Wireless Software and Hardware platforms for Flexible and Unified radio and network controL

Project Deliverable D9.3

Standardization and Regulation Report

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Abstract:
This public deliverable reports on standardization and regulation activities within the first and second year of the project.

Keywords:
Standardization, regulation

Executive Summary

This deliverable compiles a list of all standardisation activities for the first and second year of the WiSHFUL project. Several partners are involved in standardization initiatives with the goal of contributing a defined architecture for radio and network control by means of the WiSHFUL UPIs. Standardisation entities that are interacting with consortium members include ETSI, IETF, and IEEE, and industry special interest groups. Additionally, many project partners are forging stronger working relationships with regulators in Belgium, Ireland, the UK, Lithuania and the Slovak Republic. The aim is to inform these bodies about the latest evolutions of reconfigurable radios and networks and develop European-wide mechanisms to support testing of future wireless solutions that require regulation (e.g., dynamic spectrum access). To date, workshop papers, presentations and meetings presented have received very positive feedback from both industry, including Orange, B-com, Intel, and the BBC, and regulation bodies in Lithuania, the Slovak Republic, and Belgium. Additionally, regulator concerns have been highlighted. Finally, meetings and workshop activities with regulators and standardisation bodies for Year 3 of the project are identified.

List of Acronyms and Abbreviations

3GPP	3rd Generation Partnership Project
6LoWPAN	IPv6 over Low power Wireless Personal Area Networks
6TiSCH	IPv6 over the TSCH mode of IEEE 802.15.4e
AFI	Autonomic network engineering for the self-managing Future Internet
ANIMA	Autonomic Networking Integrated Model and Approach
APEK	Post and Electronic Communications Agency
API	Application Programming Interface
BIPT	Belgian Institute for Postal services and Telecommunications
CoAP	Constrained Application Protocol
ComReg	Irish Communications Regulator
COST	Commercial Off The Self
COST	European Cooperation in Science and Technology
CR	Cognitive Radio
DFS	Dynamic Frequency Selection
DoA	Description of Action
DySPAN	Dynamic Spectrum Access Networks
ERP	Effective Radiated Power
FIRE	Future Internet Research & Experimentation
GRASP	Generic Autonomic Signalling Protocol
IETF	Internet Engineering Task Force
ETSI	European Telecommunications Standards Institute
GANA	Generic Autonomic Network Architecture
GRASP	Generic Autonomic Signaling Protocol
IPSO	IP for Smart Objects
LTE	Long Term Evolution
LLN	Low-Power and Lossy Networks
LTE-A	Long Term Evolution – Advanced
LWM2M	Lightweight Machine-to-Machine
MAC	Medium Access Control
NTECH	Network TECHnologies
OF0	Objective Function zero
Ofcom	Office of Communications, UK
OMA	Open Mobile Alliance
PHY	Physical Layer

RF	Radio Frequency
RPC	Remote Procedure Call
RPL	Routing Protocol for Low-Power and Lossy Networks
RRS	Reconfigurable Radio System
RSC	Radio Spectrum Committee
SDR	Software Defined Radio
SF	Scheduling Function
TCP	Transmission Control Protocol
TPC	Transmission Power Control
TSCH	Time-Slotted Channel Hopping
UDP	User Datagram Protocol
UPI_G	Unified Programming Interface for Global control
WSN	Wireless Sensor Network

Table of contents

1 Introduction

1.1 Scope

This deliverable reports on the work completed in Year 1 and Year 2 of the project related to creating awareness of WiSHFUL to standardization and regulation bodies and policy makers. WiSHFUL is uniquely situated to influence regulatory bodies and contribute to standardization efforts as many of the project partners already have good working relations through several years of related work. The goal of this deliverable is to utilise these relationships with entities such as ETSI, IETF, and IEEE and industry special interest groups with the goal of contributing a defined architecture for radio and network control by means of WiSHFUL UPIs to standardization initiatives. WiSHFUL offers a unique opportunity to test new access proposals before their standardization by offering repeatable conditions in a vendor-neutral environment. Additionally, experience gathered in WiSHFUL and its workflow to run experiments may be considered as a good practise to standardize experimentation procedures and methodologies. Furthermore, WiSHFUL aims to interact with regulation bodies such as Ofcom, ComReg, and the BIPT to develop a European-wide mechanism to support testing of future wireless solutions that require regulations (like dynamic spectrum access). To date, workshop papers, presentations and meetings presented have received a lot of positive feedbacks from both industry, including Orange, B-com, Intel and the BBC, and regulation bodies in Lithuania, the Slovak Republic, and Belgium. Additionally, regulator concerns have been highlighted. Finally, next steps for cooperation with standardization bodies such as Network Technology (NTECH) Working Group and IEEE 802.11ax have been identified.

This deliverable is structured as follows: section 2, 3, 4, 5 outline dissemination efforts in ETSI, IETF, and IEEE workshops, conferences, and standardisation working group meetings. Section 5 outlines presentations and conclusions from meetings with Regulators, while section 6 provides details of meetings with radio spectrum committees. Section 7 describes on going efforts to develop working relationships with other standardization and regulation bodies by organizing meetings and workshops in the final year of the project. Finally, section 8 concludes this deliverable.

1.2 Document purpose and intended audience

This deliverable is primarily meant as a report towards the European Commission. However, it is also relevant for those readers interested in the current WiSHFUL activities related to standardization and regulation.

2 ETSI

The WiSHFUL Consortium participated in ETSI Workshops both with papers and demos and is involved in two ETSI Working Groups (WGs). These workshop papers have received a lot of positive feedbacks from industry, including Orange, B-com, Intel and the BBC. Additionally, the WiSHFUL project has been referred to in the framework of the ETSI standard architecture [1].

2.1 ETSI WORKSHOP – Future Radio Technologies – AIR INTERFACES

1. N. Kaminski, I. Moerman, S. Giannoulis, P. Gallo, A. Zubow, R. Leblon, I. Seskar, S. Choi, and J. de Rezende, “Unified Radio and Network Control Across Heterogeneous Hardware Platforms”, ETSI Workshop on Future Radio Technologies – Air Interfaces, 27-28 January 2016, Sophia Antipolis, France.

Publication Type: Conference Workshop

Abstract: Experimentation is an important step in the investigation of techniques for handling spectrum scarcity or the development of new waveforms in future wireless networks. However, it is impractical and not cost effective to construct custom platforms for each future network scenario to be investigated. This problem is addressed by defining Unified Programming Interfaces that allow common access to several platforms for experimentation-based prototyping, research, and development purposes. The design of these interfaces is driven by a diverse set of scenarios that capture the functionality relevant to future network implementations while trying to keep them as generic as possible. Herein, the definition of this set of scenarios is presented as well as the architecture for supporting experimentation-based wireless research over multiple hardware platforms. The proposed architecture for experimentation incorporates both local and global unified interfaces to control any aspect of a wireless system while being completely agnostic to the actual technology incorporated. Control is feasible from the low-level features of individual radios to the entire network stack, including hierarchical control combinations. A testbed to enable the use of the above architecture is utilized that uses a backbone network in order to be able to extract measurements and observe the overall behaviour of the system under test without imposing further communication overhead to the actual experiment. Based on the aforementioned architecture, a system is proposed that is able to support the advancement of intelligent techniques for future networks through experimentation while decoupling promising algorithms and techniques from the capabilities of a specific hardware platform.

2. T. Kazaz, C.V. Praet, M. Kulin, P. Willemen, and I. Moerman, “Hardware Accelerated SDR Platform for Adaptive Air Interfaces”, ETSI Workshop on Future Radio Technologies – Air Interfaces, 27-28 January 2016, Sophia Antipolis, France

Publication Type: Conference Workshop

Abstract: Advanced 5G wireless infrastructure should support any-to-any connectivity between densely arranged smart objects that form the emerging paradigm known as the Internet of Everything (IoE). While traditional wireless networks enable communication between devices using a single technology, 5G networks will need to support seamless connectivity between heterogeneous wireless objects, and consequently enable the proliferation of IoE networks. To tackle the complexity and versatility of the future IoE networks, 5G has to guarantee optimal usage of both spectrum and energy resources and further support technology-agnostic connectivity between objects. This can be realized by combining intelligent network control with adaptive software-defined air interfaces. In order to achieve this, current radio technology paradigms like Cloud RAN and Software Defined Radio (SDR) utilize centralized baseband signal

processing mainly performed in software. With traditional SDR platforms, composed of separate radio and host commodity computer units, computationally-intensive signal processing algorithms and high-throughput connectivity between processing units are hard to realize. In addition, significant power consumption and large form factor may preclude any real-life deployment of such systems. On the other hand, modern hybrid FPGA technology tightly couples a FPGA fabric with hard core CPU on a single chip. This provides opportunities for implementing air interfaces based on hardware/software co- processing, resulting in increased processing throughput, reduced form factor and power consumption, while at the same time preserving flexibility. This paper examines how hybrid FPGAs can be combined with novel ideas such as RF Network- on-Chip (RFNoC) and partial reconfiguration, to form a flexible and compact platform for implementing low-power adaptive air interfaces. The proposed platform merges software and hardware processing units of SDR systems on a single chip. Therefore, it can provide interfaces for on-the-fly composition and reconfiguration of software and hardware radio modules. The resulting system enables the abstraction of air interfaces, where each access technology is composed of a structured sequence of modular radio processing units.

2.2 ETSI WORKSHOP – From Research To Standardization

Demonstration of collaborative coexistence between IEEE 802.15.4e (TSCH) and IEEE 802.11 technologies

The ETSI organised a workshop entitled "From Research To Standardization" on 10th to 11th of May 2016 in ETSI Headquarters in Sophia Antipolis. It was organised in the context of the H2020 program of the European Commission. The WiSHFUL team provided a demonstration of the collaborative coexistence between IEEE 802.15.4e (TSCH) and IEEE 802.11 technologies.

Dates:	10th – 11th May 2016
Presenter:	Ingrid Moerman, Pieter Becue, Peter Ruckebusch and Xianjun Jiao (imec – Gent University)
Audience:	Unknown
Evidence 1:	http://www.etsi.org/news-events/events/1016-2016-05-ws-from-research-to-standardization

2.3 Participation to standardization and pre-standardization initiatives

During the ETSI Workshop "Future Radio Technologies – Air Interfaces" IMEC has expressed interest to the ETSI pre-standardisation initiative on multiple Radio Access Technology (multi-RAT). So far no further actions have been taken by ETSI.

2.4 ETSI NTECH AFI

The NTECH Autonomic network engineering for the self-managing Future Internet (AFI) is a Working Group in NTECH TC. NTECH AFI specifies requirements, use cases and scenarios and defined a Reference Model of a holistic Generic Autonomic Network Architecture (GANA). GANA is an Architectural Reference Model for Autonomic Networking, Cognitive Networking and Self-Management. It defines autonomic elements and self-manageability properties of the Future Internet. The group also evaluates the impact of autonomic management on future network technologies, including but not limited to SDN and NFV.

Contribution to this WG resides in the WiSHFUL control architecture and the WiSHFUL intelligence framework. Both are key elements for the autonomic capabilities of monitoring, deciding and taking actions.

Presentation

Terms of Reference (ToR) for ETSI Technical Committee (TC) Network Technology, (NTECH) Working Group Evolution of Management towards Autonomic Future Internet (AFI)

Dates:	29th November 2016
Location:	ETSI NTECH, Sophia Antipolis
Presenter:	Pierluigi Gallo (CNIT)
Audience:	ETSI Network Technology (NTECH) Working Group
Details	Presentation to the ETSI NTECH working group about the programmable radio architecture and the WiSHFUL project. WiSHFUL architecture could be considered as a proof of concept of their generic GANA architecture for wireless networks. The following potential next steps for cooperation with TC NTECH were identified 1. Launch an ETSI NTECH Work Item aimed at studying how GANA can be implemented using the WiSHFUL solution. 2. A WiSHFUL-based GANA implementation could be the subject of a GANA PoC demonstration. http://ntechwiki.etsi.org/index.php?title=PoC_Topics 3. Validate a GANA PoC demonstration on the WiSHFUL platform. 4. Jointly evaluate whether TC NTECH could be the right place to standardize some of the UPIs Further detailed discussions should take place during the TC NTECH AFI Working Group sessions. An NTECH AFI virtual meeting with CNIT (Pierluigi Gallo) and IMEC (ingrid Moerman) took place on Friday 16th December 2016 to discuss the way to progress implementing the actions agreed.

2.5 ETSI Reconfigurable Radio Systems (RRS)

ETSI Reconfigurable Radio Systems (RRS) encompasses system solutions related to Software Defined Radio (SDR) and Cognitive Radio (CR).

The WiSHFUL architecture and UPI, as well as multi-technology and multi-platform programmable wireless nodes (IRIS, TAISC, WMP) are examples of reconfigurable radio systems devoted to experimentation. IMEC has participated in several workshops organised by ETSI RRS in order to create awareness of the WiSHFUL projects and its results (see also sections 2.1 and 2.2)

3 IETF

The aim of the IETF is to make the Internet work better. By contributing to IETF working groups, consortium members aim to influence the design, use and management of new technologies in wireless communication based on advanced research completed during the WiSHFUL project.

3.1 IETF 6TiSCH

The WSN protocol stack used in WiSHFUL is compliant with the architecture defined in **draft-ietf-6tisch-architecture-10,** although this draft has expired and needs an updated version to be adopted by the WG. Namely the WiSHFUL WSN stack comprises a MAC protocol that can be TSCH or any other experimental research MAC algorithm and on top 6top is employed (if active MAC is TSCH) for cell management, 6LoWPAN for IPv6 header compression, IPv6, UDP and TCP, RPL as a routing protocol and finally in the application layer we support **CoAP** (RFC 7959) amongst other application layer protocols. There is also support for the ability of centralized routing control through the use of UPIs to manage the routing tables of nodes remotely.

In WiSHFUL we have implemented a partly compliant TSCH MAC layer on top of TAISC. The LLC part of the implementation is compliant with the mechanisms and the hoping sequence manipulation as this is presented in the TSCH draft. We adopt as default values in our implementation the default values mentioned in **draft-ietf-6tisch-minimal-17** like slotframe length, number of scheduled cells and Max Number of retransmission amongst others. All of the supported parameters are exposed through WiSHFUL and the user can manipulate them in real time to experiment beyond the standards.

Dynamic allocation of cells using Scheduling Function Zero (**SF0**) and Scheduling Function One (**SF1**) as defined generally in **draft-ietf-6tisch-6top-protocol** are complementary to the work we are doing. We are actually building the mechanisms in WiSHFUL to support dynamic allocation of slots in real time and not defined and configured through a set of algorithms as the ones defined in SF0 and SF1. WiSHFUL enables the user to define its own scheduling functions as well as build the standard ones if he wishes to in the upper MAC. There are no implementations yet of SF0 and SF1. So we are compliant with the static allocation of cells and also with the remote monitoring and schedule management functions as defined in **draft-ietf-6tisch-architecture-10.** As already mentioned, instead of 6top SFs, WiSHFUL exposes the cell management specific functions like ADD, DELETE, STATUS, LIST, CLEAR to the upper layer and specifically through UPIs we give the direct ability to the local or global controller of a WISHFUL enabled network to manage TSCH cell allocation dynamically in real-time. The derived architecture can therefore be centralized, in case of a global control program controlling the TSCH SF, or decentralized and compliant to how SFs are defined and function in 6TiSCH (locally per node). The WiSHFUL implementation is however compliant with the hard and soft cell definition, as there are hard cells default settings that the user is not able to alter or delete, like for instance the beacon send frame. So it can be concluded that we do support 6top functionality as it is defined but we expose this functionality directly to the control programs (local or global) so that Scheduling Functions can be implemented on top of UPIs.

As far as link layer security is concerned, WiSHFUL does not focus on this area, and we do not use any kind of authentication of nodes or encryption of transmitted data at this time. We plan to adopt ready solutions like DTLS or any other link layer encryption and authentication protocol to provide secure communication in the future.

In the routing layer, the RPL (Routing Protocol for Low-Power and Lossy Networks, RFC 6550) algorithm is supported as the default routing protocol in WISHFUL as far as LLNs (Low-Power and Lossy Networks) are concerned (using IEEE 802.15.4 based devices and SDR implementations of it) WiSHFUL further implements OF0 (Objective Function zero), as defined in **draft-ietf-6tisch-minimal-17.** Also the non-storing mode is supported, and the trickle timer is used with the RPL defined default values in RF C6550. The neighbor table is defined according to the recommended per-neighbor minimum set of information as defined as well as **draft-ietf-6tisch-minimal-17.**

We partially follow the recommendation regarding queuing principles. Since in Contiki there is only 1 IP packet buffer, we do comply with the NUM_UPPERLAYER_PACKETS set to 1. Also MAC layer generated frames are prioritized over higher layer packets since TAISC will check if there is an upper layer packet to send only if active MAC chain is in idle or stop state, meaning there is no MAC related activity at this time.

3.2 IETF CoRE/CoAP

Today, IP/IPv6 has been recognized as the de facto standard for communication between connected devices, objects and people in the Internet of Things. End-to-end IP/IPv6 architectures are seen as the only alternative to design scalable and efficient networks of large numbers of communicating devices. In the past few years, research and standardization have shown that it is possible to achieve end-to-end connectivity even down to the level of very constrained devices (10kB RAM, 100kB ROM), through the use of the **6LoWPAN adaptation layer**. Today, 6LoWPAN (RFC 4919) is an official IETF standard, with wide adoption by a variety of alliances and organizations.

However, IPv6/6LoWPAN only considers the networking layer. If we look at the success of today's Internet, it is clear that it has become so successful not because of the end-to-end IP connectivity, but because of its ability to communicate between processes using well-defined message sequences and to represent content in a universal way. In this context, efforts have been put in moving this paradigm down to the level of embedded, constrained devices. For this, the IETF established the **Constrained RESTful Environments (CoRE) working group** with the aim of realizing the REST architecture in a suitable form for the most constrained nodes and networks. Constrained devices are turned into embedded web servers that make their resources accessible via the CoAP protocol.

REST architectures enable RESTful interactions with devices, i.e. the generation of GET, PUT, POST, DELETE request to retrieve, update or manipulate resources on the devices, resources that are identified by a URI. In order to achieve full interoperability and an easy integration of new devices in the IoT, it is also necessary to standardize how these resources should be modeled (i.e. how to model specific sensors, actuators and specify which resources are being exposed, which data formats are being used, etc.). Also in this area, a lot of activity is ongoing, driven by organization such as OMA LWM2M, IPSO Alliance, Open Connectivity Foundation, etc.

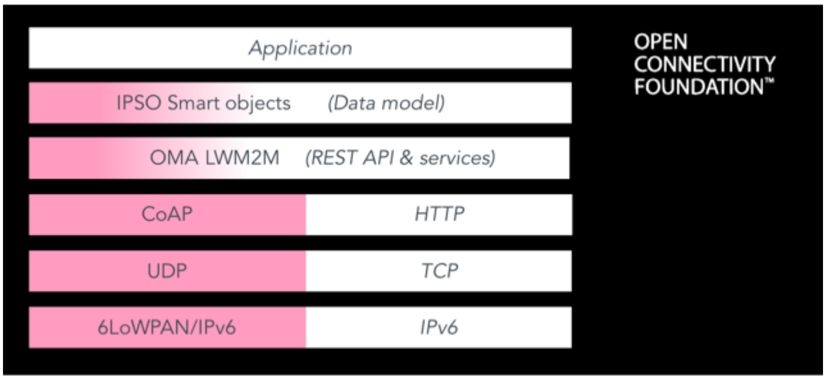

Figure 1: IoT stack in embedded (left) and les constrained (right) devices, as defined by IETF and supported by different IoT forums and alliances

With respect to the constrained IEEE 802.15.4 devices, WiSHFUL adopts the embedded IoT stack as proposed by the IETF, consisting of CoAP/UDP/6LoWPAN. At the CoAP level, the key specifications coming from the IETF CoRe working group are supported, i.e. the Constrained Application Protocol (**RFC 7252**), CoRE link format (**RFC 6690**), Block-wise transfers in CoAP (**draft-ietf-core-block**) and CoAP observe (**RFC 7641**). In terms of resource specifications, we aim to adopt the object and resource model as proposed by **OMA LWM2M** and **IPSO Alliance** and take into account the specifications of **draft-ietf-core-interfaces**. With respect to embedded IEEE 802.11 devices, we adopt a CoAP/UDP/IPv6 stack on top of low-power Wi-Fi hardware.

With respect to less constrained devices (ranging from gateways, to edge and Cloud), IMEC has developed the CoAP++ software framework (C++ framework) for the integration, at application level, of embedded sensors and actuators in the Internet and in web services. This encompasses the implementation of several specifications defined within the IETF CoRE working group such as the CoAP, CoRE link format, Block-wise transfers in CoAP, Resource Directory, CoAP observe, and mirror server (expired draft). The CoAP++ framework also provides additional functionalities such as a smart HTTP/CoAP proxy (partially making use of **draft-ietf-core-http-mapping-17**), unicast group communication (as an **alternative to RFC 7390** and described in the expired draft-ishaq-core-entities-00, proposed by IMEC), an abstraction server to provide uniform interactions with heterogeneous sensors and actuators, a configuration directory, DTLS termination and conditional observe (expired draft **draft-li-core-conditional-observe-05** to which IMEC contributed).

Currently the IETF CoRE working group is also working on "Dynamic Resource Linking for Constrained RESTful Environments" (**draft-ietf-core-dynlink-01**). This specification defines conditional observation attributes that work with Link Bindings or with CoAP Observe and leverages upon some of the ideas in IMEC's proposed expired draft **draft-li-core-conditional-observe-05**). Finally, IMEC is also following the ongoing work in the IETF LPWAN working group, where they are defining solutions for running CoAP/UDP/6LoWPAN on top of LPWAN technologies.

In WiSHFUL, the CoAP standard an in particular its group communication functions are used for transferring control messages containing Remote Procedure Calls (RPCs), hence implementing the communication bus for UPI_G.

3.3 IETF ANIMA

IETF working group called Autonomic Networking Integrated Model and Approach (ANIMA) is working on self-managing characteristics of distributed network elements, adapting to unpredictable changes while hiding intrinsic complexity from operators and users. The main objective of ANIMA is to provide *Plug-and-Play* approach for ISPs and enterprises. In order to achieve this feature, ANIMA minimizes dependencies on central elements and allows direct interactions between devices of a single domain. Therefore distribution and decentralization are its fundamentals.

To achieve this goal, ANIMA defines Generic Autonomic Signalling Protocol (GRASP), which is a protocol enabling autonomic devices to dynamically discover peers, synchronize state with them and negotiate parameters settings mutually with them. While using GRASP, network operator's role is limited to setting just a general policy intent for the whole network.

The objective of GRASP and ANIMA is to provide "Plug and play for the ISP" or "plug and play for the enterprise". Hence, it is focusing on self-management, including self-configuration: nodes will discover information about the surrounding network and negotiate parameter settings with other nodes. Users are setting just a general policy intent. Self-configuration and management is only a small part of WiSHFUL, i.e. bootstrapping phase. All aspects related to device/network control are not targeted by GRASP/ANIMA.

Currently in WiSHFUL we are using the ZRE protocol for node discovery (http://rfc.zeromq.org/spec:36/ZRE/), which is also an RFC. It should be possible to use GRASP instead of ZRE in the bootstrapping (aka node discovery) phase. However, the provided GRASP implementation is at an early development stage (https://www.cs.auckland.ac.nz/~brian/graspy/).

All those issues make concepts of ANIMA not applicable in the context of a testbed and experimentation. Additionally, to the best of our knowledge, there is only one single open-source implementation of the GRASP protocol, which is unfortunately in an early development stage: https://www.cs.auckland.ac.nz/~brian/graspy/.

4 IEEE

WiSHFUL partners are contributing to the following IEEE standards: IEEE 802.11ax and IEEE MEDCA.

4.1 IEEE 802.11ax

This IEEE extension is for High Efficiency WLANs will be published in 2019. Interference management in super high-density WLAN networks is a key issue that is going to be tackled by this standard extension. WiSHFUL contribution with a solution that is going to be experimented within a WiSHFUL showcase that uses hybrid CSMA/TDMA for

- eliminating hidden station problem in dense networks and
- to solve the neighbour capture effect in overlapping BSSs. Note, the RTS/CTS mechanism targeting the hidden node problem creates large overhead.

Furthermore, it is not helping to solve the OBSS problem. Therefore we propose reserving exclusive channel time slots to BSSs and decrease the interference from overlapped BSSs.

4.2 IEEE MEDCA

A novel backoff mechanism called Moderated Backoff (MB) has been recently proposed in the IEEE arena as a standard extension for 802.11 networks [2]. It has been experimentally validated on a commercial 802.11 card before being ratified. The MEDCA experimental setup validates a specific MAC solution and also demonstrates that evaluating non-standard protocols is simplified by using WiSHFUL facilities.

5 Regulators

In Year 2 of the project, consortium members have been meeting and presenting current research, standardisation and potential coexistence of technologies issues with regulators. These activities will continue in the final year of the project.

5.1 Belgian Institute for Postal services and Telecommunications (BIPT)

During the CREW project, first contacts have been established with BIPT to inform them about the latest evolutions of reconfigurable radios and networks. One of the actions that were defined at the end of the CREW project was to organize yearly follow-up meetings for exchanging information from technology & regulators point of view.

The IMEC team has organized a meeting on 14th December 2016 with BIPT.

Dates:	14th December 2016
Location:	IMEC – Gent University, Ghent, Belgium
Presenter:	Ingrid Moerman, Spilios Giannoulis, Vasilis Maglogiannis, Adnan Shahid and

	Dries Naudts
Audience:	BIPT has visited IMEC with a delegation of 4 people, as they also wanted to visit the IMEC testbed facilities. The BIPT delegates are: o Gino Ducheyne (Spectrum management / strategy) o Wim Aerts (Control of spectrum, special spectral measurements) o David Erzeel (Controle of spectrum) o Johan Barbier (Equipment, market surveillance)
Details	IMEC has presented some potential spectrum issues like (1) LTE-WiFi coexistence in unlicensed bands and (2) deployment and coordination issues when free Wi-Fi will be provided in public spaces across the EC states, as was recently announced by Jean-Claude Juncker, in his annual state of the union address (http://europa.eu/rapid/press-release_IP-16-3042_en.htm, *"We propose today to equip every European village and every city with free wireless internet access around the main centres of public life by 2020."*). IMEC has further presented software and hardware platforms developed in H2020 projects like WiSHFUL, eWINE and ORCA (starting 1 January 2017) and how these platforms can used to enable advanced control and coordination strategies across (heterogeneous) wireless network owned by different network providers (private network providers as well as mobile operators). The main conclusions of the meeting are: o BIPT was very happy to be informed by IMEC on the latest standardisation efforts and the potential coexistence issues. It is very difficult for them to follow all 3GPP activities. According to BIPT, LTE in unlicensed bands should only be deployed in small cells for indoor scenarios. o IMEC presented an experimental study of the impact of LTE (release 10, as currently deployed) on Wi-Fi. Although the current experimental study is limited and needs further exploration, there are already clear indications that using LTE in unlicensed bands (even when using Listen Before Talk) will disturb normal operation of Wi-Fi, and lead to unbalanced spectrum occupation (dominated by LTE). BIPT remarks that if multiple operators will be involved, the situation will be even worse. After the presentation, BIPT members had a much worse feeling about LTE operation in unlicensed spectrum than before the presentation o BIPT is concerned about the use of different technologies in the same spectral band. Mechanisms to guarantee coexistence, as defined by standardisation, often do not work in real-life deployments. For instance, BIPT still receives many complaints about Wi-Fi devices interfering with radar, because the Dynamic Frequency Selection (DFS) and Transmission Power Control (TPC) mechanisms for interference avoidance do not work properly in real-life deployments (such as for example, outdoor Wi-Fi cameras used by police). o BIPT recommends getting in touch with the ETSI BRAN Technical Committee (TC). This TC is lead by Edgard Vangeel, Cisco Systems Belgium. Apparently, this TC is not so much in favor of deploying LTE in unlicensed bands. o BIPT recognizes the importance of experimental validations, even in

	early phases of standardisation. It makes sense to extend theoretical models and simulations with experiments, when defining standards. o BIPT likes the results from the showcases in WiSHFUL (such as coordination between IEEE 802.11 and IEEE 802.15.4, and traffic-aware 802.11airtime management). They recognize the power of the WiSHFUL software platforms for coordination between different access points or between heterogeneous technologies in view of more efficient spectrum usage. There main concern is how to ensure that future flexible devices will respect regulation.

5.2 Communications and Regulatory Authorities of Slovak Republic, Czech Republic, Poland and Hungary

Presentation:	Trends in Spectrum Sharing for Future Wireless Networks
Dates:	Thursday 8th September 2016
Presenter:	Luiz Da Silva
Location:	Wroclaw, Poland
Event:	EMC EUROPE 2016 WROCLAW
Audience:	The WiSHFUL framework was promoted to personnel from the following Regulatory and Standardisation bodies: • Communications and Regulatory Authorities of the Slovak Republic, Czech Republic, Poland and Hungary • Frequency Spectrum Management, Regulatory authority for Electronic Communications and Postal Services, Slovak Republic
Abstract:	The traditional model of exclusive use of spectrum is increasingly being challenged, both in civilian and military systems. One recent example is the radar bands, which are being considered for sharing by small cells in commercial wireless systems. Sharing of spectrum can also be coupled with sharing of wireless access infrastructure. In this presentation, we will discuss solutions for enabling spectrum sharing in future systems, as well as performance trade-offs in spectrum and radio access infrastructure sharing.

5.3 Ofcom (CONNECT plenary in February 2017)

Ofcom is the independent regulator and competition authority in the UK. Professor Linda Doyle of Trinity College Dublin is on the Ofcom Spectrum Advisory Board. She regularly interacts with Ofcom and has the opportunity to discuss European-wide mechanisms to support testing of future wireless solutions. Partners at Trinity College Dublin plan to invite members of the Ofcom body to a regulation and standardisation workshop in February 2017, where work on the WiSHFUL project and research at the CONNECT group will be presented.

5.4 ComReg (CONNECT plenary in February 2017)

Commission for Communications Regulation, ComReg, is the telecommunication regulator in Ireland. Partners at Trinity College Dublin plan to invite members of ComReg to a regulation and standardisation workshop in February 2017, where work on the WiSHFUL project and research at the CONNECT group will be presented.

6 Radio Spectrum Committee

Radio Spectrum Committee (RSC) is assisting the Commission for the development of technical implementing decisions to ensure harmonised conditions across Europe for the availability and efficient use of radio spectrum. It also develops measures to ensure that information on the use of radio spectrum is provided accurately and in a timely manner.

The WiSHFUL consortium has prepared a presentation to pinpoint to potential issues related to some upcoming deployments, like:

- the use of LTE in unlicensed bands
- the deployment of free wireless internet around the main centres of public life in every European village and every city by 2020, as recently announced by Jean-Claude Juncker

This presentation has been given for the first time to BIPT (see section 5.1) and will also be presented to the RSC. Jorge Pereira will invite Ingrid Moerman (IMEC) on one of the upcoming RSC meetings.

7 Year 3 Plan

In 2017, consortium members intend to contribute to the specification of unified programming interfaces with the following groups:

- ETSI Reconfigurable Radio Systems (RRS)
- Wireless Innovation Forum
- IEEE 802.11ax
- IETF
- EPRA

Proposed meetings and contributions with regulation and standardisation bodies in 2017 include:

- Ofcom – CONNECT plenary in February 2017
- COMREG – CONNECT plenary in February 2017
- Several meetings with NTECH AFI Group
- IEEE 802.11ax extension
- ETSI NTECH Work Item about GANA
- TC NTECH standardise WiSHFUL UPIs
- BIPT
- ETSI BRAN Technical Committee led by Edgard Vangeel of Cisco Systems Belgium.

8 Conclusions

This deliverable reports on the standardization, regulation and policy work completed in Year 1 and Year 2 of the WiSHFUL project. To date, workshop papers, presentations and meetings presented have received a lot of positive feedback from both industry, including Orange, B-com, Intel and the BBC, and regulation bodies in Lithuania, the Slovak Republic, and Belgium. Regulator concerns have also been raised such using different technologies in the same spectral band, which often does not work in real-life deployments, and ensuring that future flexible devices will respect regulation. The WiSHFUL architecture is now sufficiently mature based on the implemented framework, defined UPIs, designed models, completed showcases, and tested experiments, to support adequate contributions to standardisation bodies. For example, the ETSI NTECH working group is already considering using the WiSHFUL framework as a proof of concept implementation for the generic GANA architecture. In Year 3 of the project, our goal is to launch an ETSI NTECH Work Item aimed at studying how GANA can be implemented using WiSHFUL. We also intend to jointly evaluate with whether TC NTECH could be the right place to standardize some of the WiSHFUL UPIs. Furthermore, consortium members will contribute to interference management in super high-density WLAN networks for the IEEE 802.11ax extension, which will be published in 2019. Finally, we will continue to organise meetings and participate in workshops with regulators and standardisation bodies throughout Year 3 of the project.

References

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