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Abstract	This deliverable describes the actions taken towards the final integration of SDR platforms into the ORCA facility. The Fed4Fire compliance achieved previously is maintained among the ORCA facilities, more hardware and software components are deployed.
Keywords	Testbeds, SDR

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EXECUTIVE SUMMARY

This deliverable reports on the efforts of testbed development in the third year of the ORCA project. The ORCA facility consists of 6 testbeds: (i) the w-iLab.t testbed from IMEC, (ii) the KUL Massive MIMO testbed, (iii) the ORBIT testbed from RUTGERS, (iv) the IRIS testbed from TCD, (v) the OWL testbed from TUD and (vi) the IMEC portable testbed. All 6 testbeds have achieved Fed4Fire compliance by the end of year 2 in ORCA project. This year all testbeds continue to obtain new features. More particularly:

- On w-iLab.t and portable testbed, the support for ZYNQ SDR usage has been improved, more software functions are supported (i.e., Openwifi, TAISC), a solution is offered to boot Linux on ZYNQ from JTAG interface, allowing experimenters to use multiple ORCA functionalities without manual intervention from the testbed admins.
- On TCD's IRIS testbed, a new Dell server and three new NI 2952R USRPs have been added. Besides, the IRIS testbed has been upgraded to use the OpenStack cloud platform. IRIS now offers support for repeatable and reproducible experimentation across heterogeneous cloud computing and network resources in 5G network environments compatible with the ETSI NFV standard.
- TUD's OWL testbed has been moved to a new location, and in addition to the existing experimental facilities, more SDR devices are deployed, and the core network as well as the command and control server has been updated.
- The KU Leuven Massive MIMO testbed was upgraded to create virtual scenarios with an automatic channel collection, in addition, 64 modular antennas are deployed, which can be placed into different topologies.
- The ORBIT testbed has added multiple heterogeneous compute nodes, including FPGA accelerator, and GPUs. In addition a pair of 60GHz RF transceiver evaluation kits has been offered, supporting full RF channels according to IEEE802.11ad.

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ABBREVIATIONS

CBTM	Cloud Based Testbed Manager
F4F	Fed4Fire
FPGA	Field-Programmable Gate Array
FCFS	First Come First Serve
FSBL	First Stage Boot Loader
JTAG	Joint Test Action Group
NFV	Network Function Virtualization
MANO	Management and Orchestration
OS	Operating System
RAN	Radio Access Network
SDR	Software-defined Radio
SDN	Software-defined Networking
SPI	Serial Peripheral Interface
UHD	USRP Hardware Driver
USRP	Universal Software Radio Peripheral
VIM	Virtualised Infrastructure Manager
VLAN	Virtual Local Area Network
VM	Virtual Machine

1 INTRODUCTION

This deliverable reports on the effort of testbed development in the final year of ORCA project. The ORCA facility consists of 6 testbeds: (i) the w-iLab.t testbed from IMEC, (ii) the KUL testbed, (iii) the Orbit testbed from RUTGERS, (iv) the IRIS testbed from TCD, (v) the OWL testbed from TUD, and (vi) the portable testbed from IMEC. All six testbeds achieved Fed4Fired (F4F) compliance in the 1st year of ORCA. The F4F federation monitoring function was added in the 2nd year of ORCA. And in the 3rd year all testbeds maintained the achieved F4F compliance, hence there is no further report on this task.

In this year, each of the ORCA testbed continues to integrate the newly developed ORCA functionality into the testbed facility, and deploy new state-of-the-art Software-Defined Radio (SDR) devices. In Section 3, an overview of supported SDR platforms is given, followed by a more detailed description of each of the partner's SDR integration.

2 SDR PLATFORM INTEGRATION INTO ORCA TESTBEDS

2.1 Overview of supported SDR platforms

The Table 1 gives an overview of the SDR platforms supported in ORCA facilities. The newly added hardware in the 3rd year is marked in bold.

Table 1 Overview of supported SDR platforms.

Testbed	w-iLab.t (IMEC)	ORBIT (RUTGERS)	IRIS (TCD)	TUD Testbed	KUL Testbed	Portable Testbed
Nutaq ZeptoSDR		X				
Nutaq picoSDR		X				
PicoZed Xilinx ZYNQ®-7000 SoC		X				
USRP B200-mini	X	X	X	X		X
USRP B200	X		X			
USRP B210	X		X			
USRP E310		X				
USRP N210	X	X	X	X		
USRP X310	X	X	X		X	
USRP 2920				X		
USRP 2921					X	
USRP RIO 2942R			X		X	
USRP RIO 2943R	X				X	
USRP RIO 2952R (+ GPS)					X	
USRP RIO 2953R (+ GPS)				X	X	
USRP RIO 2944R				X		
USRP RIO 2954R				X		
WARPV2	X	X				
Xilinx ZC706 Evaluation Kit - ZYNQ® 7000 SoC + AD FMCOMM radio frontend	X					X
ZedBoard Xilinx ZYNQ®-7000 SoC + AD FMCOMM radio frontend	X	X				X

BB – NI PXI 7975 Module				X		
BB – NI PXI 7965 Module				X		
FE - NI PXI 5644				X		
FE – NI PXI 7976R					X	
PXIe 8135				X		
PXIe 8880				X		
NI PXI based mmWave base band + Sibeam V-band transceiver				X		
Sivers IMA 802.11ad beamforming transceiver evaluation kit EVK06002		X				

*Legend: BB (baseband motherboard), FE (Frontend, RF daughterboard)

2.2 SDR platform integration into testbeds

This section explains the final integration of SDR functionalities on the ORCA facility from each of the testbed providers.

2.2.1 w-iLab.t

2.2.1.1 Openwifi support on w-iLab.t

In this year the Openwifi functionality is offered in the 3rd ORCA open call as full stack IEEE 802.11 solution¹. In order to support upcoming opencall experiment, a tutorial is provided, available on w-ilab.t documentation². Users following this tutorial will be able to load the Openwifi module, and use it as a native Wi-Fi interface in Linux, it is able to communicate with a commercial Wi-Fi node in the w-iLab.t testbed. Both ad-hoc and infrastructure modes are supported.

Comparing to standard Wi-Fi card, the Openwifi interface supports runtime configuration of airtime towards unicast address between two slices, in the order of 1 us.

¹ Openwifi <https://www.orca-project.eu/ieee802-11-full-stack-based-on-sdr-openwifi/>

² Openwifi tutorial on wilabt documentation <https://doc.ilabt.imec.be/ilabt/wilab/tutorials/openwifi.html>

2.2.1.2 Booting Linux on zc706 board via JTAG

Openwifi is running on zc706 board³ and requires Linux operating system. However other ORCA functionalities, such as CONSENSE⁴ is running on the same board but is using bare metal application, downloaded directly via JTAG. The majority of Linux users of zc706 board are booting from SD card, this is configured via dip switches located physically on the board. This situation creates some issues: (i) one board deployed in the testbed can either be used for Openwifi or the CONSENSE application, running both is not possible without a testbed admin to configure the dip switch manually; (ii) The SD card image can be accidentally corrupted by testbed users, which makes the board unable to boot and again requires manual intervention of testbed admins.

In order to avoid these issues, we investigated methods to boot Linux on zc706 board via JTAG. To boot Linux, the following files are required: (i) a Linux image --- *ulmage*, (ii) a devicetree blob --- *devicetree.dtb*, (iii) the first stage bootloader --- *fsbl.elf*, and (iv) the second stage bootloader --- *uboot*

Initially the plan is to download all these files via JTAG. In the first step, *fsbl* is downloaded and executed, and then the *ulmage*, *devicetree.dtb* are downloaded at known addresses in memory, finally we launch the second stage bootloader *uboot* and ask it to boot from the image from the previously downloaded memory location.

Although Linux does boot correctly in this way, we faced some issues of initialization of *ad9361* module via Serial Peripheral Interface (SPI) bus. Investigation of this issue requires indeterministic amount effort. A walk around has been created to have a fast and stable solution. In the walk around, the first stage bootloader is modified, instead of entering the normal JTAG handoff function, which is a loop written in assembly, the bootloader loads everything from the normal SD card as if it was booting from the SD card. In this way *ad9361* module is initialized correctly. The procedures and modified first stage boot loader are available at w-iLab.t tutorial

<https://doc.ilabt.imec.be/ilabt/wilab/tutorials/openwifi.html#boot-linux>.

Then there is another issue remaining, how to recover the SD card if the file system on the SD card becomes unusable. This is resolved by booting Linux by writing all required files in memory via JTAG interface, including a ramdisk image provided by Xilinx. A ramdisk is a mini file system image that is small enough to be loaded in memory and be used as the root file system. After Linux is booted from the ramdisk, we use the standard Linux command *dd* to write a usable SD card image from the host to the card. This is discussed in <https://doc.ilabt.imec.be/ilabt/wilab/tutorials/openwifi.html#restore-rootfs-if-sd-card-is-corrupted>.

In this way no manual interventions are required to recover SD card, or for running other ORCA functionalities other than Openwifi.

2.2.1.3 TAISC SDR functionality on w-iLab.t

As previously reported, TAISC is a MAC design tool originally for sensor node, which has been ported to ARM and now running on ZYNQ SDR. In Year 2, new ZED boards with FMCOMMS2 frontend are deployed in the testbed, we introduce tutorials on how to program the ZED boards in the testbed or

³ Zc706 board https://www.xilinx.com/support/documentation/boards_and_kits/zc706/ug954-zc706-eval-board-xc7z045-ap-soc.pdf

⁴ CONSENSE <https://www.orca-project.eu/multi-channel-802-11-and-802-15-4-preamble-sensing/>

connect to serial terminal so on, and how to use TAISC tools on the SDR. This year another tutorial⁵ has been introduced to explain the usage of TAISC on ZED SDR with physical layer configurations.

More specifically, TAISC is running two different FPGA implementations, one implementation supports single channel Zigbee transceiver with configurable channel bandwidth, whereas the other supports concurrent multi-channel communication via the same SDR frontend.

The tutorial is general, but a user has the option to enable the usage of WiSHFUL controller and WiSHFUL agent to configure parameters such as channel bandwidth in case of single channel FPGA implementation, or which channel to use in case of multi-channel implementation.

⁵ TAISC tutorial on zedboard https://doc.ilabt.imec.be/ilabt/wilab/tutorials/taisc_on_zed.html

2.2.2 IRIS

The IRIS testbed operates a premier open access reconfigurable 5G radio testbed in Europe (see Figure 1), which is hosted by the CONNECT Centre at Trinity College Dublin. To provide continuous upgrades, improvements, and stability for experimenters in Year 3, the IRIS team upgraded the testbed to use the OpenStack cloud platform, which is an open-source software platform for cloud computing. As a consequence of this upgrade, IRIS now offers virtualized radio hardware, software virtualisation, Cloud-RAN, Network Function Virtualisation (NFV), and Software Defined Networking (SDN) technologies to support reproducible experimental investigation of the interplay between future networks and new radio, which is compatible with the ETSI NFV standard. In 2019, we have had more than 37 VCPU years provisioned by internal (Trinity College Dublin), and external (typically open call) experimenters. Using these configurations, experimenters have performed tens of thousands of experiments.



Figure 1 IRIS testbed ceiling USRP grid.

2.2.2.1 Updates in Year 3

In Year 3 we deployed OpenStack (Rocky) with KeyStone, Glance, Nova, Neutron, and Horizon at IRIS, replacing the old Cloud Based Testbed Management (CBTM) system. The updated OpenStack cloud platform is hosted across thirteen Dell PowerEdge R620 and R440 servers. The three Dell R440 servers, each with 10GB Ethernet ports with virtualisation capabilities, connect to 24 National Instruments (NI) N210 USRPs, two NI X310s USRPs, and three NI 2952R USRPs. This equipment is connected to the OpenStack platform via a Dell S4048T-ON SDN 1.3 switch and orchestrated by the

ONOS SDN network operating system framework, which supports communication between NI USRPs and the OpenStack cloud VM instances.

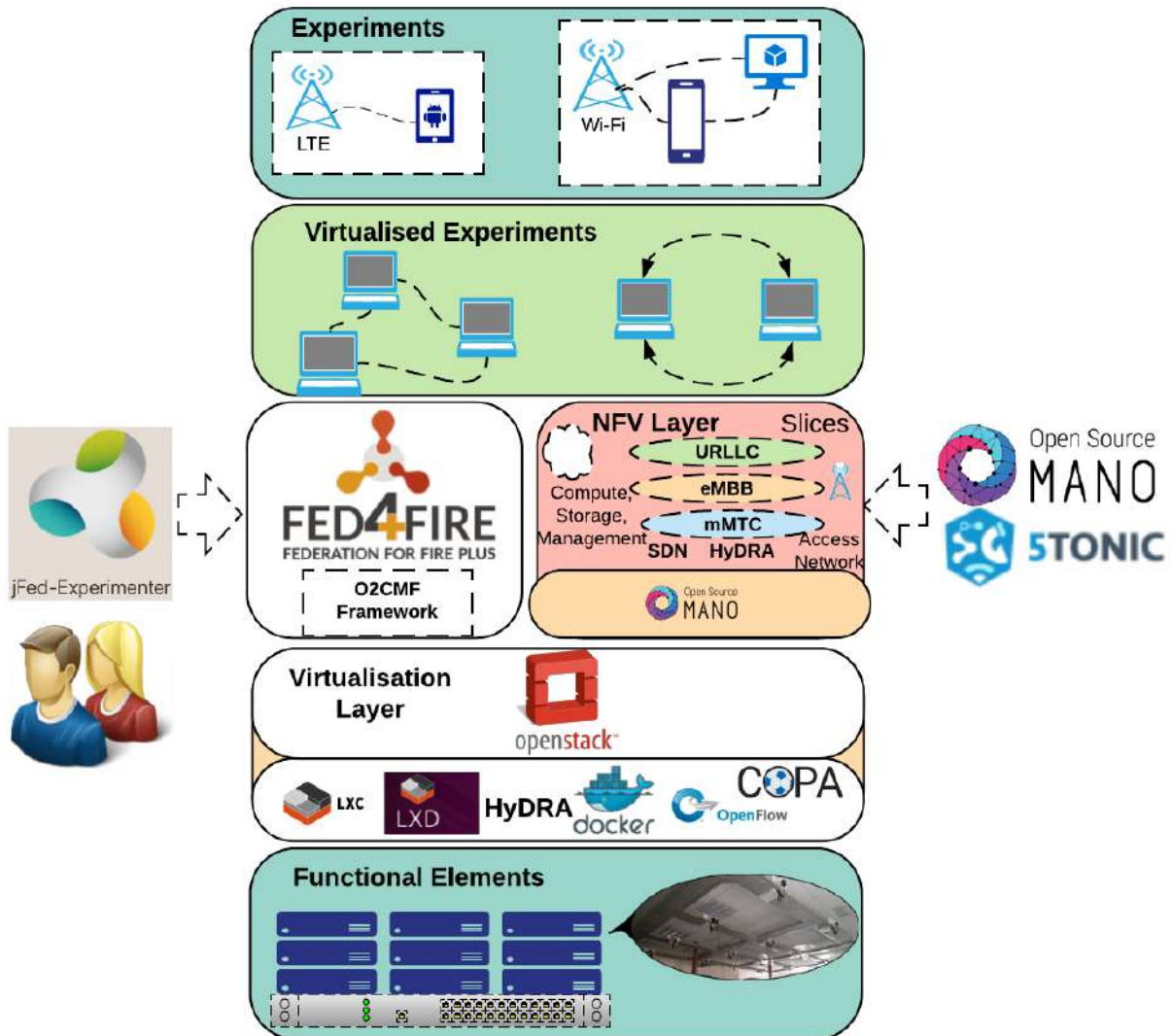


Figure 2 A high-level overview of IRIS testbed architecture.

A high-level overview of IRIS testbed architecture is depicted in Figure 2. Logically, IRIS can be thought of as consisting of five functional layers. These layers include:

- **Functional Elements:** The bottom layer represents the physical resources, such as servers, switches, National Instruments (NI) USRPs N210, X310 and 2952R, commercial Wi-Fi equipment, etc.
- **Virtualisation Layer:** To expose the functionality of physical equipment for applications, IRIS employs a variety of hypervisor tools and technologies. This layer provides support for open source cloud virtualisation technologies (OpenStack), SDN techniques (OpenFlow 1.3, and Open vSwitch), custom Linux images, and Software-Defined Radio (SDR) elements including GNU Radio, srsLTE, and Open Air Interface.
- **NFV Layer (Added in 2019):** OSM supports the deployment of Experimental Vertical Instances (EVIs) across the Virtualisation and Functional Layer elements, by supporting the creation of virtual machine instances and instantiation of communication between virtual

machines in physical rack servers. These elements provide a fully functional orchestrator for EVIs at IRIS.

- **Virtualised Experiments:** The next layer corresponds to the virtualised testbed resources, allocated to the experimenter for a specific period of time.
- **Experiments / 5G Application:** This layer sits at the top and is defined and controlled by the experimenter. It is the EVI environment that supports a 5G end-to-end application that can fully utilise the virtualised resources offered by the lower layers.

2.2.2.2 Integration with jFed

To support external experimenters accessing and using the new IRIS Testbed OpenStack cloud platform with jFed, we extended the O2CMF framework to support repeatable and reproducible experimentation of heterogeneous computing and networking resources utilising NFV principals in SDR environments. O2CMF is an open platform for control and management of experiments (O2CMF) developed during the FUTEBOL H2020 project. The IRIS SDR extension is available as a branch with GPLv3 license on the O2CMF GitLab page (<https://gitlab.com/futebol/O2CMF>).

2.2.2.3 Equipment added in Year 3

The following equipment was added to the IRIS testbed in 2019:

- 1 x Dell PowerEdge R440 Server, with a Broadcom 57416 Dual Port 10 GbE BaseT Network LOM Mezz Network Card.
- 20 x DELTA7A/X/SMAM/S/S/11 - Hinged Mount WiFi / ISM Antennas, 2.4/5.8GHz, Direct Mount, SMA Male.
- 3 x NI-USRP-2952R supporting DC to 6 GHz frequencies with SBX daughterboards offering up to 120 MHz of baseband bandwidth.

2.2.2.4 Benefits of the OpenStack Upgrade

This functionality has created the capability to support repeatable and reproducible experimentation across heterogeneous cloud computing and network resources in 5G network environments. Furthermore, experimenters can enjoy:

- Autonomy when servers, devices, and/or links fail.
- A malleable, easily extendible environment (both hardware and software), which has the potential to be extremely energy efficient
- Network isolation and automated experiment control while supporting the instantiation of Network Function Virtualization (NFV) verticals using the Open Source Management and Orchestration (MANO) (OSM) software stack.
- USRP devices and server resource sharing between FIRE projects (including Fed4FIRE+, ORCA, etc.) and the 5GINFIRE project community with no resource over provision or conflict between project experimenters. The IRIS testbed OpenStack Virtualised Infrastructure Manager (VIM) allocates available resources on a first come, first served (FCFS) basis to both projects.

2.2.3 TUD OWL testbed

In year 3, we changed the location of TUD’s testbed, which required rebuilding it. In addition to the existing experimental facilities, we have also deployed more SDR devices into the testbed. The core network as well as the command and control server have been updated in this year. In the following, we describe the new hardware available in the TUD’s testbed.

2.2.3.1 Multi-Rat Platform

The Multi-Rat Platform in our testbed is aimed to enable the experimenters to investigate the interworking of multiple radio access technologies, such as 3GPP LTE, WLAN 802.11 as well as new waveform GFDM. The Multi-Rat Platforms in our testbed are based on NI SDR Platform, LabVIEW Communication System Design Suite and the network simulator ns-3.

In the previous year, there were already 2 Multi-Rat Platforms working in the OWL testbed. In year 3, we have doubled the Multi-rat Platforms in the testbed, to enable more complicated communication scenarios and to satisfy the needs of the users from the open calls. Figure 3 shows the overview of the Multi-Rat setup. As shown in the diagram, each Multi-RAT Platform consists of one Windows 7 Host, one NI real-time Linux controller and 2 USRP RIO, and can work either as base station or user equipment terminal. All the Win7 Host PCs and Real-Time controllers are connected by Ethernet. Users can access all the Host PCs and Controllers from Experiment server via Remote desktop or SSH.

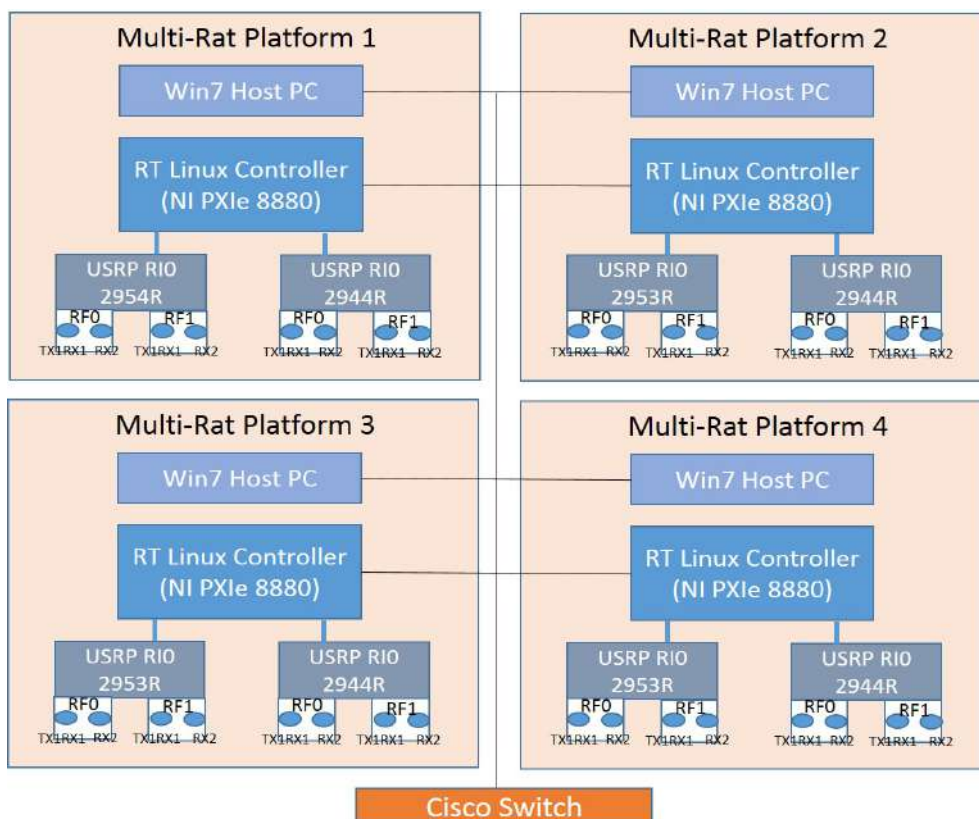


Figure 3 Overview of Multi-Rat platforms

Figure 4 shows the overview of Multi-RAT platforms in our testbed. All the SDR devices are mounted in one metal rack, which can make the testing, debugging and cabling much easier. We provide both SMA cables and antennas to enable the comparison of different backhaul technologies. Besides, we offer power combiner/splitter to enable the possibility of adding configurable interference signals through SMA cables.

The hardware and software of the current prototyping platform can be listed as:

- 2 x Fujitsu PC as MS Windows controller
- 2 x NI PXIe 1082 with controller NI PXIe-8133 (Win7 controller)
- 4 x NI PXIe 1082 with controller NI PXIe-8880 (NI Real-Time Linux controller)
- 8 x NI USRP RIO
- Antenna VERT2450, SMA cables
- OS: Windows 7, Ubuntu 16.4, NI LabVIEW Real Time Linux
- LabVIEW Communications 2.0, LVC LTE & WLAN 802.11 Application Framework 2.0,
- Matlab, ns-3



Figure 4 SDR Devices in OWL Testbed

2.2.3.2 Indoor user terminal

The SDR facilities in our testbed enable the communication-experiments to run on FPGA in real-time. Based on these facilities, we are improving our testbed to support more experiments of wireless communication systems.

In particular, we have built the indoor user terminal. The user terminal can be mounted out of the lab to enable the communication system prototyping in more realistic scenario, such as industry communication scenario and IoT scenario. As shown in Figure 5, the appearance of an indoor user terminal is a metal box with ventilation unit and antenna ports. It will be mounted on the wall of the corridor out of our laboratory.



Figure 5 Indoor User Terminal

Figure 6 depicts is the mock-up of an indoor user terminal. One user terminal consists of one USRP 2974, one USRP 2944, an RF component box as well as a power supply box

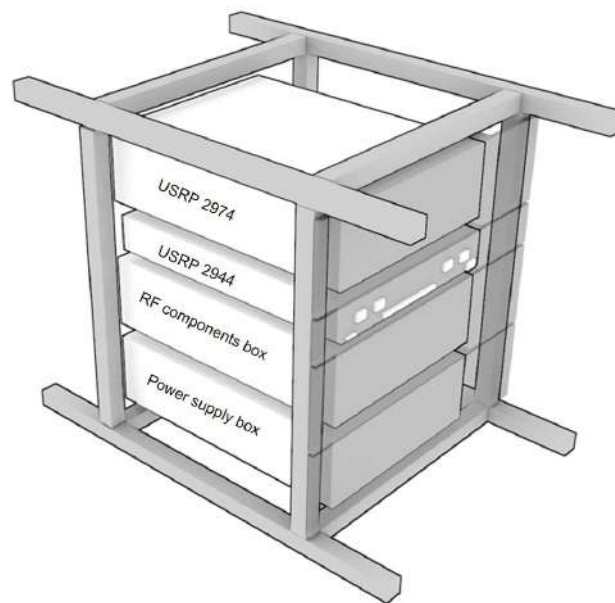


Figure 6 Structure of the indoor user terminal

The USRP 2974 is a USRP SDR Stand-Along Device. It provides a controller with Intel Core i7 processor as well as an USRP supporting the frequency range from 10 MHz to 6 GHz. The operating system running in USRP 2974 is NI Real-Time Linux. Besides the built-in USRP, the USRP 2974 is additionally connected to an USRP 2944 via PCIe cable.

The RF components box contains a power amplifier and all RF switches. We deploy a network switch and voltage converters in the power supply box. A raspberry pi and an Arduino are also working in the power supply box to control the power, network and the RF switches.

Currently, the assembling work of the above-mentioned components is already finished, as well as the design of the metal box, metal frame, and the other mechanical parts in the box.

2.2.3.3 mmWave systems

2.2.3.3.1 60 GHz system

In last year, the testbed was equipped with one user 60 GHz mmWave setup, working as a resource node of the OWL testbed. In order to accommodate an external ORCA partner from the 2nd Open Call for Experiment, we have temporarily included an additional NI PXI platform and real-time configurable mmWave antennas to allow multi-user experiments. The addition setup was acquired with collaboration between TUD and NI Dresden. The extra hardware mounted in our mobile robot is shown in Figure 7.



Figure 7 Mobile Robot

2.2.3.3.2 26 GHz system

In year 3, we have included in the testbed 2 pairs of the 26 GHz frontends, as shown in Figure 8. That is, TUD's testbed is now equipped with 2 transmitters and 2 receivers. The new extra hardware allows the design of more complex experiments involving several users in the mmWave bands.



Figure 8 26 GHz mmWave frontend

2.2.3.4 Command-and-Control Server

In year 3, we have included more SDR devices into the OWL testbed. An increasing number of experimenters have been working or plan to work on the tested. Accordingly, we are continuously adding more virtual machines (VMs) for the testbed users. Along with the increase of VMs and the more frequent experiment operations, the demand for the performance of the physical server, on which the virtual machines are running, is growing. We have updated our control and command server in order to satisfy the new performance requirements.

We replaced the previous servers with a pair of new FUJITSU PRIMERGY RX2530 M4 servers, equipped with 18 cores Intel Xeon Processor Scalable CPU and 127 GB memory, as shown in Figure 9. We have moved all existing virtual experiment servers as well as the whole Microsoft Hyper-V environment onto the new servers. Our current testbed physical server could allow a maximum number of 50 virtual servers running in parallel.

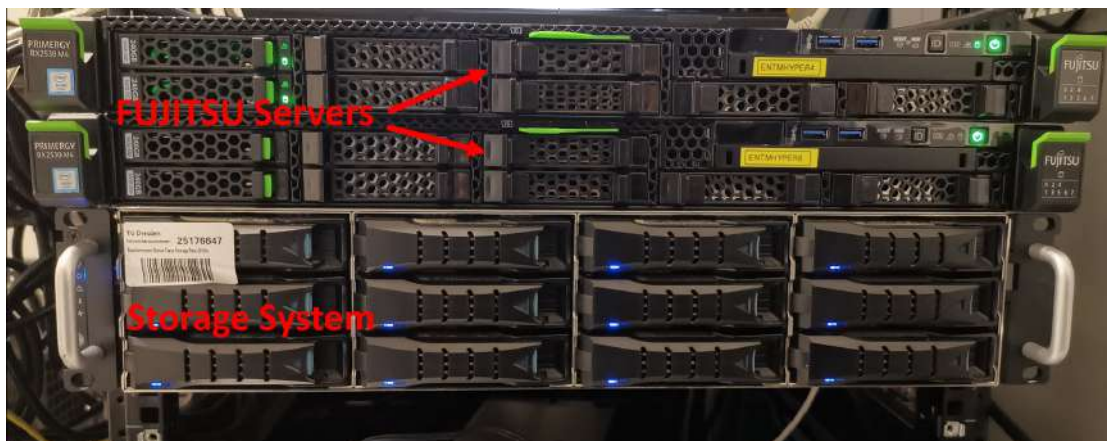


Figure 9 Server

Additionally, because we keep the hard disk image of each resource PC for each user, the requirement of the storage is also growing along with the increasing number of VMs. To raise the storage capacity and to improve the data security, we deployed the Rarox Parx Server to manage the storage system.

2.2.4 KUL testbeds

2.2.4.1 Integration XY positioners into KUL Massive MIMO testbed.

During year 3, the KU Leuven Massive MIMO testbed was upgraded to create virtual scenarios with an automatic channel collection. The four dipole antennas of two USRP denominated “users” were deployed to use four XY positioners (each one holding a dipole antenna).

As an example in Figure 10, USRP1 controls the antennas placed on XY positioners 1 and 3; and USRP2 the dipole antennas of XY positioners 2 and 4. The positioners move synchronously to 30 different positions every 30 seconds, with simultaneous and continuous signal transmission. The received uplink signal, generated by the USRPs, was collected and processed by a 64-antenna massive MIMO base station for each of the 120 positions, then the channel for each position is saved to be processed offline. A similar automatic channel collection was carried out for every 0.5mm, in an 125 × 125mm area per positioner, and a total of 252004 positions with the combination of the four positioners.

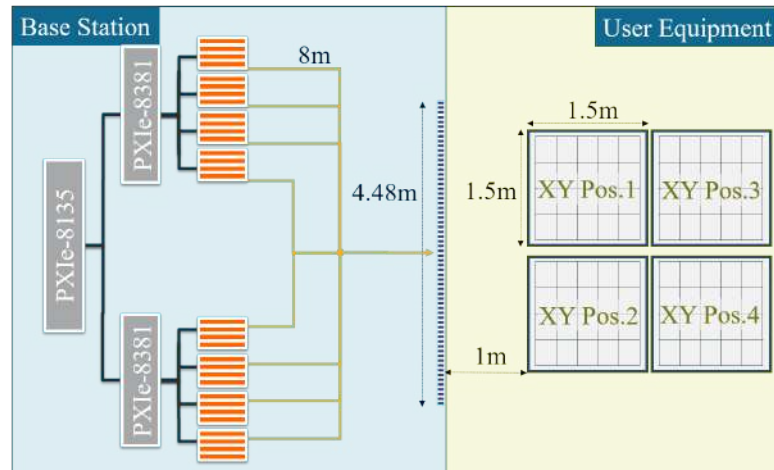


Figure 10. Integration of XY positioner as into KUL Massive MIMO testbed with a 64-ULA distribution.

2.2.4.2 64-modular antennas for KUL Massive MIMO testbed.

The 64-antennas of the base station testbed were upgraded from two rectangular arrays of 32-antennas each, to eight modular arrays of 8-antennas each. For the last case, antennas were deployed into three different distributions:

- **Uniform Rectangular Array (URA):** The 64 antennas were placed in an array of 8×8 antennas as shown in Figure 11.



Figure 11. URA antenna array.

- **Uniform Linear Array (ULA):** The 64 antennas were placed next to each other to form a 1×64 array of 4.48 m as shown in Figure 12.

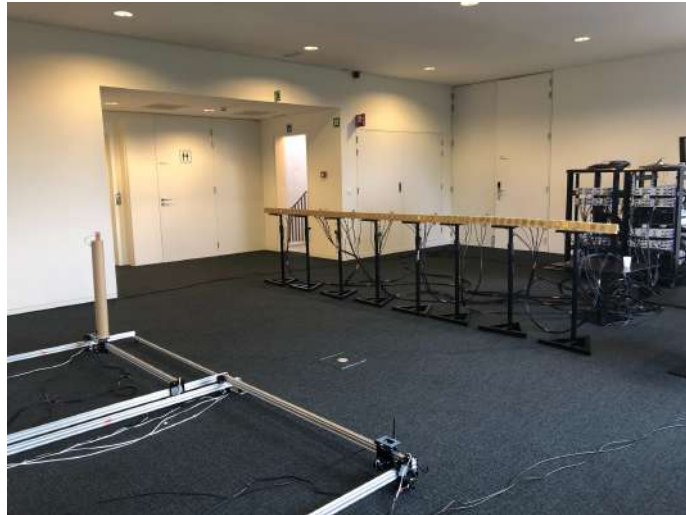


Figure 12. ULA antenna array.

- **Distributed ULA (D-ULA):** In this distributed scenario we deployed homogeneously 8 different arrays of 1×8 antennas around the outskirts of the XY positioners, as shown in Figure 13.



Figure 13. Distributed ULA

2.2.4.3 mmWave multi-beam arrays into KUL Massive MIMO testbed

The MIMO testbed was extended with two 26GHz multi-beam arrays provided by TUD. Through the use of digital precoding, this extension allowed for complex multi-user systems. A schematic overview of the system can be seen in Figure 14.

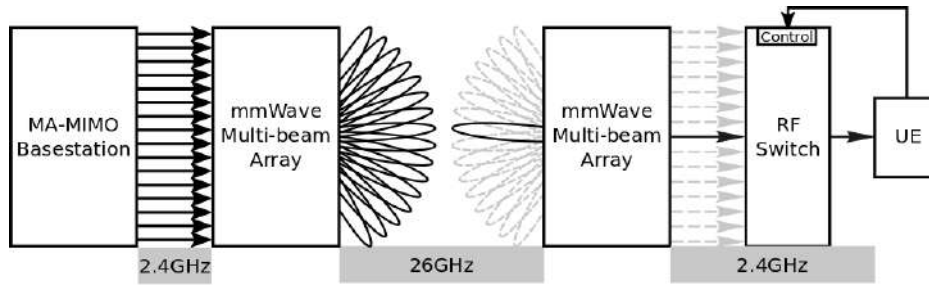


Figure 14 Schematic overview of implemented system.

At the base station side all sixteen antenna ports of the array were connected to a total of 8 USRPs, with two antennas each, as shown in figure below.

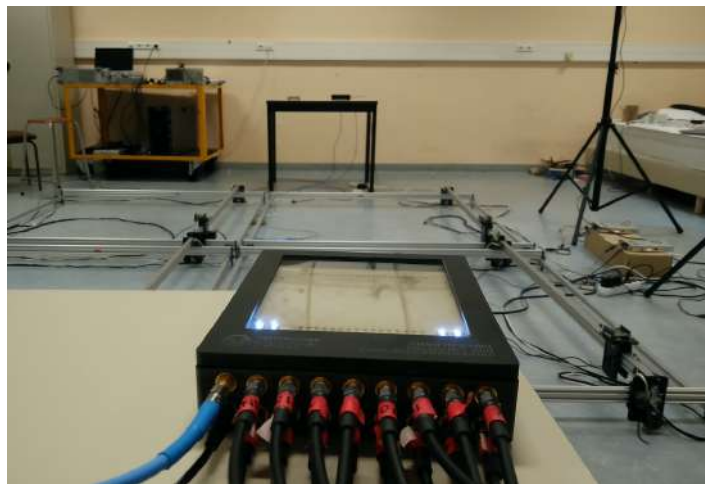


Figure 15 Base station side 26GHz antenna array.

At the user side the multi-beam array is connected to an RF switch, which can be controlled by the user, as shown in figure below.



Figure 16 User side USRP with RF switch and 26GHz antenna array.

2.2.5 ORBIT testbed

2.2.5.1 Xilinx Alveo U200 data center accelerator cards

ORBIT and COSMOS testbeds now host multiple heterogeneous compute nodes, to meet the raising demand for computing power paired with massive amounts of data. SandBox 9 in ORBIT testbed, and compute nodes in all the COSMOS sites are Dell R740XD servers with the following specifications.

Table 2 The specification of compute nodes on ORBIT.

CPU	2x Intel Xeon 12 core
RAM	192 GB
Storage	240 GB SSD
Network	2 x 25GB NICs
FPGA	Xilinx Alveo U200 Data Center Accelerator cards with 2 100G ports
GPU	NVIDIA Tesla V100 16GB VRAM

Development and deployment of FPGA accelerated applications on Alveo U200 cards require Xilinx Vitis IDE. ORBIT image with the required tools is provided for experimenters. Tutorial for getting started on FPGA accelerated application development, https://wiki.cosmos-lab.org/wiki/tutorials/alveo_getting_started features the following

- Links to instructions for a new ORBIT user such as, registering for an account, uploading ssh keys, making reservation etc.
- ORBIT image (alveo-runtime.ndz) with Vitis software platform 2019.2, XRT 2019.2, XDMA and QDMA shells for Alveo U200 is provided. The image also contains tutorials cloned from <https://github.com/Xilinx/Vitis-Tutorials> & https://github.com/Xilinx/Get_Moving_With_Alveo. This image can be loaded on any cloud lab server on ORBIT SB9 or COSMOS compute node.
- Walk through of checking the card installation, flashing the card.
- Matrix multiplication application from <https://github.com/Xilinx/Vitis-Tutorials> was built for all 3 targets, and the xclbin files are available in Vitis-Tutorials/docs/Pathway3/reference-files/run directory.
- Instructions for emulating, running the accelerated application on the hardware, and instructions for using Vitis analyzer to view profiling information, simulation waveforms.

2.2.5.2 Sivers 60GHz RF transceivers

COSMOS SandBox1 hosts of a pair of Sivers IMA EVK06002s. EVK06002 is an evaluation kit for TRX BF/01, a 16+16 IEEE802.11ad beamforming transceiver with complete radio front-end. The transceiver covers mmWave spectrum 57-66 GHz, and supports full RF channels according to IEEE802.11ad.

SandBox1 consists of a pair of USRP X310s with BasicTX, BasicRX daughtercards, dedicated for controlling the Sivers front-ends over USB, and for generating / consuming data samples to/from the Sivers front-ends. UHD / gnuradio applications can be run on the compute servers srv1-1g1 and srv2-1g1. Following figure shows the 60GHz setup on COSMOS SB1.

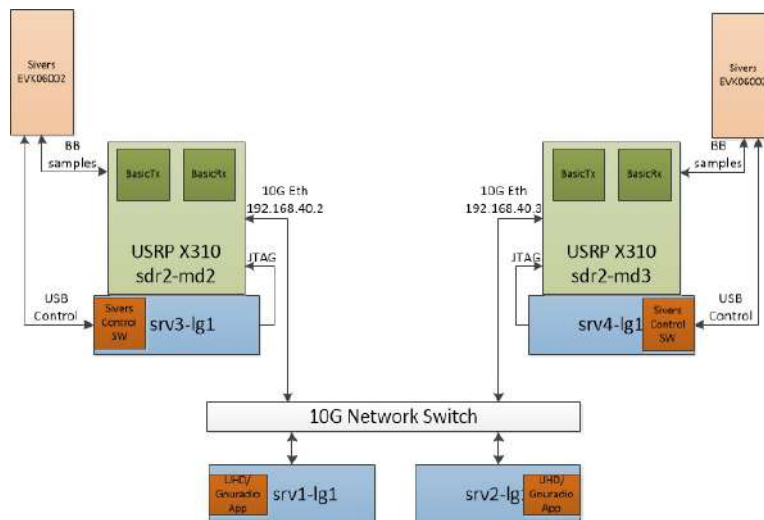


Figure 17 COSMOS SandBox1 mmWave setup.

A tutorial for running a basic UHD application is provided on the COSMOS website. Further, the 802.11ad preamble processing blocks developed as a part of ORCA OC2 extension 4 can be tested on the Servers 60GHz setup.

2.2.6 Portable testbed

In year 3, ZED Board is also supported in portable testbed. A ZED Board can be configured by the NUC node in identical way as by a Zotac node in w-iLab.t testbed.

Use cases and tutorials that have been previously discussed in Section 2.2.1.3 (ie. Single channel implementation, multi-channel implementation of Zigbee transceiver on ZED Board) can be applied to portable testbed. The only thing is that ZED board is not a part of the portable testbed by default, as it will increase shipping cost for users that only need regular nodes. User that require this hardware need to contact an admin, as explained in

<https://doc.ilabt.imec.be/ilabt/portabletestbed/architecture.html#hardware>.

3 CONCLUSIONS

This deliverable reports the effort of testbed development in the third year of ORCA project. The ORCA facility consists of 6 testbeds: (i) the w-iLab.t testbed from IMEC, (ii) the KUL Massive MIMO testbed, (iii) the ORBIT testbed from RUTGERS, (iv) the IRIS testbed from TCD, (v) the OWL testbed from TUD and the (vi) IMEC portable testbed.

During the last year of ORCA, all partners have focused on the completion of SDR related experimentation tools in the testbed facility. More particularly, we worked on the integration of new SDR hardware (e.g., 60 GHz mmWave frontend), the update of servers and testbed backbone facilities, the development of SDR specific software tools (e.g., JTAG booting of Linux on ZYNQ SDR), and the completion of online documentation for users to get started. After these efforts, all ORCA functionalities developed for SDR experimentation have been successfully integrated into the ORCA testbed facility, and made available for external users.