Orchestration and Reconfiguration Control Architecture

SIREN

ServIce level agReement ENforcement in ORCA

Open Call partner
Scuola Superiore Sant'Anna

Patron
Trinity College Dublin

OBJECTIVES

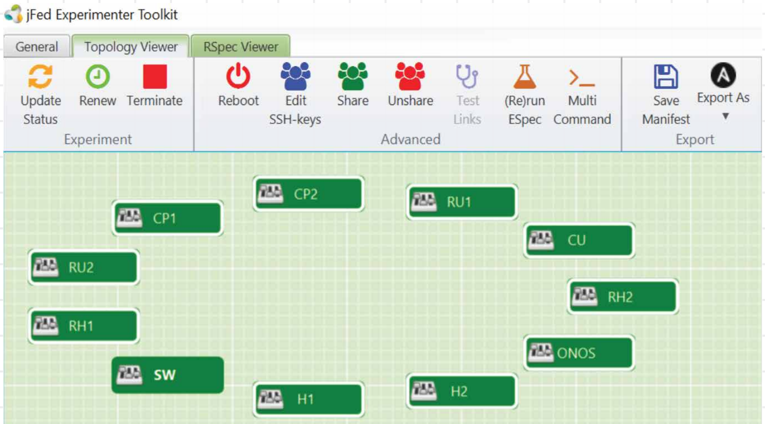
The ServIce level agReement ENforcement in ORCA (SIREN) project objective was to evaluate the viability of a solution based on Software Defined Network-Software Defined Radio (SDN-SDR) controllers in mapping Service Level Agreement (SLA) into slice Key Performance Indicators (KPIs) and enforcing KPI thresholds through specific network configurations.

CHALLENGES

To do so the SIREN project complemented current SDN-SDR control software (e.g., Openflow, FINS) with functions of SLA mapping into KPIs, KPI enforcement, and KPI monitoring.

EXPERIMENT SETUP

The performed experiments evaluated the capability of the proposed solution to fulfill such requirements by means of application-level active probes.
Moreover, it investigated how different KPIs contributed to the end-to-end performance.

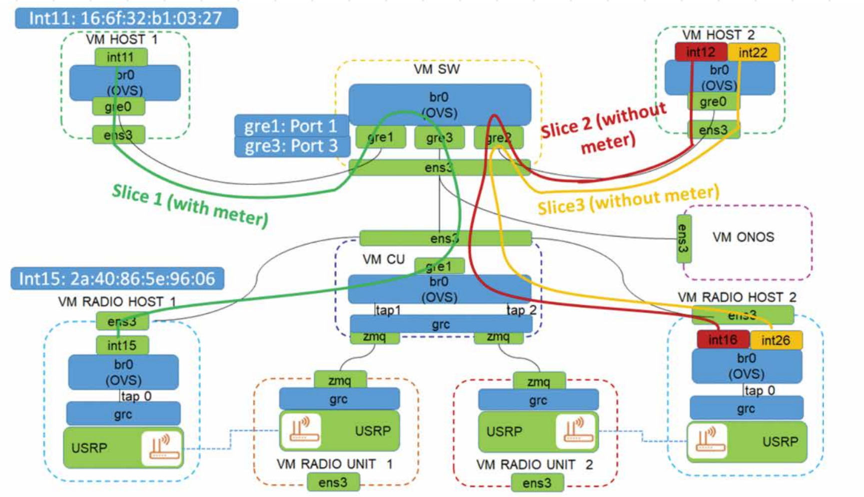


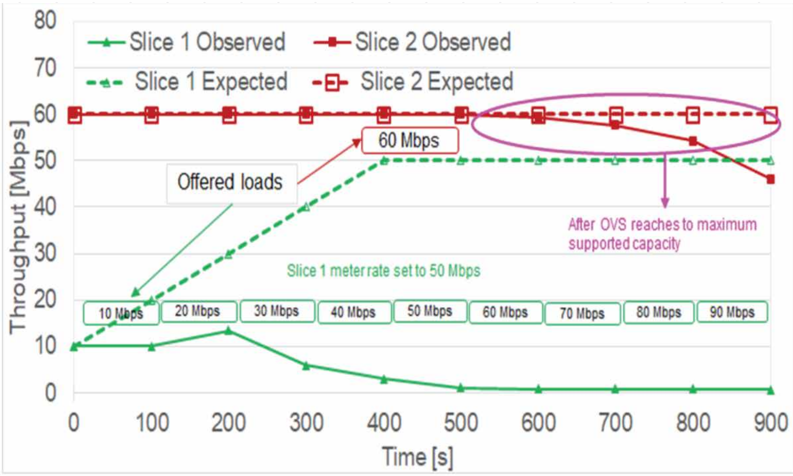
www.orca-project.eu

SIREN

ServIce level agReement ENforcement in ORCA

MAIN RESULTS





The Figure shows the throughput obtained and expected when the Slice 1 meter set to 50 Mbps and Slice 2 offered load is set to 60 Mbps without meter. The experiment duration is set to 900s and every 100s the Slice 1 offered load is increased by 10 Mbps. Slice 2 provides minimum guaranteed capacity (i.e., 60 Mbps) until the overall offered load reaches the maximum supported capacity of the OVS.

CONCLUSIONS

The utilization of meters allows to guarantee to a certain slice, based on Openflow, minimum capacity by limiting the traffic of the traffic sharing the same link. The meters, which are dropping packets, are effective when the link capacity is fully utilized by the flows sharing the link.

FEEDBACK

The ORCA facilities provided by the considered testbed were very good to perform the experiment. ORCA provided a base experiment setup that we could simply modify and integrate to evaluate our proposed solutions. An important added value was the availability of sample setups that shortened the time to experiment.

Thanks to the ORCA facility we were able to evaluate the viability of software switch meters to guarantee slice performance isolation in terms of minimum guarantee capacity

Orchestration and Reconfiguration Control Architecture

ORCA-RAT

Experimental Study of Multi-RAT Networks

Open Call partner
Technische Universität Darmstadt

Patron
National Instruments

OBJECTIVES

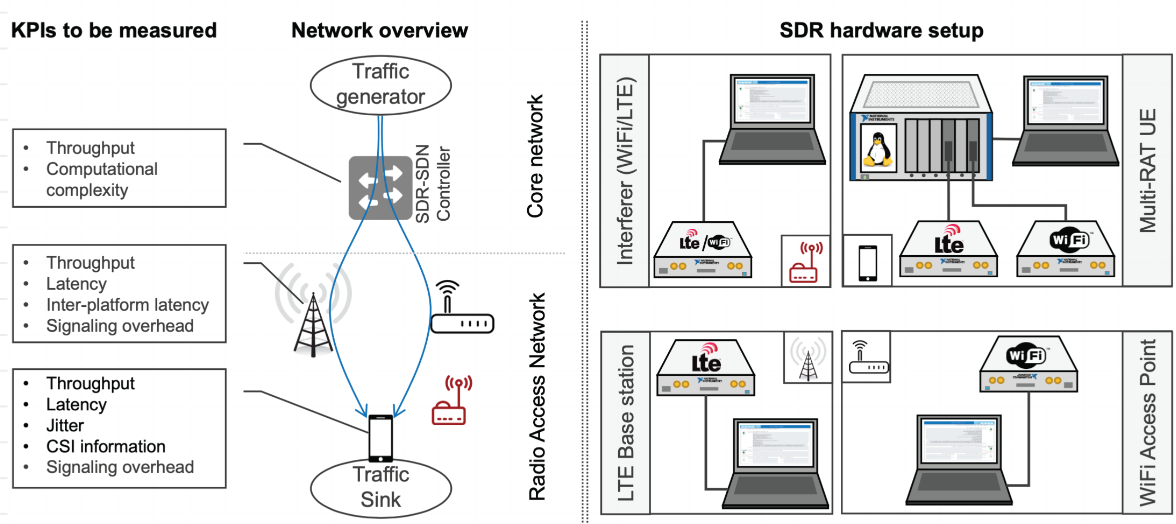
We aim to understand the complications of coupling different radio access technologies (RATs) which not only operate on different channel but also use different channel access mechanisms (OFDMA and CSMA). In particular, we aim to provide design insight into choice of RAT coupling and coordination strategies.

CHALLENGES

We face two main challenges in this experiment. Firstly, we had to modify the implementation to collect additional performance metrics at different layers of network stack and defining methods to report these values back to the central controller. Secondly, implementing the necessary functionalities to enable bi-directional TCP connections.

EXPERIMENT SETUP

Our experiments rely on the multi-RAT capability as well as the full-stack implementation of ORCA LTE-WLAN radio aggregation (LWA) and LTE-WLAN radio level integration (LWIP). PHY layer and a portion of MAC layer functionalities are implemented in the FPGA on the SDRs. The SDRs are then connected to NS3 via the L1/L2 API to complement the rest of the network stack up to the application later.



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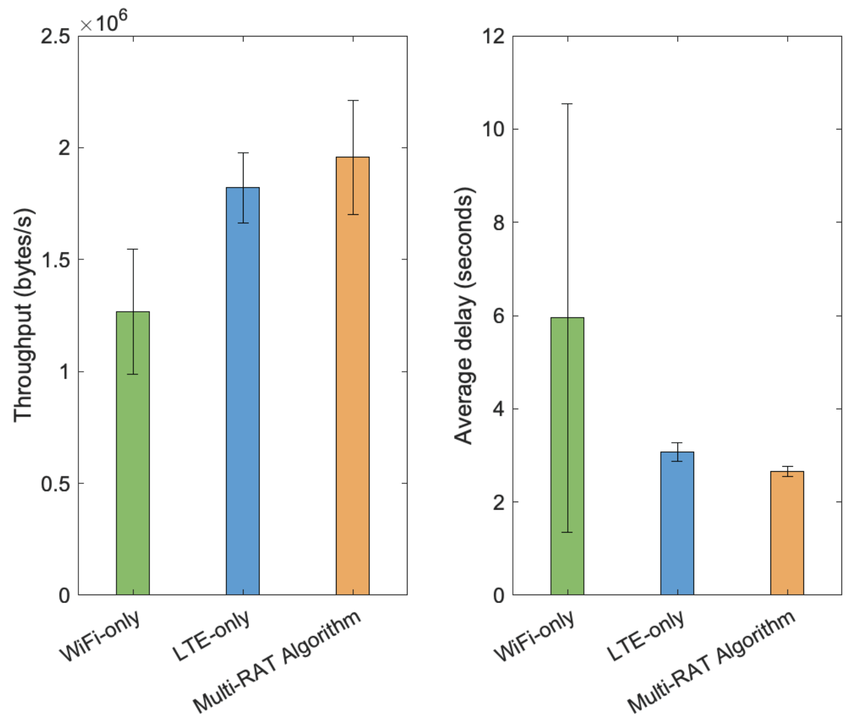
ORCA-RAT

Experimental Study of Multi-RAT Networks

MAIN RESULTS

ORCA-RAT aim at evaluating the performance of a real-time full-stack multi-RAT system. We have implemented a feedback mechanism to allow the eNodeB to access KPIs such as throughput and delay figures. Furthermore, we have devised a simple RAT selection algorithm which operates based on these KPIs. Our results show channel variation has high impacts on the performance of higher layer protocols (TCP in this experiment) and leveraging even simple RAT selection strategy to account for such variations can significantly reduce the delay/jitter experienced by the applications as well as increasing the throughput.



CONCLUSIONS

This is the first full-stack and real time experimental study of multi-RAT systems. In particular, we have shown how selection of RAT impacts the overall network capacity. Furthermore, we demonstrated the effect of RAT selection and rate imbalance between RATs on the higher layers of stack such as TCP congestion control mechanism. The outcome of this experiments can be used as design guideline for future multi-RAT systems in particular after integration of millimetre-wave radio which will increase the rate imbalance even further.

FEEDBACK

Our experience with ORCA consortium in general and our patron, National Instruments, in particular has been satisfactory. None of the aforementioned results could have been achieved without access to ORCA test facility as well as the support from patron.

Thanks to the ORCA facility, we have obtained the necessary resources and support to conduct the first experimental study of LTE-WLAN multi-RAT systems.

Orchestration and Reconfiguration Control Architecture

multiRATsched

The extension of multi-criteria LTEMAC scheduler for multiple RAT environment

Open Call partner
IS-Wireless

Patron
National Instruments

OBJECTIVES

The goal of proposed work is to utilize and exploit ORCA tools and facility to evaluate the performance of proposed LTE MAC scheduler and SD-RAN controller in the multi-RAT environment.

CHALLENGES

Testbed availability is one the biggest challenges faced during the project. Moreover, remotely accessibility of testbed was challenging as well as multiple nodes (PCs and USRPs) have to be accessed remotely with proper setting configurations.

EXPERIMENT SETUP

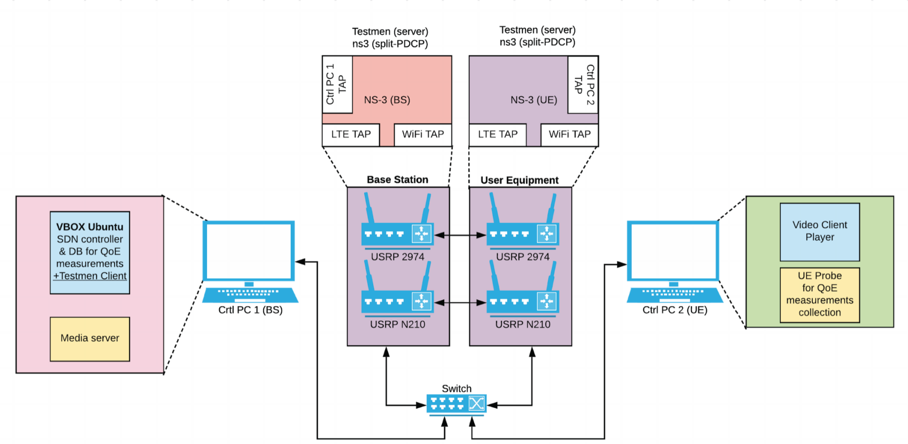


Fig. 1 Experimental Setup

Figure 1 shows an overview of the experiment setup and connectivity of the implemented modules within TUD testbed. For the experiments, the media server is implemented within the Win7 Host PC connected to the eNB PXI controller whereas media client is made at the Win7 Host PC connected the UE PXI controller. The RAN controller modules and the database for the QoE related information exchange are implemented inside the Ubuntu PC. In order to exploit the multi-RAT use case of the testbed, noise is purposely added to the LTE link so that RAN controller can trigger automatic switching to WiFi link based on the SINR and QoE measurements. For the addition of the noise, separate Labview process is generated for noise. The noise generator output is combined with the transmission of LTE link using the combiner in the cabling setup. The experiment utilizes the testbed in the TAP bridge configuration which means that external traffic is forwarded to the NS3 generated traffic. Therefore, two packet forwarding scripts are used at PXI controllers: first at eNB PXI controller for forwarding the media traffic from media server into the NS3 TAP bridge; and second at UE PXI controller to forward the media traffic from the NS3 TAP bridge to media client.

multiRATsched

The extension of multi-criteria LTEMAC scheduler for multiple RAT environment

MAIN RESULTS

Four different scenarios:

1. Round Robin scheduler in LTE without RANC;
2. Proportional Fair scheduler without RANC;
3. SINR based information centric LWA switching from LTE to WiFi using RAN controller;
4. QoE-aware LWA switching from LTE to WiFi via RAN controller.

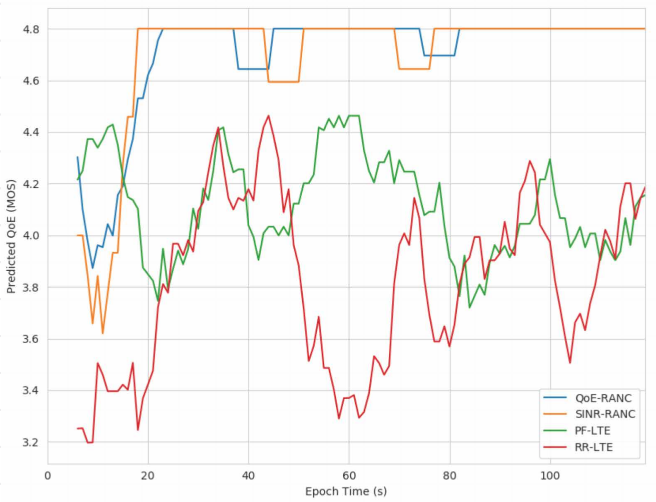


Fig. 2 Predicted QoE (MOS) over Epoch Time (s) for each scenario

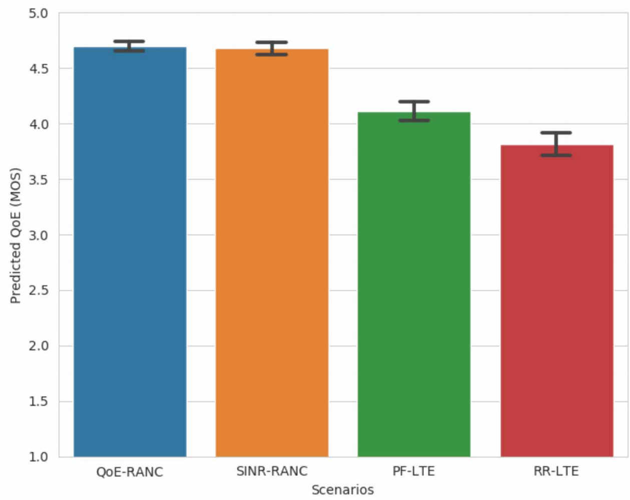


Fig. 3 Accumulated average predicted QoE for each scenario

CONCLUSIONS

With the ORCA consortium testbed, testing and validation of RAN controller product and radio resource management algorithm, both from IS-wireless, in the multi-RAT environment by just focusing on the prototype design and development without carrying about the underlying infrastructure implementation for the multi-RAT scenario.

FEEDBACK

ORCA experimentation testbed allows us to experiment the ideas and concepts in a realistic environment together with the support from patron and open source code availability. The patron also organized a workshop including essential training which proved to be quite useful to learn the functionalities of the ORCA testbed.

All in all, we had a great experience regarding communication and support from the testbed patron. Moreover, with the help ORCA facility we have been able to test and experiment novel ideas that were not tested before in realistic testbed environments. This helped us to understand the concepts as well as we managed to train ourselves with testbed and issues related with real life testing.

Orchestration and Reconfiguration Control Architecture

MinDFul

MmWave Link Doubling Full-Stack Experiments

Open Call partner
University College Cork

Patron
Technische Universität Dresden

OBJECTIVES

In this project, we aim at making the millimetre wave (mmWave) channels more stable by using an auxiliary radio frequency (RF) system along with the main RF system to use the auxiliary one when the main link is blocked. Its main applications are in virtual reality games and autonomous vehicles.

CHALLENGES

The main challenges of this project were: (1) developing and debugging the ideas in the complicated software system, which is implemented in LabVIEW; (2) recording data when the experiments were running and extracting data from the recorded format.

EXPERIMENT SETUP

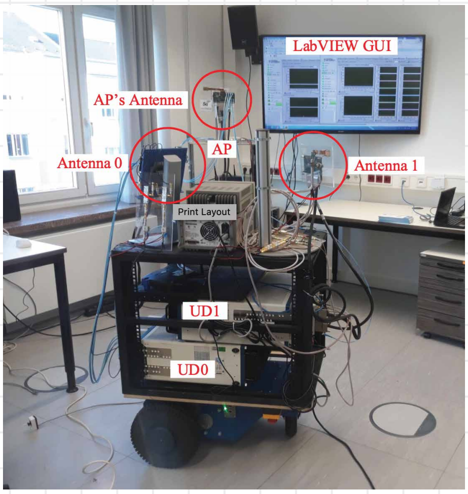


Figure 1. Setup of movement experiments.

In Figure 1, we mount all hardware of UD0 and UD1 on a trolley and move it using a robot. Antennas of two UDs are mounted back-to-back in such a way that they both cover almost 360^0 around them together. We move the robot to left and right three times in a minute. As the robot has 3 wheels, moving it to left and right causes antennas of UD0 and UD1 to be located at 3 different positions with respect to AP, shown in Figure 2.

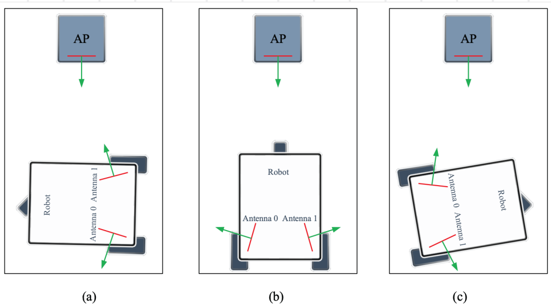


Figure 2. Top view of three extreme positions of the UDs when moving robot to left and right for movement experiments.

In Figure 2-(b), the robot's front wheel is straight, and the trolley is faced toward the AP. But, none of the UD antennas directly face to AP's antenna. The antenna faces are toward left and right and there may be small transmission/reception line-of-sight (LoS) between UD and AP antennas. When we move robot to the left, we stop at position of Figure 2-(a). In this position, Antenna 1 has a good LoS with the AP's antenna and the communication will be gone through UD1. Here, UD0's antenna has no LoS with AP's antenna, and the signal power is very small such that data rate will be zero even with strong modulation/coding schemes (MCS). When we move the robot to the right, we stop at the position of Figure 2-(c). Here, Antenna 0 has a good LoS with the AP's antenna and the communication will be gone through UD0.

MinDFul

MmWave Link Doubling Full-Stack Experiments

MAIN RESULTS

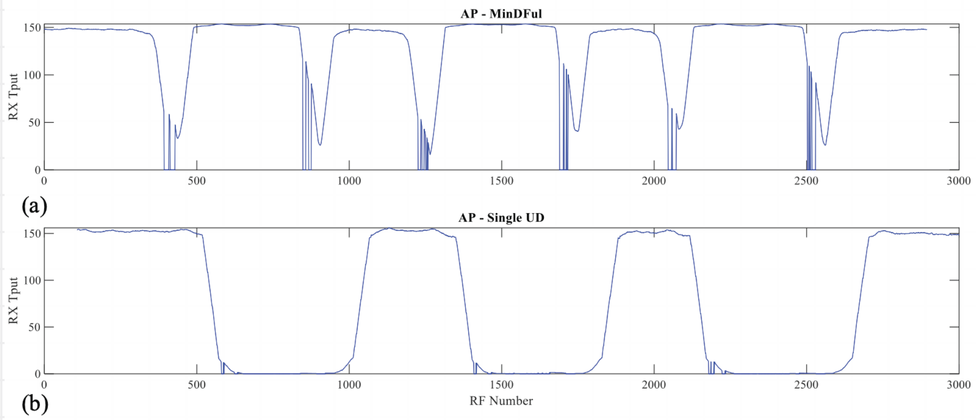


Figure 3. Received throughput over time for movement setup using MCS of 3/4 QPSK. (a) MinDFul; (b) Single-UD. While in single UD setup, there are large gaps at which the data rate falls to zero because of lack of LoS of UD's antenna with the AP's antenna, using double links in MinDFul could almost fill these gaps and made them smaller, and so made the mmWave channel more stable.

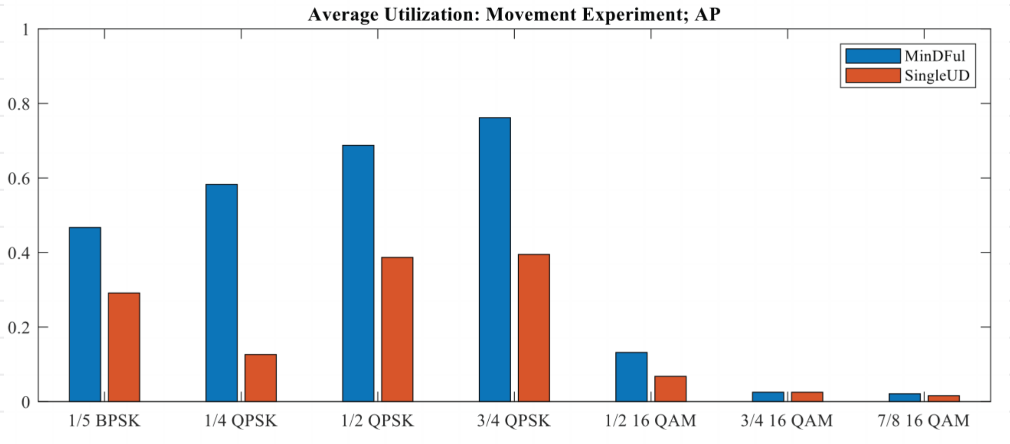


Figure 4. Average utilization of MinDFul compared to Single UD setup for Movement Experiment vs different MCSs. Using double links in MinDFul doubled the utilization with respect to single UD setup.

CONCLUSIONS

Our developed solution and experiments show using two links in one side of wireless communication which moves frequently, or its antennas can be blocked, we can increase the utilization of the mmWave channel and making it more stable. These results are promising for applications which require +10Gbps wireless data-rate.

FEEDBACK

The ORCA's mmWave testbed is one of the best available ones for research community in the sense that new ideas can be implemented in software and it covers both PHY and MAC layers. Lack of good documentation requires testbed designers' support and using LabVIEW makes software development and debugging difficult.

Thanks to the ORCA facility we were able to implement and test our ideas on making the mmWave channel more stable to show it can be considered as a promising solution for ultra-high data-rate demanding applications such as VR games and autonomous vehicles.

Orchestration and Reconfiguration Control Architecture

MAGNUM

Multi-Access edGe computiNg for FutUre Wireless SysteMs

Open Call partner
Ss.Cyril and Methodius University

Patron
Rutgers

OBJECTIVES

The main goal of the MAGNUM experiment is to investigate the container-based virtualization of radio access networks and identify its main benefits and drawbacks. The experiment also analyses the effects of scalability and traffic types and provides valuable insights for future practical deployments of full-stack containerized MEC-based RAN solutions.

CHALLENGES

Exploit the software-defined operation of LTE and implement a Docker-based LTE virtualization. Analyse the computational resource footprint based on the underlying communication/network load and configuration. Evaluate the effect of scalability in terms of active UEs and their traffic types. Discover the most appropriate computational resource scaling solution.

EXPERIMENT SETUP

The MAGNUM architecture comprises of two core logical entities, Remote Radio Heads (RRHs) and Multi-access Edge Computing (MEC) segment (Figure 1). The RRHs contain the RF hardware in the system and that do not perform any baseband signal processing. MAGNUM uses the Universal Software Radio Peripheral (USRP) X310 and B210 devices as RRHs. The MEC segment incorporates a container-based virtualization of an LTE base station that utilizes the docker framework. The specific experiment platform uses the Amarisoft commercial LTE BBU software, implementing a full stack LTE Rel.14 base station. The LTE mobile stations i.e. UEs, are also ran over USRP devices and use the srsLTE software.

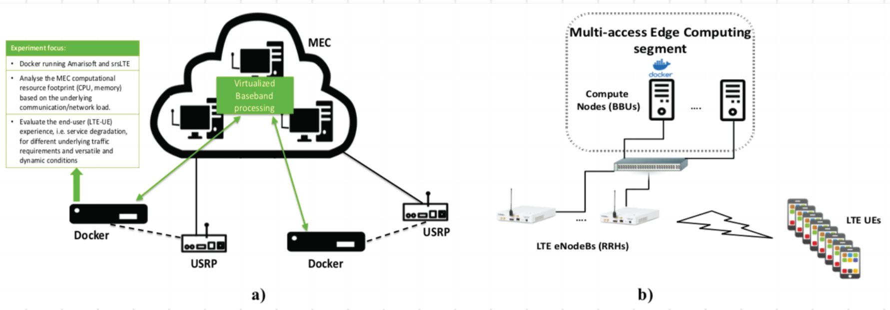


Figure 1 – MAGNUM experiment: a) Outline of the experiment; b) Platform generic architecture

The MEC segment runs over a set of dedicated compute nodes. The nodes represent the available MEC pool of resources such as, CPU and RAM that are allocated to the virtual LTE instances. The nodes run on a server-grade machines with Intel Xeon processors over an Ubuntu 16.04 LTS using a low latency kernel. The fronthaul link between the RRHs and the BBUs is enabled by 10GbE links, routed over an 10GbE switch. Figure 2 depicts the implementation layout of the MAGNUM experiment in the ORBIT testbed.

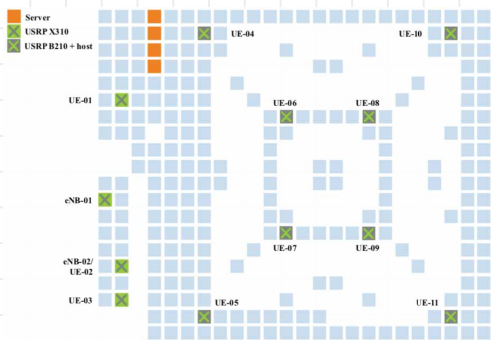


Figure 2 – MAGNUM experiment layout over ORBIT's grid

MAGNUM

Multi-Access edGe computiNg for FutUre Wireless SysteMs

MAIN RESULTS

Fostering efficient operation of the enabling self-organization and intelligence-based technologies for Cloud-RAN deployment, requires large knowledge base and understanding of the virtualized RAN performance behavior. MAGNUM specifically focuses on evaluating the full stack containerized LTE performance behavior for different system configuration and traffic loads. The results will be used as the primary step in understanding large scale commercial deployments. The experiment also focuses on the resource scaling and its impacts on the underlying user performance.

The MAGNUM experiment showcases the benefits of RAN virtualization and its fast deployments and rapid/diverse system reconfigurations. These benefits come at a price of higher computational cost, which is not significantly affected by the number of served UEs, but significantly affected by the physical layer configuration of the RAN. Infrastructure issues such as fronthaul design, need to be carefully considered, in order to provide stable and reliable virtualized RANs.

Figure 3 presents the time series of the CPU utilization and the LTE cell reconfiguration time between LTE bandwidths of 5 MHz and 10MHz for the SISO and the MIMO case. These results show that the reconfiguration delay is in order of few seconds, which proves the flexibility and the swiftness of the virtualized LTE solution. Moreover, the results clearly show that the MIMO configuration requires higher processing power, compared to the SISO case.

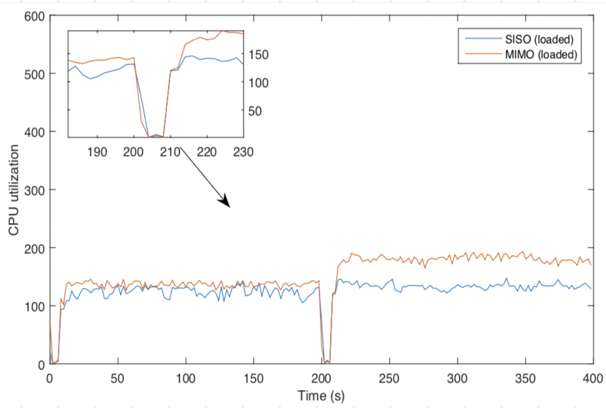


Figure 3: Time series of the transitions between 5 MHz (0-200s) and 10 MHz (200-400s) in terms of CPU utilization, for the SISO and MIMO case and fully loaded LTE base station

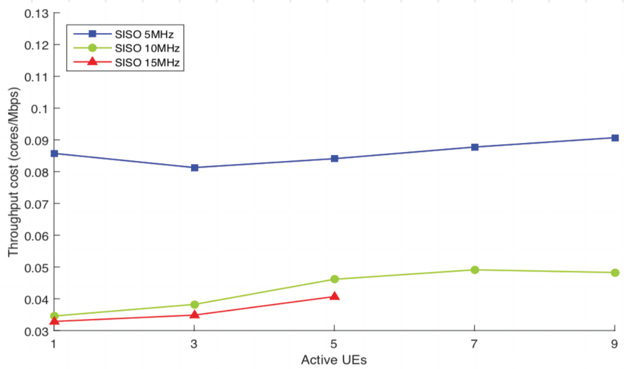


Figure 4 depicts the throughput cost in dependence of the number of active UEs, for a containerized full stack LTE base station in SISO mode. The throughput cost is defined as the ratio between the number of CPU cores used for each served Mpbs of aggregate traffic. The results clearly show that serving higher number of users, as well as using lower channel bandwidths is more resource costly, but the scalability effect (number of UEs) is not significant.

Figure 4: Throughput cost vs number of UEs for a containerized full stack LTE base station in SISO mode

CONCLUSIONS

The main benefits of RAN virtualization are the fast deployments and rapid/diverse system reconfigurations. The number of served UEs has no significant impact on CPU consumption in LTE and 5G deployments, but physical layer configuration does. A high capacity, low latency fronthaul implementation is a necessity in C-RAN solutions.

FEEDBACK

ORCA provides a playground for fostering and experimenting with new ideas in the area of wireless networks. It is easy to use and deploy experiments on the platform. Thanks to the software tools and the hardware provided by ORCA it was easy to run the envisioned experiment.

Thanks to the ORCA facility we were able to demonstrate the advantages of a full-stack virtualized cellular RAN and provide valuable insights for future practical large-scale deployments.

Orchestration and Reconfiguration Control Architecture

ELASTIC

Experimental validation of resource management algorithms for elastic network slicing based on end-to-end QoS

Open Call partner
Allbesmart LDA

Patron
Trinity College Dublin

OBJECTIVES

The main objective of this experiment is the validation of elastic resource management algorithms able to serve multiple Network Slice Instances (NSI) over the same physical resources while optimizing the allocation of computational resources to each slice based on its requirements and demands. The experiment deploys a use case on top of the IRIS testbed that provides two services over two network slices, with a focus on the QoS-aware controland CPU usage.
The goal is to have two competing network slices on the cloud infrastructure: one emulating a MVNO Public Safety service with high throughput and reduced latency requirements and the other emulating an OTT service provider (delay tolerant–best effort slice). A resource management algorithm is implemented and evaluated in terms of performance gains when operating under computational resource limitations.

CHALLENGES

The main challenges of this experiment can be divided into two distinct dimensions: understanding how the srslte software uses computational resources under distinct eNodeB configurations and traffic profiles and how to manage computational resources so that the high priority slice can cope with stringent SLA requirements without disrupting the low priority slice.

EXPERIMENT SETUP

The experiment setup created in IRIS uses four computing nodes, as can be seen in the diagram shown in Figure 1. Machine A implements the EPC and eNodeB components of the LTE network, while machine B contains the UE component. Machine C is used to exchange traffic patterns with the UE through the LTE network, using the iperf tool. Finally, machine D implements the ELASTIC algorithm: it receives traffic and CPU usage data from the two probes and determines the actions to perform in order to comply with QoS requirements.

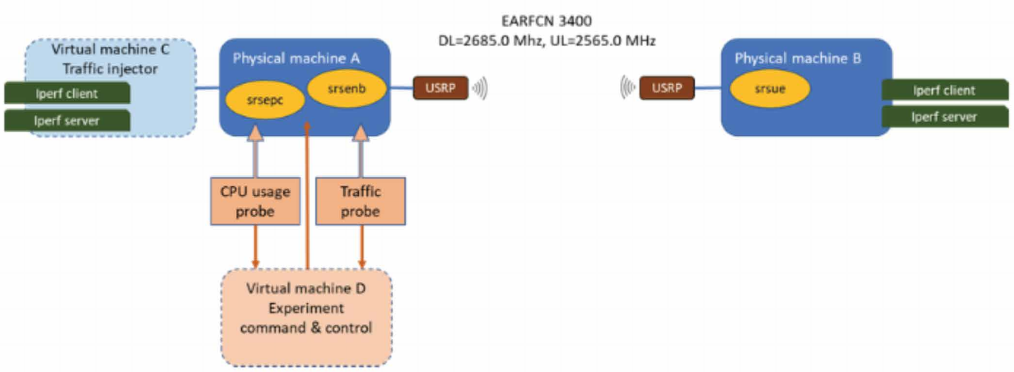


Figure 1 - Experiment setup in IRIS.

The two B210 USRPs are configured in single antenna mode, using the LTE EARFCN frequencies: DL=2685.0 MHZ, UL=2565.0 MHz. Access to each virtual machine is achieved through JFED, using SSH terminal sessions.

ELASTIC

Experimental validation of resource management algorithms for elastic network slicing based on end-to-end QoS

MAIN RESULTS

The ELASTIC algorithm proved to be very effective to increase the TCP throughput of the high priority slice if more CPU resources are required to comply with stringent QoS requirements. Testing revealed gains of 48% in downlink, 55,6% in uplink and 49,8% in simultaneous downlink and uplink. Figure 2 shows the results of theTCP downlink test.

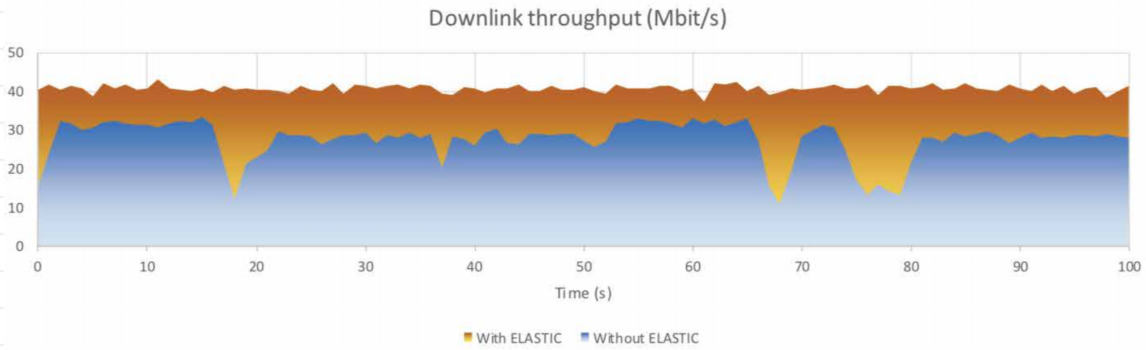


Figure 2 – TCP download throughput comparison.

ELASTIC was also successful dealing with UDP traffic bursts, even with high throughput demand in both directions at the same time. Figure 3 illustrates how ELASTIC deals with UDP traffic bursts and its impact on CPU usage.

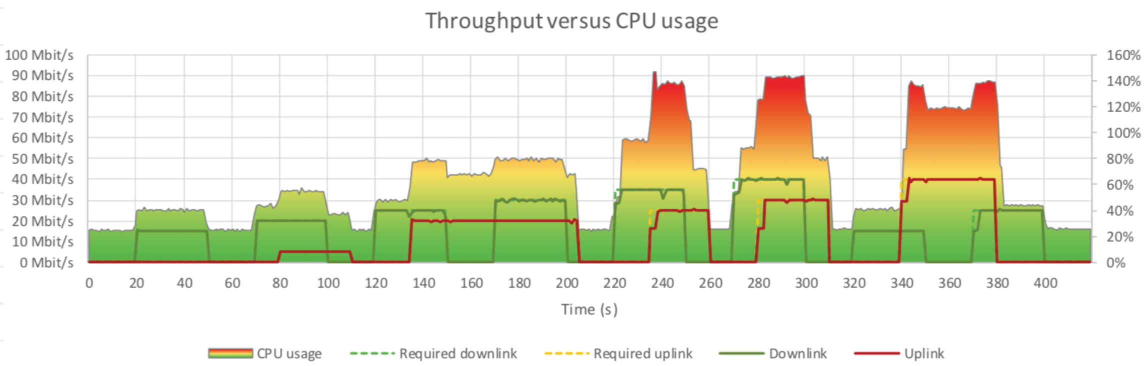


Figure 3 – How ELASTIC handles UDP traffic bursts.

CONCLUSIONS

When two competing cloud RAN LTE slices are implemented over the same computational infrastructure, optimized management of computational resources is an effective instrument to ensure that the high priority slice can cope with demanding QoS requirements under shortage of computational resources. The ELASTIC algorithm implemented in this experiment proved to be effective to increase the performance of the priority slice without disrupting the operation of the low priority slice.

FEEDBACK

ORCA was extremely useful to support this experiment, by allowing our company to have remote access to equipment and resources, namely USRPs and computational nodes, that are usually beyond our reach. The way how different network scenarios can be easily created within JFED, even interconnecting nodes of distinct testbeds, has been perceived as a major advantage of ORCA.

Thanks to the ORCA facility we were able to substantially increase our expertise on cloud RAN technologies and test resource management algorithms using radio equipment that otherwise would be beyond our reach.

Orca

Orchestration and Reconfiguration Control Architecture

BEE

Building Emergency Ecosystems

Open Call partner
Level7 S.r.l.

Patron
imec

OBJECTIVES

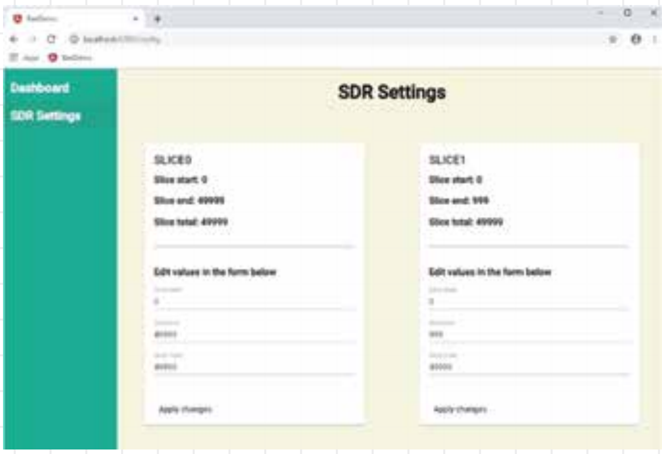
The goal of the BEE experiment is to provide a robust wireless access infrastructure in indoor environment where emergency services should be provided. The use of the existing wireless infrastructure will permit a better use of resources as well as better indoor support and deployment.

CHALLENGES

The main challenge in the BEE experiment has been to use implement QoS/QoE ideas in a novel and open SDR implementation. The support from the ORCA facilities permitted to quickly focus on the main aspects of SDR technologies and provide traffic differentiation.

EXPERIMENT SETUP

The BEE experiment controls the SDR device in order to support emergency scenarios. The SDR can be driven in real time via the GUI thanks to the APIs.

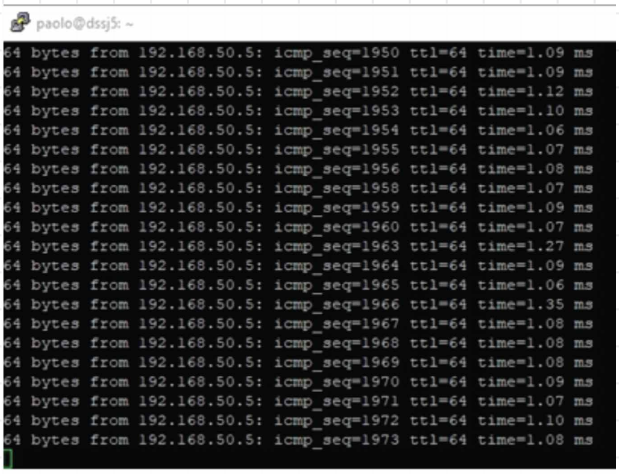


www.orca-project.eu

BEE
Building Emergency Ecosystems

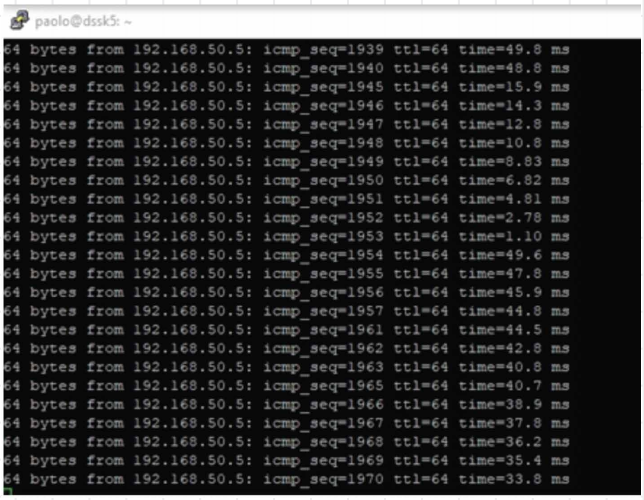
MAIN RESULTS

The SDR device permits traffic differentiation and the full support of an emergency terminal that whose traffic is never degraded, while normal traffic can show degradation.



```
paolo@dssj5: ~
64 bytes from 192.168.50.5: icmp_seq=1950 ttl=64 time=1.09 ms
64 bytes from 192.168.50.5: icmp_seq=1951 ttl=64 time=1.09 ms
64 bytes from 192.168.50.5: icmp_seq=1952 ttl=64 time=1.12 ms
64 bytes from 192.168.50.5: icmp_seq=1953 ttl=64 time=1.10 ms
64 bytes from 192.168.50.5: icmp_seq=1954 ttl=64 time=1.06 ms
64 bytes from 192.168.50.5: icmp_seq=1955 ttl=64 time=1.07 ms
64 bytes from 192.168.50.5: icmp_seq=1956 ttl=64 time=1.08 ms
64 bytes from 192.168.50.5: icmp_seq=1958 ttl=64 time=1.07 ms
64 bytes from 192.168.50.5: icmp_seq=1959 ttl=64 time=1.09 ms
64 bytes from 192.168.50.5: icmp_seq=1960 ttl=64 time=1.07 ms
64 bytes from 192.168.50.5: icmp_seq=1963 ttl=64 time=1.27 ms
64 bytes from 192.168.50.5: icmp_seq=1964 ttl=64 time=1.09 ms
64 bytes from 192.168.50.5: icmp_seq=1965 ttl=64 time=1.06 ms
64 bytes from 192.168.50.5: icmp_seq=1966 ttl=64 time=1.35 ms
64 bytes from 192.168.50.5: icmp_seq=1967 ttl=64 time=1.08 ms
64 bytes from 192.168.50.5: icmp_seq=1968 ttl=64 time=1.08 ms
64 bytes from 192.168.50.5: icmp_seq=1969 ttl=64 time=1.08 ms
64 bytes from 192.168.50.5: icmp_seq=1970 ttl=64 time=1.09 ms
64 bytes from 192.168.50.5: icmp_seq=1971 ttl=64 time=1.07 ms
64 bytes from 192.168.50.5: icmp_seq=1972 ttl=64 time=1.10 ms
64 bytes from 192.168.50.5: icmp_seq=1973 ttl=64 time=1.08 ms
```

Ping results for the "panic button" terminal during the emergency status



```
paolo@dssk5: ~
64 bytes from 192.168.50.5: icmp_seq=1939 ttl=64 time=49.8 ms
64 bytes from 192.168.50.5: icmp_seq=1940 ttl=64 time=48.8 ms
64 bytes from 192.168.50.5: icmp_seq=1945 ttl=64 time=15.9 ms
64 bytes from 192.168.50.5: icmp_seq=1946 ttl=64 time=14.3 ms
64 bytes from 192.168.50.5: icmp_seq=1947 ttl=64 time=12.8 ms
64 bytes from 192.168.50.5: icmp_seq=1948 ttl=64 time=10.8 ms
64 bytes from 192.168.50.5: icmp_seq=1949 ttl=64 time=8.83 ms
64 bytes from 192.168.50.5: icmp_seq=1950 ttl=64 time=6.82 ms
64 bytes from 192.168.50.5: icmp_seq=1951 ttl=64 time=4.81 ms
64 bytes from 192.168.50.5: icmp_seq=1952 ttl=64 time=2.78 ms
64 bytes from 192.168.50.5: icmp_seq=1953 ttl=64 time=1.10 ms
64 bytes from 192.168.50.5: icmp_seq=1954 ttl=64 time=49.6 ms
64 bytes from 192.168.50.5: icmp_seq=1955 ttl=64 time=47.8 ms
64 bytes from 192.168.50.5: icmp_seq=1956 ttl=64 time=45.9 ms
64 bytes from 192.168.50.5: icmp_seq=1957 ttl=64 time=44.8 ms
64 bytes from 192.168.50.5: icmp_seq=1961 ttl=64 time=44.5 ms
64 bytes from 192.168.50.5: icmp_seq=1962 ttl=64 time=42.8 ms
64 bytes from 192.168.50.5: icmp_seq=1963 ttl=64 time=40.8 ms
64 bytes from 192.168.50.5: icmp_seq=1965 ttl=64 time=40.7 ms
64 bytes from 192.168.50.5: icmp_seq=1966 ttl=64 time=38.9 ms
64 bytes from 192.168.50.5: icmp_seq=1967 ttl=64 time=37.8 ms
64 bytes from 192.168.50.5: icmp_seq=1968 ttl=64 time=36.2 ms
64 bytes from 192.168.50.5: icmp_seq=1969 ttl=64 time=35.4 ms
64 bytes from 192.168.50.5: icmp_seq=1970 ttl=64 time=33.8 ms
```

Ping results for the for the normal terminal during the emergency status

CONCLUSIONS

The ORCA facilities permitted Level7 to successfully implement the BEE experiment that will be the foundation for new added value services and novel experiments on the SDR/SDN architectures.

FEEDBACK

The ORCA facilities permits the experimenters to focus on the main topic of the research in order to speed up the implementation of new added value services or ideas.

Thanks to ORCA we have been able to focus on the main topic of our research without wasting time in secondary aspects thus speeding up the time to market.

Orchestration and Reconfiguration Control Architecture

Concurrent HaLow

Concurrent multiple sensing for better channel utilization of Wi-Fi HaLow networks

Open Call partner
Methods2Business

Patron
imec

OBJECTIVES

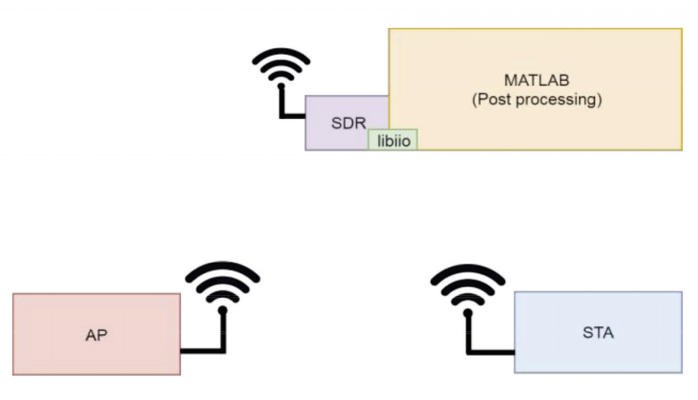
Methods2Business' major objective was to prove that concurrent sensing of multiple channels in a Wi-Fi HaLow network leads to a more efficient channel utilization, maximizing the throughput of Wi-Fi HaLow devices in the network. The intention was to apply the Digital Down Converter (DDC) filters provided by the ORCA project for the channel sensing and develop a mechanism for channel switching.

CHALLENGES

The two main challenge were on one side to identify a reliable metric for classifying channels in a Wi-Fi network based on the measured wireless activity in the channel, and on the other side, to develop an efficient mechanism for channel switching that complies with the IEEE 802.11ah standard.

EXPERIMENT SETUP

The experiment consists of two Xilinx ZC706 Evaluation Kit - Zynq® 7000 SoC boards: the first one represents an Access Point (AP) and the second one represents a Station (STA). The traffic between them is captured with an SDR-based sniffer that is connected to MatLab using the libiio library from Analog Devices Inc. The figure below shows the experiment setup at the imec w-iLab.t.2 lab.



Concurrent HaLow

Concurrent multiple sensing for better channel utilization of Wi-Fi HaLow networks

MAIN RESULTS

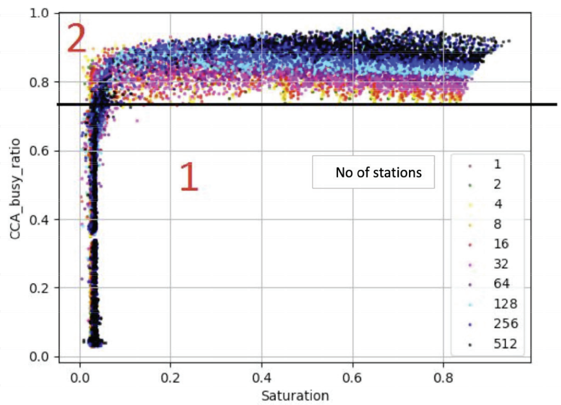
Methods2Business developed two metrics for channel classification, one based upon the CCA_busy_ratio which represents the percentage of period of time that the channel is occupied and another one based upon the Traffic Saturation Metric (TSM) representing the average channel idle time. Based on these two metrics, channels could be classified.

The figures below show the CCA_busy_ratio and the Traffic Saturation Metric in function of the saturation of the network which is defined by the following formula.

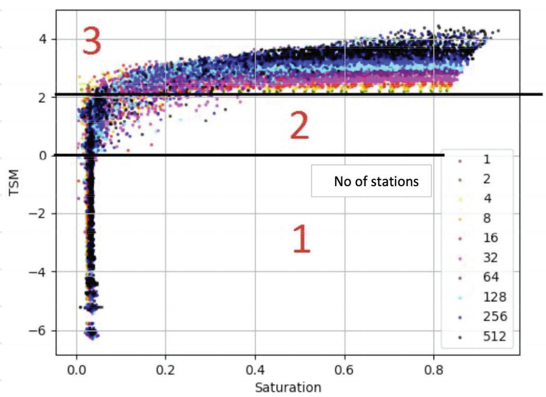
SAT = 1- Effective throughput/Desired throughput / where Desired throughput is the sum of the throughputs STAs are trying to achieve

The numbers (1, 2 and 3) mean: 1- No Saturation, meaning effective throughput equals desired throughput. 2- Partial saturation. 3- Full saturation

As indicated by the figures below, classification based upon the Traffic Saturation Metric gives a more precise indication of the channel condition.



CCA_busy_ratio in function of network saturation



Traffic Saturation Metric in function of Network Saturation

In addition to channel classification, Methods2Business developed two mechanisms for channel switching, one to be applied during initialization of the network and another for a network in operation.

CONCLUSIONS

Concurrent sensing of multiple channels to enable channel switching, is a promising concept for maximizing throughput in a Wi-Fi HaLow network. The mechanisms developed for channel sensing based on ORCA's DDC filters and channel switching, were illustrated using the imec test facility and showed promising results for further implementation in Methods2Business commercial Wi-Fi HaLow access points.

FEEDBACK

Methods2Business is very satisfied with the ease of use and tool support provided in ORCA to bring-up our full Wi-Fi HaLow MAC and Baseband implementation for a client and an access point on the available prototyping boards (ZYNQ FPGA with AD9361 radio cards) present in the imec w-iLab.t.2 lab. Thereafter, it was very straightforward to run remotely our intended experiments. For the near future, Methods2Business sees great opportunities to further exploit the services offered by imec w-iLab.t.2 lab facilities for offering remote access to our Wi-Fi HaLow demonstration platform to early adopters of the Wi-Fi HaLow technology all over the world.

Thanks to the DDC filters provided by the ORCA team and the access to the Testbed of the imec test lab, Methods2Business was able to develop and test a working mechanism for channel sensing for the purpose of channel switching to maximize the throughput of devices in the network. Methods2Business will apply these concepts into their access point products to create a competitive advantage in the market. The Methods2Business team very much appreciated the professionalisms of the people running the imec test lab and the in-depth knowledge in wireless networks of the ORCA team.