Gesbert, EURECOM, France
David Grace, Univ. of York, UK
Steve McLaughlin, Heriot-Watt Univ., UK
Markus Muck, Intel Mobile Communications, Germany
Loutfi Nuaymi, Telecom Bretagne, France
Eric Pottier, Univ. Rennes 1/IETR, France
Ramesh Pyndiah, Telecom Bretagne, France
Isabelle Siaud, B-COM/Orange Labs, France
Chunming Wu, Zhejiang University, China
Ganghua Yang, Huawei Communications Technology Lab, China
Arrangements Members
Karine Bernard, Supélec, France
Sumit Darak, ComInLabs UEB/Supélec, France
Hadi Noureddine, ComInLabs UEB/ Supélec, France

A major challenge of the upcoming 5G and next generation wireless networks is to meet the growing demand on data rates while improving the energy efficiency and inherently reducing the emissions of greenhouse gases. Fostered by this challenge and the economical benefits for service operators, the research on green wireless communications has been gaining an increasing interest during the last few years. Furthermore, attaining better levels of coexistence of various wireless systems and reducing the human exposure to electromagnetic radiations are among the key topics covered by this research area.

Following a series of successful workshops that aim at providing an overview of the latest achievements and state of the art in the field of green wireless communications and discussing the different challenges and research trends, the 3rd International Workshop on Next Generation Green Wireless Networks (Next-GWiN 2014) will take place from 1-3 October 2014 at Rennes, France.

Next-GWiN 2014 gathers world class speakers from various academic, consulting and industrial institutions. It consists of 5 keynotes and 16 invited talks, and a joint special session from Chinese 973 Program (National Basic Research Program). It covers the following aspects of next generation green wireless communications:

- Theory, modeling, optimization, and analysis
- Architecture, strategies, algorithms, and protocols
- Evaluation, standardization, and regulation policies
- Applications, economics, and social issues

The intended audience is students close to complete their education, PhD students, researchers and senior engineers involved in R&D with technical background in fields related to green wireless communications and networks.

For registration and additional information
www.next-gwin.org

- ➢ **TPC Co-Chairs, IEEE Online-GreenComm 2014** (IEEE ComSoc Flagship Conference on Green Communications)

- ➢ **Guest Editors, IEEE ComSoc Best Readings on Green Communications**: As one of the 7 Guest Editors (Prof. Vijay Bhargava, Dr. Jinsong Wu, Prof. John Thompson, Prof. Honggang Zhang, Prof. Ekram Hossain, Prof. Rod Tucker, Dr. Dan Kilper), have been involving in selecting and editing the "**IEEE ComSoc Best Readings on Green Communications**" in 2013.

- **Strategic Cooperation between Supélec (France) and Zhejiang University (China)**: The official **MoU** for mutual strategic cooperation has been approved and signed by the **General Director of Supélec** and the **President of Zhejiang University** in 2013.
- **TPC Co-Chairs**, **IEEE ICUWB 2013** (2013 IEEE International Conference on Ultra-Wideband).
- **Symposium Co-Chairs, IEEE ICC 2013.**
- **Panel Co-Chairs**, **IEEE GreenCom 2013** (IEEE International Conference on Green Computing and Communications), Beijing, China (together with Prof. Jacques Palicot).
- **Keynote Speech**: "**Cognitive Green Communications: A Harmonized Evolution to Sustainable Future**", Conférence de la Recherche de l'UEB, Brest, France, April, 2013.
- **Plenary Talk for the UEB/Inria Colloquium**: "**Cognitive Green Communications**", at the four laboratories in digital sciences of Rennes (IETR, Inria/IRISA, LTSI-Laboratoire Traitement du Signal et Image, IRMAR-Institut de Recherche en Mathématiques de Rennes), November, 2013.
- **Tutorial "Cognitive Radio for Green Communications"** at the **NEWCOM#** Summer School on Green Wireless Communications in Poznan, Poland, September, 2013 (together with Prof. Jacques Palicot).
- **Tutorial de Jacques Palicot et Honggang Zhang, "Cognitive Radio for Green Communications and Networking"** à The Ninth Advanced International Conference on Telecommunication (AICT 2013), Rome, Italy, June, 2013.

- ➤ **Invited Talk** at the **GreenTouch Workshop** on "Creating Intelligent Networks - Energy Efficiency in Action" as its Panelist, Nantes, France, September, 2013 (together with Mr. Bernard Jouga).
- ➤ **URSI GASS 2014** (The XXXI General Assembly of the International Union of Radio Science), Beijing, China, 2014.
- ➤ **ATC'13** (The 2013 International Conference on Advanced Technologies for Communications), Special Section on Green Communications, Vietnam, October 2013 (together with Prof. Jacques Palicot).
- ➤ Special Session at **IEEE CCS 2014**, Germany.
- ➤ **TEPN (Toward Energy Proportional Networks),** CominLabs Project, UEB. Note: The project involves the following people and teams : Nicolas Montavont, Xavier Lagrange, Alberto Blanc (IRISA OCIF - Telecom Bretagne), Rémi Gribonval (IRISA METISS) Philippe Mary, Jean-Yves Baudais, Jean-François Hélard, Matthieu Crussière (IETR SCN), Jacques Palicot, Yves Louët (IETR SCEE), and Honggang Zhang (UEB/CominLabs Chair).

➤ **Environmental-friendly Green Communications:**

– A paradigm change from traditional coverage- & capacity-driven to energy-efficiency driven communications and networks (**S**mart, **S**ustainable, and **S**elf-harmonized greener ICT).

➤ **Cognitive Green Radio Communications:**

– Besides spectrum and energy, intelligence is the THIRD kind of resource, but without limitation of scarcity.

– Learning and decision making algorithms under green constraint can play a significant role in enabling energy- and spectral-efficient greener future communications.

– Effective energy saving can be realized by using various learning approaches in mobile cellular networks.

Cognitive Green Communications: From Concept to GREAT!