



## Wireless Software and Hardware platforms for Flexible and Unified radio and network control

### Project Deliverable D9.1

#### First Dissemination Report

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#### Abstract:

This deliverable will report on dissemination and promotion activities within the first year of the project

#### Keywords:

Dissemination, communication, promotion, publications, demonstrations, presentations

## Executive Summary

This document compiles all dissemination activities for the first year of the WiSHFUL project. Herein, such activities are organized into the following categories:

**Scientific publications:** this category includes publications in international conferences and scientific journals. Entries in this category include a citation and abstract

**Other presentations:** this category includes presentations of project concepts to the broad public. Entries in this category include a citation of the presentation.

**Demonstrations:** this category includes display of project capabilities through live experimentation. Entries in this category include a citation of the presentation.

**Workshops & Tutorials:** this category includes workshops and tutorial held on the topic of the project. Entries in this category include a citation, an agenda and a report of the event.

**Open Calls:** this category includes open calls for experimentation. Entries in this category include the scope of the open call and the promotion activities.

## List of Acronyms and Abbreviations

Acronym	Explanation
CF-MAC	Collision-Free Medium Access Control
CPU	Central Processing Unit
CR	Cognitive Radio
CR-BS	Cognitive Radio Base Station
CRN	Cognitive Radio Network
CSMA/CA	Carrier Sense Multiple Access with Collision Avoidance
GITAR	Generic extension for Internet-of-Things Architectures
IoT	Internet of Things
KDP	Knowledge Discovery Process
LAN	Local Area Network
MAC	Medium Access Control
M2M	Machine to Machine
NLOS	None-Line-of-Sight
SB	Spectrum Broker
SDN	Software-Defined Networking
TAISC	Time Annotated Instruction Set Computer
TDMA	Time Division Multiple Access
TDoA	Time Difference of Arrival
ToA	Time of Arrival
WiFi	Wireless Fidelity

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## **1 Introduction**

### **1.1 Scope**

This document provides an overview of all WP9 communication, dissemination, and exploitation activities. It compiles all the publications and dissemination activities produced by the members of the WiSHFUL consortium.

### **1.2 Document purpose and intended audience**

This document is a public deliverable, primarily targeting the European Commission as a report of external activities towards maximizing the impact of the project. As such, this document provides one measure of the impact of the project on the scientific community. Finally, this document provides a catalogue of the major achievements of the WiSHFUL project.

## 2 Scientific publications

In this section an overview is given of all published and accepted scientific publications. Publications that are being prepared or are still under review are not listed.

1. Anatolij Zubow, Michael Döring, Mikolaj Chwalisz, and Adam Wolisz (2015), A SDN Approach to Spectrum Brokerage in Infrastructure-based Cognitive Radio Networks, *DySPAN 2015*, Stockholm, 29 September – 2 October 2015

**Abstract:** Cognitive Radio (CR) is a promising approach to overcome the *spectrum crunch* faced by today's enterprise and residential WiFi (IEEE 802.11) due to rapid growth of wireless devices and traffic load. However, the expected high-density CR Networks (CRN) will suffer from similar problems as we see today with WiFi, i.e. any uncoordinated spectrum access will inevitably result in interference between Secondary Users and hence in a low spectral efficiency.

In this paper we take advantages of the ideas of Software-Defined Networking (SDN) and cloud computing technology to manage interference in CRN deployments in residential areas. Specifically, we propose a SDN-based CR architecture where a cloud-based centralized controller, the Spectrum Broker (SB), takes control over the spectrum assignment to CR Base Stations (CR-BS). Therefore, the CR-BSs under control report aggregated wireless statistics to the SB. Moreover, by configuring proper rules in OpenFlow-enabled CR-BSs, the SB controller can get up-to-date information about the network traffic condition in the CRN. With this information the SB can perform a very fine-grained topology-, traffic-, and channel-aware spectrum allocation.

Our architecture, as well as the proposed spectrum allocation scheme, were analyzed by means of emulation within Mininet. Results demonstrate a gain of up to 5x as compared to a static spectrum allocation scheme.

2. Ruckebusch, P.; De Poorter, E.; Fortuna, C.; and Moerman, I. (2015). GITAR: enabling dynamic updates of network and application modules. *Ad Hoc Networks*, January 2016, Vol. 36, Part 1, Pages 127–151

**Abstract:** The Internet-of-Things (IoT) represents the third wave of computing innovation and relies on small, cheap and/or energy efficient devices, densely deployed in various spaces. Automatically managing, updating, and upgrading the software on these devices, particularly the network stacks, with new, improved functionality is currently a major challenge. In this paper we propose GITAR, a generic extension for Internet-of-Things architectures that enables dynamic application and network level upgrades in an efficient way. GITAR consists of four design concepts, which can be applied to any operating system running on IoT/M2M devices. The proof of concept implementation in this paper uses the Contiki OS and the evaluation, based on analytical and experimental methods, shows that GITAR i) is up to 14% more efficient in terms of memory usage and ii) has less or similar run-time CPU overhead as state of the art solutions while offering upgrade functionality down to the network level and ii) can reuse existing Contiki network protocols for dynamic updates without requiring modifications to the code.

3. Facchi, N.; Gringoli, F.; Ricciato, F.; and Toma A., "Emitter Localisation from Reception Timestamps in Asynchronous Networks". *Computer Networks*, September 2015, Vol. 88, Pages 202–217.

**Abstract:** We address the problem of localising a mobile terminal ("blind" node) in unknown position from a set of "anchor" nodes in known positions. The proposed method does not require any form of node synchronisation nor measurement (or control) of the transmission times, which is difficult or anyway costly to achieve in practice. It relies exclusively on reception timestamps collected by the anchor nodes, according to their local clocks, that overhear packets transmitted by the blind node and by (at least one) other transmitting node(s) in known position, e.g., other anchors. The clock differences between the nodes are not eliminated *ex ante* through clock synchronisation, as in traditional ToA and TDoA methods. Instead, they are counteracted *ex post*, during the data processing stage, leveraging the data redundancy that is intrinsic to the multiple

reception of the same packet by different (anchor) nodes. We validate the proposed method in different experimental settings, indoor and outdoor, using exclusively low-cost Commercial-Off-The-Shelf WiFi devices, achieving sub-meter accuracy in full Line-of-Sight conditions and meter-level accuracy in mild NLOS environment. The proposed method does not require that the blind node participate actively to the localisation procedure and can use “opportunistically” any legacy signal or packet available over-the-air for communication purposes. Considering the very minimal requirement on the system - basically, only that anchors in known positions are able to collect and share reception timestamps - the proposed approach can enable practical adoption of opportunistic and/or cooperative localisation on top of existing radio communication systems.

- Fortuna, C; Ruckebusch, P.; Van Praet, C.; Moerman, I.; Kaminski, N.; DaSilva, L.; Tinirello, I.; Bianchi, G.; Gringoli, F.; Zubow, A.; Chwalisz, M.; Wolisz, A.; Leblon, R.; Seskar, I.; Choi, S.; de Rezende, J. F. (2015). *Wireless Software and Hardware platforms for Flexible and Unified radio and network control*. European Conference on Networks and Communications (EuCNC 2015), *Workshop on 5G Testbeds and Hands-on Experimental Research*, Paris, France, June 29, 2015

**Abstract:** Wireless networks have recently evolved to very complex systems, due to the increasing diversity of competing radio technologies, applications and services providers, which coexist in the same environments. In such a scenario, we argue that performance optimization cannot only rely on advanced hardware platforms and radio capabilities, but mainly depends on the availability of suitable software platforms for controlling and coordinating radio communication and network protocols within the complex wireless ecosystems. The WiSHFUL project addresses these issues by proposing a flexible and unified radio and network control framework for standardized technologies as well as Software Defined Radios.

- Jan Bauwens, Bart Jooris, Eli De Poorter, Peter Ruckebusch and Ingrid Moerman, "Towards a MAC protocol App Store", demo abstract paper accepted for the *International Conference on Embedded Wireless Systems and Networks*, EWSN 2016, Graz, Austria, February 15-17, 2016

**Abstract:** The demo showcases Time Annotated Instruction Set Computer (TAISC), a software architecture for hardware independent MAC protocol development, control and management. TAISC enables to (i) make on-the-fly changes to MAC protocol parameters, (ii) to switch between MAC protocols and (iii) upgrade protocols over the air. The end goal is to create an App Store where protocol developers can make their custom MAC protocols available to the public. This way a user can select the protocol(s) that most suit his needs without any knowledge about the protocol implementation. This demo will focus on the switching between pre-installed MAC protocols (CSMA/CA and TDMA). Attendees will be able to change protocol parameters (for example the contention window of the CSMA protocol) in an attempt to better handle the traffic, and can also decide to switch to another protocol.

- Nicholas Kaminski, Ingrid Moerman, Spilios Giannoulis, Pierluigi Gallo, , Anatolij Zubow, Robin, Leblon, Ivan, Seskar, Sunghyun, Choi, Jose, de Rezende, "Unified Radio and Network Control Across Heterogeneous Hardware Platforms", abstract accepted for ETSI Workshop on Future Radio Technologies - Air Interfaces, 27-28 January 2016, Sophia Antipolis, France

**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. Therefore 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.

7. Salvador P.; Gringoli, F.; Serrano, P.; Facchi, N.; and Paris, S., "Making a Case for Flexible 802.11 Architectures", *IEEE International Conference on Communications, ICC 2015, London (UK), June 8-12, 2015*.

**Abstract:** In the past years, researchers have been advocating for flexible 802.11 devices that dynamically adapt to the varying network conditions, looking for efficient alternatives to the 802.11 standard MAC. In this work we demonstrate that this flexibility is readily available at the MAC level, and its operation can be tuned by re-programming the firmware inside the wireless chipsets that are built on relatively generic hardware modules. We show this by implementing the new amendment IEEE 802.11aa in legacy equipments by simply coding the frame exchange schemes at the firmware level. Nevertheless, we claim that the lack of flexibility in the way these modules interact results in a bottleneck that severely degrades performance. In our work, we prove this inefficiency of the 802.11 hardware architecture that hinders high throughput features, as in our case study of 802.11aa reliable multicast. To solve this problem, we provide new directions for the revision of the current hardware architecture and propose a new vision for the future design of wireless chipsets.

8. Sanabria-Russo, L.; Gringoli, F.; Barcelo, J.; and Bellalta, B., "Implementation and Experimental Evaluation of a Collision-Free MAC Protocol for WLANs", *IEEE International Conference on Communications, ICC 2015, London (UK), June 8-12, 2015*.

**Abstract:** Collisions are a main cause of throughput degradation in Wireless LANs. The current contention mechanism for these networks is based on a random backoff strategy to avoid collisions with other transmitters. Even though it can reduce the probability of collisions, the random backoff prevents users from achieving Collision-Free schedules, where the channel would be used more efficiently. Modifying the contention mechanism by waiting for a deterministic timer after successful transmissions, users would be able to construct a Collision-Free schedule among successful contenders. This work shows the experimental results of a Collision-Free MAC (CF-MAC) protocol for WLANs using commercial hardware and open firmware for wireless network cards, which is able to support many users. Testbed results show that the proposed CF-MAC protocol leads to a better distribution of the available bandwidth among users, higher throughput and lower losses than the unmodified WLANs clients using a legacy firmware.



### 3 Other presentations

1. Information about WiSHFUL got published in the German national newsletter for scientists and researchers in the area of “Communication and Distributed Systems” (“Kommunikation und Verteilte Systeme” KuVS) [https://www.kuvs.de/wp-content/uploads/2015/06/kuvs-newsletter\\_\\_2015-06.pdf](https://www.kuvs.de/wp-content/uploads/2015/06/kuvs-newsletter__2015-06.pdf)
2. Robin Leblon, Concrete problems/cases in wireless networks, European Conference on Networks and Communications (EuCNC 2015), *Workshop on 5G Testbeds and Hands-on Experimental Research*, Paris, France, June 29, 2015
3. Ingrid Moerman, WiSHFUL: addressing challenges in wireless networks, European Conference on Networks and Communications (EuCNC 2015), *Workshop on 5G Testbeds and Hands-on Experimental Research*, Paris, France, June 29, 2015
4. Nicholas Kaminski, Intelligence for wireless networks, European Conference on Networks and Communications (EuCNC 2015), *Workshop on 5G Testbeds and Hands-on Experimental Research*, Paris, France, June 29, 2015
5. Ingrid Moerman, “Intelligent control in wireless networks”, presentation at *the fourth GENI / FIRE Collaboration Workshop*, September 17-18, 2015, Washington DC
6. Ingrid Moerman, Pieter Becue, “Emphasizing 5G System Measurements”, presentation at the fourth GENI / FIRE Collaboration Workshop, September 17-18, 2015, Washington DC
7. Ingrid Moerman, “Wireless testbeds for the Future Internet”, presentation at *FIRE Board - “Facilities Define the Future”*, Friday 2nd October 2015, Brussels, Belgium [The presentation discusses progress in CREW and WiSHFUL, and introduces the new eWine project.]
8. Ingrid Moerman, “the eWINE project”, presentation at the *FIRE Forum - “European Experimental Infrastructure Driving Innovation”*, Wednesday 9th December 2015, Brussels, Belgium [This presentation gives a short overview of the eWINE project, that will start on 1 January 2016, and further explains how eWINE is related the WiSHFUL project]

## 4 Demonstrations

1. Cross-technology TDMA in the 2.4 GHz ISM band using programmable MAC solutions on off-the-shelf hardware, Demo presented by CNIT and IMINDS at exhibition booth at *European Conference on Networks and Communications*, EuCNC 2015, Paris, France, June 29/July 2, 2015
2. IoT Demonstration of TAISC software platform by iMINDS at IoT launch event, 10 November, 2015 Ghent
3. Jan Bauwens, Bart Jooris, Eli De Poorter, Peter Ruckebusch and Ingrid Moerman, "Towards a MAC protocol App Store", demo at the *International Conference on Embedded Wireless Systems and Networks*, EWSN 2016, Graz, Austria, February 15-17, 2016

## 5 Workshops & Tutorials

1. Organisation and chairing of *Workshop on 5G Testbeds and Hands-on Experimental Research* European Conference on Networks and Communications (EuCNC 2015), Paris, France, June 29, 2015

### Agenda:

#### *Morning session: FIRE and 5G –the way beyond*

- 9:00 – 9:15 Welcome and introduction; presentation of the workshop (Ingrid Moerman, iMinds, Belgium – CREW/WiSHFUL)
- 09:15 – 09:45 5G Experimental Facilities in Europe - The NetWorld2020 White Paper (Antonio Manzalini, Telecom Italia, Italy; Roberto Verdone, University of Bologna, Italy - NetWorld2020 Expert Group, editors of the white paper)
- 9:45 – 10:00 FIRE portfolio: the current status (Hans Schaffers, Aalto University, Finland - AmpliFIRE)
- 10:00 – 10:30 Federating FIRE facilities, a step towards 5G testing? (Brecht Vermeulen, iMinds, Belgium - Fed4FIRE)
- 10:30 – 11:00 Break
- 11:00 – 11:15 OneLab (Timur Friedman, OneLab Executive Director, France): Introduction to OneLab and Industrial Innovation capabilities on experimental platforms
- 11:15 – 11:45 FIRE+ and the 5G PPP: how to converge? (Jacques Magen, InterInnov - AmpliFIRE and 5G Infrastructure Association; Didier Bourse, Alcatel Lucent, France - 5G Infrastructure Association)
- 11:45 – 12:30 Panel session (including Q&As with the audience): FIRE and 5G, the way beyond – what shall we do next and how shall we proceed? (Bernard Barani, EC - 5G PPP representative, Jorge Pereira, EC - FIRE representative, Jean-Sébastien Bedo, Orange representative of 5G Infrastructure Association)
- 12:30 – 14:00 Lunch break

#### *Afternoon session: Enabling intelligence in heterogeneous wireless networks*

- 14:00 – 14:15 Challenges in wireless networks (Mikolaj Chwalisz, TU Berlin, Germany - CREW)
- 14:15 – 14:30 Concrete problems/cases (Robin Leblon, nCentric, Belgium)
- 14:30 – 14:45 Solutions for these challenges (Ingrid Moerman, iMinds, Belgium - WiSHFUL)
- 14:45 – 15:00 Intelligence for wireless networks (Nicholas Kaminski, Trinity College Dublin, Ireland)
- 15:00 – 15:30 Machine learning for wireless networks (Eric Moulines, ParisTech, France)
- 15:30 – 16:00 Break
- 16:00 – 16:30 Distributed artificial intelligence for wireless networks (David Grace, University of York, UK)
- 16:30 – 17:30 OneLab hands-on tutorial ((Timur Friedman, OneLab Executive Director, France)

### Report on panel discussion:

Although the FIRE projects like CREW, WiSHFUL, FLEX, eWINE, and FUTEBOL, offer the precursor testbeds for building the complex/large testbed that is needed for end-to-end 5G validation, the second ambition (*the reference platform for upcoming 5G developments*) seems to be less

obvious. A panel session on 5G & FIRE convergence has been organized by the WISHFUL project (together with the CREW and AMPLIFIRE projects and OneLab) at EuCNC on June 29<sup>th</sup>, 2015. The traditional big telecom stakeholders, members of 5G-PPP, currently have no interest in open federated research testbeds like the ones developed in FIRE. If they want to validate 5G solutions, they prefer to build their own closed testbeds. The main conclusion from the panel session was that 5G-PPP aims at big traditional telecom players, while FIRE has to focus more on the innovation driven by smaller players (e.g. SMEs). 5G does not only follow the traditional telecom approach, but also offers big opportunities for other approaches and other players (e.g. offering over-the-top services). Smaller players should not be afraid to compete with traditional telecom players in the context of 5G. Smaller players have several assets that give them a competitive advantage with respect to the bigger telecom players: (1) faster introduction of new products/solution into the markets (some 5G products are already available now!), and (2) cheaper products/solutions. 5G solutions offered by traditional telecom players solutions will be introduced a much slower pace, as standardization takes time (the 5G specification in 3GPP only expected by end 2019!).

2. Organisation and chairing of “Wireless” workshop at *the fourth GENI / FIRE Collaboration Workshop*, September 17-18, 2015, Washington DC

**Agenda:** *The role of research infrastructures for wireless network validation*

In the previous “wireless session”, participants were asked to explore the shortcomings of wireless testbeds by considering, “the current shortcomings of wireless experimentation facilities and to come up with ideas for the ultimate 'golden' wireless test facility (or strongly argue for more than one).” To explore this issue, participants were asked to a 3-dimensional space of choices, which included: standard based versus open-ended experimentation facilities; testbed operator perspective versus experimenter perspective; and academic versus industrial-oriented research. The findings of this exercise were that (1) the complexity of wireless testbeds increases, as experimentation comes closer to applications, (2) technology evolutions are mainly driven by research projects, but also from industrial customers, and (3) it is wrong to assume that experimenters have domain knowledge (testbeds should be easy to use, exposing simple APIs). While informative, questions remain and we will consider the following in this next session.

- What is the role of testbeds in defining the precursors to 5G?
  - Will 5G come to subsume other network technologies (IEEE.802) and if so how will we evaluate the implication of this?
  - How might we influence the direction of the 5G process in a way that assures continued growth and innovation in the wireless space?
  - While the 5G community thinks that it will encompass all things wireless, how might IEEE.802, DSA, virtualization and other technology impact the directions of 5G?
  - What will be the struggle between 3GPP and 802.11? How will academia impact wireless futures and how might testbeds impact 5G and the role of IEEE.802?
  - Can testbeds be used to show where 3GPP is failing to deliver and to demonstrate better alternatives?
  - How might LAA (License Assisted Access) impact these standards?
  - What is the future of unlicensed, exclusive unlicensed versus shared licensed?
- What kind of research do we need to support with research infrastructures?
  - Will end-to-end solutions be the norm or will we continue to build for local optimality?
  - What are the driving application scenarios?

- How might application level expectations make us rethink how we design and operate wireless networks?
  - What contributions might be made in terms of use cases and services and the development of new architectural technologies for the whole network (not only for the telecom networks)?
  - What is the implication of network control as the network grows smarter (this touches on flexibility, adaptability, reconfigurability, scalability, heterogeneity, intelligent control, softwarization, virtualization). How might flexibility, reconfigurability, softwarization and virtualization impact the edge of the network and how we design the core?
- What are main challenges for experimentally-driven research and wireless research infrastructures?

**Report: Presentation Highlights**

- Ingrid Moerman (iMinds): Experimental facilities should not only offer hardware infrastructure, but also software platforms with unified programming interfaces for flexible and intelligent control of radio and network settings, together with technical support to experimenters. There is an evolution of wireless experiments, moving from academia to industry (mainly SME) and in some (limited) cases also the end-users.
- Luiz DaSilva (Trinity College Dublin): Wireless networks of the future will be virtualised: virtual wireless access network will feel to the user like a traditional network operated by a single entity, but is in fact orchestrated out of a diverse pool of resources with different ownership models. Main challenges are: How to select physical resources to meet the needs of a virtual operator? How to dynamically manage these virtual networks? How to ensure security, and privacy? What economic and public policy models will support this new model?
- Raymond Knopp (Eurecom): Today the cellular world is closed, impeding real impact from Academia to 3GPP. The future wireless world will be characterized by software radio, flexibility, commoditization of real-time RF and open source; a world where the open-source community will have impact and can introduce disruptive technologies.
- Ivan Seskar (Rutgers University): In order to deal with 5G technical challenges (mixed environment, C-RAN with NFV and SDN, massive/cooperative MIMO, real-time issues, etc.), FPGA programming skills are required, while today there is no expertise with programming of large FPGA in academic world.
- Suman Banerjee (University of Wisconsin-Madison): Paradrop offers a virtualization framework that moves the cloud to the home router and drops 3rd part apps & services on demand. Paradrop avoids the typical problems associated to cloud-based networking, like disruptions and network viability.
- Kobus van der Merve (University of Utah): PhantomNet is an open programmable end-to-end mobile testbed that integrated OpenEPC with Emulab to enable research at the intersection of mobile networking, cloud computing and software defined networking.
- Yahya Al-Hamzi (Fraunhofer Fokus): 5G Playground answers industry experimentation requirements addressing multiple use cases: Interoperability (providing a common ground for product development), Product prototyping (using parts of the 5G Playground software for developing PoC prototypes for new products), Remote experimentation (using the Fraunhofer FOKUS Facilities), calibration and benchmarking (customizing prototypes and products for the specific market).

The following issues were raised during discussion:

- Real-time requirements of software radios are particularly challenging for WiFi technologies (order 10  $\mu$ s inter frame spacing versus latency requirements of order ms for LTE)
- There is an increasing interest in SR (Software Radio) platforms. However, today software radio ends at the base station (at the LTE eNode B), while there is an increasing demand for smaller, low-power SR platforms for UE (user equipment) developments (e.g., LTE-unlicensed)
- Main challenges for experimentation with SR platforms are: dealing with many (500+) GPP cores, clock distribution, high-performance computing, finding researchers with FPGA programming skills

## 6 Open Calls

The first WiSHFUL open call has been launched on December 9<sup>th</sup>, 2015, at FIRE Forum in Brussels.

The **first Open Call** includes 2 tracks:

- **Track 1 – Call for experiments:** this track targets advanced solutions for controlling wireless networks using the WiSHFUL software platforms and unified programming interfaces (UPIs), and using the facilities and hardware supported by the WiSHFUL Consortium.
- **Track 2 – Call for extensions:** this track targets (1) development of new software functionality for the currently supported WiSHFUL software and hardware platforms, (2) adding new hardware that is compliant with the WiSHFUL software platforms, at least supporting the WiSHFUL unified programming interfaces, or (3) integration of new Fed4FIRE compliant testbeds that offer WiSHFUL software platforms that are compliant with the WiSHFUL software platforms and its unified programming interfaces (UPIs).

More information on the first Open Call can be found at <http://www.wishful-project.eu/open-calls>

The Open Call is promoted via various communication channels:

- WiSHFUL in project website
- WiSHFUL communication letter
- Presence at relevant events (NetFutures, EuCNC) with demos at exhibition booth. At these events contact info from potential proposers is collected.
- Announcement via FIRE (FIRE website, FIRE Communication at Dissemination and Communication Working Group (DWG), FIRE Forum)
- Announcement to other relevant European & national projects via the WiSHFUL partners
- Dissemination via national research and industrial networks (e.g. iMinds communication letter)

## **7 Conclusion**

This document has catalogued the dissemination activities of the first year of the WiSHFUL project. Within this first year, the project has exceeded the goal of 5 scientific publications and doubled the goal of an exhibition. Furthermore, the project partners have begun to build a community through presentations to the broader public and demonstrations of project capabilities. These activities have already increased interest in the project, including activities such as the open call.