

A dark blue, semi-transparent background image showing a close-up of network equipment, including cables and a fan, with the text '5G Network Emulator' overlaid in white.

5G Network Emulator

Emulate 5G core network nodes and generate realistic traffic between network devices

OVERVIEW

The Valid8 5G Network Emulator provides an all-in-one, cost-effective and ultra-portable 5G network for demonstration, testing and training purposes.

WHAT IT CAN DO FOR YOU

The 5G Network Emulator solution is capable of simulating and testing several devices individually or in parallel. There are options available to include a real eNodeB if you need to use real UEs or IoT devices with traffic generation, or our simulated eNodeB if you don't need the RF interface. Subsystems can be switched on or off depending on how much of the network you need simulated.

Example: A network service provider would want to test how his network would function in a real deployment.

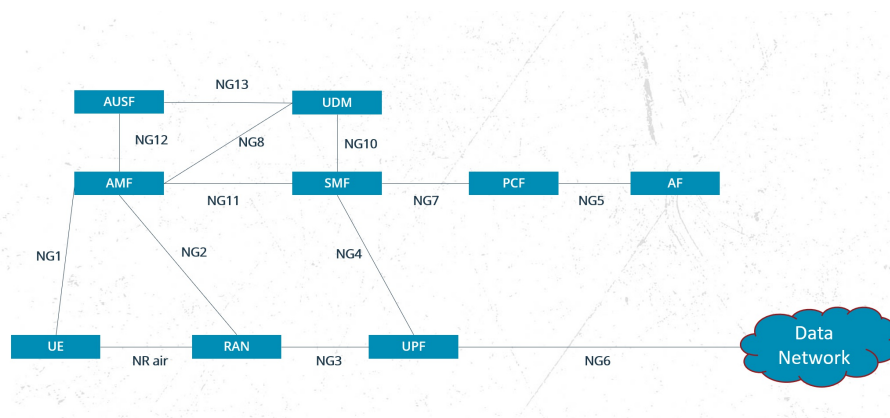
- Will it properly handle Control plane and User plane traffic?
- Will it conform to 3GPP standards?
- How will it perform under load?

FEATURES

- Emulates some or all of core network, exposing all internal interfaces
- Conformance tests available for each interface
- Emulators available per subsystem
- OTA connection available for UEs and IoT devices
- True stateful simulation
- Handover support on X2 and S1
- Signaling request/response messages for call handling, mobility management, authentication, QoS
- Report on media received, call connect time, call duration, jitter, packet loss
- Generate valid and invalid/negative messages and call-scenarios (fully editable scenarios)
- Supports sending invalid messages including malformed, dropped, and misordered packets
- Check parameters in messages from SUT and flag errors
- 3GPP-compliant interfaces

WHY IT'S DIFFERENT

- Software based solution can be run on high-end customer hardware/VM to achieve better performance, or in the Cloud (e.g. Amazon AWS) for maximum versatility
- Web-based Graphical User Interface provides customer with intuitive, easy access via browser
- API's used (REST, HTTP) enable automated testing using test tools.
- Emulated nodes behave exactly as true real nodes, due to Finite State Machine architecture
- Testing is scalable across multiple cores and multiple systems



SUBSYSTEMS

The Valid8 5G Network Emulator is comprised of multiple subsystems that are available individually or in parallel, and are scalable to fit your needs. The individual emulators are controllable through their call controllers, and the traffic can be captured through use of a remote capture tool such as Wireshark.

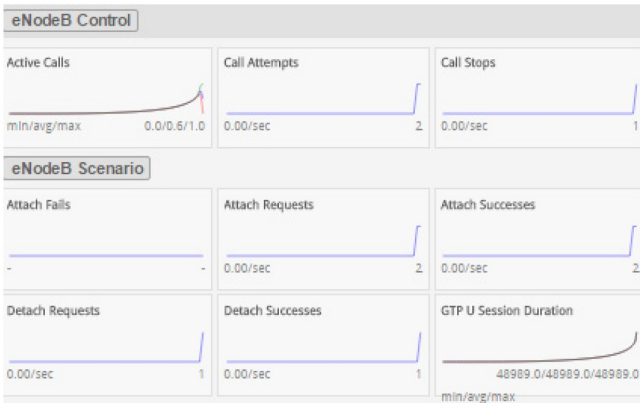
- eNodeB (femto, pico, or emulated)
- AMF
- SMF
- PCF
- AUSF
- UDM
- MME
- SGW
- PGW
- OCS
- HSS
- PCRF
- ePDG

The image shows a Wireshark interface with a packet list and packet details pane. The packet list shows several DNS and HTTP packets. The packet details pane for packet 384 shows a Domain Name System (response) with a request ID of 381. The response includes a query for www.cnn.com and an answer with IP address 64.236.91.21.

The image shows the eNodeB Controls interface. It includes a Call Controller section with Start, Stop, Abort, and Events buttons. Below are Volume (1, 2, 4, 10, 100, 1000), Length (30000 to 91000), Gap (10000 to 15000), and Stagger (500 to 1500) sliders. The Commands section includes buttons for Attach Std (Next Call), Attach Emerg (Next Call), Attach Cstm (Next Call), TAU (Next Call), X2 HO, S1 HO, Hard Reset UE, Service Req (Next Call), UE IPv4, and UE IPv6.

KPIs

- Attach Requests/Successes/Fails
- Detach Requests/Successes/Fails
- Dedicated Bearer Requests/Successes/Fails
- Current Active Sessions/ Bearers
- Number of Sessions/ Bearers Created
- Attach Request Response Time
- Dedicated Bearer Setup Request Response Time
- Detach Request Response Time
- Authentication Request Response Time
- Tracking Area Update Request Response Time



Configurable Parameters

- Mobile Country Code
- Mobile Network Code
- eNodeB Type
- IPAdress
- S1 Interface
- IP Address eNodeB
- Primary DNS Address
- Secondary DNS Address
- MAC Address Public Gateway
- GTP Tunnel IP Address and Port
- GTP Tunnel eNodeB IP Address
- Integrity Algorithm
- IP Address to assign UEs on LAN

```
"20001000000000":
{
  "status":"granted",
  "msisdn":"2000100000",
  "nickname":"SamsungS5",
  "profileName":"Valid8profile",
  "featureId":1,
  "op":"#####",
  "amf":"8000",
  "k":"#####",
  "apn":"internet",
  "algorithm":"milenage"
},
```

AUTOMATION API

User commands can be fully automated using REST API. This includes performing all test control functions as well as collecting results and metrics.

Load Application

PUT /api/1/application/{PRODUCT}/{APPLICATION}/{CONFIGURATION}

Start

PUT /api/1/control/{ELEMENT}/start

Reset Report

DELETE /api/1/report

Get Events

GET /api/1/events

Last 10 commands

- GET /api/1/control {}
- GET /api/1/control {}
- GET /api/1/history {}
- GET /api/1/report {}
- PUT /api/1/application/fixed/networkTester/selftest {"traceFlags":319,"development":false}

Raw Close

SCRIPTING

The application's subsystems can be edited directly in the browser using Javascript or by using the graphical tools seen below. The Message Workshop allows for creating of test scenarios directly from the hex stream of a remote capture, while the Graphical Editor allows for creating customized call scenarios by dragging and dropping the call flow to meet your test needs.

Packet Builder MSC Builder Base Converter Data Rate Converter Help

Mode: Native Protocol: gtp

Input

```

1 0082547230a0369f884c00808450006d3e80004011000c0a86801c0a8689208
4088f0d0559000e4621894d000000180000000020020810005700091a8000f424c0
808014f00050014552000150020004500019005500020010005700090411901e04
80c0a868015e00040000000010300010001

```

Output

```

{
  flags: 0 [0x00],
  version: 0 [0x00],
  seqNum: 2085 [0x825],
  nPdu: 164 [0x44],
  iss: [
    {
      type: 1 [0x01],
      value: "862080b40b409950000841200"
      instance: 0 [0x00]
    },
    {
      type: 3 [0x03],
      value: 64 [0x40],
      instance: 0 [0x00]
    },
    {
      type: 17 [0x11],
      value: 40320 [0xc000],
      instance: 0 [0x00]
    },
    {
      type: 114 [0x72],
      value: 159 [0x9f],
      instance: 0 [0x00]
    }
  ]
}

```

(Untitled) - Wireshark

File Edit View Go Capture Analyze Statistics Help

Time	Source	Destination	Protocol	Info
366.11.767290	192.168.0.31	192.168.0.28	SNMP	get-response SNMPv2-SMI::enterprises.11.2
367.11.768865	192.168.0.28	192.168.0.31	SNMP	get-request SNMPv2-SMI::enterprises.11.2
369.11.775952	192.168.0.31	192.168.0.28	SNMP	get-response SNMPv2-SMI::enterprises.11.2
381.12.286091	192.168.0.28	192.168.0.1	DNS	Standard query A www.cnn.com
384.12.311602	192.168.0.1	192.168.0.28	DNS	Standard query response A 64.236.91.21
385.12.312427	192.168.0.28	64.236.91.21	TCP	56606 > http [SYN] Seq=0 Win=8192 Len=0
386.12.361495	64.236.91.21	192.168.0.28	TCP	http > 56606 [SYN, ACK] Seq=0 Ack=1 Win=0
387.12.361583	192.168.0.28	64.236.91.21	TCP	56606 > http [ACK] Seq=1 Ack=1 Win=17520
388.12.361805	192.168.0.28	64.236.91.21	HTTP	GET / HTTP/1.1
389.12.413166	64.236.91.21	192.168.0.28	TCP	http > 56606 [ACK] Seq=1 Ack=845 Win=696
390.12.413611	64.236.91.21	192.168.0.28	TCP	[TCP segment of a reassembled PDU]
391.12.414386	64.236.91.21	192.168.0.28	TCP	[TCP segment of a reassembled PDU]

Frame 384 (167 bytes on wire, 167 bytes captured)

Ethernet II, Src: Sparklan_04:00:9e (00:0e:9e:04:d0:9e), Dst: HonHaiPr_26:66:a2 (00:1c:26:26:66:a2)

Internet Protocol, Src: 192.168.0.1 (192.168.0.1), Dst: 192.168.0.28 (192.168.0.28)

User Datagram Protocol, Src Port: domain (53), Dst Port: 62872 (62872)

Domain Name System (response)

[Request_In=384]

[Time: 0.02571000 seconds]

Transaction ID: 0xc1f1

Flags: 0x180 (Standard query response, No error)

Questions: 1

Answer RRs: 6

Authority RRs: 0

Additional RRs: 0

Queries

- www.cnn.com: type A, class IN
 - Name: www.cnn.com
 - Type: A (Most address)
 - Class: IN (0x0001)

Answers

- www.cnn.com: type A, class IN, addr 64.236.91.21

```

100 00 1c 26 26 66 a2 00 0e 8e 04 d0 9e 08 00 45 00 ..66f.....E.
110 00 99 00 00 00 40 00 11 b8 e6 c0 a8 00 01 c0 a8 ...9.0.....
120 00 1c 00 25 f5 98 00 85 98 5a cf 1f 81 80 00 01 ...5.....Z.....
130 00 06 00 00 00 00 03 77 77 77 03 63 6e 6e 03 63 .....Www.cnn.c
140 ef 6d 00 00 01 00 01 c0 0c 00 01 00 01 00 00 00 .....
150 b7 00 04 40 ec 5b 15 c0 0c 00 01 00 01 00 00 00 ...8[L.....
160 b7 00 04 40 ec 5b 17 c0 0c 00 01 00 01 00 00 00 ...8[L.....
170 b7 00 04 40 ec 10 14 c0 0c 00 01 00 01 00 00 00 ...8[L.....

```

is a response to the DNS query in this fr... Packets: 1273 Displayed: 909 Marked: 0 Dropped: 0 Profile: 0

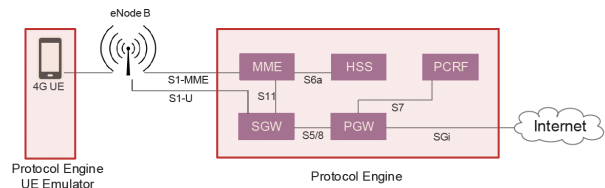
USE CASES

ENODEB UNDER TEST

In the scenario where the eNodeB is to be tested, it can be tested by the Valid8 4G Network Emulator emulating the core network. Additionally, load and conformance tests are available for interfaces S1-MME and S1-U. In the case where the eNodeB needs to be tested on the RF side, it can be tested by the Valid8 4G UE Emulator.

Supported Scenarios:

- Power on / Start up
- 4 Attach
- 4 TAU
- 4 Attach
- 4 eRAB Setup
- 4 Detach
- **UE Under**



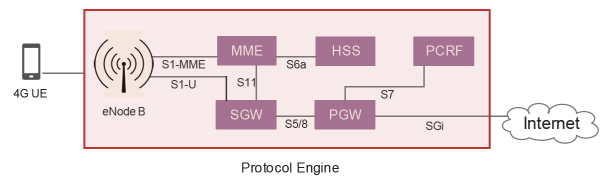
- Emulates MME (for S1-MME) and SGW (for S1-U) along with all other needed core network elements, exposing all internal interfaces
- Conformance tests available for S1-MME, S1-U, and X2

UE UNDER TEST

For testing UE or IoT devices, the 4G Network Emulator can provide the entire 4G core network as well as an emulated or real eNodeB depending on your test needs.

Supported Scenarios:

- Power on
- 4 Attach
- 4 Detach
- 4 TAU
- 4 Data Connection
- 4 VoLTE Call



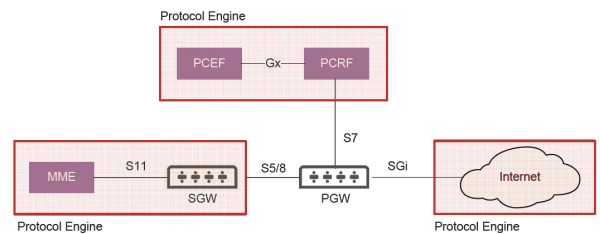
- End to end VoLTE test capability
- Includes real femto, pico, or microcell eNodeB
- Emulates all core network nodes and allows for data connection to external networks

PGW UNDER TEST

For testing the PGW, the 4G Network Emulator can wrap around the node using the S5/8, S7, and SGi interfaces. Traffic can be originated from real or emulated UE and IoT devices.

Supported Scenarios:

- Create Session
- 4 Delete Session
- 4 Create Bearer
- 4 Modify Bearer
- 4 Delete Bearer
- 4 Echo



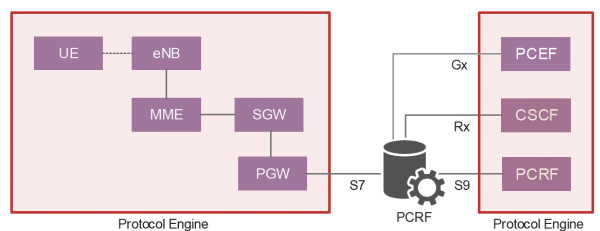
- Emulates all required nodes for wrapping around, including MME and PCRF for testing over interfaces S5/8, S7, and SGi
- Exposes all internal interfaces
- Conformance tests available for each interface (S5/8, S7, SGi)

PCRF UNDER TEST

For testing the PCRF, the 4G Network Emulator can wrap around the PCRF with the core network and IMS.

Supported Scenarios:

- CC-Request / Answer (CCR / CCA)
- 4 Re-Auth-Request / Answer (RAR / RAA)
- 4 Capability-Exchange-Request / Answer (CER / CEA)
- 4 Session-Termination-Request / Answer (STR / STA)
- 4 Abort-Termination-Request / Answer (ASR / ASA)
- 4 Device-Watchdog-Request / Answer (DWR / DWA)
- 4 Disconnect-Peer-Request / Answer (DPR / DPA)



- Emulates core network, Diameter, and IMS nodes as needed for testing the PCRF, exposing all internal interfaces
- Conformance tests available for each interface (S7, S9, Rx, Gx)

SUMMARY OF SPECIFICATIONS

The Valid8 5G Network Emulator is capable of simulating and testing several devices individually or in parallel and is scalable to fit your needs.

SPECIFICATIONS

Protocols	<ul style="list-style-type: none"> 3GPP TS 23.401 v10.13.0 (EUTRAN) 3GPP TS 24.301 v10.15.0 (NAS) 3GPP TS 29.060 v10.12.0 (GTPv1) 3GPP TS 29.272 v10.9.0 (S6a) 3GPP TS 29.212 v10.16.0 (Gx) 3GPP TS 29.214 v10.14.0 (Rx) 3GPP TS 29.274 v10.14.0 (GTPv2-C) 3GPP TS 29.281 v10.3.0 (GTPv1-U) 3GPP TS 32.299 v10.16.0 (Gy) 3GPP TS 36.413 v10.9.0 (S1AP) 3GPP TS 36.414 v10.1.0 (S1-U) IETF RFC6733 - Diameter IETF RFC4006 - Ro IETF RFC5246 - TLS, Protocol (1.0,1.1,1.2) IETF RFC6101 - SSL, Protocol Version 3.0 IETF RFC793 - TCP IETF RFC768 - UDP IETF RFC4960 - SCTP IETF RFC791 - IPv4 IETF RFC2460 - IPv6 IETF RFC3550 - RTP / RTCP IETF RFC3711 - SRTP IETF RFC1035 - DNS IETF RFC2131 - DHCP
Mobile Management Entity	<ul style="list-style-type: none"> 3NAS SAE Bearer Management UE Location, Subscriber Data Handling Authentication Fault Recovery Notification Mix of PDN types, IPv4, IPv6 Up to 2 sessions per IMSI Interface S1-MME to eNodeB: S1-AP Interface S6a to HSS: Diameter over SCTP Interface S11 to SGW: eGTP-C/GTPv2- C Supports up to 4 eNodeBs (scalable)
Serving Gateway SGW	<ul style="list-style-type: none"> 3Packet Routing and Transfer Functions IP Address Allocation Interface S1-U to eNodeB: GTP-U Interface S4 to SGSN: GTP-U, eGTP- C/GTPv2-C Interface S5 to PGW: GTP-U, eGTP- C/GTPv2-C Interface S11 to MME: eGTP-C/GTPv2- C
PDN Gateway	<ul style="list-style-type: none"> 3Packet Routing and Transfer Functions IP Address Allocation Interface S5 to SGW: GTP-U, eGTP- C/GTPv2-C Interface S7 to PCRF: Diameter over SCTP
HSS	<ul style="list-style-type: none"> 3Subscriber profiles UE Location Subscriber Data Handling Authentication (AuC) Fault Recovery Notification
ePDG	<ul style="list-style-type: none"> 3GTP (S2a/b) to PGW
eNodeB	

PCRF	<ul style="list-style-type: none"> ▣Operational Frequency Bands: Internal femtocell: 400 - 6000 Mhz (includes unlicensed 5Ghz bands) External picocell: Bands 2, 3, 4, 7, 9, 10, 12, 17, 20, 25, 38, 40, 41, 42, 43 Duplex: FDD & TDD Synchronization: GPS Modulations from QPSK to 256QAM (Rel 12) Connector type - Femtocell: SMA female Connector type - Picocell: N-type female Interface S1-MME to MME: S1-AP Interface S1-U to SGW: GTP-U Interface X2 to eNodeB: X2-AP Interface Uu to UE Interface M1 to eMBMS Supports up to 32 UEs with 4 bearers each * - roadmap
Diameter	<ul style="list-style-type: none"> ▣Policy Control Functions QoS Authorization
IP	<ul style="list-style-type: none"> ▣CER/A, DWR/A, CCR-I/A, CCR-U/A, CCR-T/A, RAR/A request/response messages
Test Scenarios	<ul style="list-style-type: none"> ▣1,000 Mbps total throughput
Network Emulation	<ul style="list-style-type: none"> ▣Attach and Default EPS Bearer Context Activation Attach / Reject Detach Tracking Area Update E-UTRA Handover PDN Connectivity Request HTTP Browsing
Quality Testing	<ul style="list-style-type: none"> ▣Simulated network delays and packet loss

▣VoLTE Voice Quality Analysis
QoE

PRODUCT DETAILS

Hardware	<ul style="list-style-type: none"> ▣Intel-based; scalable to meet performance needs
Options	<ul style="list-style-type: none"> ▣P5088/01 includes base kit (simulated eNB) P5089/01 includes LTE pico eNB (single band) P8110/02 includes LTE femto eNB (multi band) Conformance tests available for each interface (S1, S5, S6a, S7, S11, Rx, Gx, Gy, Ro)
Operating System	<ul style="list-style-type: none"> ▣Protocol Engine (Linux-based)
User Interface	<ul style="list-style-type: none"> ▣Browser-based, touch-optimized graphical user interface
Automation	<ul style="list-style-type: none"> ▣HTTP API
Max output power	<ul style="list-style-type: none"> ▣31 mW (femto RF module option) 1000 mW per Tx (external picocell option)
Connector types	<ul style="list-style-type: none"> ▣Femtocell: SMA female Picocell: N-type female
Hardware dimensions	<ul style="list-style-type: none"> ▣M1: 4.5" x 4.5" x 1.75" M3: 19" x 15.75" x 3.5"; appx. 16.7lb
Power supply	<ul style="list-style-type: none"> ▣M3: 520W AC to DC, 100 - 240v