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

Open Call 4

Fourth WiSHFUL Open Call for Experiments

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1. General call objectives

The WiSHFUL project hereby announces its fourth Open Call for Experiments, targeting advanced solutions for intelligent control of wireless networks using the WiSHFUL software platforms and its unified programming interfaces (UPIs), and using the facilities and hardware supported by the WiSHFUL Consortium.

WiSHFUL has extended several wireless radio platforms with control plane functionality and as such offers an experimentation environment for early implementation and validation of end-to-end 5G solutions that improve resource utilization through advanced reconfigurabilty of radio and network settings. WiSHFUL further provides all the experimentation tools to validate 5G solutions and can adopt new 5G technologies from external experimenters and support new technologies within a minimum amount of time.

More information on the scope of this fourth Open Call of the WiSHFUL project can be found in section 4 of this document

2. Call information

Project full name:	WiSHFUL - Wireless Software and Hardware platforms for Flexible and Unified radio and network controL
Project grant agreement number:	645274
Call identifier:	WiSHFUL-OC4
Call title:	Fourth WiSHFUL Open Call for Experiments
Submission deadline:	Wednesday 3 May 2017, at 17:00 Brussels local time
Feasibility check deadline:	Wednesday 26 April 2017, at 17:00 Brussels local time

For the ***feasibility check***, it is essential that the proposing party gets in contact with the WiSHFUL partner in charge of the testbed(s) or software platform(s), which are intended to be used for the proposed Experiment, to discuss its feasibility within the WiSHFUL federation and the related specific requirements. Each proposing party must therefore identify a possible Patron either by contacting an appropriate WiSHFUL partner (see section 7) or through contact@wishful-project.eu, in case support is required for selecting an appropriate WiSHFUL partner. The proposing party must submit its draft proposal to the Patron using the WiSHFUL submission portal by Wednesday 26 April 2017, at 17:00 Brussels local time. **In this draft proposal at least sections A, B and C needs to be fully completed.** The feedback will be provided by the Patron at the latest by Wednesday 3 May 2017 at 17:00, and must be copied into section D of the proposal template.

Financial information:

Call	Category / identifier	Call budget	Max. budget per experiment	Minimum no. of experiments to be funded	Guaranteed support[1]
Experiments	Scientific Excellence WiSHFUL-OC4-EXP-EXC	€ 100 000	€ 50 000	2	€ 10 000
	Innovation by Industry WiSHFUL-OC4-EXP-IND	€ 115 000	€ 40 000	3	€ 15 000
Total funding of this call		€ 215 000			€ 25 000

Requirements related to the proposer:

- Proposers must be eligible for participation in EC H2020 projects
- Proposals will only be accepted from a **single party**.
- For the Experiments in the category 'Innovation by Industry, only proposals from small, medium and large size enterprises, including unipersonal companies and individuals, will be accepted. The WiSHFUL project encourages in particular the participation of small and medium size enterprises (SMEs) and unipersonal companies. Proposals submitted by SMEs or unipersonal companies will receive a bonus in their score (more information see section 11 of this document).
- A proposer can only be selected for funding for one proposal, even if the proposer submitted multiple proposals that are ranked high enough to be selected for funding. In the latter case, the proposer might be given the opportunity to choose the one to be retained for funding.
- Parties having been selected in previous WiSHFUL Open Calls are not eligible to participate again.
- The WiSHFUL project especially welcomes and stimulates the participation of new players in the FIRE community. Proposals submitted by such new players will receive a bonus in their score (more information see section 11 of this document).

Other conditions:

- Language in which the proposal must be submitted: English
- Proposals must follow the provided template (see section 6 of this document and Appendix A)
- Proposals (draft as well as final proposals) must be submitted through the online submission portal (accessible from http://www.wishful-project.eu/open-calls)[2]

Contact: contact@wishful-project.eu

[1] An extra budget of typically € 5 000 per Experiment will be allocated to the WiSHFUL consortium partner acting as Patron for guaranteed support.

[2] Please note that the submission portal for WiSHFUL Open Call proposals is NOT the H2020 portal.

3. Background information on the WiSHFUL project

The WiSHFUL project is a Research and Innovation Action under the European Horizon 2020 Programme addressing the work programme topic Future Internet Research and Experimentation. The project started in January 2015 and runs for 36 months, until the end of 2017.

The WiSHFUL project offers several **software platforms** that comprise data plane and control plane functionality for advanced and **intelligent radio and network control**. The WiSHFUL project offers unified radio and network control interfaces for off-the-shelf as well as advanced SDR equipment that allow customizing wireless solutions for specific networking and traffic contexts. Although different wireless technologies and platforms can be very heterogeneous in terms of memory and processing capabilities and supported operating systems and software, the software platforms offered by the WiSHFUL project come **with a unified, technology-agonistic interface**, called UPI or Unified Programming Interface. The proposed unified radio control abstracts hardware specific instructions and thus enables full, vendor-independent radio configuration, while the unified network control allows rapid prototyping and adaptations of network protocol stacks in a heterogeneous, multi-vendor environment. As such experimenters can focus on network optimization without the need to dig into complex hardware and software specifications for different radio hardware platform, network protocols and software architectures.

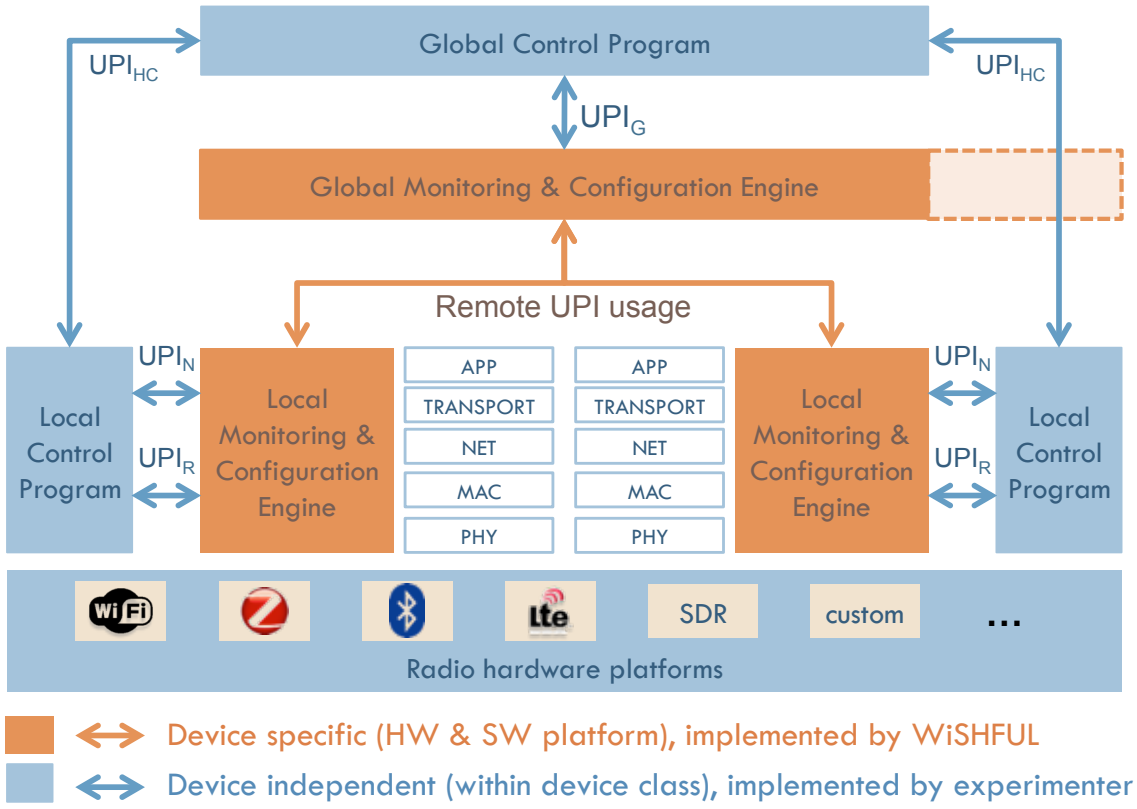

Figure 1: WiSHFUL software architecture

The **WiSHFUL software architecture** (see Figure 1) is devised to enable the definition of cognitive adaptations of radio operation and automated runtime network intelligence, by means of flexible and unified radio and network control. With flexible control we mean the possibility to maximize the configuration space of the devices, exploiting all the radio functionalities and programmable protocol logics supported by the radio and platform hardware. With unified control we mean the possibility to expose platform-independent programming interfaces over very heterogeneous hardware platforms, including standardized technologies and SDR platforms. WiSHFUL adopts the

general idea of software defined networking (SDN), implemented in core IP networks, and applies it to the more heterogeneous access networks.

The terminology used in the high-level WiSHFUL software architecture is listed below:

- **Unified Programming Interface – Radio (UPI_R)**: this is a software interface consisting of a ***set of functions*** that ensures ***uniform control*** of the radio and lower MAC behaviour ***on heterogeneous devices***. The functions forming the interface are ***generic***, their implementation is hardware and platform specific, and is provided by the Local Monitoring and Configuration Engine.
- **Unified Programming Interface – Network (UPI_N)**: this is a software interface consisting of a ***set of functions*** that ensures ***uniform control*** of the upper MAC and higher layer protocol behaviour on ***heterogeneous devices***. The functions forming the interface are generic, their implementation is hardware and platform specific and is provided by the Local Monitoring and Configuration Engine.
- **Unified Programming Interface – Global (UPI_G)**: this is a software interface consisting of a set of functions that ensures uniform control of the behaviour of a **group of** heterogeneous **devices**. The functions forming the interface are generic, their implementation is deployment specific and is provided by the Global Monitoring and Configuration Engine.
- **Unified Programming Interface – Hierarchical Control (UPI_{HC})**: this is a software interface that enables hierarchical control between control programs that are structured in a hierarchical way.
- **Local Monitoring and Configuration Engine**: the role of this engine is to provide a ***device-specific implementation of the UPI_R and UPI_N***. It ensures that the functions defined in the two UPIs execute correctly on the hardware and software platform for which they were developed.
- **Local Control Program**: it is a piece of software that ***uses the UPI_R and UPI_N*** and ***implements the algorithm/logic*** that controls the radio and network protocol stack and adapts the behaviour of the wireless system to meet the QoS requirements established by end users (or applications). It uses locally observed information. Because it uses the UPIs, the same code can be compiled and run on several heterogeneous devices within the same device class that support that UPI. Example implementations are provided by the WiSHFUL consortium, most implementations should come from the users through open call Experiments.
- **Global Monitoring and Configuration Engine**: the role of this engine is to provide an implementation of the UPI_G that is common to a **group of nodes**. It ensures that the functions defined in the UPI execute correctly and if necessary simultaneously on the group of nodes for which they were developed. The Global Monitoring and Configuration Engine supports the remote call of local UPI functions simultaneously on a group of nodes and also other basic supporting services like automatic node discovery, discovery of node capabilities, time-scheduled execution of UPI functions at a particular point in time, time synchronisation among (heterogeneous) wireless nodes, etc.
- **Global Control Program**: it is a piece of software that uses the UPI_G and implements the algorithm/logic that controls the radio and network protocol stack of a group of nodes and adapts the behaviour of the wireless networked system to meet the QoS requirements established by end users. It uses information observed from a group of nodes. Because it uses the UPI_G, the code can be compiled and run in several different deployments that support that UPI. Example implementations are provided by the WiSHFUL consortium, most implementations should come from the users through open call Experiments.
- **Device class**: represents a set of devices that are similar in terms of system architecture and capabilities. We consider three classes of devices: 1) microcontroller devices that have a radio

chip, 2) general purpose devices with a wireless network interface card and 3) software defined radios.

- **Lower MAC:** The lower-level MAC (lower MAC) directly interacts with the PHY Tx and Rx cores and handles all wireless transmissions and receptions. Minimizing processing latency in the lower level MAC is critical in order to meet the channel access timing requirements. Typical lower MAC functions are: sending, receiving, CCA, back-off, inter frame spacing, CTS/RTS, ACKs, slot synchronization (adjust timing using info in synchronization beacon), next slot scheduling, superframe scheduling, channel hopping, etc.
- **Upper MAC:** The upper-level MAC (upper MAC) is responsible for inter-packet states that are not time critical. This includes among others framing and management functions where some form of negotiation between nodes is required (like association, the allocation of extra time slots, blacklisting channels for hopping sequences).

The WiSHFUL project offers implementations for the Local/Global Monitoring & configuration Engine (see orange blocks in the software architecture) and a basic set of functions for the Unified Program Interfaces (UPI_R, UPI_N, UPI_G and UPI_{HC}) for several radio hardware platforms. More information of the supported radio HW and SW platforms and available functions supported by the UPIs can be found further in this section.

The WiSHFUL project offers **open and free of charge access to a number of advanced wireless testbeds**, such as TWIST (TU Berlin), w-iLab.t (imec), IRIS (TCD), Orbit (Rutgers University), a FIBRE Island at UFRJ, and NITOS (University of Thessaly). These testbeds offer **different wireless technologies** (such as IEEE 802.11, IEEE 802.15.4, LTE, DVB-T and SDR) and further guarantee support by skilled people. All of these testbeds are installed in either office environments or other dedicated testbed environments. Because some research requires doing measurement campaigns or actual testing in real-world environments, the WiSHFUL project also offers a **portable testbed** to the community (see **Error! Reference source not found.**Figure 2). The portable testbed can be deployed at any location allowing validation in the real world and involving real users.

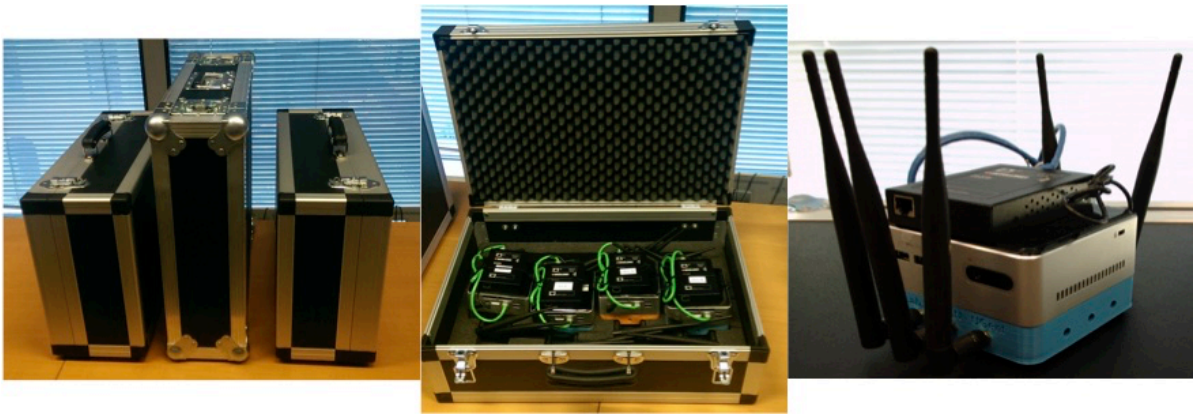

Figure 2: WiSHFUL portable testbed

The portable testbed offers almost identical functionality to the experimenters as if they would run their Experiments on one of the fixed testbeds:

- The experimenter can use one user account to access all WiSHFUL testbeds, including the portable testbed. The same user account can be used to access all Fed4FIRE testbeds.
- The experimenter can use one tool (jFed) to design and setup the Experiment. The same tool can be used to access multiple other testbeds inside the Fed4FIRE federation.

- The portable testbed provides powerful embedded Linux nodes (DUT – Device Under Test) to which the experimenter can gain full (root) access. The nodes are by default equipped with 2 Wi-Fi cards, an IEEE 802.15.4 sensor node and a Bluetooth USB dongle. The USB connections of the node can be used to attach extra hardware (e.g. LTE dongles or other USB compatible hardware). The experimenter has full control over the operating system and the software packages that are installed on the DUT. The DUT can also be used as a proxy to access all USB peripherals of the node, like sensor nodes. If the embedded PC provided by WiSHFUL does not satisfy the experimenter's needs, other hardware can be used as long as it can interface over Ethernet with the backbone nodes.
- To replace the fixed wired backbone, WiSHFUL provides a highly reliable wireless backbone that allows the experimenter to interact with the nodes during the Experiment (see **Error! Reference source not found.**Figure 3). The interaction with the nodes can be done using either SSH or the OMF6 Experiment control framework.
- Measurements can be collected using the OML framework. The (aggregated) live data can be sent over the wireless backbone towards an OML server, or can be stored locally and dumped to a database server after the Experiment.
- The portable testbed is packaged into ruggedized lightweight cases to ensure safe and easy transportation of the hardware.
- Deployment of the portable testbed is as easy as plug-and-play to lower the boundary for experimenters. The duration of the deployment of the portable testbed can vary from several hours to several weeks or even months. Depending on the duration of the deployment and the accessibility of the environment in which the testbed is deployed, extra fail-safe mechanisms may be activated to allow for better remote management of the portable testbed. Several ways to power the DUTs are supported: AC power, Power-Over-Ethernet or 19V battery packs.

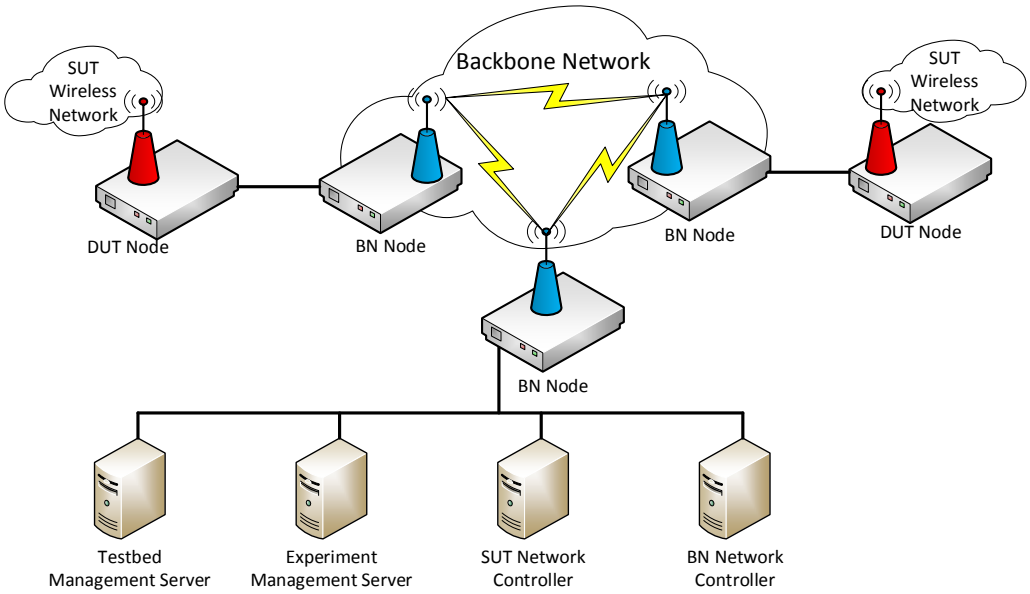

Figure 3: Architecture of WiSHFUL portable testbed (SUT: System Under Test, DUT: Device Under Test, BN: Backbone Node)

The table below gives an overview of the ***software platforms, radio hardware platforms and testbeds*** that are supported in the present Open Call.

Hardware	Type	Technology/ spectral range	Software supported	Testbed Support
wireless Wi-Fi card	Atheros athxk,	IEEE 802.11 a/b/g/n	Linux	w.iLab.t, TWIST, ORBIT, FIBRE@UFRJ, Portable testbed
	Broadcom b43	IEEE 802.11 b/g	Linux, Wireless MAC Processor (WMP)	w.iLab.t, Portable testbed
Wireless sensor node	RM090	IEEE 802.15.4	Contiki, TAISC, GITAR	w.iLab.t, Portable testbed
	Zolertia Z1	IEEE 802.15.4	Contiki, GITAR	w.iLab.t, Portable testbed
	Zolertia RE-Mote	IEEE 802.15.4 (dual band)	Contiki, TAISC, GITAR	w.iLab.t, Portable testbed
	Jennic JN516X	IEEE 802.15.4	TinyOS	TWIST, Portable testbed
Software Defined Radio (SDR)	WARPv3	IEEE 802.11 b/g	Wireless Mac Processor (WMP)	Portable testbed
	USRP2-N210	2.4 – 2.5 GHz 4.9 – 5.85 GHz	IRIS software radio, GNU Radio	w.iLab.t, IRIS testbed, ORBIT
	USRP2-N210	50 – 860 MHz (RX only) 800 – 1000 MHz 1.5 – 2.1 GHz 2.3 – 2.9 GHz 50 MHz – 2.2 GHz 400 MHz – 4.4 GHz	GNU Radio IRIS software radio IRIS DVB-T	IRIS testbed
	USRP-B200mini	70 MHz - 6 GHz	IRIS software radio GNU radio IRIS software radio	w.iLab.t, portable testebd
	USRP X310	10 MHz – 6 Ghz	GNU radio	ORBIT
	USRP B210	70 MHz - 6 GHz	GNU radio	ORBIT
	ZedBoard Xilinx Zynq®-7000 SoC	400 MHz - 4 GHz (Analog Devices FMCOMMS1) 70 MHz -6 GHz (Analog Devices FMCOMMS2)	Contiki, TAISC, GITAR	w.iLab.t
	Xilinx ZC706 Evaluation Kit - Zynq® SoC		Contiki, TAISC, GITAR	w.iLab.t
LTE	Airspan	2.59 GHz TDD	Linux	ORBIT
	ip.access (+ SIRRAN EPC SW core)	2500-2570 MHZ (indoor uplink) 2620-2690 MHZ	Linux	w.iLab.t (indoor), UTH (outdoor)

		(indoor downlink) 2.53-2.63 GHz (outdoor)		
Antenna	RAS (Reconfigurable Antenna System)	2.4 GHz 5 GHz	Linux, Wireless Mac Processor (WMP)	w.iLab.t , Portable testbed

More detailed information on the supported software platforms can be found at http://www.wishful-project.eu/software.

More detailed information on implemented UPIs can be found on the WiSHFUL Github (https://wishful-project.github.io/wishful_upis/). The source code of UPI implementations can be found at https://github.com/wishful-project.

More (information on the testbeds and radio hardware platforms can be found at http://www.wishful-project.eu/testbeds).

Sample configurations on experimentation tools use in WiSHFUL testbeds can be found at https://github.com/WirelessTestbedsAcademy/ExperimentationTools).

This Open Call also offers the **WiSHFUL Intelligence framework** enabling intelligent network and radio control. This intelligence framework is developed in collaboration with the eWINE project (https://ewine-project.eu). The connection between the WiSHFUL software architecture for radio and network control and the intelligence framework is made by the Unified Programming Interfaces. As the UPIs are unified abstractions that span several wireless technology platforms, the components of the intelligence framework are generic. The framework has the following components:

- The ***Data Collection Component*** is responsible for data acquisition of the network status (through interaction with the WiSHFUL UPIs, to retrieve data about radio and network operation) and the application requirements. With respect to the network status, the experimenter can specify the radio and/or network parameters he wants to monitor by choosing the parameters of interest from a predefined set of possible options (offered by the UPI interfaces) and the collection time window.
- The Data Collection Component also implements ***aggregation*** functionality to compress or summarize the amount of data for enhancing network lifetime, to extract relevant features, or to change the representation of data.
- The ***Intelligence Composition Module*** offers support for composing and configuring several algorithms available in the WiSHFUL Intelligence Repository into a self-contained intelligence engine that uses the data provided by the Data Collection Component and triggers configuration through the Action Component. The Intelligence Composition Component offers different approaches that can be selected by the experimenter for finding optimal radio and network settings. The intelligence modules will be offered as a collection of algorithms (e.g. optimisation and machine learning techniques) that can be applied for user-specific scenarios. The Intelligence Composition Component also offers modules for pre-processing data such as data cleaning (removing outliers), normalization, and data transformation.
- The ***Action Component*** represents an interface between the outputs of the intelligence algorithm and the UPI functions that enable the control of the behaviour of wireless nodes. This component translates the intelligence decisions taken by the Intelligence Composition Component in a sequence of UPI calls.

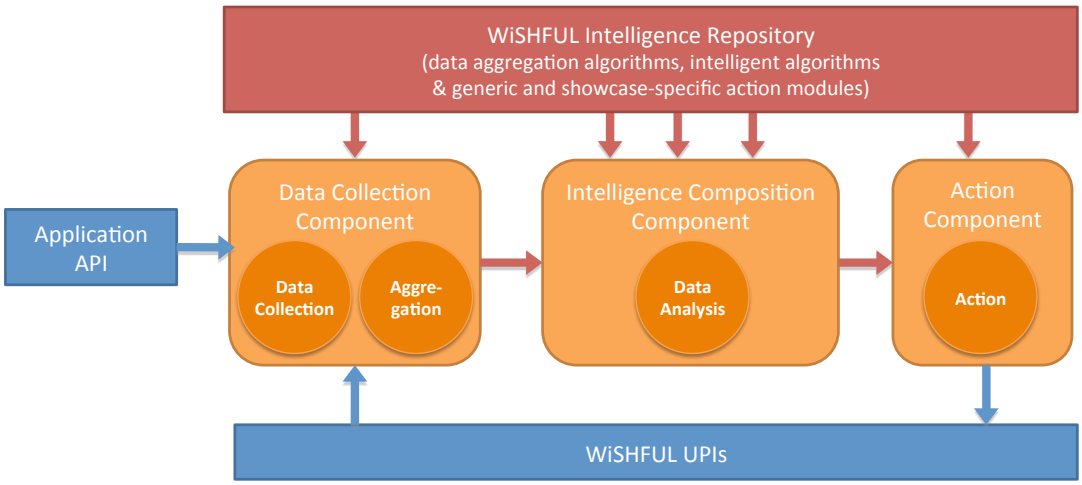

Figure 4 WiSHFUL intelligence framework

Together with the UPIs, the WiSHFUL software architecture of the intelligence framework enables reasoning about the current network state and applying actions to change the configuration of radio and network. More information can be found in WiSHFUL deliverable D10.1 “Design of software architecture for intelligent control and showcases” (https://goo.gl/Sg4jCE).

The intelligence framework has been implemented using the Node-RED tool (http://nodered.org), that serves as a front-end (an intuitive graphical user interface) for designing and executing process flows involving data collection, data aggregation, machine learning and configuration (action) steps steps, as illustrated in Figure 5

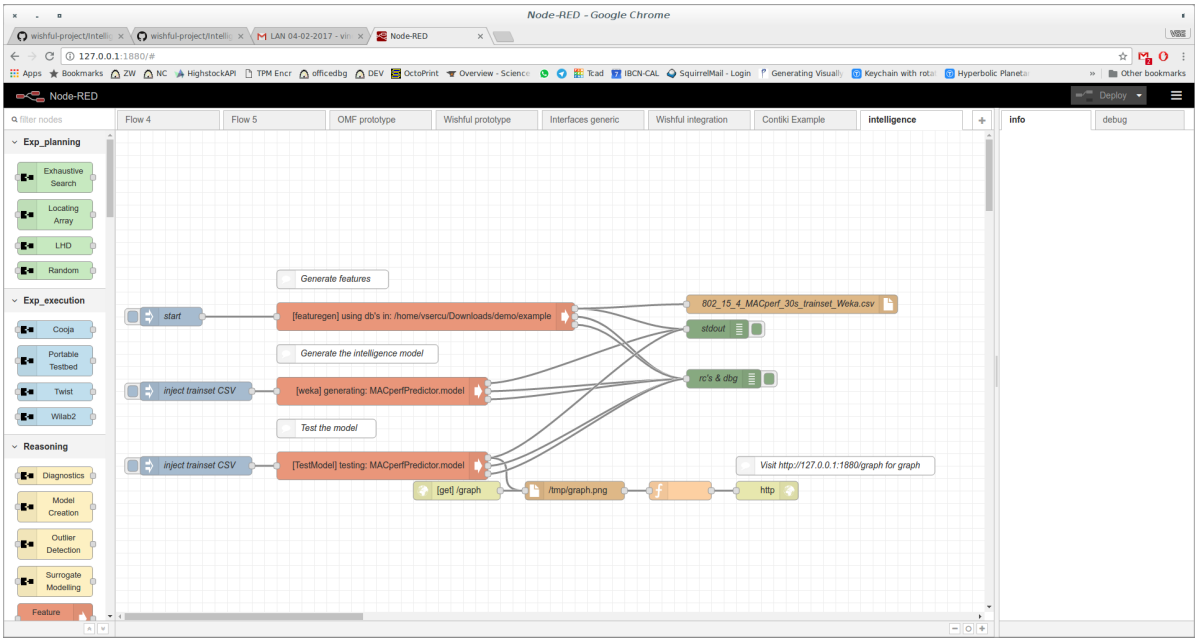

Figure 5 Process flow in Node-RED GUI for off-line modelling of MAC protocols

In the following table you can find a list of the available intelligence modules offered by WiSHFUL as well a link to the relevant repository. The list is regularly updated as more modules are implemented and offered continuously. All of the components below can be found in the general link https://github.com/wishful-project/Intelligence-Framework. The path to each component within the general repository is provided in the table as well.

Intelligence Components	Brief description	Specific Path
WiSHFUL UPI exec component	A Node-Red component implementation that supports the direct execution of UPIs from within Node-Red	/Action-Component/upi-exec
Measurement collection component	Utilising Cooja network simulator and Node-Red framework to provide a data collection component for wireless sensor networks	/Collect-Component/
Feature generation component	A intelligent component to extract features from datasets	/Intelligence-Engine/reasoning-featuregen/
WECA based model training component	A component that can accept as input datasets to train a neural network based model based on defined features.	/Intelligence-Engine/reasoning-weka/
Interference classification component	An intelligence component that can distinguish between various interference sources and identify nature of interference	/Intelligence-Engine/interference-classification/
Surrogate model creation and optimization	Surrogate models create performance-predicting models based on incomplete or noisy data. It is based on MATLAB and can be used through Node-RED	/Intelligence-Engine/Surrogate-model/
802.15.4 MAC layer performance data set	MAC performance dataset from experiments with 802.15.4 nodes on the wilab2 testbed.	/Datasets/IEEE-802.15.4/
Technology classification dataset	Dataset comprised of LTE, WIFI and DVB signals captured via USRP from various locations in Ghent, Belgium.	/Datasets/Technology-classification/

4. Scope of the present call

This call solicits for **Experiments** to validate 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.

These Experiments should be of a short duration (maximum 6 months). Experiments can be inspired by, but not limited to, the **example showcases** below, currently implemented or being implemented by the WiSHFUL consortium:

- **MAC adaptations**
  - ***Intra-technology airtime management***: WiSHFUL allows building hybrid TDMA on top of today's off-the-shelf WiFi hardware running DCF by providing an API to allow local or global control programs to configure the channel access function. In particular, it allows configuring the TDMA downlink channel access by defining the number and size of airtime slots in the TDMA superframe. Moreover, for each time slot a medium access policy can be assigned which allows restricting the medium access for particular stations (identified by their MAC address) and traffic identification (e.g. VoIP or video). The latter can be used to program flow-level medium access. The data plane itself resides in each AP and is controlled by the WiSHFUL runtime system.

- ***Load-aware & platform-independent MAC adaptation***: the selection of CSMA or TDMA access protocols should depend on network load and application requirements, rather than being defined one-for-all. WiSHFUL UPIs allow to easily collect low-level channel measurements (e.g. link quality indicators, number of successful or failed transmissions, number of contending nodes, etc.) to estimate the network operating conditions, select the best possible access protocol and optimize its performance (e.g. by tuning the CSMA contention window as a function of the collision probability), regardless of the specific radio access technology (IEEE 802.11 or IEEE 802.15.4) and PHY-layer parameters.
- ***Co-existence of IEEE 802.11 and IEEE 802.15.4e***: The WiSHFUL UPIs can facilitate efficient spectrum management of co-existing heterogeneous technologies by making them aware of each other. WiSHFUL facilitates the implementation of interference avoidance schemes where, depending on the network load in both networks, other decisions are made. For example, if the sensor network is highly loaded, interference avoidance happens in the WiFi network by deferring WiFi transmission taking into account the scheduling information from the sensor network. If the network load in the WiFi network is high, the spectrum used by WiFi can be excluded from the hopping scheme of the sensor network through blacklisting. Yet another approach is to use a cross-technology TDMA protocol to coordinate the transmission between both types of nodes.
- ***Multi-hop load-aware MAC adaptations***: WiSHFUL offers a solution for mitigating typical problems in multi-hop connected and high-density networks like starvation, hidden nodes, and unfairness phenomena of CSMA-based protocols. The solution is based on distributed allocations of airtimes. A distributed protocol, based on an auction scheme, is implemented for negotiating airtime allocations among the nodes on the basis of the specific traffic requirements and local views of the network. The negotiation protocol also allows reservation of channel resources for control and management operations. The distributed protocol is implemented in terms of a control program running on each node.
- ***MAC adaptation in presence of legacy stations***: WiSHFUL enables customized tuning of the contention window for a subset of nodes (for example, implementing a moderated backoff scheme or the optimal window as a function of the number of stations), while coexisting with nodes that implement legacy 802.11 exponential backoff, by guaranteeing that legacy stations still achieve the same performance that they would achieve when all the stations employ exponential backoff.

- **Intelligent MAC adaptations**
  - ***MetaMAC*** : This approach provides adaptations by selecting dynamically a MAC protocol among a list of available ones, which may include completely different protocols or multiple instantiations of the same protocol with different configuration parameters. The selection can be performed in run-time as a function of the network context and is transparent to network applications. The local control program is able to virtually execute the MAC protocols, which are not running on the node, on the basis of a channel trace gathered by exploiting the WiSHFUL UPIs. By comparing the performance results of virtually executed protocols and running protocols, the control program updates the weights of each protocol component and decides about protocol switching when needed.
  - ***Cognitive MAC protocol selection:*** this showcase aims to demonstrate how to increase network performance by adding intelligent mechanisms for deciding on the selection of the most suitable MAC protocol for the current network conditions, while taking into account the application requirements To this end, off-line machine learning techniques are applied to build general MAC models for predicting the performance based on the monitoring of the current network conditions and application demands. All data processing steps (data

collection, data aggregation, machine learning) can be executed using an intuitive Node-RED user interface.

- ***Intelligent interference mitigation in dense networks***: The WiSHFUL architecture allows to recognize and distinguish specific interference conditions (hidden nodes, exposed nodes, flow in the middle, etc.) from those due to scarce link quality or extremely crowded channels. A dedicated intelligent module implemented in the local control program, receives customized low-level statistics about local channel utilization and feeds a classification algorithm to recognize the reason of unfairness among pre-defined possible sources. The output of the classification algorithm is passed to the global control program that applies BSS-specific access policies. Intelligent modules can further analyse busy time intervals and reveal unused slots, allowing optimal tuning of TDMA parameters across BSSs.
- ***Intelligent MCS selection:*** Current wireless access technologies select the MCS index based on local communication characteristics (SINR, bit error rate, etc.). Recently, there have been some studies on more advanced MCS algorithms. However, these solutions are NP-hard optimization algorithms that have two major drawbacks: (*i*) the MCS selection is based only on local information observed by the wireless node, and (*ii*) several limitations are imposed to reduce the complexity of the optimization problem. Developing MCS algorithms based on Machine Learning can eliminate these drawbacks. WiSHFUL UPIs can assist the development of Intelligent MCS selection algorithms by (*i*) providing the means to quickly gather any information from the wireless medium, build data-driven learning algorithms based on the observations from the wireless medium, (*iii*) providing the framework to design local or centralized MCS algorithms.

- **Load and topology aware networking:**
  - ***Routing adaptation:*** Via the WiSHFUL UPIs it is possible to (*i*) dynamically monitor the network performance and neighbourhood, and (*ii*) change routing protocol configuration or change routing modules, without the need for redeploying code. The control program can increase the overall network performance by dynamically selecting the optimal link estimation algorithm that drives the routing decisions, by monitoring the achieved performance and node density. The UPIs enable to create an adaptive routing strategy based on the measured QoS and topology information.
  - ***Modulation and Coding Scheme (MCS) selection***: WiSHFUL supports dynamic and adaptive selection of the MCS in the physical layer based on the monitored quality of the wireless links towards neighboring wireless nodes. Each node can locally decide its MCS when attempting to communicate with a specific neighboring node based on past monitored statistics of the characteristics of the wireless link.
  - ***Dynamic Link estimator selection***: WiSHFUL supports dynamic link estimator selection based on a per packet strategy. The ability to dynamically alter the link estimator algorithm will provide multi objective capabilities to any routing protocol operating in the system in real time

- ***Prioritization in wireless mesh networks:*** Wireless mesh networks are generally deployed in dynamic wireless environments and further have to carry different types of traffic: (1) control traffic for monitoring of the link qualities, load, etc., and updating the settings of the mesh nodes, and (2) data traffic with different requirements in terms of latency and throughput. In order to deal with the well-known performance limits of wireless mesh networks, WiSHFUL UPIs can be used for implementing prioritization mechanisms (traffic shaping, flow marking, flow steering) that can differentiate the channel resources allocated to different traffic classes.
- ***Multiple Radio Access Technologies (Multi-RATs) sharing the same antenna:*** The GNU Radio platform provides the necessary functionality to virtualize multiple heterogeneous RATs.

WiSHFUL has deployed a wide-band RF front-end to receive wireless signals from multiple wireless standards, and use software basebands to separate and demodulate information streams for each coexisting wireless standard. WiSHFUL UPIs are used to (*i*) provide seamless interface to configure the different characteristics of multiple virtualized base station, (*ii*) implement mechanisms at the Hypervisor layer to manage the RF Front-End resource slicing (for and (*iii*) manage the lifecycle of a virtualized base station.

More details on the showcases and the results obtained can be found in:

- the WiSHFUL deliverables (http://www.wishful-project.eu/deliverables)
- the booklet with Year 1 showcase results (http://www.wishful-project.eu/sites/default/files/images/WiSHFUL_Year1_results.pdf)
- the Open Call 1 results (http://www.wishful-project.eu/OC1results)
- the booklet with Year 2 showcase results (http://www.wishful-project.eu/sites/default/files/WiSHFUL_demo_booklet_Y2.pdf)

Experiments can build further on top of these example showcases by adding more advanced wireless monitoring and control. Experiments can focus on the control of radio, lower networking layers, and/or higher networking layers (such as control of routing and transport protocols). Experimenters can also design their own showcases using the HW platforms and UPIs currently supported by the WiSHFUL projects. Small extensions to the UPIs are possible to enable specific control and monitoring functionality required by the proposed Experiment that is not yet supported by WiSHFUL. For this purpose the required functionality must clearly be described in the proposal and discussed with the Patron. For the selected Experiments, these extensions will be supported by the Patron.

This call is split in two **categories** of Experiments:

- ***Scientific excellence*** targeting Experiments validating novel wireless solutions that clearly advance the current state-of-the-art.
- ***Innovation by Industry*** targeting Experiments validating wireless solutions that have a large potential for commercial exploitation in existing or new products or services.

Independent evaluations of the submitted proposals will be performed, in order to select the Experiments that will be supported by the project. Different categories of Experiments will be evaluated against different criteria (see section 11). It is required that the Experiments are performed by a single organization. In the category 'Innovation by Industry', only proposals from small and medium-size enterprises, as defined by H2020 guidelines, including unipersonal companies and individuals, will be accepted.

Benefits for an experimenter to participate in this open call are:

- Possibility to perform wireless Experiments starting from advanced flexible software platforms with clearly defined control interfaces without the need for deep technical knowledge on radio hardware platforms or network protocol implementations; This allows the experimenter to focus on advanced/intelligent control strategies for optimizing wireless network solutions, instead of digging into complex hardware and software specifications for different radio hardware platform, network protocols and software architectures.
- Easy access to all the required wireless devices, wireless software platforms and intelligence components in different testbeds with a single account and unified Experimentation tools (cf. tools for testbed access and Experimentation developed in and/or supported by the FED4FIRE/FED4FIREplus project). This allows the experimenter to focus on his core task of

Experimentation, instead of on practical aspects such as learning to work with different tools for each testbed, requesting accounts on each testbed separately, etc.;

- The simplified application (and reporting) process compared to the one from the standard H2020 calls together with a rapid review process by independent external evaluators;
- An extra benefit is the dedicated support from skilled WiSHFUL members. Each proposer should seek a supporting WiSHFUL consortium partner (the Patron) that will be in charge of dedicated (advanced) support of the Experiment.

Per proposal a budget can be made available up to a maximum of 50 k€ for an Experiment of the category 'Scientific excellence' and up to a maximum of 40 k€ for an Experiment of the category 'Innovation by Industry'. In parallel, an extra budget (on average 5 k€ / Experiment) can be assigned to a WiSHFUL consortium partner acting as the Patron in charge of dedicated (advanced) support of the Experiment.

5. Inclusion into the consortium

Once a proposer is selected to perform the proposed Experiment, he/she will become a Third Party using Cascade Funding, and to this end he will be contracted by the project coordinator (imec) as 'Subcontractor'. In the remainder of this document a 'Third Party using Cascade Funding' is referred to as 'Subcontractor'.

This implies that the administrative load for the Subcontractor will be minimal as only an invoice needs to be submitted to imec at the end of the Experiment with a final report describing the tasks performed and the results achieved. This final report will be required before payment will be carried out. A payment of up to 75% of the requested funding will be carried out by the project coordinator based on the evaluation of the final report. The remaining 25% will be paid following a formal approval of the report and the work at a technical project review by the European Commission (EC). More details on the payment scheme are given in section 8.

Each proposing party should seek contact with the WiSHFUL consortium and identify a WiSHFUL partner acting as "Patron". The role of the Patron is to carry out an obligatory feasibility check and to provide support during the execution of the Experiment. This Patron will also be consulted for evaluation before payment by imec of the invoices. The role of this Patron is further described in section 7.

The contract template is available in Annex B of this document. Upon submission, the proposer has to declare the acceptance of the conditions of the contract between imec and the proposer.

6. Proposal template

The use of a specific proposal format as described in this section is mandatory. The template is limited in size and is focusing on "what the proposer wants to do" and "what the expected result is".

Section A **Summary** (maximum 300 words).

The information in this section may be used in public documents and reports by the WiSHFUL consortium.

Section B **Detailed description and expected results** (minimum 4 pages, and maximum 6 pages)

This section describes the details on the planned Experiment (what does the proposer hope to obtain?, how?, why is it relevant?). This section should also include all

information with respect to the State-of-the-Art, or a comparison to competing commercial wireless solutions in case of Experiments of category 'Innovation by Industry' to show the innovative character of the Experiment and the expected scientific or business impact.

Section C **Requested WiSHFUL software platforms, UPI interfaces, radio hardware platforms, testbeds** (target length 1 page)

The information in this section needs to be collected in collaboration with the WiSHFUL partner acting as Patron on this Experiment. For this section a specific format needs to be used, which is included in the proposal template.

Section D **Compliance check** (max. 1 page)

This section contains the feedback from the WiSHFUL partner acting as Patron on this Experiment. Each proposing party must contact the WiSHFUL consortium regarding its submission to identify a possible Patron. This Patron can be the WiSHFUL partner responsible for the testbed, hardware or software platform the proposer will use or extend. The proposing party must submit its draft proposal to this Patron by 26 April 2017. The feedback by the Patron is copied into this section of the proposal.

Section E **Background and qualifications** (maximum 2 pages)

This section describes the proposer and includes an overview of the activities, the proposer's qualifications, technical expertise and other information to allow the reviewers to judge the proposer's ability to carry out the Experiment.

Section F **Expected feedback to the WiSHFUL Consortium** (maximum 2 pages)

This section contains valuable information for the WiSHFUL consortium and should indicate the expected feedback the WiSHFUL consortium can expect from the use of its software platforms and/or testbeds after carrying out the Experiment. This information is essential in view of the further improving the WiSHFUL software platforms and UPIs, and the testbeds. Note that providing this feedback is one of the key motivations for the existence of the WiSHFUL Open Calls.

Section G **Requested funding** (1 page)

This section provides an overview of the budgeted costs and the requested funding. A split is made in personnel costs, other direct costs (travel, consumables, etc.) and indirect costs.

Section H **Use of proposal information**

In this section the proposing party is asked to include some statements related to sharing information of his proposal within the WiSHFUL consortium.

Proposals are treated in a confidential way, meaning that only successful proposals must be disclosed to the WiSHFUL consortium. Open calls previously organized by other FIRE projects were very successful and have revealed that many submitted non-granted proposals also contain very interesting and valuable information that could be used for setting up collaborations or to extract ideas for further improving the federated test infrastructures. Therefore the WiSHFUL project would like to have the opportunity to collect more detailed information and further use this information, also if the proposal is not selected for funding. In any case, the WiSHFUL consortium will treat all information of a proposal confidentially.

Section I **Involvement in FIRE-projects**

In this section proposers need to list their involvement in FIRE-projects, both as partner

or as proposer in Open Calls from FIRE-projects.

Proposals originating from new players in the FIRE community will be positively discriminated and will receive a higher score.

The full proposal template can be found in Annex A to this document.

Please note that **in the draft proposal** that will be submitted for feasibility check, **at least sections A, B and C should be fully completed**.

7. Support during Experiment and the role of the Patron

Successful proposers in this open call have access to basic and advanced support:

A. Basic support

- Guaranteeing that the facility is up and running (e.g. answering/solving "Why can I not reach wireless node X?")
- Providing pointers to documentation on how the facility and software platforms can be used (e.g. "how to use the w-iLab.t testbed" => answer: check out our tutorial online at page x")
- Providing pointers to technical questions as far as relevant (e.g. answering "do you know how I could change the Wi-Fi channel" => answer: yes, it is described on following page: y"; irrelevant questions are for example "how to copy a directory under Linux")

B. Dedicated (advanced) support includes all of the following supporting activities by the Patron:

- Deeper study of the problem (in particular relevant for Industrial proposers): invest effort to fully understand what the proposer's goals are, suggest (alternative) ways to reach the proposer's goals. To put it more concretely (again using the example of the w-iLab.t testbed), proposers do not need to know the details of the w-iLab.t testbed or how it should be used, they will be told what is relevant to them and can focus on their problem, not on how to solve a testbed problem.
- Help with setting up the Experiments (e.g. "how to use the w-iLab.t testbed " => answer: the tutorial is there, but let me show you what is relevant for you, let me sit together with you while going through this example and let us then also make (together) an Experiment description that matches what you are trying to do).
- (Joint) solving of practical technical problems (e.g. "do you know how I could change the Wi-Fi channel" => yes, it is described on page y, in your case you could implement this as follows.., perhaps we should quickly make a script that helps you to do it more easily, ...)
- Technical consultancy during or after the Experiment (e.g. "I do get result x, but would have expected y, what could be the problem?")

It is essential that the proposer gets in contact with the WiSHFUL partner in charge of the testbed(s) and software platform(s) that will be used for the Experiment to discuss your Experiment and the specific requirements. Each proposing party must therefore identify an appropriate Patron. A list of possible Patrons is given below:

Partner	Contact	Supported Testbeds, HW and SW
imec	Spilios Giannoulis Spilios.giannoulis@intec.ugent.be	Testbeds: w.iLab.t, Portable testbed
		HW:

		• IEEE 802.11 a/b/g/n: Atheros athxk • IEEE 802.15.4: RM090, Zolertia Z1, Zolertia RE-Mote • SDR: USRP2-N210, USRP B200mini, ZebBoard Xilinx Zynq®-7000 SoC, Xilinx ZC706 Evaluation Kit - Zynq® SoC • LTE: ip.access
		SW: • IEEE 802.11: Linux • IEEE 802.15.4: Contiki, TAISC, GITAR
TCD	Maicon Kist kistm@tcd.ie	Testbed: IRIS
		HW: • SDR: USRP2-N210
		SW: • SDR: GNU Radio, IRIS software radio
CNIT	Pierluigi Gallo pierluigi.gallo@unipa.it	HW: • IEEE 802.11 b/g: Broadcom b43 • SDR WARPv3 • 40 RAS (Reconfigurable Antenna System) 2.4GHz and 5 GHz)
		SW: • IEEE 802.11 & SDR: Wireless MAC Processor (WMP)
TUB	Anatolij Zubow anatolij.zubow@tu-berlin.de	Testbeds: TWIST, Portable Testbed
		HW: • IEEE 802.11 a/b/g/n: Atheros athxk • IEEE 802.15.4: Jennic JN516X
		SW: • IEEE 802.11: Linux • IEEE 802.15.4: TinyOS • SDR: GNU radio
RUTGERS	Ivan Seskar seskar@winlab.rutgers.edu	Testbeds: ORBIT
		HW: • IEEE 802.11 a/b/g/n: Atheros athxk • SDR: USRP2-N210, USRP X310, USRP B210 • LTE
		SW: • IEEE 802.11: Linux • SDR: GNU Radio
UFRJ	Jose De Rezende rezende@land.ufrj.br	Testbed: FIBRE@UFRJ
		HW: • IEEE 802.11 a/b/g/n: Atheros athxk
		SW: • IEEE 802.11: Linux
Univ. of Thessaly	Thanasis Korakis, korakis@uth.gr	Testbed: Nitos
		HW: • IEEE 802.11: Atheros 5k-9k

		• WiMAX • LTE: ip.access, airspan • SDR: USRP1, USRP N210, USRP B210	
		SW: • IEEE 802.11: Linux • WiMAX: Linux • SDR: GNU radio	

The proposing party must submit its draft proposal to his Patron by 26 April 2017 at 17:00. The feedback by the Patron is copied into section D of the proposal.

8. Payment scheme

As the selected proposers will be linked to the WiSHFUL consortium as Third Party using Cascade Funding, further referred to as Subcontractor to imec, specific arrangements exist with respect to financial costs and payment schemes:

1. As a Subcontractor, the proposing party needs to include an overview of the estimated costs in its proposal at the time of submission. Costs consist of personnel costs, direct costs (such as travel, consumables, etc.) and indirect costs. The costs of a Subcontractor have to comply with the rules and the principles mentioned in Section I, Article 6 (Eligible and ineligible costs) of the H2020 AGA — Annotated Model Grant Agreement (see http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/amga/h2020-amga_en.pdf), in the same way as the beneficiaries, and must be recorded in the accounts of the Subcontractor. In other words, the rules relating to eligibility of costs, identification of direct and indirect costs and upper funding limits apply. Equally those concerning controls and audits of Section I, Article 22 of the H2020 AGA.
2. The maximum requested funding for an Experiment in this Call is set at 50 k€ for an Experiment of the category 'Scientific excellence', at 40 k€ for an Experiment of the category 'Innovation by Industry'.
3. The maximum requested funding for the WiSHFUL partner acting as the Patron for an Experiment is limited to 5 k€ euro on average. Costs in this case are related to the provision of dedicated (advanced) support.
4. As a Subcontractor, the selected parties for Experiments need to submit a report at the end of the Experiment (for this call this will be at the latest end of Dec 2017 for an Experiment, under the assumption that the Experiment start at the latest on 1 July 2017). This report (see section 10), must include an overview of the costs incurred and will be accompanied by an invoice to the project coordinator, in this case imec.
5. The report and the declared costs will be evaluated by the WiSHFUL consortium including the partner acting as Patron.
6. Based on this evaluation, a payment of up to 75% of the requested funding will be carried out by the project coordinator.
7. The remaining 25% will be paid following a formal approval of the report and the work at a technical project review by the European Commission (EC).
8. For Open Call 4 review meetings with the EC are planned in January-February 2018. The exact date will be fixed at the start of the Experiment. The review meeting will be held in Ghent at imec or in Brussels at the EC. At the review meeting the results of the Experiment need to be

presented, preferably through a real-life (remote) demo running in one the WiSHFUL testbeds. Either the Subcontractor or the Patron has to present the final results. In the latter case, the Patron should be very well informed, as 25% of the payment depends on the formal approval of the work at the review meeting.

9. Foreground rights

As indicated by the EC Guidelines, a Subcontractor is paid in full for its contribution made to a project by the beneficiary with whom it has a subcontract. As a consequence Subcontractors do not have any IPR rights on the foreground of the project.

10. Reporting

As the selected proposers will be linked to the WiSHFUL consortium as Subcontractor to imec, no input will be required for any of the regular project reports (WiSHFUL deliverables), which the WiSHFUL consortium needs to submit to the EC.

The Subcontractor only has to submit a final report after completion of the Experiment. A specific template needs to be used and will include:

Part A. ***Summary***

Part B. ***Detailed description***

This section describes the details on the Experiment

It includes:

- B.1 Concept, Objectives, Set-up and Background
- B.2 Technical Results and Lessons learned
- B.3 Impact

Please note that section B.4 should focus on scientific impact for Experiments of the category 'Scientific Excellence' and business impact for Experiments of the category 'Innovation for SME'.

Part C. ***Feedback to WiSHFUL***

This section contains valuable information for the WiSHFUL consortium and describes the Subcontractor's experiences while performing the Experiment starting from the available testbeds, radio hardware and software platforms. Note that the production of this feedback is one of the key motivations for the existence of the WiSHFUL open calls. It includes:

- C.1 Testbeds/Hardware/Software Resources & UPIs used
- C.2 Feedback on getting acquainted and using the testbeds offered in WiSHFUL
- C.3 Feedback on getting acquainted and using the WiSHFUL software frameworks and UPIs
- C.4 Feedback on the administration process of your proposal, Patron communication, and support received from the consortium
- C.5 Why WiSHFUL was useful?

- C.6 Other feedback
- C.7 Quote

Part D. Leaflet

This section provides information that can be used to make a leaflet/poster of your Experiment for promotional purposes

This report will not only serve as an evaluation tool to judge payment of the Subcontractor, but will also serve as (1) input to the evaluation of the user-friendliness of the WiSHFUL testbeds, software platforms and interfaces, and (2) identification of missing gaps in both testbeds and software platforms.

Part of this report may be used by the WiSHFUL consortium for inclusion in their reporting documents to the EC and in public presentations. Inclusion of confidential information should therefore be indicated and discussed with the WiSHFUL consortium.

This report will also be used for the formal review by the European Commission. Each Subcontractor is expected to attend this formal review meeting with the EC. In exceptional cases (to be motivated by the Subcontractor), the Subcontractor can be represented by his Patron.

The template for the final report will be available at the start of the Experiment.

11. Criteria for evaluation of Experiments

Proposals can only be submitted by:

- Parties eligible for participation in the EC Horizon 2020 Programme;
- SMEs, unipersonal and large companies according to the definition used by the EC (for Experiments in the category 'Innovation by Industry');
- Single parties (no consortia are allowed);
- Multiple proposals may be submitted by the same party. However, in case multiple proposals are submitted, reference should be made to each submitted proposal and clear indication should be given on the complementarity of the proposals;
- Proposals submitted by new players in the FIRE community will receive a higher score.

Evaluation and ranking will be carried out by an external jury.

Selection will mainly be based upon he following criteria:

General criteria (applicable to both categories of Experiments)

1. ***Clarity and methodology*** (Cf. Section B of the Proposal Template)

   The Experiment should be scientifically and/or technically sound. There should be a clear problem statement, a solid Experiment design, a good methodology, etc.

2. ***Feasibility*** (Cf. Sections C and D of the Proposal Template)

   Experiments with low chances for success or requiring excessive support from the WiSHFUL partners will get a lower score.

3. ***Qualifications of the proposer*** (Cf. Section E of the Proposal Template)

   The proposer should exhibit prior research/development experience and the necessary qualifications to perform the Experiment

4. ***Potential for Feedback*** (Cf. Section F of the Proposal Template)

The WiSHFUL consortium is seeking feedback regarding the available WiSHFUL software platforms, UPIs, and testbeds. Proposals that can indicate that a lot of information and feedback on the use of software platforms, UPIs, and testbeds will be provided, will get a higher score.

5. ***Value for money*** (Cf. Section G of the Proposal Template)

   The requested budget should be in line with the proposed work plan.

6. ***Involvement in FIRE projects*** (cf. Section I of the Proposal Template)

   Participation in previous FIRE projects. This criterion will not be judged by the evaluators, but by the WiSHFUL Project officer.

Specific criteria:

- Category 'Scientific Excellence':

  7. ***Scientific innovation:*** the degree of scientific innovation of the solution for wireless control (cf. Section B of the proposal template)

     The score given here should reflect the degree of innovation: if an Experiment is pushing the boundaries of its domain, then it should get a higher score then Experiments testing trivial things. In order to demonstrate this criterion, the proposer is expected to clearly motivate his Experiment and indicate the State of the Art in the appropriate field.

  8. ***Scientific relevance:*** potential for take-up of the results by the broader scientific community (cf. Section B of the proposal template)

     The proposed Experiment should be sufficiently relevant form a scientific point of view to be taken up by the broader scientific community. The score given here should reflect the extent to which the broader scientific community can benefit from the solution proposed in the Experiment.

  9. ***Publication potential*** (cf. Section B of the proposal template)

     The expected results of the Experiment should have potential for publication in high-impact scientific journals and/or for presentation/demonstration of the results on major scientific conferences. The proposer is expected to identify publication/presentation/ demonstration opportunities.

- Category 'Innovation by Industry':

  10. ***Industrial innovation***: the degree of industrial innovation of the solution for wireless control (cf. Section B of the proposal template)

      The score given here should reflect the degree of innovation: there should be a indication to which extent the proposed wireless solution is different and innovative compared to existing and/or competing commercial wireless solutions. In order to demonstrate this criterion, the proposer is expected to clearly motivate his Experiment and compare his proposed solution with existing solutions in the appropriate field.

  11. ***Industrial and/or standardisation relevance:*** (cf. Section B of the proposal template)

      Potential for exploiting the results of the Experiment in commercial wireless solutions and/or for providing a verifiable impact on the standardisation process.

      This score should reflect the industrial relevance including the expected and projected impact on the company through product development.

12. ***Demonstration potential*** (cf. Section B of the proposal template)

    The expected results of the Experiment should have potential for demonstration of the results on relevant events (exhibitions, congresses, technical seminars, networking events, user group events, etc.). The proposer is expected to identify relevant demonstration opportunities.

13. ***Type of industrial innovator***: Unipersonal company, SME or large company.

The table below shows the weights and maximal scores for the different criteria.

Criterion	Short description	Weight	Maximum score
1	Clarity and methodology	1	5
2	Feasibility	1	5
3	Qualifications of the proposer	1	5
4	Potential for Feedback	2	10
5	Value for money	1	5
6	Involvement in FIRE projects	n.a.	+ 3
7	Scientific innovation	2	10
8	Scientific relevance	2	10
9	Publication potential	1	5
10	Industrial innovation	2	10
11	Industrial and/or standardisation relevance	2	10
12	Demonstration potential	1	5
13	Type of industrial innovator	n.a.	+ 3
	Maximum Total score		**55**

The proposals submitted by parties who have not yet been or are not participating in FIRE-projects or Open Calls from FIRE-projects will receive an extra 3 points (for criterion 6) on top of their total score. This measure is introduced to positively discriminate such new players and open the FIRE testbeds to a wider community.

The proposals submitted by unipersonal companies or SMEs in the category 'Innovation by Industry' will receive an extra 3 points (for criterion 13) on top of their total score. This measure is introduced to encourage participation of smaller and unipersonal companies.

The maximum score is 55. This maximum score cannot be exceeded by criterion 6 and 13.

12. Timing of the evaluation and Experiments

The duration of the evaluation of the proposals and approval by the EU will be kept within 1 month.

In case of this specific Call, the target date for acknowledgement of selection is set at 5 June 2017.

Experiments can start at the earliest on 15 June 2017, but no later than 1 August 2017.

The deadline for the final report for an Experiment is expected 6 months after the start of the Experiment, and no later than the end of December 2017. Please note that a later start will imply a shorter (than 6 months) experiment.

The final evaluation of the Experiments will happen at a review meeting with the EC. The review meeting for Experiments is currently scheduled for January-February 2018 either in Ghent at imec or in Brussels at the EC. The exact date will be fixed at the start of the Experiment.

13. Submission

Submission deadline of draft proposal to WiSHFUL partner acting as Patron for feasibility check:	Wednesday 26 April 2017,, at 17:00 Brussels local time
Submission deadline:	Wednesday 3 May 2017, at 17:00 Brussels local time

The proposal must be:

1. Submitted on-line through: http://www.wishful-project.eu/open-calls
2. Submitted in English

Feasibility check: A technical feasibility check is required before submission. This feasibility check will be carried out by the WiSHFUL members responsible for the facilities, radio hardware platforms, and software platforms involved. As a result of this, an additional concise section is added to the proposal (section D of the Proposal Template) and is provided in collaboration with the WiSHFUL project consortium members. This section also identifies the Patron of the Experiment, who is the lead contact person within the project who will be responsible for the follow up of this Experiment (see section 7 of this document).

Annex A: Proposal Template

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

Open Call 4

Fourth WiSHFUL Competitive Call for Experiments

Full Title of your proposal

Acronym of your proposal (optional)

Call[3] - Identifier[4] - Category[5]	WiSHFUL-OC4-EXP- category
Date of preparation of your proposal:	xx/yy/2017
Version number (optional):	
Your organisation name:	name
Name of the coordinating person:	First name Last name
Coordinator telephone number:	number
Coordinator email: [This is the email address to which the Acknowledgment of receipt will be sent]	Email address

Note: Grey highlighted areas need to be filled. Word template can be downloaded from WiSHFUL project website (see http://www.wishful-project.eu/open-calls)

[3] This call: WiSHFUL-OC4

[4] 'Experiments (EXP)'

[5] 'Scientific Excellence (EXC)' or 'Innovation by Industry (IND)'

Section A Project Summary

(Maximum 300 words – summary of the proposed work)

Remark: The information in this section may be used in public documents and reports by the WiSHFUL consortium.

This section needs to be completed in the draft proposal and will be used for the feasibility check (cf. Section D)

Section B Detailed description and expected results

(minimum 4 pages, and maximum 6 pages)

This section describes the details on the planned Experiment (what does the proposer hope to obtain?, how?, why is it relevant?). This section should also include all information with respect to the State-of-the-Art, or a comparison to competing commercial wireless solutions in case of Experiments of category 'Innovation by Industry' to show the innovative character of the Experiment and the expected scientific or business impact.

This section needs to be completed in the draft proposal and will be used for the feasibility check (cf. Section D)

B.1 Concept and objectives

Describe the specific objectives of the proposed Experiment, which should be clear, measurable, realistic and achievable within the duration of the Experiment (not through subsequent development). Show how they relate to the topic(s) addressed by the competitive call and how and why WiSHFUL is needed for realizing them.

Describe and explain the overall concept that forms the basis for your Experiment. Describe the main ideas, models or assumptions involved.

B.2 Impact

For Experiments of category "Scientific Excellence": *Describe how this Experiment fits in your internal research roadmap, and to which extent the broader research community can benefit from the results of the Experiment.*

For Experiments of category "Innovation by Industry": *Describe how this Experiment fits in your activities, and how this Experiment may strengthen the competitiveness of your business and the growth of your company. Having close contacts with possible end-users during this Experimental phase might be used to illustrate the business impact of the Experiment.*

For any Experiment*: Show that the proposed Experiment has sufficient sustainable benefits for the WiSHFUL project, meaning that there should be an added value for the WiSHFUL project, after the proposer has finished his Experiment.*

B.3 Description of State-of-the-Art

For Experiments of category "Scientific Excellence": *Describe the advances the proposed Experiment would provide beyond the state-of-the-art, and the extent the Experiment is ambitious.*

Is this Experiment expected to lead to groundbreaking results or rather incremental results compared to existing work?

For Experiments of category "Innovation by Industry": *Describe in detail how the proposed solution compares with existing solutions in the field covered by the Experiment. Are there similar Experiments, products, services, etc. on the market? Is this Experiment incremental to existing work?*

B.4 Methodology and associated work plan

Provide a work plan. Provide clear goals and verifiable results, and also a clear timing.

The work plan involves at least the following phases:

1. *Design of Experiment*
2. *Executing the Experiment*
3. *Analysis & feedback*
    - *Analysis of the results of the Experiment*
    - *Feedback on user experience*
    - *Recommendations for improvements and/or future extensions of WiSHFUL software platforms, UPIs and testbeds*
4. *Showcase: Set up of a showcase (demonstration) to be used for the evaluation of the Experiment at the review meeting with the EC, and for further promotion of WiSHFUL*
5. *Dissemination: Regular dissemination actions (journal publications, conferences, workshops, exhibitions, FIRE events, advertising of results at WiSHFUL website, etc.)*
6. *Final report, code and documentation*

NOTE: there is NO need to define work packages or deliverables. All results need to be reported in the final report at the end of the Experiment. Of course, a good communication plan with the Patron is required to exchange progress within different phases.

Section C Requested WiSHFUL software platforms, UPI interfaces, radio hardware platforms and testbeds

Please check the WiSHFUL software platforms, UPI interfaces, radio hardware platforms and testbeds that will be required for your Experiment.

Please visit the following websites to get details on the specific testbeds, hardware platforms, software platforms and UPIs:

- http://www.wishful-project.eu/testbeds
- http://www.wishful-project.eu/software
- https://wishful-project.github.io/wishful_upis/
- https://github.com/wishful-project

This section needs to be completed in the draft proposal and will be used for the feasibility check (cf. Section D). Especially the usage the UPI interfaces must be clearly defined (with identification of specific functions and parameters).

TESTBEDS	**Required (Yes/No)**
w.iLab.t (Heterogeneous wireless testbed @ imec, Ghent, Belgium)	
IRIS (Software Defined Radio testbed @ TCD, Dublin, Ireland)	
TWIST (Sensor testbed and openWRT router testbed @ TU Berlin, Berlin, Germany)	
ORBIT (20 x 20 radio grid testbed @ Rutgers University, New Jersey, US)	
FIBRE@UFRJ (OMF testbed @ UFRJ, Rio de Janeiro, Brazil)	
WiSHFUL portable testbed	
NITOS Testbed (network implementation testbed using open source platforms @ University of Thessaly, Volos, Greece)	

HARDWARE PLATFORMS			
Hardware	**Type**	**Technology**	**Number of nodes required**
wireless Wi-Fi card	Atheros athxk,	IEEE 802.11 a/b/g/n	
	Broadcom b43	IEEE 802.11 b/g	
Wireless sensor node	RM090	IEEE 802.15.4	
	Zolertia Z1	IEEE 802.15.4	
	Zolertia RE-Mote	IEEE 802.15.4	
	Jennic JN516X	IEEE 802.15.4	
Software Defined Radio	WARPv3	IEEE 802.11 b/g	

(SDR)	USRP2-N210	2.4 – 2.5 GHz	
		4.9 – 5.85 GHz	
		50 – 860 MHz (RX only)	
		800 – 1000 MHz	
		1.5 – 2.1 GHz	
		2.3 – 2.9 GHz	
		50 MHz – 2.2 GHz	
		400 MHz – 4.4 GHz	
	USRP-B200mini	70 MHz - 6 GHz	
	USRP X310	10 MHz – 6 Ghz	
	USRP B210	70 MHz - 6 GHz	
LTE	Airspan	2.59 GHz TDD	
	ip.access (+ SIRRAN EPC SW core)	2500-2570 MHZ (indoor uplink) 2620-2690 MHZ (indoor downlink) 2.53-2.63 GHz (outdoor)	

SOFTWARE	
OPERATING SYSTEMS	**Required (Yes/No)**
Linux	
Contiki	
TinyOS	
PLATFORMS	**Required (Yes/No)**
Wireless MAC Processor (WMP)	
Time-Annotated Instruction Set Computer (TAISC)	
Generic Internet-of-Things ARchitecture (GITAR)	
IRIS Software Radio	
GNU Radio	

UPI Interfaces *Please list the UPI functions that are needed to support your Experiment together with the parameters of interest. Try to be as specific as possible.*
Unified Programming Interface – Radio (UPI_R)
[Example: UPI function: wishful_upis.radio.get_measurements Parameters: RSSI, SNR, BER, TX_ACIVITY, NUM_TX_SUCCESS]
[Another example: wishful_upis.wifi.radio.set_modulation_rate]
Unified Programming Interface – Network (UPI_N)
[Example: UPI function: wishful_upis.net.set_parameters Parameter: ROUTING_MAX_TTL]
[Another example: wishful_upis.net.inject_frame(iface, frame, is_layer_2_packet, tx_count=1, pkt_interval=1)]
Unified Programming Interface – Global (UPI_G)
[mention here the functions that will be called remotely together with the parameters that will set/controlled remotely)
Unified Programming Interface – Hierarchical (UPI_{HC})
[describe what kind of information will be exchanged in a hierarchical way] [Example: the global control program sends control policies to local control programs, to be executed locally when the connectivity between them is not more available]

Intelligence Components	**Required (Yes/No)**
WiSHFUL UPI exec component	
Measurement collection component	
Feature generation component	
WECA based model training component	
Interference classification component	

Surrogate model creation and optimization	
802.15.4 MAC layer performance data set	
Technology classification dataset	

Please provide a short motivation on why specific testbeds, hardware platforms, software platforms, intelligence components, and/or UPIs will be required for the proposed Experiment. (maximum ½ page)

Section D Compliance check

(maximum 1 page)

This section contains the feedback from the WiSHFUL partner acting as Patron on this Experiment. Each proposing party must contact the WiSHFUL consortium regarding its submission to identify a possible Patron. This Patron can be the WiSHFUL partner responsible for the testbed, hardware or software platform the proposer will use during its Experiment. The proposing party must submit its draft proposal to this Patron by Wednesday 26 April 2017 at 17:00. The feedback by the Patron is copied into this section of the proposal.

Section E Background and qualifications

(maximum 2 pages)

This section describes the proposer and includes an overview of the activities, the proposer's qualifications, technical expertise and other information to allow the reviewers to judge the proposer's ability to carry out the Experiment.

Section F Expected feedback to the WiSHFUL Consortium

(maximum 2 pages)

This section contains valuable information for the WiSHFUL consortium and should indicate the expected feedback the WiSHFUL consortium can expect from the use of its software platforms, hardware platforms and/or testbeds after carrying out the Experiment. This information is essential in view of the further improving the WiSHFUL software platforms and UPIs, and the testbeds. Note that providing this feedback is one of the key motivations for the existence of the WiSHFUL open calls.

Section G Requested funding

(maximum 1 page)

This section provides an overview of the budgeted costs and the requested funding. A split is made in personnel costs, other direct costs (travel, consumables, etc.) and indirect costs.

Besides the table below, extra information can be provided to support the requested funding and which may help to judge the cost to the WiSHFUL project.

Please show your figures in euros (not thousands of euros).

	Total PM	**Cost (€)**
(1) Direct personnel costs		
(2) Other direct costs, of which:		
Travel		
Equipment		
Other goods and services		
(3) Indirect costs		
(4) Total costs (Sum of 1, 2 and 3)		

In row (1), insert your direct personnel costs for the work involved.

In row (2), insert any other costs, for example travel or equipment costs. Please allocate sufficient budget for participation at the final review meeting, and visit(s) to WiSHFUL partners, in case this is required in view of advanced support by the Patron.

In row (3), calculate the indirect costs (for personnel and other direct costs)

In row (4), calculate the sum of your personnel, other direct costs and indirect costs.

The maximum funding which is allowed in this call is set at 50 000 € for an Experiment of the category 'Scientific excellence', and 40 000 € for an Experiment of the category 'Innovation by Industry',

In view of the review of your proposal it is best to list the costs related to the proposed Experiment as would be done for any European Project.

Section H Use of proposal information

In this section the proposing party is asked to include some statements related to sharing information of his proposal within the WiSHFUL consortium.

Proposals are treated in a confidential way, meaning that only successful proposals must be disclosed to the WiSHFUL consortium. Open calls previously organized by other FIRE projects were very successful and have revealed that many submitted non-granted proposals also contain very interesting and valuable information that could be used for setting up collaborations or to extract ideas for further improving the federated test infrastructures. Therefore the WiSHFUL project would like to have the opportunity to collect more detailed information and further use this information, also if the proposal is not selected for funding. In any case, the WiSHFUL consortium will treat all information of a proposal confidentially.

Two types of information usage are envisaged:

- *Information which is part of the Sections A, C, D and F will be used within the WiSHFUL project as input for tasks related to testbed and software platform optimizations, sustainability studies, etc. The same information can also be used in an anonymous way to create statistics and reports about this first open call. All proposals submitted to this competitive open call are obliged to allow this form of information access and usage.*
- *Other information belonging to this proposal might also be accessed by the WiSHFUL consortium, if allowed by the corresponding proposer. Any use of such information will be*

discussed and agreed upon with the proposers. Proposers have the freedom to select if they wish to support this kind of information usage.

I allow that the material provided in Sections A, C, D and F of this proposal may be accessed by the WiSHFUL consortium, also if the proposal is not selected for funding. In any case, the WiSHFUL consortium will treat all this information confidentially. It will be used within the WiSHFUL project as input for tasks related to testbed and software platform optimizations, sustainability studies, etc. The same information can also be used in an anonymous way to create statistics and reports about this first open call.	Yes ☐	
Furthermore, I allow that the other parts of this proposal may be accessed by the WiSHFUL consortium, also if the proposal is not selected for funding. In any case, the WiSHFUL consortium will treat all information of this proposal confidentially. Any use of this information will be discussed and agreed upon with the proposers.	Yes ☐	No ☐

Section I Involvement in FIRE-projects

In this section proposers need to list their involvement in FIRE-projects, either as full partner or as successful proposer in Open Calls from FIRE-projects.

Proposals originating from new players in the FIRE community will be positively discriminated and will receive a higher score.

Annex B: Agreement for the Use of the WISHFUL Platform for Experimentation

This Agreement is entered into between the H2020 project consortium WiSHFUL, hereinafter referred to as the Project, and [*Organization 1*] hereafter referred to as the Experimenter.

Interuniversitair Micro-Electronica Centrum vzw, a non-profit organisation duly organized under the laws of Belgium, Register of Legal Entities Leuven VAT BE 0425.260.668, with its registered office situated at Kapeldreef 75, 3001 Leuven, Belgium and hereby duly represented by Luc Van den hove, President and CEO, hereinafter referred to as "the Coordinator" or "IMEC". IMEC has received from the other members of the consortium for the execution of the Project a mandate to represent them by signing the agreements with the Third Parties selected in the Open Calls for Experiments.

1. Objectives and scope

The scope of this agreement is to stipulate the terms and conditions under which Experimenters can make use of the WISHFUL facilities for Experimental validation of their wireless solution(s). The WISHFUL facilities and supported software platforms for radio and network control as a whole are further referred to as the Platform. The Experimentation activity that is performed by the experimenter is further referred to as the Experiment.

In addition to offering its Experimental facilities and software platforms, the Project also provides the essential training and support to the experimenter in order to enable them to successfully execute their Experiment. The specific members of the WISHFUL consortium and its personnel that provide the facilities and software platforms and give support to the experimenters for executing their Experiment are further referred to as Providers.

Details of the Experiment can be found in the application form submitted by the experimenters for the first WISHFUL Open Call. The Experiment has been selected for support by the Project as a result of an evaluation process that is approved by the EC.

The specific content of the Experiment, the specific WISHFUL facilities and software platforms used, the Providers involved in the Experiment and the related budget and financial support granted by the Project are further defined in the Experimenter's proposal as approved by the Project.

2. Terms and conditions

2.1 Applicability

These Terms and Conditions apply to every Experimenter using the Platform. Next to these Terms and Conditions contained in this Agreement, specific regulations of the Provider may apply. These will be available at http://www.wishful-project.eu/testbeds and http://www.wishful-project.eu/software and links therein. It is the Experimenter's responsibility to remain aware of all applicable regulations and of any changes made to them

The Terms and Conditions apply to the use of all equipment connected to the Platform. This includes wireless components, servers, network(s) residing in the Platform.

These Terms and Conditions apply to use of all software and data within the Platform.

These Terms and Conditions apply to third parties, if accepted by the Project, using the Platform through services Experimenters have made available through the Platform as part of an Experiment whereby the Experimenters remain liable for this use by third parties.

2.2 Liability

The Project assumes no liability in regards to interruption, corruption, loss or disclosure of the services, processes and data hosted on the Platform.

Experimenters shall be liable for actions performed on the Platform. In case of misuse, Experimenters are responsible for making good all damages to the Testbed(s) and are responsible for any loss or damage incurred.

Experimenters are granted account(s) to the Platform, for own and personal use. Experimenters should take appropriate measures to protect their credentials and prevent their use by third parties. The information Experimenters provide when requesting an account should be correct. Experimenters shall be responsible for all and any loss or damages incurred by them and/or the Project as a result of any unauthorized transfer by them of their password.

Experimenters must respect the regulations of the various Platform resources they use in their Experiment.

Experimenters must not interfere with others' work or attempt to invade their privacy. Experimenters must not attempt modify any element of the Platform nor to disrupt the working of the Platform or any other system.

If there is evidence that the actions of Experimenters are adversely impacting the quality offered by the Platform, Providers are empowered to take reasonable measures to terminate or reprioritize usage in order to protect the overall operation of their services. Implicated Experimenters will be contacted by the Providers as early as is reasonable.

Copyright, other intellectual property and data protection legislations apply to software and data and Experimenters must respect them. The terms of applicable software and data licenses must be respected.

In order to keep the Platform operating correctly both the technically and legally, it may become necessary to investigate network traffic (for example, wireless traffic) as well as examine information held on systems that are, or have been, connected to the Platform. Experimenters are deemed to have agreed to this and to provide the required access.

Resources provided by the Project are under the jurisdiction of the Wassenaar Arrangement. Therefore certain nationalities will not be allowed to get access to the Platform and according Testbeds. According to the Wassenaar Arrangement, the following nationalities are restricted from accessing the Platform and according Testbeds: Cuba, Iran, Iraq, Libya, North Korea, Sudan, and Syria.

Should Experimenters' usage imply giving access to the Platform to third parties, Experimenters understand they will need to gather explicit consent from the relevant Providers and they agree to enforce any restrictions imposed by this Provider and accept to fulfill their legal obligations as a service provider regarding data protection and retention laws.

This implies also respecting the Wassenaar Arrangement.

The following Experiments are explicitly forbidden on the Platform:

- The development and production of weapons of mass destruction or any military usage. This includes but is not limited to:
  - Nuclear weapons
  - Biological weapons
  - Chemical weapons
  - Missiles
  - Conventional weapons
  - Any activity resulting in compromising the security or integrity of any sites or networks connected to the Platform or parts thereof.
  - Distribution of documents or materials containing:
  - Insults or defamation
  - Racial hatred or revisionism
  - Advertising for commercial products
  - Distribution of material in a way that infringes the copyright of another person

Further, additional national regulations from the government of the Provider(s) must be observed.

2.3 Enforcement

Whenever Experimenters use the Platform they are bound by all the above regulations and the legislation in force at the time.

The regulations and legislation that applies to Experimenters will be enforced by IMEC, as leader of the WISHFUL consortium, or/and by the affected Testbed Providers, even if a breach of either has been evidenced from elsewhere.

Experimenters agree that the Providers involved may monitor the systems and traffic for vulnerabilities and conformance to the acceptable uses, and Experimenters will collaborate with the Project and any third party involved should any violations or breaches be noticed. The Providers involved may suspend or stop systems without notice if such violations are found or suspected, or suspend network connectivity. To fulfill legal and contractual requirements, they may communicate to authorized third parties the owner and user of any resource provisioned and connected to the Internet.

2.4 Research use of Platform resources

The WISHFUL Platform has been constructed for Experiment-driven research activities, where Experiment-driven research is defined as any activity that furthers the Experimenters' knowledge and/or understanding of concepts, algorithms, protocols of wireless solutions (more specifically related to control of wireless networks), provided that this activity is legal.

All other use of the Platform by the Experimenter than the use explicitly contained in the Experiment is not permitted.

The use of the WISHFUL Platform to host commercial activities is explicitly disallowed.

2.5 Dissemination of Experiment results

The results achieved will be owned by the Experimenter.

The Experimenters will have to deliver a final report describing the results of the Experiment and the experience gained in using the Platform.

The final report can be made public by the Project for further promotion of the WISHFUL Platform unless the Experimenter invokes commercial interests to limit the publication thereof.

Publications/demonstrations that are made based on the results of the Experiment should clearly mention the usage of the WISHFUL Platform and Provider also if the publication/demonstration occurs after the end date of the Experiment.

3. WISHFUL support policy

Subcontractors will receive the support as described in the WISHFUL Open Call. All support to Experiments is provided on a reasonable-effort basis. Support should first be sought in the user documentation, which is a living online resource (see http://www.wishful-project.eu/testbeds for documentation on the testbeds supported by WiSHFUL, and http://www.wishful-project.eu/software for documentation on the WiSHFUL software platforms, and links therein) that has a 'getting started' guide and a FAQ section to deal with common questions and problems. It is expected that Experimenters will go through this to master the basics of managing resources for Experimentation on the Platform.

4. Period for this collaboration

The start date of the Experiment is [*start date*] and the end date is [*end date*].

5. Resources and Financial provisions

By signing this agreement, the Project commits to provide the necessary facility resources and manpower resources to the Experimenters, free of charge on a reasonable efforts basis.

By signing this agreement, the Experimenter confirms that they have the necessary manpower resources to execute the Experiment.

The Project will support the Experimenter by granting the support as approved by the Project.

Experiment will invoice IMEC for the total amount of this support after approval by the Project of the Final Report defined in 2.5 hereof. The final report, code and documentation and the declared costs will be evaluated by the WiSHFUL consortium including the Provider(s) that have given support. Based on this evaluation, a payment of up to 75% of the requested funding will be carried out by the project coordinator. The remaining 25% will be paid following a formal approval of the report and the work at a technical project review by the EC.

6. Signatures

IMEC, on behalf of the H2020 WISHFUL project consortium By: Name: Title: Phone: Email:
Subcontractor By: Name: Title: Phone: Email: