Orca

Orchestration and Reconfiguration Control Architecture

CSI-MURDER

Experimental analysis of CSI-based anti-sensing techniques

Open Call partner
University of Brescia

Patron
imec

OBJECTIVES

The goal of the Experiment is to study and propose an anti-sensing technique against novel device-free CSI-based localization frameworks. In particular, we intend to safeguard users' privacy by preventing both passive and active environment sensing attacks without affecting too much the ongoing Wi-Fi communications.

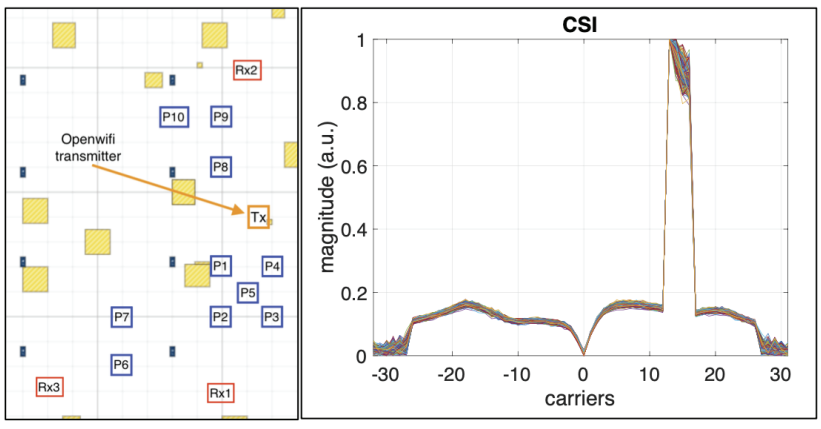
CHALLENGES

- Choose from the Wi-Fi sensing literature a passive localization technique and deploy it using lab facilities

- Find and implement a randomization mechanism at the Wi-Fi physical layer that makes the localization technique above useless without compromising the communication capabilities of the randomized devices, should they be actively adopting randomization or passively being randomized from an external device.

EXPERIMENT SETUP

The experiment demonstrated that it is possible i) to use the facilities in w.iLab.2 to discover the location of a victim moving in the lab (e.g. among 10 target positions as shown in Figure a) by analyzing the CSI received at a given node; and ii) to adopt a proper countermeasure at the transmitter to make the deployed localization technique useless. In fact, the countermeasure is able to modify the CSI almost arbitrarily. We show the effect of amplifying 4 adjacent subcarriers in Figure b, but in general we can generate random patterns that do not depend on the actual channel condition, so that CSI cannot be used anymore for localization purposes.



a) b)

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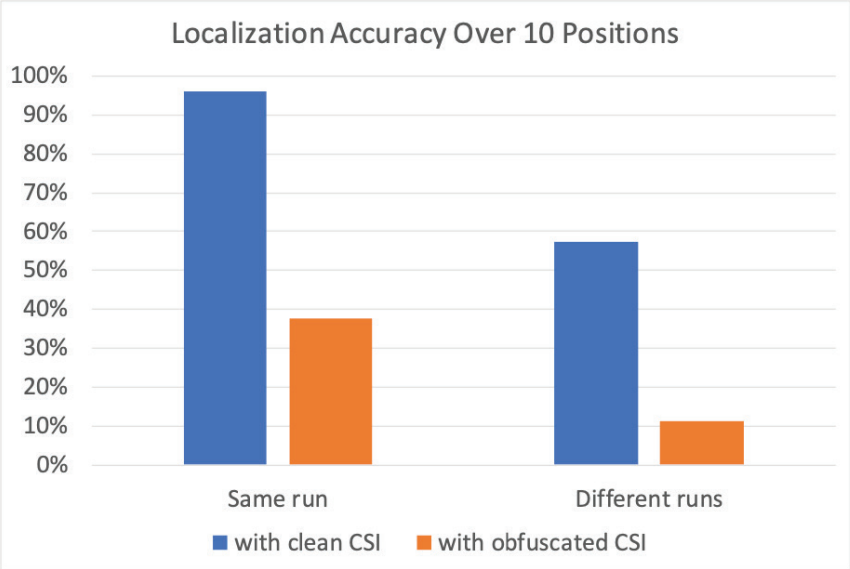
CSI-MURDER

Experimental analysis of CSI-based anti-sensing techniques

MAIN RESULTS

The Figure shows the average classification accuracy of a person over 10 possible target positions in the w.iLab.2 testbed. The label same run refers to the fact that training and testing samples are drawn (without reinsertion) from the same CSI collection experiment, while for label different runs we collected training and testing CSI samples at two different times. It is interesting to notice that the localization system still works fairly well in the second case, but more importantly we show that the proposed anti-sensing techniques disrupts localization accuracy in both cases.



CONCLUSIONS

This is the first study to characterize the possibility of obfuscating Wi-Fi frames to prevent environment sensing. Our experiments in the w.iLab.2 testbed confirm that an eavesdropper is not able to infer the location of a victim in a room, while Wi-Fi communications are preserved. The outcome of this experiment can be used for designing future privacy-aware chipsets.

FEEDBACK

Our experience has been positive. Many results in this Experiment could not have been achieved without the tools available in the testbed and the constant support of our patron, which promptly solved a few issues that we encountered while using the facility.

Thanks to the ORCA facility, we have obtained the necessary resources and support to conduct the first systematic and experimental study of an obfuscation technique to prevent unauthorized use of CSI information to breech people privacy. Such results, beyond opening an entire new field of research, are also fundamental to guarantee the future socio-economic sustainability of Wi-Fi technology.

Orchestration and Reconfiguration Control Architecture

MARRMOT

Massive MIMO for reliable remote monitoring

Open Call partner
Lund University

Patron
KU Leuven

OBJECTIVES

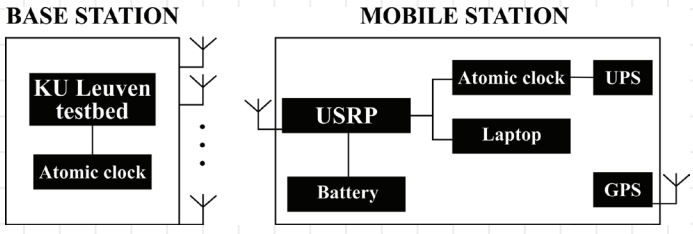
The goal of the experiments was to extend the KU Leuven testbed to a real- time sub-GHz massive MIMO system, respecting the regulations in the unlicensed band, validate the results and perform measurements comparing different antenna array configurations and frequencies.

CHALLENGES

The main challenge during the implementation phase was the LabVIEW implementation in an already quite involved framework and for the experiments; the Corona pandemic also caused delays. The unstable Belgian summer weather made planning for the outdoor measurements difficult.

EXPERIMENT SETUP

For the outdoor experiments, the base station was on a balcony with either a Uniform Linear Array or a Uniform Rectangular Array. All the user equipment for the mobile station was in a cargo bike, making it completely mobile. The two systems were synchronised through atomic clocks.



Picture 1: Block diagram of experiment setup

Picture 2: Rectangular array on the balcony of KU Leuven, with the bike-mounted mobile station in front

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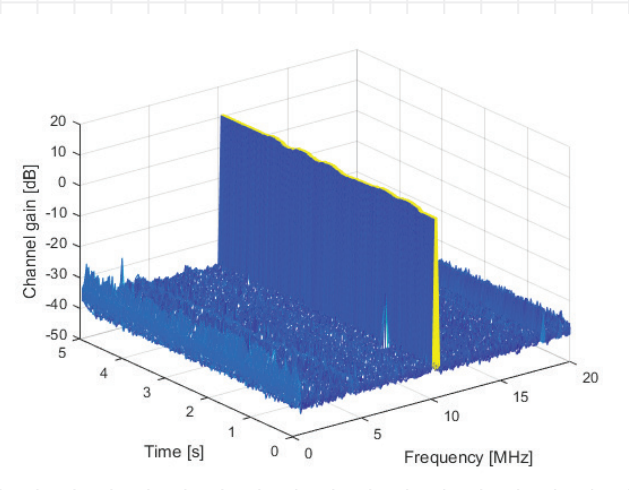
MARRMOT

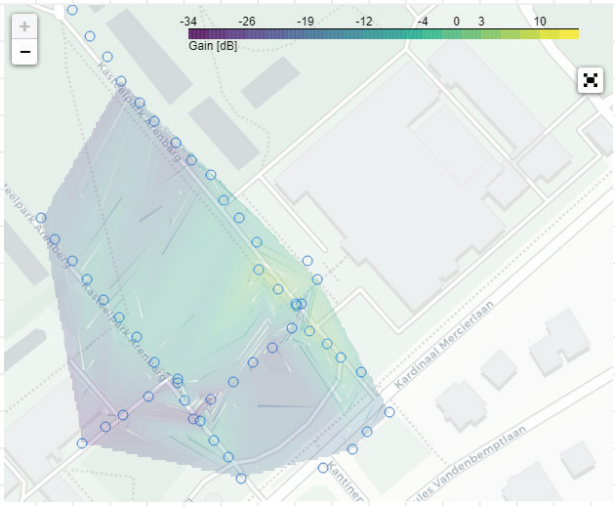
Massive MIMO for reliable remote monitoring

MAIN RESULTS

It was possible to extend the KU Leuven testbed to a real-time sub-GHz massive MIMO system, respecting the regulations in the unlicensed band, with EVM and channel capturing capabilities. The feasibility of performing experiments with the setup, as well as the achievable range, have been validated and tested.



Picture 3: Plot of the channel gain over time and frequency, showcasing the working narrowband implementation and channel logging.



Picture 4: Map of the measurement points, marked with circles, and the interpolated median channel gain in colour when deploying a uniform linear sub-GHz antenna array.

CONCLUSIONS

It is now possible to run the KU Leuven testbed with a sub-GHz antenna array, respecting applicable regulations and make unique experiments, which will enable interesting results and further analysis.

FEEDBACK

Due to the already quite involved framework running on the testbed, it can be hard to implement and validate changes. Despite that, our previous experience with similar testbeds and the complementary expertise of the patron has made the process smooth and the collaboration with the patron has worked very well.

Thanks to the ORCA facility we were able to implement, test and validate a real-time sub- GHz massive MIMO system.

Orca

Orchestration and Reconfiguration Control Architecture

NFV2X

Network Function Virtualization for Vehicle to Anything Configurations

Open Call partner
Feron Technologies

Patron
imec

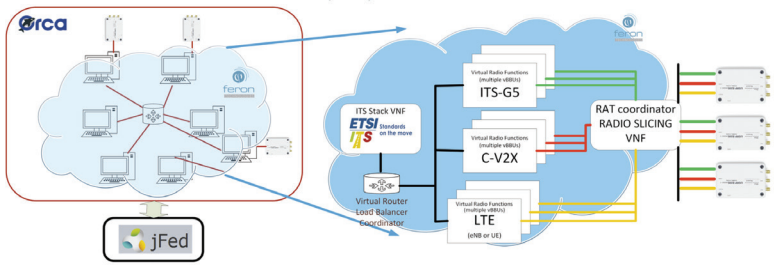
OBJECTIVES

The goal of NFV2X was to investigate configurations and perform experiment campaigns that address issues of network slicing and virtualization that extends up to the radio. This is performed by addressing several emulated scenarios for the automated driving-connected vehicle use case.

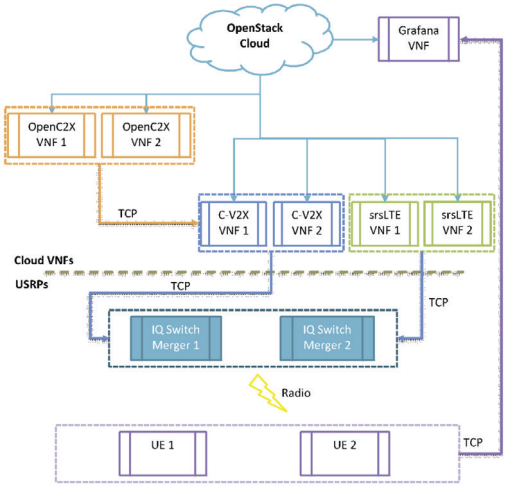
CHALLENGES

The NFV2X project: transformed ORCA resources into a Network Function Virtualization Infrastructure; extended the ORCA IQ Switch for Radio Slicing over both V2X radio standards and LTE; unified various virtualization manifestations; performed experiment campaigns for various V2X-focused use cases for system validation.

EXPERIMENT SETUP



The NFV2X concept – experimentation with multilevel virtualization



The experiment configuration

Virtualization is a major structural feature for 5G and an enabling force in order to fulfil its demanding objectives Virtualization is applied in multiple stages -from the core to the edge- and occurs in various forms and manifestations:

- **Virtual partitioning of the mobile radio access network (RAN) or radio network slicing**
- **The C-RAN concept and the use of Network Function Virtualization (NFV) and Software Defined Networking (SDN)**
- **Software-Defined-Radio (SDR) slicing for joint support of multiple interfaces**
- **5G core and higher-layer virtualization with NFV and SDN**

NFV2X addresses all the aforementioned cases, with an experiment configuration that allows multi-dimensional analysis and experimentation. In NFV2X, an OpenStack cloud is deployed over the ORCA resources, and all the major system components of an end-to-end softwarized modem are implemented as Virtual Network Functions – form monitoring tools, to baseband processing (see figures). Focus is given in V2X communications with the use of all possible radio technologies considered today.

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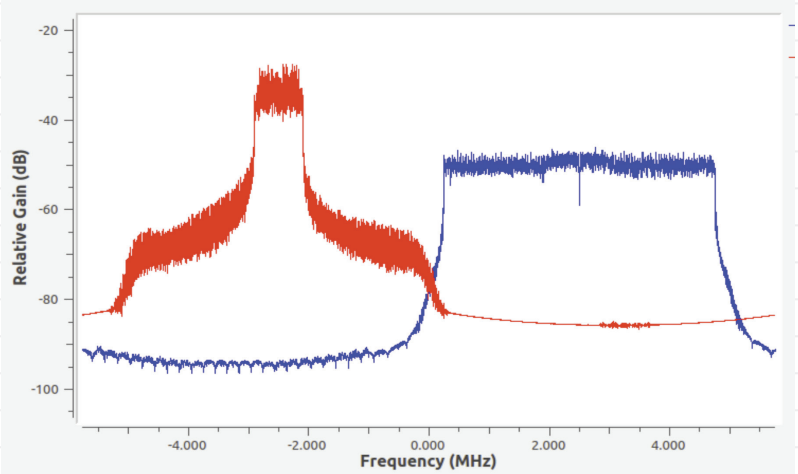
NFV2X

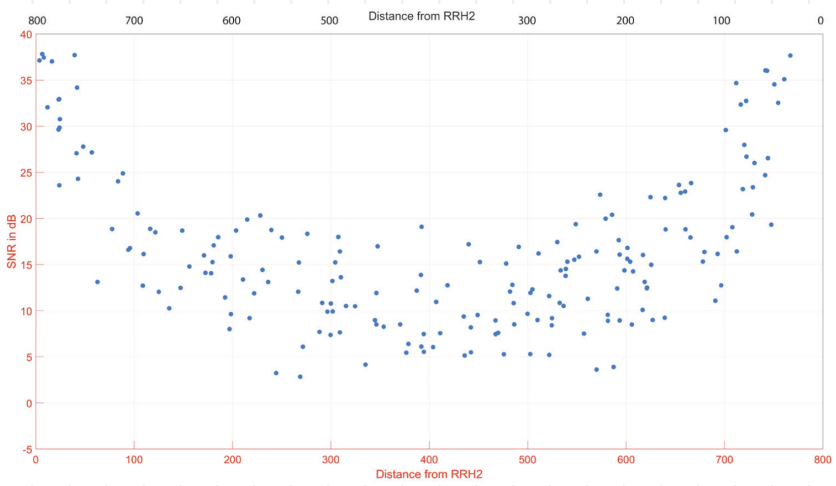
Network Function Virtualization for Vehicle to Anything Configurations

MAIN RESULTS

The NFV2X setup was used to test, validate and evaluate various levels of virtualization in radio. Radio slicing between different technologies and services was investigated (e.g. figure) – implementing VNFs of fully flexible systems with multiple radio systems – and introducing new potential for SDR development.



IQ Switch with LTE-CV2X transmitting CAM messages at a 10msec rate (left channel) and an LTE-CV2X slice transmitting ftp traffic (full resource allocation) (right channel)



Additionally, the platform was used to evaluate the benefits of C-RAN manifestations on emulated vehicular scenarios and how it can be utilized to maintain the quality of the links above a predefined level (see figure on the left).

SNR vs. distance when a virtual RSU utilizes two remote radio heads (LTE-CV2X)

CONCLUSIONS

A generic experiment configuration was developed allowing us to investigate various levels of network and radio virtualization – from radio slicing to C-RAN. The configuration was tested on vehicular communication technologies allowing us to develop flexible and interoperable setups.

FEEDBACK

The NFV2X experience was dictated by a platform of stable remote operation, short learning curve, high system availability, direct and qualitative support. NFV2X and ORCA were a very positive and pleasant experience for Feron Technologies and we have the will to pursue new future collaborations.

Orca Orchestration and Reconfiguration Control Architecture

OCTAGON

Orchestration of complex tasks through OTA reprogramming of wireless nodes

Open Call partner
INTELLIA ICT

Patron
imec

OBJECTIVES

OCTAGON intends to:
• adapt different task assignment schemes taking advantage of the real nodes and the features offered by ORCA control plane.
• integrate the energy efficiency algorithms with ORCA.
• validate their proper execution via the offered SDR capabilities and evaluate their performance.

CHALLENGES

• The evaluation of optimised energy efficiency schemes in real nodes.
• The over-the-air reprogramming of wireless nodes to minimise energy consumption.
• The provision of a set of best practices and practical recommendations to wireless network experimenters for the domain of energy consumption.

EXPERIMENT SETUP

For the first set of OCTAGON experiments, up to eight nodes were allocated at the same time from wilab2 testbed by assuming a set of directed network communication edges. We considered a predefined set of 4 algorithms, with different complexities that represent the pool of available subtasks: two sorting algorithms with different computational complexities (QUICKSORT and BUBBLESORT) an average number calculation algorithm (MEAN), and an algorithmic calculation of the 'n' power (POWER). We also considered tasks with exactly one sink subtask.

The average number of subtask vertices per task was 7 while the average number of subtask edges per task was 12 (i.e., some subtasks provide output to multiple parent subtasks). The average number of measurements produced per subtask was set to 80 values. Furthermore, 320 Kbit were exchanged per subtask edge on average.

After each experiment execution, we measured the total energy consumed by each node. The first set of experiment was executed over the Zolertia Re-Mote nodes where the calculation of the consumed energy was feasible by taking advantage of an energy plugin. By adding the energy consumed in each node, we could calculate the total energy required to be spent by the network W in order to carry out the task T.

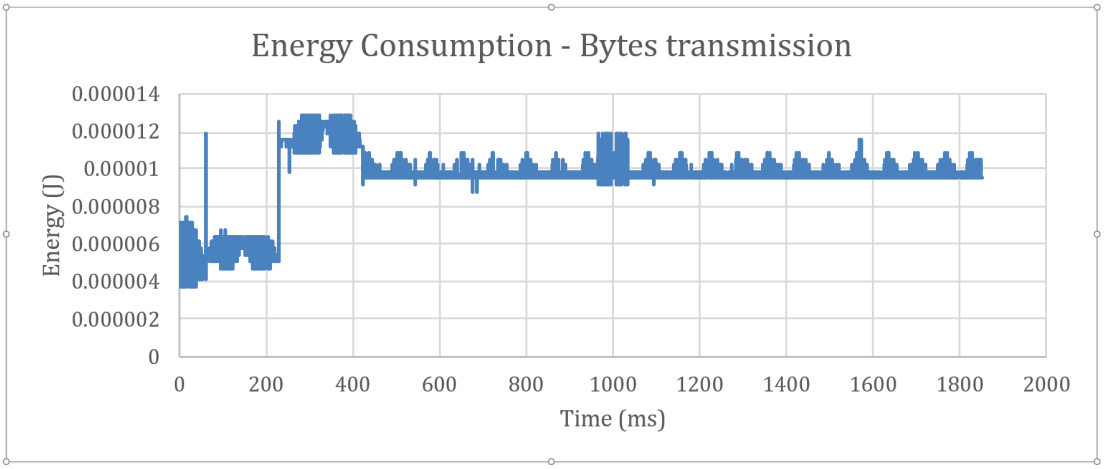
In the second set of experiments, the network was consisted of one Xilinx ZC706 SDR node and six commercial wifi nodes. We were capable of allocating one Xilinx node to verify the feasibility of the OTA reprogramming and SDR management concepts. We deployed our algorithms and we managed to reconfigure the nodes over-the-air (OTA) by stopping/starting the subtask algorithms. The energy costs were estimated using the NS2 energy model.

OCTAGON

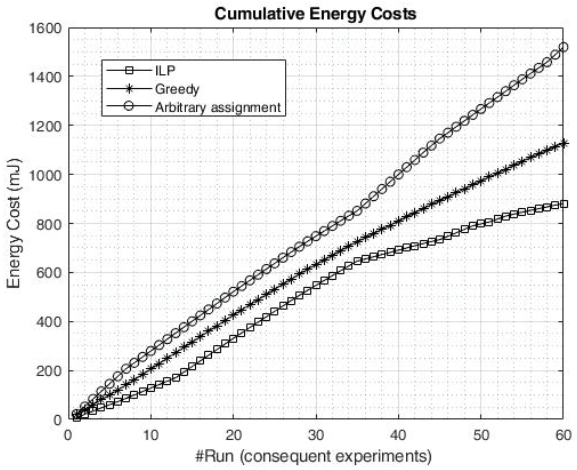
Orchestration of complex tasks through OTA reprogramming of wireless nodes

MAIN RESULTS

The experimental tests validated the results of an energy-efficient scheme for task allocation over a real network. The experiment investigated both the execution energy costs (energy costs caused by the execution of the subtasks in the nodes) and the communication costs (energy costs caused by the exchange of data required between the nodes in order to facilitate the proper execution of the subtasks).



Energy consumption for transmitting data



Cumulative energy costs (execution + communication) for different task assignment schemes

CONCLUSIONS

The OCTAGON experiment (a) proved the feasibility of the concept in SDR nodes by allowing for OTA reprogramming and SDR-based reconfiguration, (b) estimated the energy costs for the SDR experiment using an external energy model, and (c) applied the optimisation results in real network nodes and calculated and compared real energy costs resulted within the network.

FEEDBACK

The experience in using the ORCA was great. Supporting real energy calculations on all ORCA nodes would be a plus in order to facilitate applications that need access to real energy costs such as the ones dealing with optimized energy efficiency based on SDR technology.

Thanks to the ORCA facility we were able to test our optimisation scheme on real nodes.

Orchestration and Reconfiguration Control Architecture

5G-ROSE

5G Broadcast SDR Experiment

Open Call partner
Universidad Politècnica de València

Patron
Trinity College Dublin

OBJECTIVES

The main objective of the experiment has been to develop a virtualised Single Frequency Network (SFN) using open source LTE software implementation. Other secondary objective has been the physical layer update, extending the srsLTE suite with all the PHY updates of FeMBMS Release-14 and to perform Network Slicing with HyDRA software testing unicast and multicast content using the same physical resources.

CHALLENGES

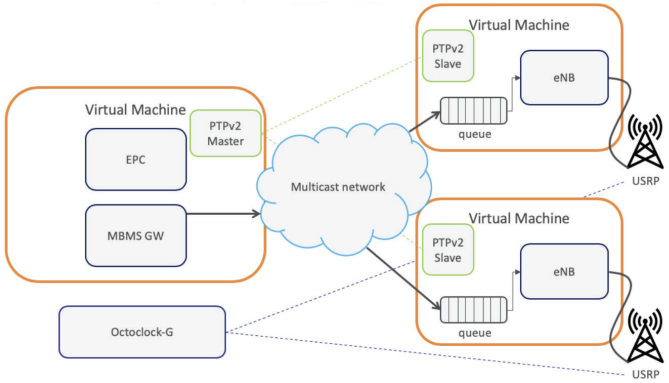
One of the great challenges that we have encountered in the project has been to carry out the sync protocol, along with updating the physical layer, in the time that the project has lasted. These problems have been related to the free code platform srsLTE, which has presented many hardcoding problems and errors. On the other hand, everything related to virtualisation has been quite easy, thanks to the help of the project coordination.

EXPERIMENT SETUP

Experiment 1:
The minimum setup needed for this experiment using virtual machines is (as shown in the figure here below):

- **Four virtual machines, three of them connected to a USRP**
- **Three USRP x310, all connected to the Octoclock-G**
- **The srsLTE version with MBSFN features (https://github.com/Borjis131/srsLTE.git)**
- **PTPd sourceforge implementation (https://sourceforge.net/projects/ptpd/)**

First the virtual machines and USRP will be reserved using the rspec file attached through jFed. The first virtual machine, without an USRP connected, will act as EPC and MBMS gateway. The two machines connected both to USRPs and Octoclock, will act as eNodeBs and the fourth machine connected to the USRP, will act as the UE.



Architecture using virtual machines

First a PTPd daemon is started as Master in the first VM. And two PTPd daemons are started as Slave in the eNBs VM. This step will synchronise the virtual machines to share the same clock. After starting the daemons, the LTE components will be started, EPC and MBMS-GW in VM, eNB in the second and third VM and UE in the third VM. The MBMS gateway will be started using the configuration file provided and specifying the sync_sequence_packets that will be sent every SYNC sequence.
The expected behaviour of this experiment is to receive the video transmitted, by using ffmpeg software, over the MBMS GW through the SFN created. The UE should decode it and reproduce it using ffplay.

5G-ROSE

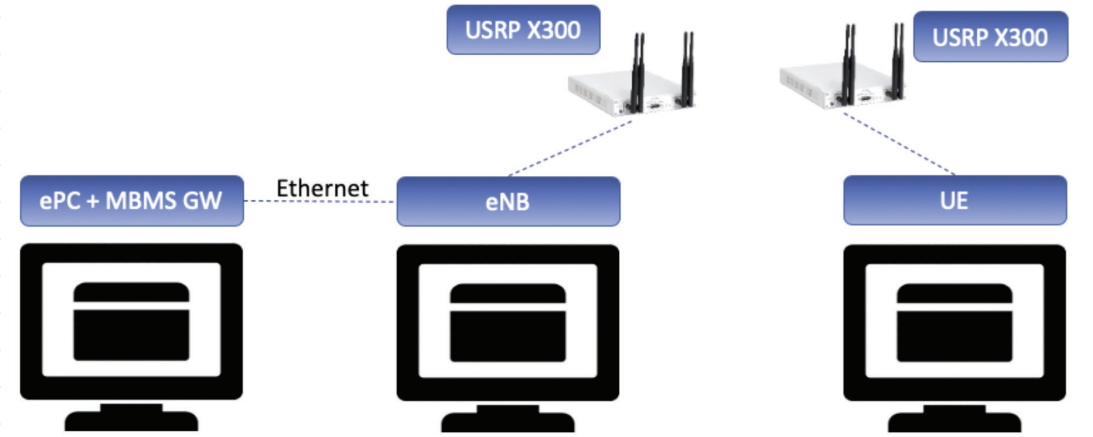
5G Broadcast SDR Experiment

EXPERIMENT SETUP

Sub-experiment 2-1

In this sub-experiment, three virtual machines have been used (see figure below). The setup consists in:

- **1 VM acting as ePC and with the MBMS gateway (GW) active.**
- **1 VM acting as eNB, connected to the ePC through an Ethernet connection. This virtual machine is connected to a USRP X300.**
- **1 VM acting as User, connected to a USRP X300.**
- **SrsLTE code with the added features: Available at https://github.com/alibla/srsLTE.git**



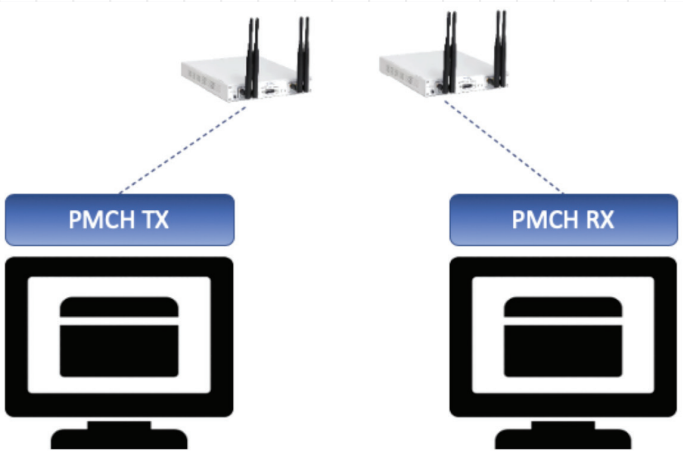
Sub-experiment 2-1 Setup

The choice of separating the ePC and MBMS GW with the eNB into two virtual machines is due to the high performance it has shown. The user is expected to be able to connect to the created LTE network and, subsequently, to be able to receive and decode the content received by the PMCH with the new numerology.

Sub-experiment 2-2

In this case, just two VM have been required, as can be seen in the figure on the left. Each VM has been connected to one USRP X300.

In this case, as the control signal is already known by both transmitter and receiver, the configuration that can be edited is reduced to parameters such as bandwidth, that is the PRBs, and also with more related parameters of the USRP, such as transmission or reception gains, etc. Since the full stack protocol is not necessary, as it is a simulation of physical channels, only random content is retransmitted. The virtual machine that receives only has to decode that content and show it on the screen.



Sub-experiment 2-2 Setup

5G-ROSE

5G Broadcast SDR Experiment

MAIN RESULTS

Experiment 1

The current code developed works as expected but the reception at the UE is not currently possible due to unknown errors dropping all the received packets. The figure below shows the reception of the packets at the UE in the RLC level in which the parts of the packets are concatenated and sent to the GW level. The screenshot shows an example of the received packets.

```
15:40:52.660026 [RLC ] [I] Concatenating 769 bytes in to current length 0. rx_window remaining bytes=1593, vr_ur_in_rx_sdu=10, vr_ur=10, rx_mod=32, last_mod=11
           0000: 83 e6 10 13 51 00 00 00 00 00 00 00 04 45 00 02
           0010: f4 a4 d5 40 00 10 11 26 15 ac 10 00 fe ef ff 00
15:40:52.660041 [RLC ] [I]  Rx SDU vr_ur=10, i=1, (update vr_ur middle segments)
           0000: 83 e6 10 13 51 00 00 00 00 00 00 00 04 45 00 02
           0010: f4 a4 d5 40 00 10 11 26 15 ac 10 00 fe ef ff 00
15:40:52.660056 [GW  ] [I] RX MCH PDU (769 B). Stack latency: 0 us
           0000: 83 e6 10 13 51 00 00 00 00 00 00 00 04 45 00 02
           0010: f4 a4 d5 40 00 10 11 26 15 ac 10 00 fe ef ff 00
```

Packets received at RLC and GW

Experiment 2

For sub-experiment 2-1, as can be seen in the figure below, one user is able to connect to the network with the new numerology. But, errors are observed, all of them directly related to the PDCCH physical control channel. These errors indicate an erroneous calculation of the channel's own parameters, such as ncce, number of CCE, and location L. Apart from the observed errors, no content has been sent from the eNB to the user.

```
[INFO] [B200] Asking for clock rate 23.040000 MHz...
[INFO] [B200] Actually got clock rate 23.040000 MHz.
Setting frequency: DL=2685.0 Mhz, UL=2565.0 MHz
Setting Sampling frequency 11.52 MHz

==== eNodeB started ===
Type <t> to view trace
RACH:  tti=351, preamble=31, offset=1, temp_crnti=0x46
RACH:  tti=371, preamble=47, offset=1, temp_crnti=0x47
/home/srslte/srsLTE/lib/src/phy/phch/pdcch.c.626: Illegal DCI message nCCE: 16, L: 3, nof_cce: 10, nof_bits=27

/home/srslte/srsLTE/lib/src/phy/enb/enb_dl.c.382: Error encoding UL DCI message

/home/srslte/srsLTE/srsenb/src/phy/cc_worker.cc.608: Error putting PUSCH 0

RACH:  tti=391, preamble=0, offset=1, temp_crnti=0x48
RACH:  tti=411, preamble=13, offset=1, temp_crnti=0x49
RACH:  tti=431, preamble=39, offset=1, temp_crnti=0x4a
/home/srslte/srsLTE/lib/src/phy/phch/pdcch.c.626: Illegal DCI message nCCE: 8, L: 3, nof_cce: 10, nof_bits=27

/home/srslte/srsLTE/lib/src/phy/enb/enb_dl.c.382: Error encoding UL DCI message

/home/srslte/srsLTE/srsenb/src/phy/cc_worker.cc.608: Error putting PUSCH 0

Disconnecting rnti=0x46.
RACH:  tti=451, preamble=50, offset=1, temp_crnti=0x4b
/home/srslte/srsLTE/lib/src/phy/phch/pdcch.c.626: Illegal DCI message nCCE: 16, L: 3, nof_cce: 10, nof_bits=27

/home/srslte/srsLTE/lib/src/phy/enb/enb_dl.c.382: Error encoding UL DCI message

/home/srslte/srsLTE/srsenb/src/phy/cc_worker.cc.608: Error putting PUSCH 0

Disconnecting rnti=0x47.
Disconnecting rnti=0x48.
Disconnecting rnti=0x49.
Disconnecting rnti=0x4a.
User 0x4b connected
```

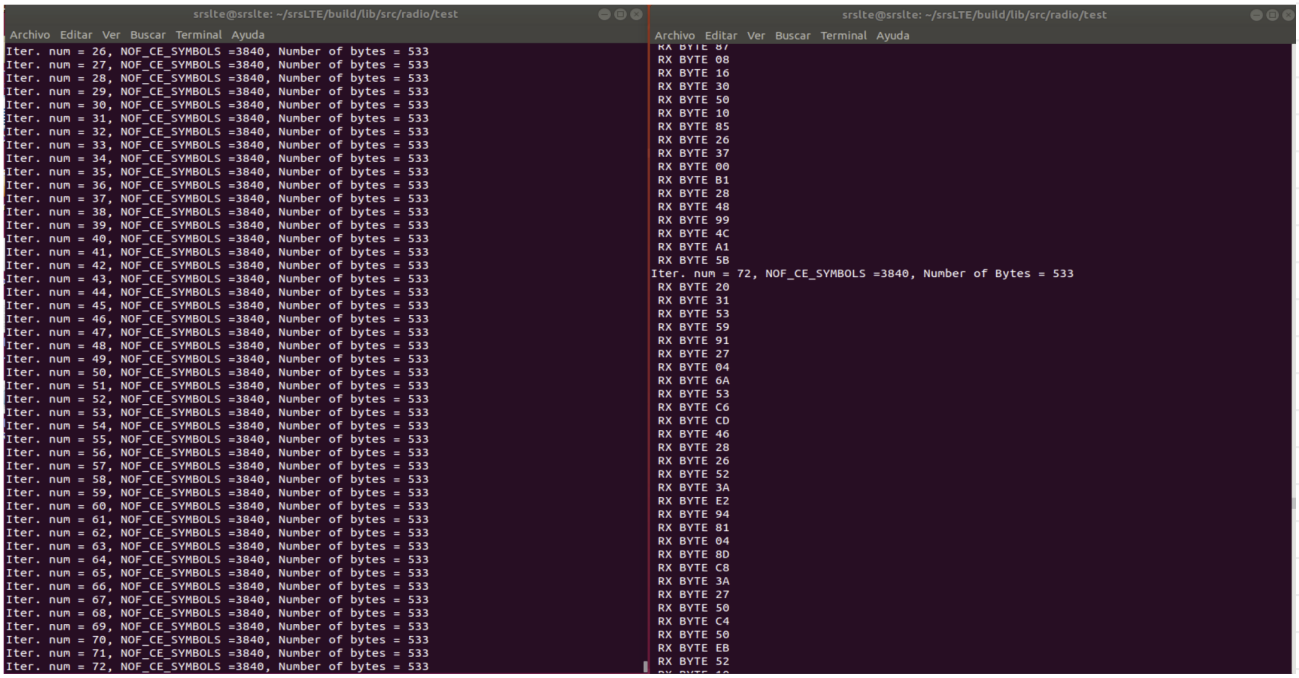
eNB Messages

5G-ROSE

5G Broadcast SDR Experiment

MAIN RESULTS

In case of sub-experiment 2-2, as shown in the figure below, it is easy to identify that in the receiver side (the command window on the right side) the signal is being received. The transmitter (on the left side of the figure) generates a random signal, that is copied locally, in order to compare with the received signal, and it is transmitting the signal over the air. Comparing the signals, we are observing an error rate of around 20% is being observed for each of the subframes that are being sent.



Sub-experiment 2-2 running in real time

CONCLUSIONS

This work consists of the implementation of a virtualised SFN for the transmission of 5G broadcast services in an SDR laboratory environment. The implementation uses the IRIS testbed facility in Trinity College of Dublin (Ireland) and it is based on the srsLTE open-source software. The work is divided into three parts, i.e. the development and testing of the first virtualised MBSFN transmission; the introduction of physical layer Rel-16 components; and, as part of our future work, the implementation of network slicing for the simultaneous transmission of both unicast and multicast content. It has been described in detail the implemented technologies as well as the setup to carry out the experiment.

FEEDBACK

The IRIS testbed, the main testbed used for the experiments presented, has been a useful software tool and we would like to contribute to the development of this testbed by sharing the results of the experimentation and the errors encountered. And continue contributing to the development testing new architectures, providing the results of these experiments.

Thanks to the ORCA facilities and the great help and effort that the project coordinators have given us, it has been possible to carry out the experiments.

Orca

Orchestration and Reconfiguration Control Architecture

SOFTUCITY

Software Defined Radio and multiple nodes cooperation for ubiquitous identification of RF attacks in Cities

Open Call partner
HOP Ubiquitous S.L

Patron
Rutgers

OBJECTIVES

RF attacks identification, detection and mitigation adaptive to dynamic context
The first objective is focused on the understanding of the vulnerabilities from specific systems, end-to-end communication protocols and the affected scenarios. In details, the experiment will focus on the communication protocols FM RDS-TMC and GPS, since they are well-identified as commonly used protocols in urban environments with well-known spoofing attacks.

Multiple SDR nodes cooperation for ubiquitous identification
The second objective aims to extend the capability of the individual SDR nodes to cooperate among the multiple nodes deployed in a city.

Evaluation of the solution for its exploitation and transferability
The final objective is to use and demonstrate the use of the proposed solution into the urban solution/devices manufactured by HOPU.

CHALLENGES

Softucity is an innovative experiment addressing the detection, identification, and neutralization of rogue/suspicious RF communications in urban environments.

Softucity aims to monitor and surveillance the use of the RF spectrum in order to detect, identify and mitigate potential attacks. First, jamming attacks to impact on availability of networks. Second, spoofing over specific frequencies such as GPS and FM for RDS-TMC since its usage in navigation systems. These technologies vulnerabilities influence in public safety since potential attacks for traffic management, and over unmanned air/ground vehicles (e.g. drones, autonomous cars). Softucity will create a near-real time Radio Environment Map (REM) and will detect/identify these attacks, and contribute to their mitigation and neutralization. In order to cover large areas, this experiment will study the support of multiple RATs and flexibility for dynamic configuration over the SDR nodes.

Softucity aims to deploy SDR-based technology in the SmartSpot product from HOPU.

EXPERIMENT SETUP

The proposed methodology that Softucity will follow is articulated in the following phases:

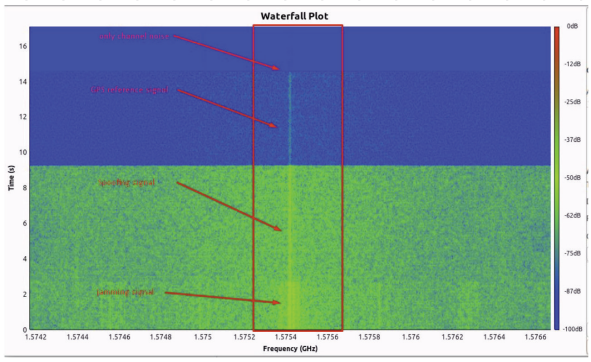
- **Phase one: analysis, Definition and Design of the experiments**
- **Phase two: implementation and execution of the experiments**
- **Phase three: analysis, evaluation of the experiments and feedback**

SOFTUCITY

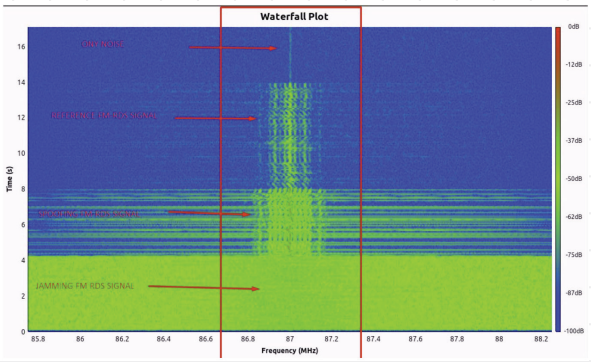
Software Defined Radio and multiple nodes cooperation for ubiquitous identification of RF attacks in Cities

MAIN RESULTS

As the main goal of these experiments is a speedy detection and mitigation of spoofing attacks, two Radio Emission Map have been generated by the monitor node as a Waterfall graph. With this type of graphs, both GPS L1 band frequency and FM-RDS-TMC services are monitored through time and it is drawn in order to detect significant changes of the GPS signal patron or FM-RDS-TMC services.



GPS L1 Band service Waterfall Graph where a spoofing attack is disabled with a jamming signal

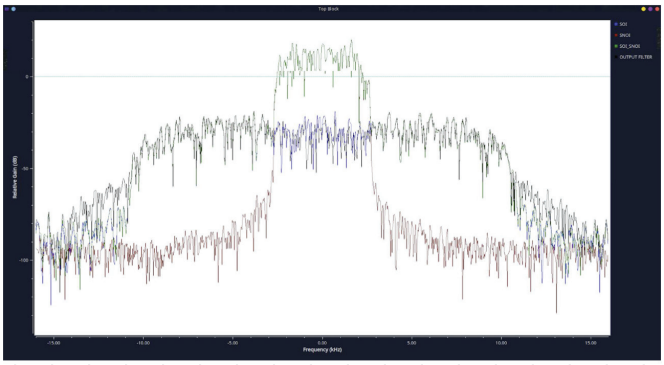


FM-RDS-TMC service Waterfall Graph where a spoofing attack is disabled with a jamming signal

In a third experiment, successive interference cancellation with adaptive filters over SDR devices has been developed in a cooperative way using 2 monitor nodes: one monitoring signal noise and the other one monitoring the mixed signal (noise + signal of interest).

Multiple SDR nodes cooperation for ubiquitous identification: one for monitoring and the other one for sending jamming signals.

Finally, it has evaluated this solution for its exploitation and transferability on embedding GNU Radio over an ARM based embedded board.



(Right) Signal of Interest is equal to output filter due to cancellation of interference being applied

CONCLUSIONS

The project has developed a set of SDR-based experiments for identification and mitigation of RF jamming and spoofing attacks against important networks that are used for public safety (e.g. GPS and FM RDS-TMC). The proposed experiments have used a number of cooperating SDR nodes and their dynamic reconfigurability to support creation of a near real-time Radio Emissions Map that can be used for bot detection and localization of unauthorized emitters/interferers.

FEEDBACK

Softucity aims to provide feedback to the ORCA consortium about the experience working with ORCA facilities, tool suites and testbed use mechanisms (e.g. reservation tools, schedulers). It also provides an experiment and experience about the role of SDR to address these challenges, supporting this complementary research domain and opportunity for ORCA consortium about this other nature of European Projects and research activities, more focused on security and urban innovation actions. Softucity has delivered a full experience and validation in terms of performance, about how to transfer GNURadio projects from lab environment to a commercial product.

Thanks to the ORCA facility we were able to complete the extension of Smart Spot for Radio Emissions Monitoring (REM), extending our market to urban safety and security.

Orchestration and Reconfiguration Control Architecture

XTRA-CARS

eXploiting multi-radio access Technologies for emeRgency communicAtions in vehiCulAr envirRonmentS

Open Call partner
Università degli Studi di Modena e Reggio Emilia

Patron
National Instruments

OBJECTIVES

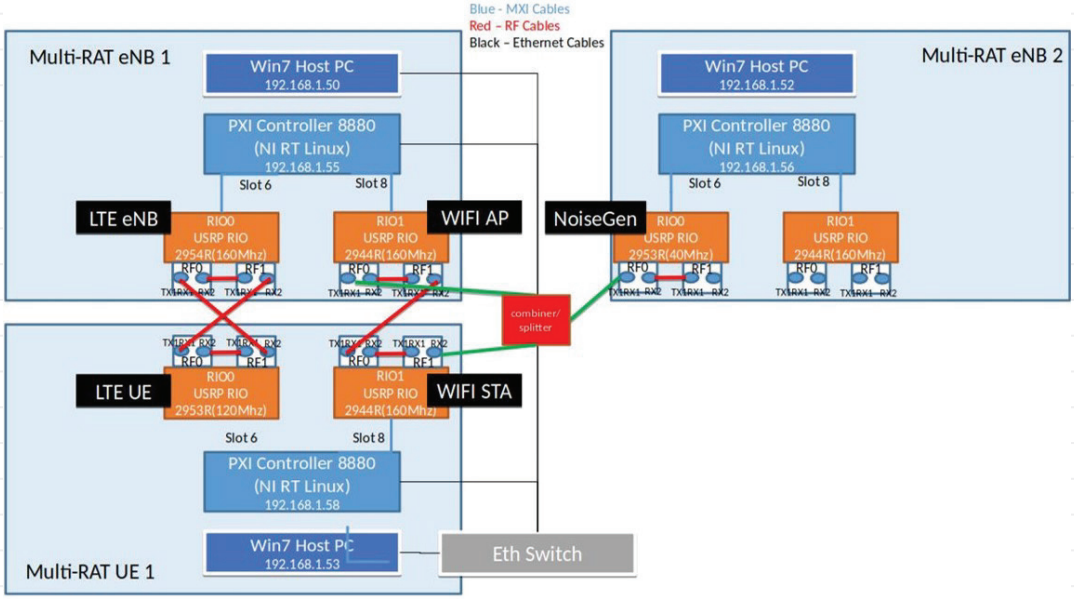
The experiment aimed at exploring the adoption of Multi Radio Access Technologies in a vehicular environment. The intent was to investigate the dynamic reconfiguration of LWA for the data dispatch to an emergency vehicle, guaranteeing its communications the highest priority through an adequate reservation of radio resources.

CHALLENGES

The first challenge was to recreate within the ORCA testbed an environment that effectively mimicked the presence of different vehicle types and their mutual influence. Secondly, the dynamic reconfiguration of LWA had to be implemented, relying on real time measurements of MAC KPIs.

EXPERIMENT SETUP

In addition to the SDR taking the role of the MultiRAT eNB, a pair of SDRs was alternatively utilized to represent: (i) the emergency vehicle or (ii) an ordinary car; a further SDR generated noise that represented ordinary vehicular traffic in circumstance (i), or the traffic directed to the ambulance in circumstance (ii). In both cases, the amount of noise was dynamically set through ns-3. Furthermore, in circumstance (ii), the amount of packets transmitted to the ordinary vehicle on the Wi-Fi DL interface was also dynamically tuned through ns-3.



Testbed configuration

www.orca-project.eu

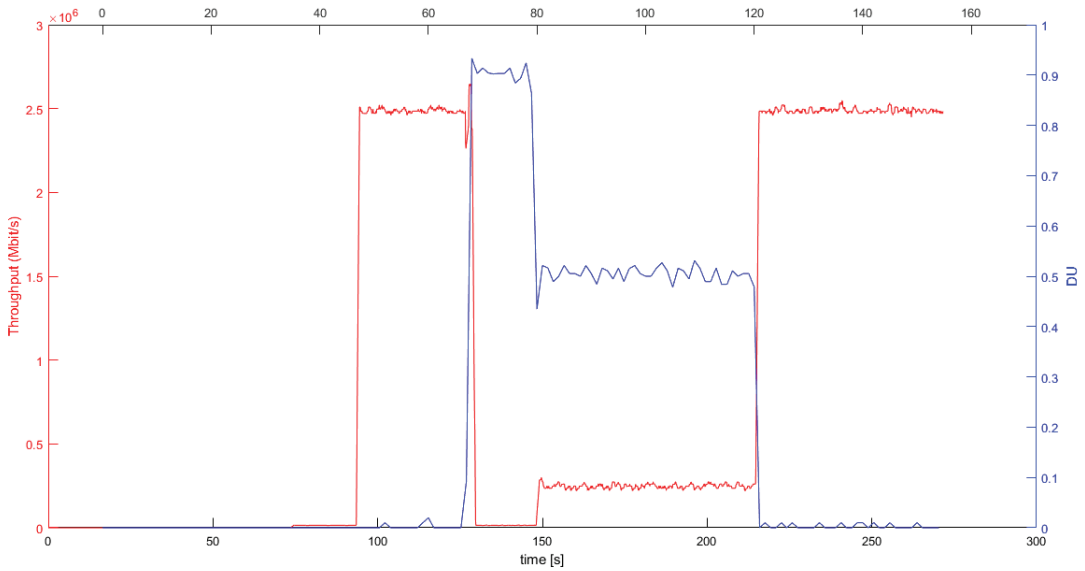
XTRA-CARS

eXploiting multi-radio access Technologies for emeRgency communicAtions in vehiCulAr envirRonmentS

MAIN RESULTS

We demonstrated that LWA can be employed dynamically, on a per-vehicle basis, in order to warrant different throughput levels to cars belonging to different categories. We validated this statement in the specific setting where an ITS application has to guarantee an emergency vehicle the exclusive usage of all Wi-Fi resources, at the expense of ordinary vehicles. These are gradually allowed to use LWA again, to a different extent, depending on the selected Wi-Fi performance indices, i.e., the radio channel occupancy and/or the delay incurred by the packets, whose values have to be kept under control.

As a meaningful example of the testbed results, the figure below reports the DL throughput variations experienced by the UE that embodies the ordinary car, when the noise intensity representing the traffic directed to the ambulance varies.



Variations of Wi-Fi DL throughput for the ordinary vehicle (red) in response to different emergency traffic levels (blue)

CONCLUSIONS

The experiment demonstrated that in a critical road situation, LWA can be successfully adopted to enhance the bandwidth employed for the communications to an emergency vehicle. Both simulations and testbed experiments showed the effectiveness of the dynamic LWA approach and the feasibility of its real-time implementation.

FEEDBACK

The expertise and support from the ORCA patrons were excellent and always timely. We unfortunately experienced intermittent connectivity issues with the testbed server at the University of Dresden; when this happened, it forced us to reconfigure the testbed from scratch or to patiently wait until the connection became operational again. The main bottleneck was definitely represented by the remote access.

Through the ORCA facility, we tested in a real environment an LWA strategy to flexibly reallocate Wi-Fi and LTE radio resources among different classes of users. We could achieve this goal leveraging on powerful SDRs that also allowed us to gain practice with FPGA programming through LabVIEW.