

Review Open Call SME F4Fp-09-M08 5GFed experiment

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Remote Review

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5GFed

Integration and testing of 5G NR OpenAirInterface in the Fed4FIRE+ federation

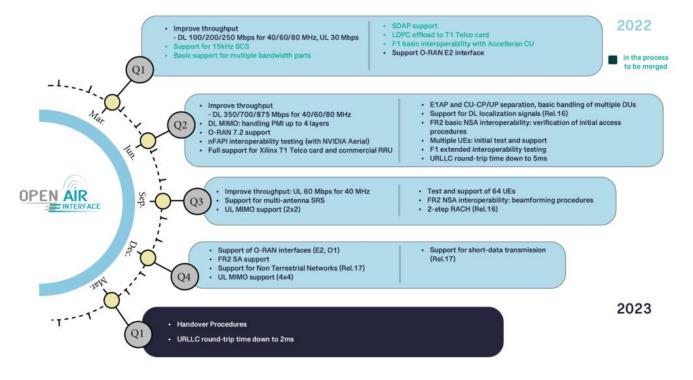
IRIS (TCD) and CityLab (imec) testbeds



- The practical experimentation with 3GPP networks has been historically reserved exclusively to network equipment vendors and telecommunication operators, primarily due to high equipment costs and licensing constraints.
- In recent years, the state of play has been changing with the advent of open source 3GPP stacks based on increasingly more affordable Software Defined Radio (SDR) systems.
- In this context, OpenAirInterface (OAI) emerges as an open-source initiative that provides a reference implementation of 5G gNB, User Equipment (UE), and 5G core network (5GC), standard compliant with 3GPP NR Release 15 and that runs on general purpose x86 computing platforms along with off-the-shelf SDR hardware platforms like USRPs.



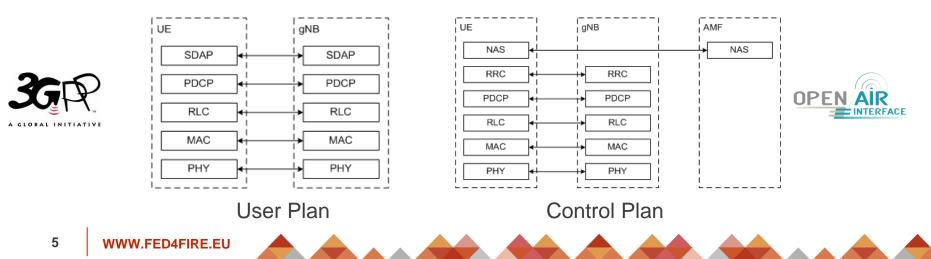
• OAI RAN roadmap.

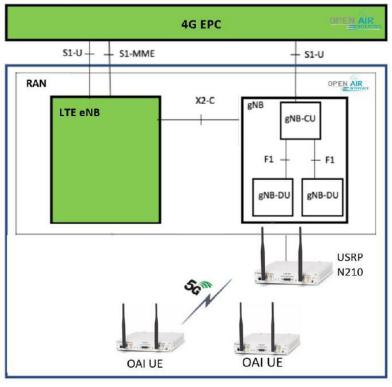




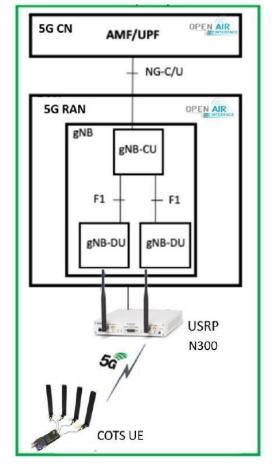


- The OAI code can be adapted to different use cases and deployment and new functionality can be implemented, making it an ideal platform for both industrial and academic research on 3GPP networks.
- The main objective of the 5GFed experiment is to integrate and test the latest OAI 5G NR standard-compliant implementation within two Fed4FIRE+ testbeds: IRIS (TCD) and CityLab (imec).





Setup1: 5G NSA with USRPs











- End-to-end implementation of OAI 5GNR in the IRIS testbed
- Interoperability test between OAI gNB and COTS UE (Quectel RM500Q).
 - TDD configuration, 30kHz SCS (Subcarrier Spacing)
 - Downlink configurations: 256 QAM max, 60 MHz bandwidth (162 PRB), single layer
 - Uplink configurations: QPSK max, 60MHz bandwidth (162 PRB), single layer
 - iPerf UDP between OAI CN5G and QUECTEL RM500Q







• End-to-end implementation of OAI 5GNR in the IRIS testbed (TCD)

Activities 🖸 Terminal +	nov 23 12:41	Command Prompt - gent -s -u + 1 - p 5002 -0 12.1.1.2	
👔 👔 user@userPC:-/openairinterfaceSg/cmake_targets/ran_bull 🔾 🗉 🗕 c		Nicrosoft Windows (Version 10.0.19044.1526)	
UE ID 0 RNTI ce6a (1/1) PH 24 dB PCRAX 11 dBn, average RSRP 0 (0 meas) UE 0: dlsch_rounds 47003/12/0/0, dlsch_errors 0, pucch0_DTX 12, BLER 0.0000	Ele Idit Yiew Go Capture Analyze Statistics Telephony Workers Iools Help 1 mcs 🖉 🔳 🥂 🐵 🔐 🗮 🐼 😳 🔍 🄇 🔍 🌜 🐎 🕪 📲 💭 🚳 🗇 🖄 🔛	C:\Users\Users\usersipconfig	
UE 0: disch_total_bytes 466265708	il ngap 01	Windows IP Configuration	
UE 0: ulsch_rounds 24408/3/0/0, ulsch_DTX 3, ulsch_errors 0 UE 0: ulsch total bytes scheduled 22313540, ulsch total bytes received 2233	2634 No. Time Source Destination Protocol Length Info		
LUE 0: LCID 1: 613 bytes TX UE 0: LCID 4: 464898079 bytes TX	- 19 22.930682015 192.168.79.129 192.168.79.132 NGAP 126 NGSetupRequest 21 22.930688209 192.168.79.132 192.168.79.129 NGAP 574 NGSetupResponse	Ethernet adapter Bluetopth Network Connection:	
UE 8: LCID 4: 12987 bytes RX	42 42.582660443 192.168.70.129 192.168.70.132 NGAP 126 NGSetupRequest 44 42.583447967 192.168.70.132 192.168.70.129 NGAP 574 NGSetupResponse	Ethernet augter statututa network connection.	
INR PHY1 Number of bad PUCCH received: 8	62 06.514962412 192.168.70.129 192.168.70.132 NGAP/N. 218 InitialUEMessage, Registration request, Regist	Media State : Media disconnected	
[NR_MAC] Frame.Slot 648.0	63 66.515838895 192.168.70.132 192.168.70.129 NGAP/N. 326 DownlinkNASTransport, Identity request 64 66.529972076 192.168.70.129 192.168.70.132 NGAP/N. 150 UplinkNASTransport, Identity response	Connection-specific DNS Suffix . :	
UE ID 0 RNTI ce6a (1/1) PH 24 d8 PCMAX 11 d8m, average RSRP 0 (0 meas) UE 6: dlsch rounds 48539/12/0/0, dlsch errors 0, pucch0 DTX 12, BLER 0.0000	65 66.536436867 192.168.70.132 192.168.70.129 NGAP/N. 630 DownlinkNASTransport, Authentication request	Mobile Broadband adapter Cellular 3:	
28 UE 8: dlsch total bytes 481783038	66 66.544942922 192.168.70.129 192.168.70.132 NGAP/N. 138 UplinkNASTransport, Authentication failure (ng 67 66.545613957 192.168.70.132 192.168.70.129 NGAP/N. 639 DownlinkNASTransport, Authentication request	Connection-specific DMS Suffix , :	
UE 0: ulsch_rounds 24724/3/0/0, ulsch_DTX 3, ulsch_errors 0	69 66.889893915 192.168.70.129 192.168.70.132 NGAP/N. 138 UplinkNASTransport, Authentication response 79 66.896381816 192.168.70.132 192.168.70.129 NGAP/N. 462 DownlinkNASTransport, Security mode command	IPV4 Address	
UE 8: ulsch_total_bytes_scheduled 22547018, ulsch_total_bytes_received 2254 UE 8: LCID 1: 613 bytes TX	71 66.904927779 192.168.70.129 192.168.70.132 NGAP/N_ 222 UplinkNASTransport, Security mode complete, Re	Subnet Mask	
UE 0: LCID 4: 480363889 bytes TX	72 66.996136320 192.168.78.132 192.168.78.129 NGAP/N. 1398 InitialContextSetupRequest, Registration accep 73 66.935669929 192.168.79.129 192.168.79.132 NGAP 1278 UERadioCapabilityInfoIndication	Default Gateway : 12.1.1.1	
UE 0: LCID 4: 13371 bytes RX gNB	75 67.137664784 192.168.70.129 192.168.70.132 NGAP/N. 158 InitialContextSetupResponse, UplinkNASTranspor		
[NR_PHY] Number of bad PUCCH received: 8	79 74.944939107 192.168.70.129 192.168.70.132 NGAP/N. 242 UplinkNASTransport, UL NAS transport, PDU sess 82 74.051362328 192.168.70.132 192.168.70.129 NGAP/N. 294 PDUSessionResourceSetupReguest, DL NAS transpo		
	67 75.014994190 192.168.70.129 192.168.70.132 NGAP 122 PDUSessionResourceSetupResponse		
Ti sser@user-PC:-/oal-cn5g-fed/docker-compose Ci = - C		Server listenia on UDP port 5002 Binding to local address 12:1.1.2	
[2621-11-23 12:33:19,017] root:OEBUG: for example: odi-onf Registration wi longf can be checked on this orl /norf-ofm/vi/off-instances/inf-types 'SHE' ("		Unnoing to local address 12:1:1:2 Receiving 1379 byte datagrams	
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		UDP buffer size: 200 KByte (default)	tra 60
[2021-11-23 1CONTEND CLOBERG: AND, SAF and UPF are registered to h [2021-11-23 1C-5112, CF ClobeBuG: Checking (* 547 16. able to connect a	• • • Frame 19: 126 bytes on wire (1008 bits), 126 bytes captured (1008 bits) on interface demo-oni, id 0	[3] local 12.1.1.2 port 5002 connected with 192.108.70.135 port 36792	
[2021-11-23 12:33:19,027] root:DEBUG: Checking (7 5HF is able to connect a	10.0 • Ethernet II, Src: 02:42:6d:ec:dc:63 (02:42:6d:ec:dc:63), Dst: 02:42:c0:a8:46:84 (02:42:c0:a8:46:84) • Internet Protocol Version 4, Src: 102.108.70.129, Dst: 102.108.70.132	[ID] Interval Transfer Bandwidth Jitter Lost/Total Datagrams	
[2021-11-23 12:33:19,915] root:DEBUG: UPF receiving heathbeats from Ser [2021-11-23 12:33:19,915] root:DEBUG: OAL SC Core Antwork is configured and and SC Core Antwork is configured and set of the second se	 Stream Control Transmission Protocol, Src Port: 38412 (38412), Dst Port: 38412 (38412) 	[3] 0.0-1.0 sec 16.3 H0ytes 137 Hbits/sec 0.070 ms 32/11651 (0.27%) [3] 1.0-2.0 sec 23.6 H8ytes 108 Hbits/sec 0.097 ms 14/16841 (0.083%) [3] 2.0-3.0 sec 24.0 H0ytes 2014 Hbits/sec 0.083 ms 7/21205 (0.041%)	
serguser-PC:-/ost-cnbg-fed/docker-conposes		[3] 2.00-3.00 sec 7 datagrams received out-of-order	
P user@userPC:- Q = - 0		[3] 3.0-4.0 Sec 24.0 MBytes 201 Mblts/Sec 0.094 ms 30/27135 (0.18%) [3] 4.0-5.0 sec 24.0 MBytes 201 Mblts/Sec 0.100 ms 7/27120 (0.0413)	
[3] 25.0-20.0 sec 11519 KBytes 94362 Kbits/sec		[3] 4.00-5.00 sec 7 datagrams received out-of-order	
[3] 26.0-27.0 sec 11520 KBytes 94374 Kbits/sec		[3] 5.0-6.0 sec 24.0 Möytes 201 Mbits/sec 0.113 ms 15/17120 (0.000%) [3] 6.0-7.0 sec 24.0 Möytes 201 Mbits/sec 0.104 ms 15/17105 (0.000%) 201 Mbps	
[3] 27.0-28.0 sec 11520 KBytes 94374 Kbits/sec [3] 28.0-29.0 sec 11520 KBytes 94374 Kbits/sec	OPEN AIR	[3] 6.0-7.0 sec 24.0 M8ytes 201 Mblts/sec 0.104 ms 15/2/108 (0.088%) ∠UT IVIDUS [3] 7.0-8.0 sec 24.0 M8ytes 201 Mblts/sec 0.101 ms 7/3/120 (0.0415)	
[3] 29.0-30.0 sec 11520 KBytes 94374 Kblts/sec		[3] 7.00-8.00 sec 7 datagrams received out-of-order	
<pre>[3] 30.0-31.0 sec 11520 KBytes 94374 Kbits/sec [3] 31.0-32.0 sec 11520 KBytes 94374 Kbits/sec</pre>		[3] 8.0-9.0 sec 23.9 M8ytes 200 Mb1ts/sec 0.105 ms 16/17054 (0.094%)	/
[3] 32.8-33.0 sec 11519 K8ytes 94362 Kbits/sec [3] 33.8-34.0 sec 11520 K8ytes 94374 Kbits/sec		[3] 9.0-10.0 sec 23.9 MBytes 201 Mbits/sec 0.087 ms 30/17106 (0.18%)	
[3] 34.0-35.0 sec 11519 KBytes 94362 Kblts/sec	0 2 42 c0 a8 46 84 02 42 6d ec dc 63 00 00 45 02 B F B n c E 00 70 00 14 60 00 14 6d 04 08 42 b1 c0 a8 48 11 c0 a8 p ∂ a b + F	[3] 10.0-11.0 sec 24.0 MBytes 201 Mbits/sec 0.110 ms 15/27120 (0.088%)	
<pre>[3] 35.0-36.0 sec 11522 KBytes 94386 Kbits/sec [3] 36.0-37.0 sec 11520 KBytes 94374 Kbits/sec</pre>	0020 46 84 96 0c 95 0c 53 9b 05 d2 eb 91 f8 83 00 03 F S	[3] 11.0-12.0 Sec 24.0 MBytes 201 Mbits/sec 0.105 ms 15/17120 (0.0883) [3] 11.0-12.0 Sec 7 datagrams Preciment	
••• [3] 37.0-38.0 sec 11520 KBytes 94374 Kbits/sec ••• [3] 38.0-39.0 sec 11519 KBytes 94362 Kbits/sec	Frame (126 bytes) Bitstring tvb (4 bytes) Unaligned OCTET STRING (1 byte) Unaligned OCTET STRING (1 byte)	[3] 12.0-13.0 sec 23.9 MBytes 200 Mbits/sec 0.089 ms 61/17092 (0.36%)	et settimos
3] 39.0-40.0 sec 11519 KBytes 94374 Kbits/sec	Wireshark_demo-oaiH52CD1.pcapng Packets: 641521 - Displayed: 19 (0.0%) Profile: Default		as making a connection metered.

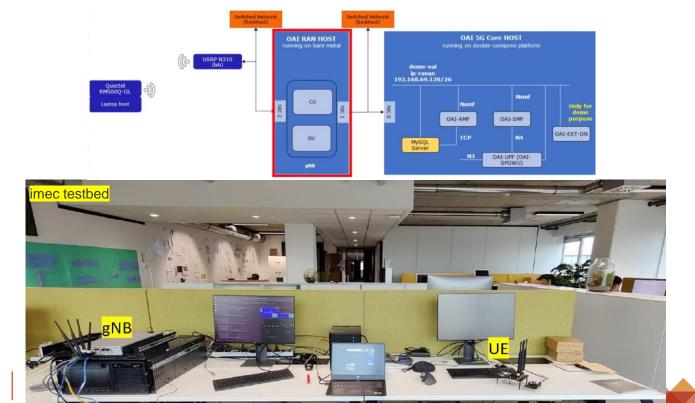








• End-to-end implementation of OAI 5GNR in the testbed CityLab (imec).





• Indoor testing @ imec



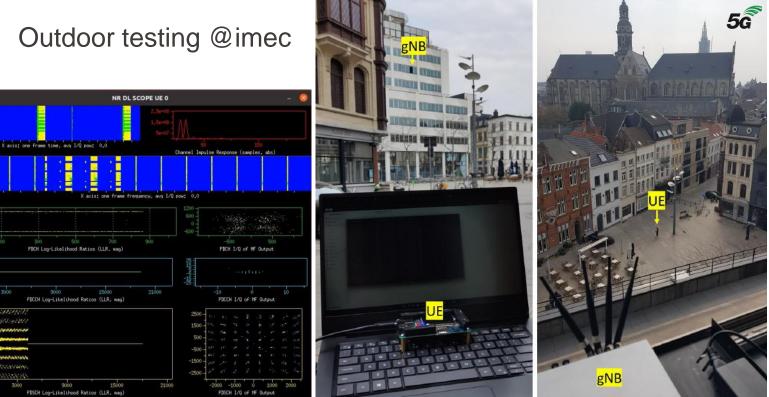
Configuration	Bandwidth [MHz]	DL throughput [Mbit/s]
SISO	40	123
SISO	60	188
MIMO 2x2	40	184
MIMO 2x2	60	240

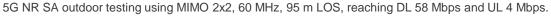


5G NR SA indoor testing using MIMO 2x2, 60 MHz bandwidth and reaching DL 240 Mbps.



Outdoor testing @imec

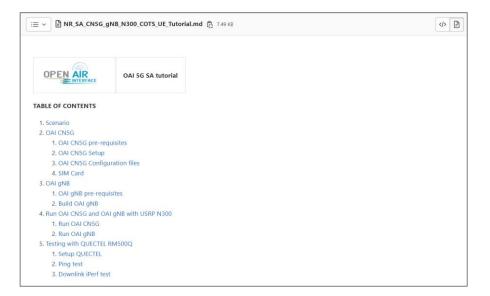








Allbesmart has published a tutorial to allow the OAI community to replicate the 5GFed experiment. The tutorial is available in the gitlab repository from EURECOM.



Business impact



- Fed4FIRE+ has provided a unique opportunity for Allbesmart to have access to state-of-art Software Defined Radio (SDR) testbed infrastructure.
- This experiment helps us to speed up our developing and testing phase and position the company as a player in the emerging market of 5G open-source solutions.
- This experiment has allowed us to mature the technology sufficiently to offer it to our commercial partners and to approach potential new partners for proof-of-concept testing and trials.
- Allbesmart wants to leverage its OAI deep expertise to provide consultancy services on OAI implementations of 3GPP 5G NR protocol stack to accelerate 5G product development and innovations.



Business impact

15



• Thanks to this experiment, IRIS and CityLab testbeds will be able to provide end-to-end 5G open-source implementation for protocol testing, contributing to the sustainability of the Fed4FIRE+ project.





- A very good point is that in OC projects the level of administrative burden for experimenters is very low compared with other H2020 projects.
- Excellent support from TCD and imec teams.
- The documentation available was sufficient to run the experiment.
- We aim to build on top of this experiment and strength the collaboration with TCD (Open Ireland testbed) and imec on open-source solutions for 5G and beyond.





MANY THANKS TO FED4FIRE+ AND TO THE TCD AND IMEC TEAMS !



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WWW.FED4FIRE.EU