

O-RAN ALLIANCE

O-RAN Global PlugFest Spring 2022

Verification and validation of applicability of
tests in a real lab

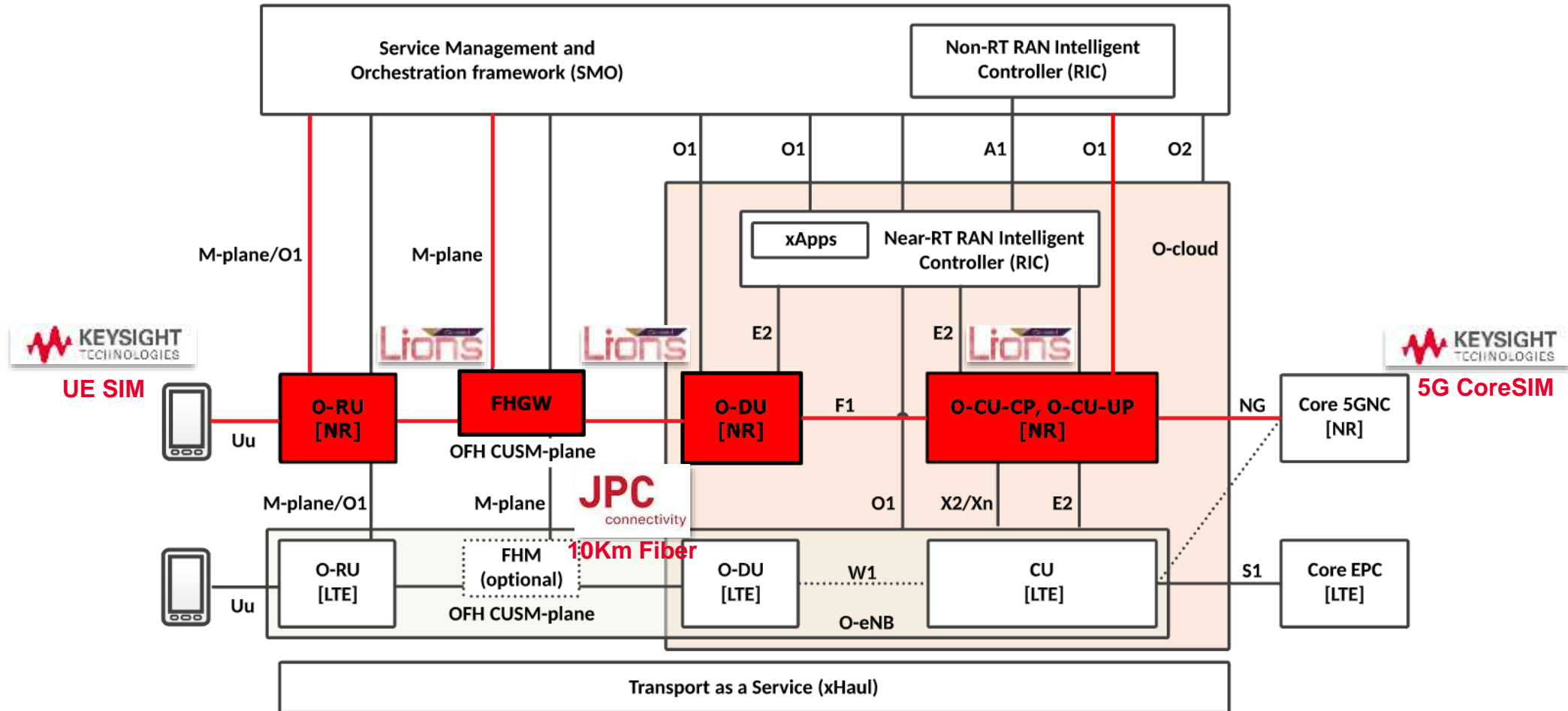
Lions O-RU, FHGW, O-DU & O-CU

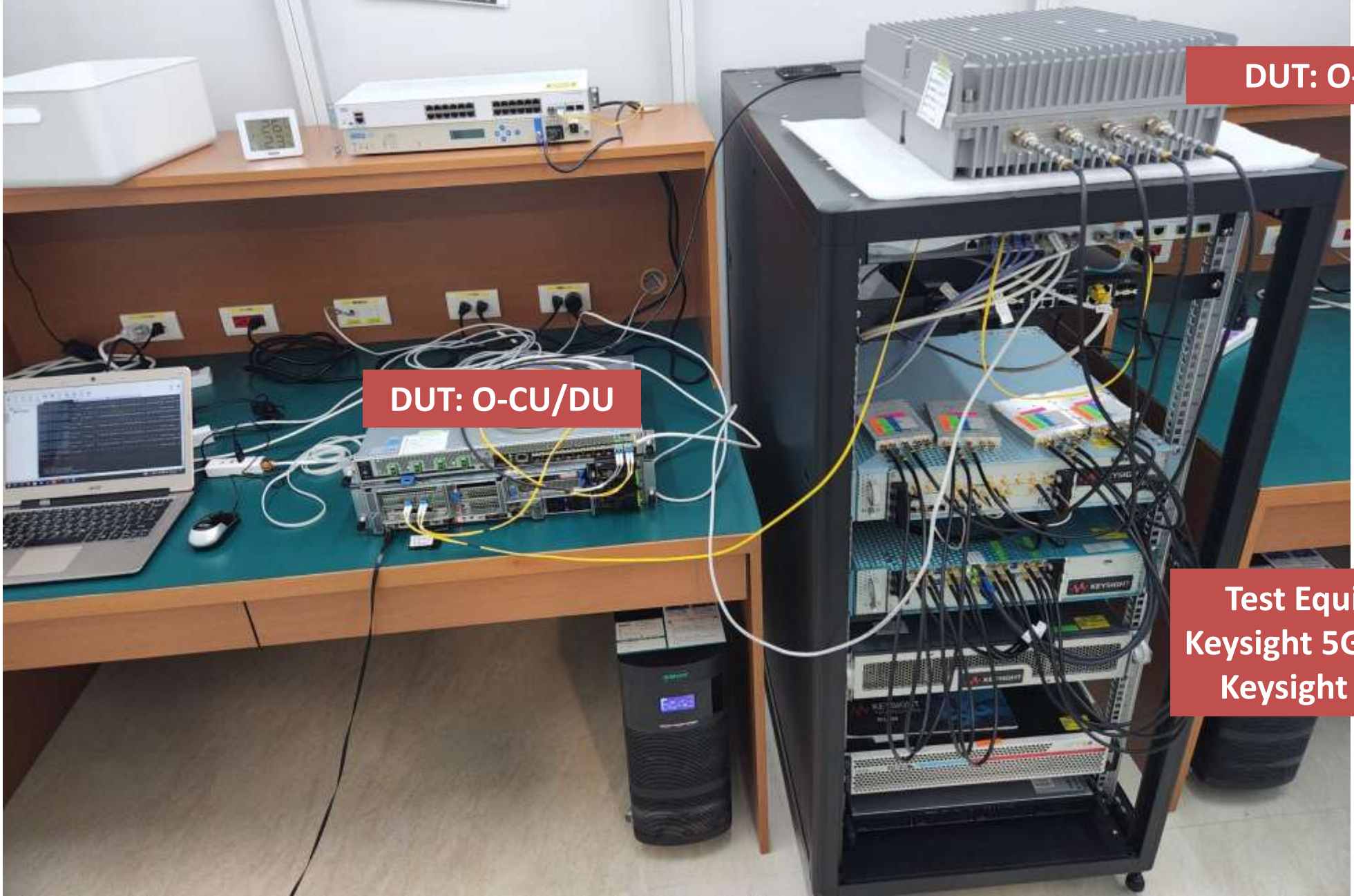
2022-06-22

Tony Huang, Project Manager

- *Test Scenarios in Auray OTIC*
 - *Scenario Architecture*
 - *Testbed Setup*
 - *Devices Under Test*
 - *Test Scenario Introduction*
- *Benefits to the Industry*

- The involved O-RAN components (functions and interfaces) are highlighted in red in the logical O-RAN architecture diagram below:





DUT: O-CU/DU

DUT: O-RU

Test Equipment
Keysight 5G CoreSIM
Keysight UE SIM

Headquarters Hsinchu, Taiwan

LIONS Taiwan Technology Inc.

Business operation/ R&D/ Technical Services/
Supplier Chain/ Procurement/ Manufacture PM



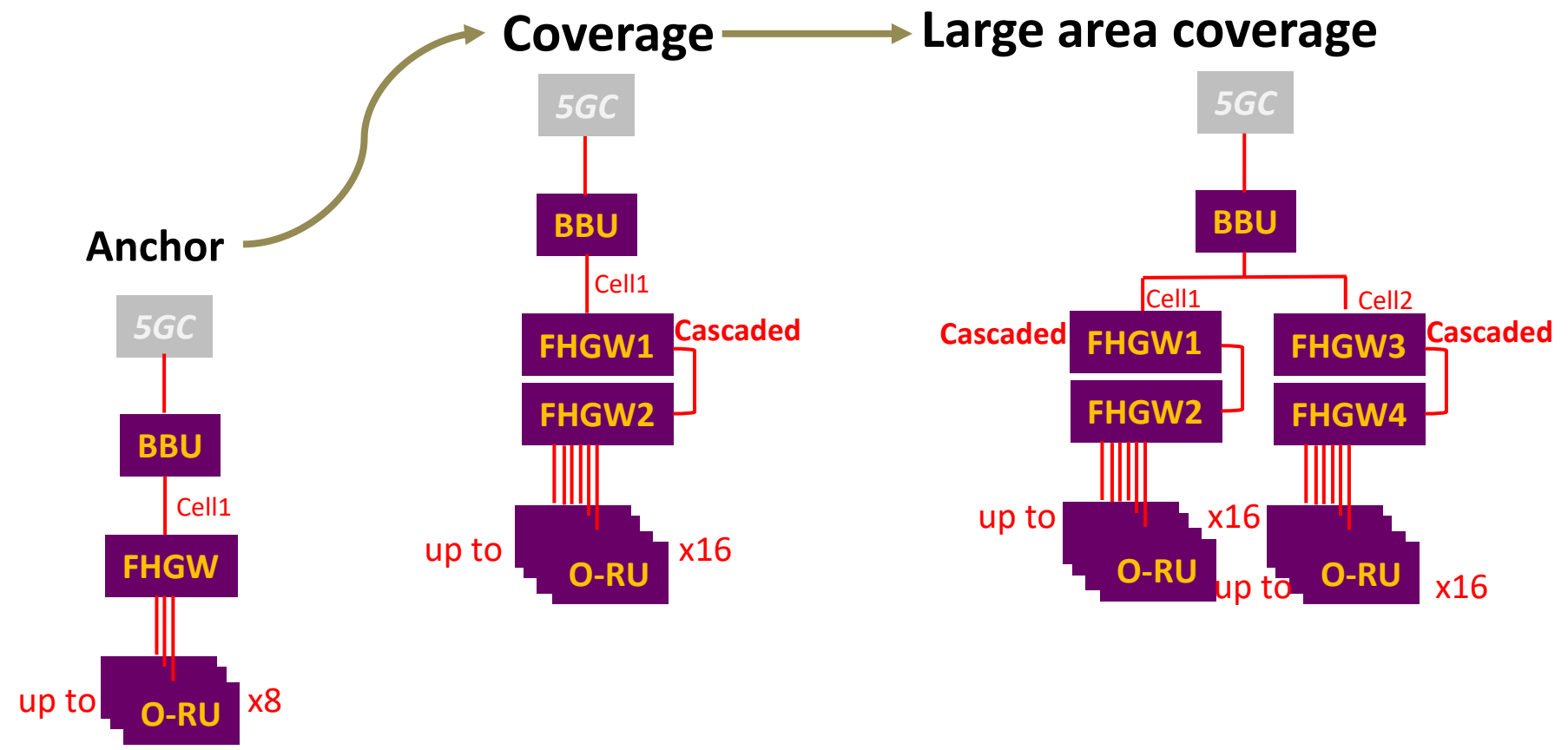
Los Angeles, USA

LIONS USA Technology, INC.

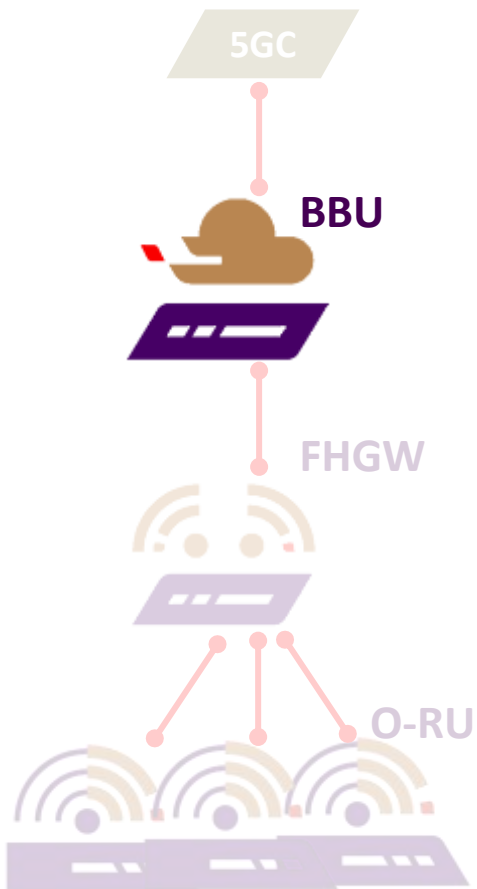
5G technology research/ 5G market
analysis/ 5G product line design and
management (PLM)/ Technical
service/ RMA

- LIONS Technology, established in July 2019, is dedicating to wireless SmallCell base stations and RF technology development, manufacturing, marketing, sales, and customer support.
- LIONS team was established with core competencies in 2G/3G/4G all-RAT and all-bands SmallCell products, LIONS team takes all experiences to participate in the 5G wireless communication market.
- Unlike other O-RAN suppliers, LIONS is not only developing base stations software, but also design and fine tune RF technologies from bottom up. The integration of the end-to-end O-RAN function is guaranteed.
- LIONS strategically partners with a Fortune 500 company in manufacturing, supply chain, and quality assurance to ensure its products meet the world-class standards.

LIONS RANathon 5G gNB Scalability

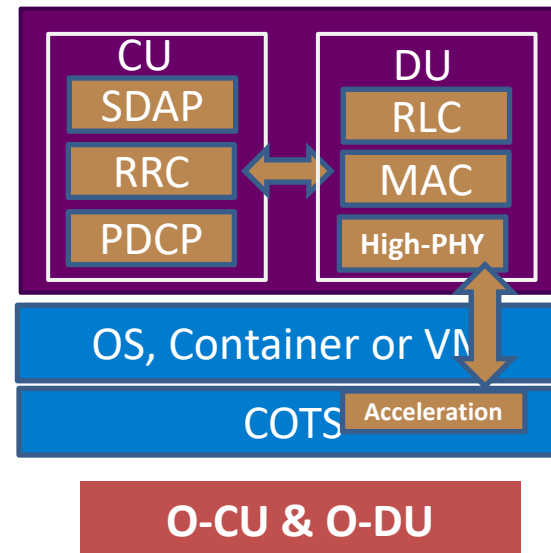


LIONS RANathon O-CU and O-DU

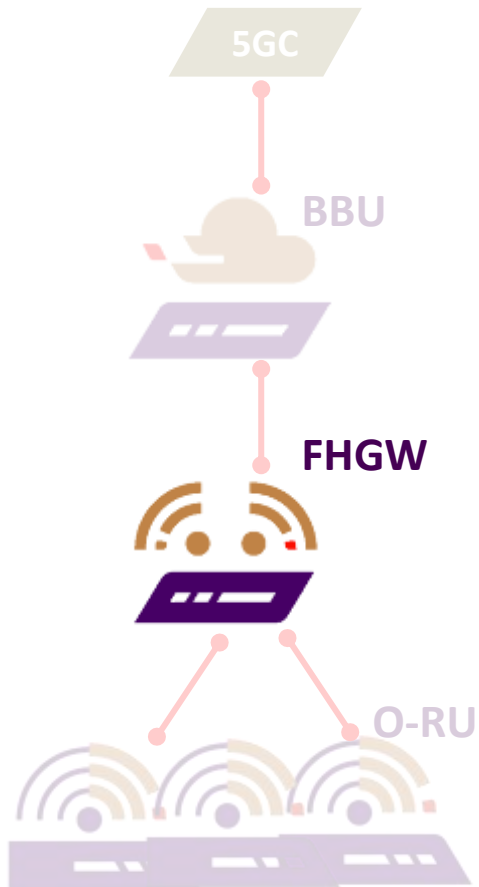


Baseband Unit (O-CU and O-DU)

- NFV kit: software and hi-PHY acceleration
- 3GPP R15, FR1 SA architecture
- Backhaul: NG/ 5GC, Xn/ O-CU handover, O1/ SMO
- Supports 2 FR1 cells per BBU, 400 connect UEs/ cell



LIONS RANathon FHGW



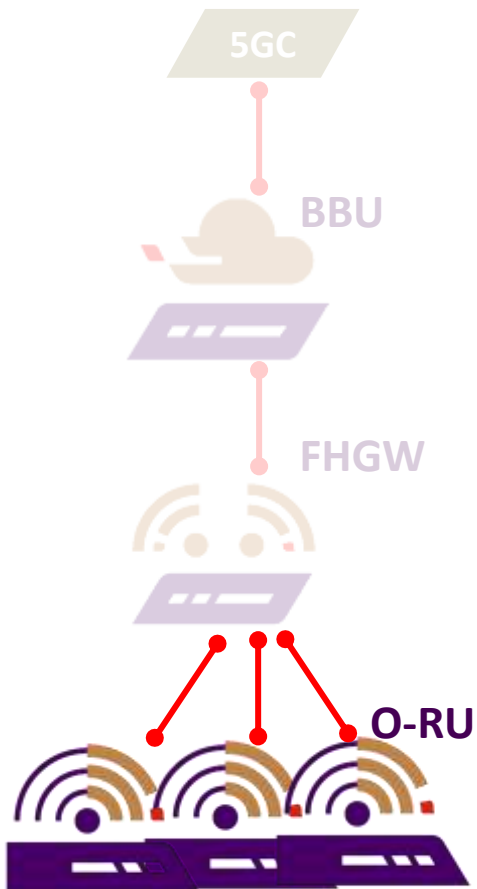
Fronthaul Gateway

- Fronthaul UL aggregation and DL relay
- O-RAN Option 7-2x split/ eCPRI : 1 for BBU, 8 for O-RU
- Clock source



FHGW

LIONS RANathon 5G O-RU Outdoor & Indoor Unit



O-RAN Radio Unit

- Output power: Outdoor: 5W/chx4, Indoor: 250mW/chx4
- MIMO 4T4R/ n78, n79
- O-RAN split 7-2x Fronthaul



Outdoor: 428X316X137mm



Indoor: 260X205X55mm

■ 5.6 Bidirectional throughput in different radio conditions.

	Excellent (cell centre)	Good	Fair	Poor (cell edge)
	UDP	UDP	UDP	UDP
Received L1 UL throughput [Mbps]	255.16	255.209	169.942	154.665
L1 UL Spectral efficiency [bps/Hz]	2.5516	2.55209	1.69942	1.54665
Received L1 DL throughput [Mbps]	789.133	802.664	806.22	532.878
L1 DL Spectral efficiency [bps/Hz]	7.89133	8.02664	8.0622	5.32878
Received Application DL throughput [Mbps]	778.94	793.44	626.36	506.22
UE RSRP [dBm]	-67.6	-75.3	-85.7	-97.6
UE PDSCH SINR [dB]	31.4	32.3	30.6	28.8
DL MIMO rank	4	4	4	4
UL MSC	28	28	25	24
DL RB number	273	273	273	273
UL RB number	264	264	264	264
DL PDSCH BLER [%]	0	0	0	0

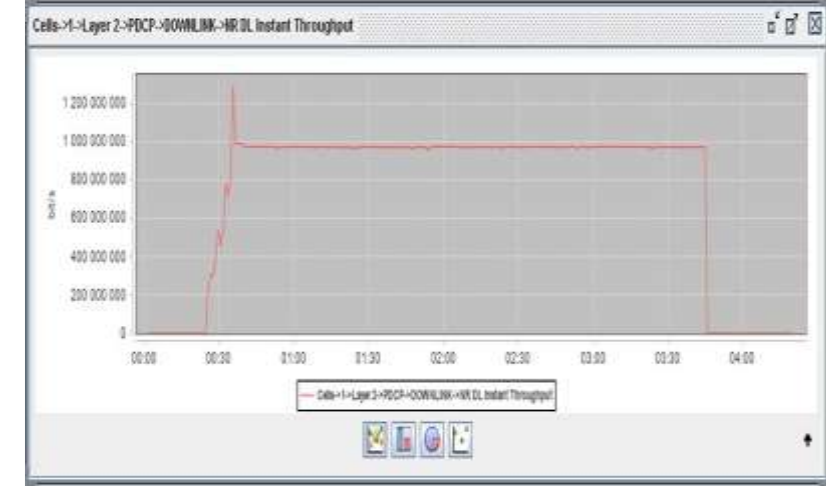
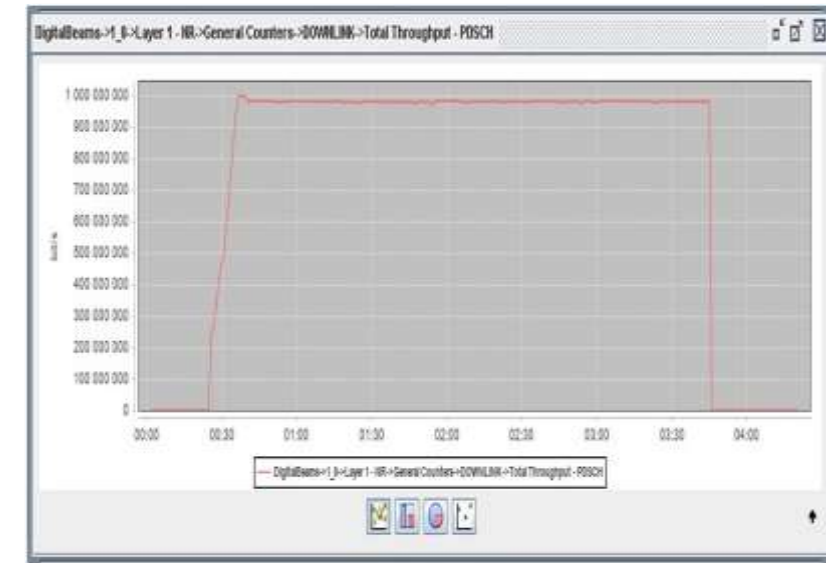
RSRP -97.6 dBm DL



5.7 Downlink coverage throughput.

	Excellent (cell centre)	Good	Fair	Poor (cell edge)
	UDP	UDP	UDP	UDP
Received L1 DL throughput [Mbps]	1536.024	1272.345	971.475	982.669
L1 DL Spectral efficiency [bps/Hz]	15.36024	12.72345	9.71475	9.82669
Received Application DL throughput [Mbps]	1189.709	867.36	994.86	971.96
UE RSRP [dBm]	-66.2	-75.6	-85	-94.6
UE PDSCH SINR [dB]	32.8	34.5	32	28.8
DL MIMO rank	4	4	4	4
DL MSC	27	27	27	15
DL RB number	273	273	273	273
DL PDSCH BLER [%]	0	2.9	0	0

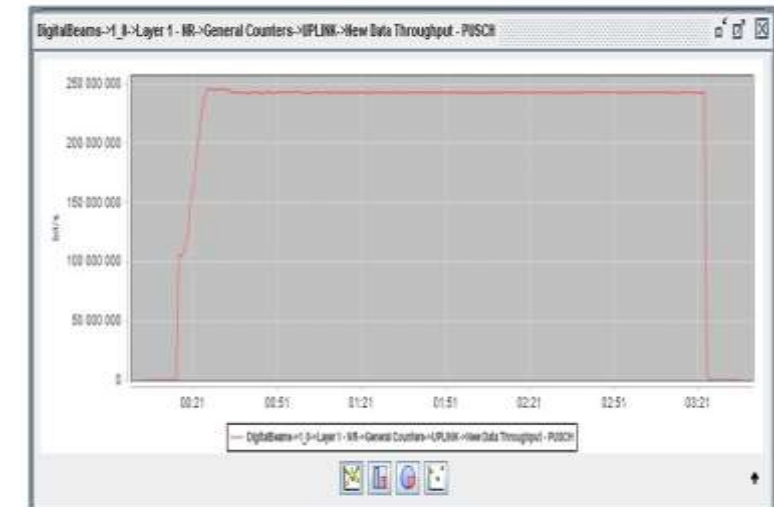
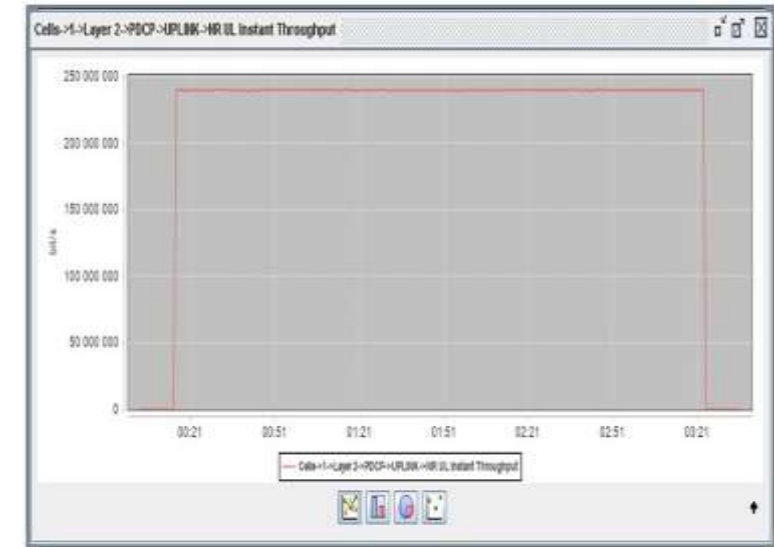
RSRP -94.6 dBm DL



■ 5.8 Uplink coverage throughput.

	Excellent (cell centre)	Good	Fair	Poor (cell edge)
	UDP	UDP	UDP	UDP
Received L1 UL throughput [Mbps]	255.209	255.16	245.673	177.483
L1 UL Spectral efficiency [bps/Hz]	2.55209	2.5516	2.45673	1.77483
Received Application UL throughput [Mbps]	240.673	240.192	239.952	240.192
UE RSRP [dBm]	-66	-75.5	-85	-94.7
UE PDSCH SINR [dB]	32.5	32.5	32	28.8
UL MSC	28	28	27	25
UL RB number	264	264	264	264

RSRP -85 dBm UL



5.11 Impact of fronthaul latency on downlink peak throughput.

	Measured Result
	UDP
Total fronthaul transport latency (T12/T34) [us]	50
Received L1 DL throughput [Mbps]	974.753
Degradation of Received L1 DL throughput [%]#	19.36
Received Application DL throughput [Mbps]	958.403
UE RSRP [dBm]	-65.8
UE RSRQ [dB]	11.5
UE PDSCH SINR [dB]	32.5
MIMO rank	4
PDSCH MSC	16
DL PRB number	273
PDSCH BLER [%]	0

Cells->1->Layer 2->PDCP

PDCP	
DOWNLINK	UPLINK
NR DL Instant Throughput 958.403 Mbit/s	NR UL Instant Throughput 3.466 Kbit/s

DigitalBeams->1_0->Layer 1 - NR->General Counters->DOWNLINK

DOWNLINK	
New Data Transmissions - PDSCH	48372
New Data Volume - PDSCH	3.295 Gbyte
New Data Throughput - PDSCH	974.753 Mbit/s
Total Data Transmissions - PDSCH	48374
Total Data Volume - PDSCH	3.295 Gbyte
Total Throughput - PDSCH	974.753 Mbit/s
Unexpected Retransmissions - PDSCH	0
Retransmissions RV=0 - PDSCH	0
Retransmissions RV!=0 - PDSCH	0
Total Retransmissions - PDSCH	0
Retransmission Rate on PDSCH %	0.0 %
CRC OK TBs - PDSCH	48372
CRC Fail TBs - PDSCH	2
TB BLER on PDSCH %	0.0 %
Simulated CRC Fail TBs - PDSCH	0
Simulated TB BLER on PDSCH %	0.0 %
CRC OK CBs - PDSCH	3377232
CRC Fail CBs - PDSCH	8
CB BLER on PDSCH %	0.0 %
1 Layer Transmissions - PDSCH	1
2 Layers Transmissions - PDSCH	0
3 Layers Transmissions - PDSCH	0
4 Layers Transmissions - PDSCH	48373
HARQ Feedback - ACK	6391
HARQ Feedback - NACK	0
HARQ Feedback - Total	6391

5.12 Impact of fronthaul latency on uplink peak throughput.

	Measured Result
	TCP
Total fronthaul transport latency (T12/T34) [us]	50
Received L1 UL throughput [Mbps]	255.209
Degradation of Received L1 UL throughput [%]#	0
Received Application UL throughput [Mbps]	252.912
UE RSRP [dBm]	-65.8
UE RSRQ [dB]	11.5
UE PDSCH SINR [dB]	32.4
PUSCH MSC	27
UL PRB number	264

Cells->1->Layer 2->PDCP	
PDCP	
DOWNLINK	UPLINK
NR DL Instant Throughput	NR UL Instant Throughput
1.678 Mbit/s	252.912 Mbit/s

DigitalBeams->1_0->Layer 1 - NR->General Counters->UPLINK	
UPLINK	
New Data Transmissions - PUSCH	6964
New Data Volume - PUSCH	259.477 Mbyte
New Data Throughput - PUSCH	255.209 Mbit/s
Total Data Transmissions - PUSCH	6966
Total Data Volume - PUSCH	259.477 Mbyte
Total Throughput - PUSCH	255.209 Mbit/s
Retransmissions RV=0 - PUSCH	0
Retransmissions RV!=0 - PUSCH	2
Total Retransmissions - PUSCH	2
Transmissions - PRACH	0
Transmissions - PUCCH	307
Transmissions - PUSCH	300
Transmissions - SR	0
Transmissions - Aperiodic SRS	0
Transmissions - Periodic SRS	0
Total Transmissions - SRS	0
Reports - Aperiodic CSI	0
Reports - Periodic CSI	13
Total Reports - CSI	13
1 Layer Transmissions - PUSCH	0
2 Layers Transmissions - PUSCH	0
HARQ Feedback - PUCCH	307
HARQ Feedback - PUSCH	300
HARQ Feedback - Total	607

JPC 10Km Fiber



8.1 Simultaneous RRC_CONNECTED UEs.

The Maximum Number of simultaneous RRC_CONNECTED UEs are 256

The screenshot displays a network simulation software interface with several key components:

- Scenario Elements (Left):** A tree view showing the test scenario configuration, including 'Test Scenario: Subscriber: (256), Group', 'Static 5GHz Mobility (Cells: 1)', 'Subscriber List (256)', and 'Session List (1)'. A red box highlights the 'New session 3 - Status: failed' section, which contains the following data:

256	0	256	Registration	100%
256	0	256	Delay	100%
254	2	256	PDU Session Establish	99.9%
256	0	256	Delay	100%
256	0	256	Deregistration	100%
- Charts (Center):** Two performance graphs are visible:
 - Top Graph:** 'DigitalBeams-1_5-Layer 1 - NR - General Counters - DOWNLINK - Total Throughput - PDSCH'. The Y-axis represents Throughput (bits/s) from 0 to 1,000,000. The X-axis shows time from 00:23 to 06:27. The graph shows a sharp peak in throughput around 00:27, reaching approximately 900,000 bits/s, followed by a period of low activity.
 - Bottom Graph:** 'Cells-1-Layer 2 - PDCP - DOWNLINK - NR DL Instant Throughput'. The Y-axis represents Throughput (bits/s) from -40 to 0. The X-axis shows time from 00:23 to 06:27. The graph shows a constant throughput of approximately -20 bits/s throughout the duration.
- Subscriber List (Center-Right):** A list of 256 subscribers, labeled from 'New Subscriber 001' to 'New Subscriber 027'.
- Counter Player (Bottom-Left):** A tree view showing various test scenarios and protocols, including 'Internet Applications', 'FTP Session', 'HTTP Session', 'ICMP Ping', 'Two-Way Active Measurement Protocol', 'IP Passthrough', and 'Miscellaneous'.
- Scenario Logger (Bottom-Center):** A 'Warning View' showing a message: 'Can not find the verbosity configuration file in the SD file. The remote LSU file has the version 3. Trying to create a new verbosity configuration.'
- Properties Panel (Right):** A 'New session 3 - Properties' window showing session details such as 'Session Name: New session 3', 'Access Network: 101', 'Session Scheduling: Session Interval Time: 100', 'Random Rate: [checkbox]', 'Session Repetition: 256', 'Execution Mode: Normal', 'Scheduling Type: Timer Triggered', 'Block Scheduling: Block Interval Time (ms): 3000', 'Block Repetition: 1', 'Block Loop Enabled: [checkbox]', 'Block Scheduling Mode Variable Rate', and 'Dependence: Start Dependence: 002g10013New'.

8.2 Benchmark of UE State Transition.

	Maximum Rate of UE State Transition (per second)	Number of UEs
NR(SA)	9	220

The screenshot displays a network simulation environment with several key components:

- Scenario Elements:** A tree view on the left showing test scenario subscribers (250), flows (0), and session lists. A red box highlights the 'New session 3 - Status' list, which includes:
 - 220 0 220 Registration 100%
 - 220 0 220 Delay 100%
 - 220 0 220 PDN Session Establish 100%
 - 0 0 0 220 Delay 0%
 - 0 0 0 220 Beregistration
 - 0 0 0 220 Deregistration - Successful 0%, Failure 0, Attempted 0
- Charts:** Two performance graphs are visible:
 - Top Chart:** 'DigitalBeams->1_B->Layer 1 - NR ->General Counters->DOWNLINK->Total Throughput - PDSCH'. The graph shows throughput in bits/sec over time, peaking around 300,000.
 - Bottom Chart:** 'Cells->1->Layer 2->PDCP->DOWNLINK->NR DL Instant Throughput'. This graph shows a constant throughput of approximately 100,000 bits/sec.
- Configuration Panel (Right):** 'New session 3 - Properties' window. A red box highlights the 'Session Scheduling' section:
 - Session Interval Time (ms): 115
 - Random Rate:
 - Session Repetition: 220
 - Session Repetitions Mode: Repetitions
- Scenario Logger (Bottom):** Shows a warning message: 'Can not find the verbosity configuration table/Cfg in the SD file. The remote LSU file has the version 3. Trying to create a new verbosity configuration.'

8.3 Traffic Load Testing.

	RRC Access Success Rate	Packet Error Rate	
		Uplink	Downlink
NR(SA)	100	0	0

UDG Downlink

UDG Statistics			
Transactions - Attempted	32	Sessions - Attempted	32
Transactions - Successful	0	Session - Successful	0
Transactions - Failed	0	Session - Failed	0
Transactions - Rate	0.170	Session - Rate	612.0 sessions
Transactions - Success %	0.0 %	Session - Success %	0.0 %
DL Instant Throughput - UE	35.844 Mbit/s	UL Instant Throughput - NET	0.0 bit/s
DL Average Throughput - UE	35.841 Mbit/s	UL Average Throughput - NET	0.0 bit/s
DL Instant Throughput - NET	35.844 Mbit/s	UL Instant Throughput - UE	0.0 bit/s
DL Average Throughput - NET	35.841 Mbit/s	UL Average Throughput - UE	0.0 bit/s
DL Bytes - Received	718.236 Mbyte	UL Bytes - Received	0.0 byte
DL Packets - Received	1.0758927E7 packets	UL Packets - Received	0.0 packets
DL Packets - Discarded	0.0 packets	UL Packets - Discarded	0.0 packets
DL Packets - Discarded %	0.0 %	UL Packets - Discarded %	0.0 %
DL Bytes - Sent	718.236 Mbyte	UL Bytes - Sent	0.0 byte
DL Packets - Sent	1.0758927E7 packets	UL Packets - Sent	0.0 packets
DL Bytes - Lost	0.0 byte	UL Bytes - Lost	0.0 byte
DL Bytes - Lost %	0.0 %	UL Bytes - Lost %	0.0 %
DL Packets - Lost	0.0 packets	UL Packets - Lost	0.0 packets
DL Packets - Lost %	0.0 %	UL Packets - Lost %	0.0 %
DL Packets - Out of Sequence	0.0 packets	UL Packets - Out of Sequence	0.0 packets
DL Packets - Out of Sequence...	0.0 %	UL Packets - Out of Sequence...	0.0 %
DL Transit Time - Minimum	3100 us	UL Transit Time - Minimum	0 us
DL Transit Time - Maximum	4594260 us	UL Transit Time - Maximum	0 us
DL Transit Time - Average	9076 us	UL Transit Time - Average	0 us
DL Transit Time - Variance	29484355	UL Transit Time - Variance	0

UDG Uplink

Sessions - Attempted	32
Session - Successful	0
Session - Failed	0
Session - Rate	882.0 sessions/h
Session - Success %	0.0 %
UL Instant Throughput - NET	35.194 Mbit/s
UL Average Throughput - NET	35.037 Mbit/s
UL Instant Throughput - UE	35.194 Mbit/s
UL Average Throughput - UE	35.037 Mbit/s
UL Bytes - Received	461.447 Mbyte
UL Packets - Received	387090.0 packets
UL Packets - Discarded	0.0 packets
UL Packets - Discarded %	0.0 %
UL Bytes - Sent	461.447 Mbyte
UL Packets - Sent	387090.0 packets
UL Bytes - Lost	0.0 byte
UL Bytes - Lost %	0.0 %
UL Packets - Lost	0.0 packets
UL Packets - Lost %	0.0 %
UL Packets - Out of Sequence	0.0 packets
UL Packets - Out of Sequence %	0.0 %
UL Transit Time - Minimum	4250 us
UL Transit Time - Maximum	880062 us
UL Transit Time - Average	229281 us
UL Transit Time - Variance	86458156

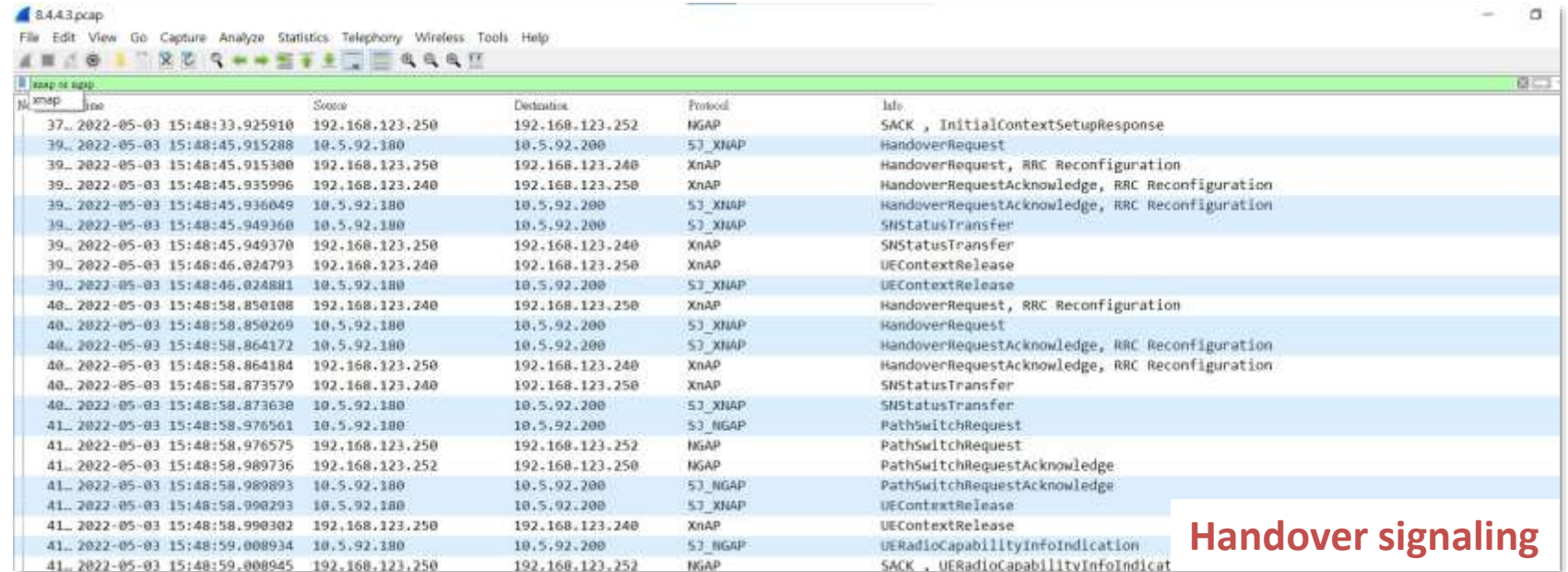
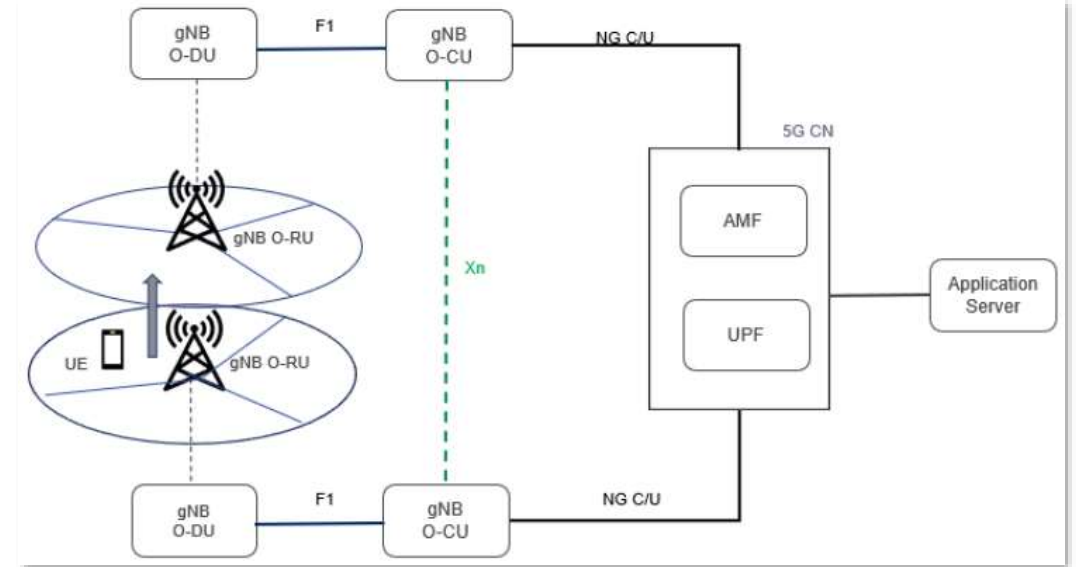
UDG Monodirectional Transmission DL - Properties

DL Packet Size (byte)	48
DL Burst Packet Number	1
DL Time Interval (ms)	500
Unit for DL Time Interval	Microsecond
UDG Transport Configuration Parameters	
Protocol Layer	IP
Remote Port	50100
NUDG IPv4 Address	192.168.100.100
NUDG IPv6 Address	2222::22
UDG Test Scheduling	
First Transaction Delay (ms)	100
Transaction Number	1
Transaction Duration (ms)	300000
Transaction Interval Time (ms)	1000
Idle Timer (ms)	1000
Transaction Duration (ms)	
This is the duration of each UDG transaction in milliseconds.	

4.6 Inter-O-CU Mobility.



5G SA mode handover through Xn interface.



- Great opportunities to practice O-RAN standards and fronthaul interface through plug fest.
- Good exercise to measure KPIs of E2E test in plug fest venue.
- Accelerate the maturity of O-RAN compliance products.

Thank you