BLACK BOOK

Long Term Evolution – Evolved Packet Core Network

Edition 11

ixia

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Our goal in the preparation of this Black Book was to create high-value, high-quality content. Your feedback is an important ingredient that will help guide our future books.

If you have any comments regarding how we could improve the quality of this book, or suggestions for topics to be included in future Black Books, please contact us at ProductMgmtBooklets@ixiacom.com.

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Contents

How to Read this Book

The book is structured as several standalone sections that discuss test methodologies by type. Every section starts by introducing the reader to relevant information from a technology and testing perspective.

Each test case has the following organization structure:

Overview	Provides background information specific to the test case.
Objective	Describes the goal of the test.
Setup	An illustration of the test configuration highlighting the test ports, simulated elements and other details.
Step-by-Step Instructions	Detailed configuration procedures using Ixia test equipment and applications.
Test Variables	A summary of the key test parameters that affect the test's performance and scale. These can be modified to construct other tests.
Results Analysis	Provides the background useful for test result analysis, explaining the metrics and providing examples of expected results.
Troubleshooting and Diagnostics	Provides guidance on how to troubleshoot common issues.
Conclusions	Summarizes the result of the test.

Typographic Conventions

In this document, the following conventions are used to indicate items that are selected or typed by you:

- **Bold** items are those that you select or click on. It is also used to indicate text found on the current GUI screen.
- *Italicized* items are those that you type into fields.

Dear Reader

Ixia’s Black Books include network, application, and security test methodologies that will help you become familiar with new technologies and the key testing issues associated with them.

The Black Books are primers on technology and testing. They include test methodologies to verify device and system functionality and performance. The methodologies are universally applicable to any test equipment. Step-by-step instructions use Ixia’s test platforms and applications to demonstrate the test methodology.

Our library of Black Books includes twenty-two volumes that cover key technologies and test methodologies:

Volume 1 – Network Security
Volume 2 – Application Delivery
Volume 3 – QoS Validation
Volume 4 – Voice over IP
Volume 5 – Video over IP
Volume 6 – LTE Access
Volume 7 – LTE Evolved Packet Core
Volume 8 – Carrier Ethernet
Volume 9 – IPv6 Transition Technologies
Volume 10 – Converged Data Center
Volume 11 –Converged Network Adapters
Volume 12 – Network Convergence Testing
Volume 13 –Ethernet Synchronization
Volume 14 – Advanced MPLS
Volume 15 – MPLS-TP
Volume 16 – Ultra Low Latency (ULL) Testing
Volume 17 – Network Impairment
Volume 18 – Test Automation
Volume 19 – 802.11ac Wi-Fi Benchmarking
Volume 20 – SDN/OpenFlow
Volume 21 – Audio Video Bridging
Volume 22 – Automotive Ethernet

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We are committed to helping our customers build and maintain networks that perform at the highest level, ensuring end users get the best application experience possible. We hope this Black Book series provides valuable insight into the evolution of our industry, and helps customers deploy applications and network services—in a physical, virtual, or hybrid network configurations.

Bethany Mayer, Ixia President and CEO

Long Term Evolution - EPC

Core - Test Methodologies

This document covers the Long Term Evolution (LTE) wireless technology. The document presents a general overview of LTE technology market followed by a focused discussion on Evolved Packet Core (EPC) testing. It also includes multiple test cases based on Ixia’s IxLoad application. LTE Access is detailed in its own black book.

LTE Overview

The Third Generation Partnership Project (3GPP) conducted the Evolved UTRA and UTRAN study, finalized in September 2006, to define the long term evolution (LTE) of the 3GPP wireless access technology. A parallel study known as system architecture evolution (SAE) defined the evolution of the wireless core network.

Important objectives of LTE include:

- Reduced latency
- Higher data rates
- Faster connection times
- Improved system capacity
- Improved system coverage
- Reduced operator cost

To achieve these objectives, 3GPP defines a new radio interface and evolved radio access network architecture. LTE provides users with an always-on IP connectivity service.

SAE defines the evolved packet core (EPC) network architecture for LTE. The EPC simplifies connectivity with 3GPP and 3GPP2 technologies as well as Wi-Fi and fixed line broadband networks.

The LTE access network, which consists of base stations known as evolved Node Bs (eNode Bs), is known as the evolved universal terrestrial radio access network (E-UTRAN). The evolved packet system (EPS) consists of E-UTRAN combined with an EPC.

LTE Requirements and 3GPP Evolution

The 3GPP release 8 specifications define new requirements for LTE technology. Some of these requirements are:

- Scalable bandwidth
  - 1.4, 3.0, 5.0, 10.0, 15.0, and 20 MHz bandwidths in both uplink and downlink directions
- Operation in both paired and unpaired spectrum (FDD and TDD modes)
- Significantly increased peak data rates, scaled according to the size of the bandwidth allocation:
  - Downlink peak data rate of 300 Mbps with a 20 MHz downlink bandwidth when using a 4x4 multiple-input multiple-output (MIMO) antenna configuration
  - Uplink peak data rate of 75 Mbps with a 20 MHz uplink bandwidth when using a single-input single-output (SISO) antenna configuration

  - Uplink peak data rate of 150 Mbps with a 20 MHz uplink bandwidth when using multi-user MIMO
- Improved system performance
  - A two- to four-fold increase in performance in downlink bit rates compared with basic Release 6 system high speed downlink packet access (HSPDA) when using a maximum of two transmit antennas at the eNode B and two receive antennas at the user equipment (UE).
  - A two- to three-fold increase in performance in uplink bit rates compared with basic Release 6 system enhanced dedicated channel (E-DCH) when using a single transmit antenna at the UE and two receive antennas at the eNode B.
- Significantly reduced control plane latency
  - Transition time of less than 100ms from a camped state to an active state (excluding downlink paging delay and non-access stratum (NAS) signaling delay).
- Control plane capacity
  - At least 200 users per cell must be supported in an active state with spectrum allocations of up to 5 MHz and at least 400 users per cell with spectrum allocations greater than 5 MHz.
- Significantly reduced user plane latency
  - User plane latency of less than 5ms in an unloaded condition (a single user with a single data stream) and a small IP packet size (0 byte payload) calculated as the one-way transit time between the access network edge node and the UE at the IP layer in both the uplink and downlink directions.
- Interwork with other wireless technologies
  - GSM and UMTS
  - CDMA2000 1xRTT and high rate packet data (HRPD)

The 3GPP Release 9 specification baseline was set in the December 2009 specification release. Release 9 is now being adopted by eNode B manufacturers.

Key new features available in Release 9 are as follows:

- Multicast, MCH, eMBMS support
- Home eNode Bs, Femtocells and Picocells
- Emergency Bearer Services
- UE Positioning with Positioning Reference Signals
- Transmission Mode 8, a Beam Forming mode extending TM7 under 2x2 MIMO
- DCI Format 2B

Release 9 NAS protocol updates include messages for the following:

- Uplink/Downlink Generic NAS Transport
- Notification
- NF Capability
- LSC (Location Services)

Release 9 RRC protocol updates include messages for the following:

- Proximity
- UE Information
- MBMS
- SIBs 12,13
- UE CMAS

The evolution of 3GPP mobile technology for FDD and TDD modes is shown below.

Table 1. Evolution of 3GPP FDD and TDD Technology

FDD evolution	TDD evolution	3GPP release	Network rollout year	Peak DL data rate	Peak UL data rate	Latency (round trip)
WCDMA	TD-SCDMA	Release 99/4	2003/2004	384 kbps	128 kbps	150 ms
HSDPA/HSUPA	TD-HSDPA	Release 5/6	2005/2006 (HSDPA) 2007/2008 (HSUPA)	14 Mbps	5.7 Mbps	100 ms
HSPA+	TD-HSUPA	Release 7	2008/2009	28 Mbps	11 Mbps	50 ms
LTE and HSPA+	TD-LTE and TD-HSPA+	Release 8	2010	LTE: 150 Mbps (2x2 MIMO and 20 MHz bandwidth) HSPA+: 42 Mbps	LTE: 75 Mbps; HSPA+: 11 Mbps	LTE: 10 ms
LTE Advanced		Study item initiated		High mobility: 100 Mbps Low mobility: 1Gbps		

The LTE Market

Informa predicts a dramatic increase in the use of advanced mobile applications, such as mobile browsing and video, and predicts that mobile video traffic will grow by a factor of 30 by 2012. In fact, mobile video traffic could overtake voice traffic by 2011. Since the design, rollout, and operation of mobile networks has always been driven by voice, the future dominance of data traffic will have a significant impact on the design of future mobile networks.

In voice dominated networks, in the past revenue has closely been correlated with traffic, but in data dominated networks this relationship is not true because the value to application users is no longer proportional to data volume.

To remain profitable in data dominated networks, the per-bit cost must be reduced for operators, as shown in Figure 1. One way to do this is to optimize the network by moving from a voice traffic oriented architecture to a data traffic oriented architecture such as LTE.

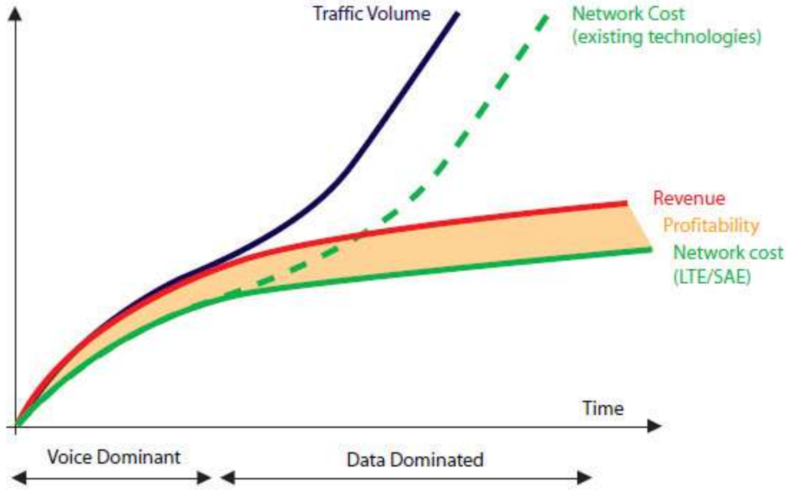


Figure 1. Divergence between Traffic Volume and Revenue over Time (Source: Nokia Siemens Networks)

LTE promises to deliver the massive capacity required for the shift in mobile traffic patterns from voice to data and video at a lower cost compared to previous 3GPP technologies. Analysys Mason, in a study presented to the UMTS Forum in 2008, estimated that dual band 10 MHz (2x10 MHz) deployment of 10,000 eNode Bs would provide a significant increase in downlink capacity over a comparable 3GPP HSPA deployment, as shown in Figure 2. According to the Analysys Mason study, the cost per megabit could drop by a factor of three in going from HSPA (2x5 MHz) to LTE (2x5 MHz).

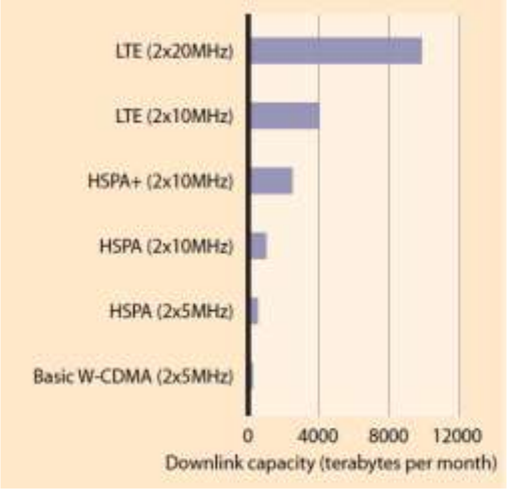


Figure 2. Estimated Network Capacities for a Typical 10,000 Base Station Deployment (Source: Analysys Mason, 2008)

LTE offers a number of upgrade paths for operators of 3GPP and non-3GPP networks, as shown in Figure 3. LTE is the next step on the roadmap of 3GPP cellular systems that includes GSM, GPRS, EDGE, UMTS (WCDMA) and HSPA. LTE also fulfills the goal of harmonious coexistence with legacy circuit switched systems through the EPC, as shown in Figure 3.

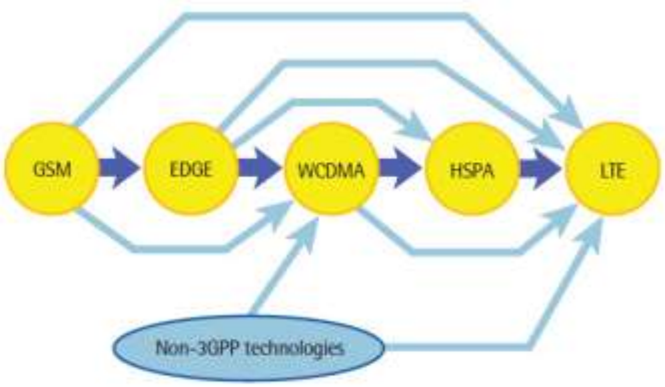


Figure 3. Upgrade Paths to LTE (Source: UMTS Forum, *Towards Global Mobile* Broadband, 2008)

Infonetics explains that the LTE infrastructure market is expected to grow at a compound annual growth rate of 56% to $5 billion by 2013, driven by E-UTRAN deployment during this period (see Figure 4). The market for E-UTRAN is expected to reach $4.7 billion by 2013, while the market for EPC is expected to reach $350 million by the same time.

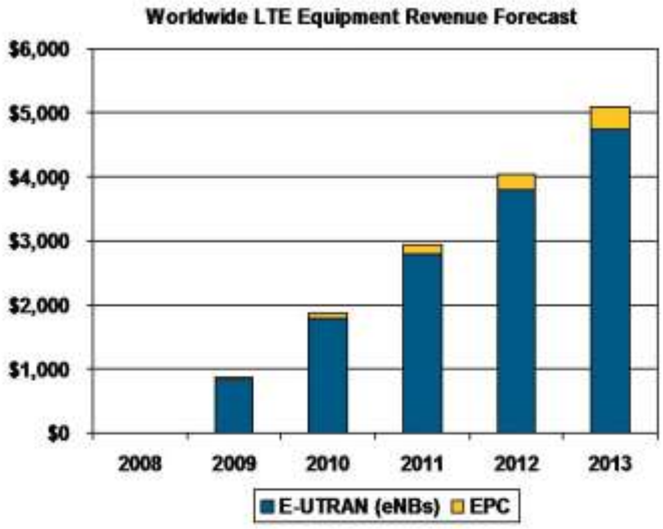


Figure 4. Worldwide LTE Equipment Revenue Forecast (Source: Infonetics, *Infrastructure and Subscribers*, April 2009); Note: eNode B has been abbreviated as eNB in the figure

In addition, according to Infonetics, the number of LTE subscribers could exceed 72 million by 2013, largely split between the Asia Pacific and North American regions. NTT Docomo, KDDI, Verizon Wireless, and AT&T are expected to deploy the technology during this time frame. Europe is expected to lag behind because it is deploying HSDA+ in the interim between HSDA and LTE, as shown in Figure 5.

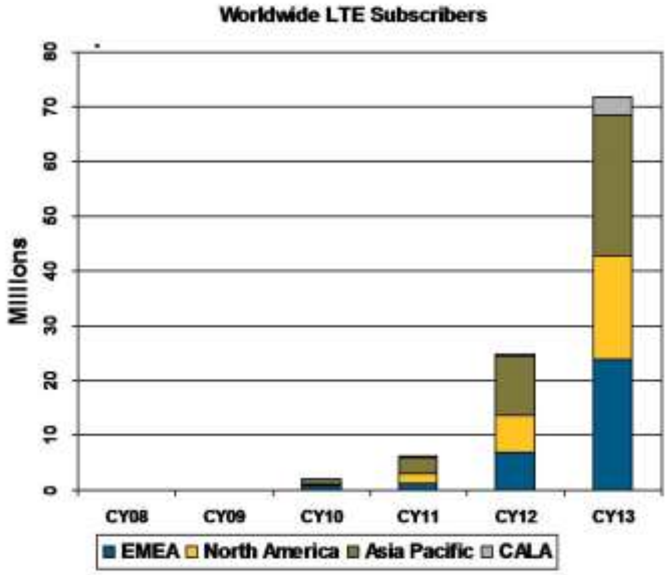


Figure 5. Worldwide LTE Subscribers (Source: Infonetics, *Infrastructure and Subscribers*, April 2009)

Technical deployments of LTE are expected in the last half of 2009 and commercial offerings are expected between 2010 and 2012.

The Global Mobile Suppliers Association (GSA) conducted a study of LTE commitments worldwide. The study was released on August 26, 2009. The study shows growing support and commitment to LTE as the next broadband technology. Verizon Wireless and NTT Docomo are scheduled to introduce commercial LTE service in the U.S. and Japan, respectively, in 2009-2010 and 2010. In 2010, an additional eleven carriers are expected to launch LTE services in Canada, Japan, Norway, South Korea, Sweden and the U.S. According to the GSA study, it is anticipated that by the end of 2012 at least 31 carriers located in 14 countries will have launched LTE services.

EPS Architecture

Compared to the UMTS and GSM architectures that preceded it, LTE reduces the number of network elements and eliminates the circuit-switched domain. The LTE architecture defines the evolved packet system (EPS) as a combination of the IP-based core network and LTE access system. The EPS consists of the E-UTRAN and the EPC, as illustrated in Figure 6. The EPC is the LTE core network and the E-UTRAN is the LTE access network. The E-UTRAN consists of E-UTRAN Node B (eNode B) network elements.

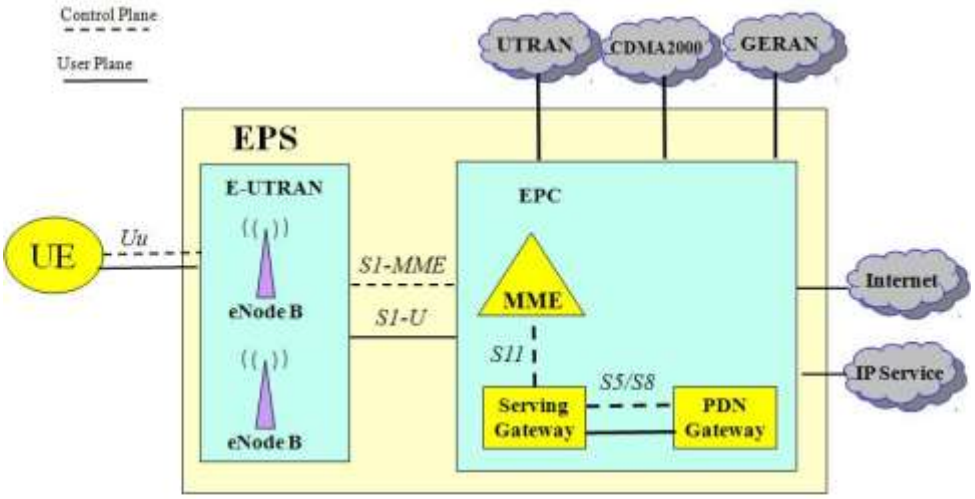


Figure 6. EPS Architecture

The EPC contains the following components:

- Mobility management entity (MME)—terminates control plane signaling between the EPC and the UE as well as between the EPC and the E-UTRAN. The MME also contains bearer management functions and inter-core network mobility to other access networks such as UTRAN (UMTS) and GERAN (GSM) or to other MME.
- Serving gateway (S-GW)—a gateway that terminates the EPC user plane interface towards the E-UTRAN. For each UE associated with the EPS, there is a single S-GW.
- Packet data network (PDN) gateway (PDN-GW)—a gateway that terminates the user plane interface towards a PDN. There is a PDN-GW for each PDN accessed by the UE. The eNode B is a much more complex network element than its counterparts, the Node B in UMTS and the BTS in GSM, as it operates without a central controller (RNC or BSC). The

functions of the central controller is performed by the eNode B itself in LTE, elevating the critical role of the base station in the LTE architecture.

An eNode B interconnects with other eNode Bs over the X2 interface and to the EPC over the S1 interface. The S1 interface is composed of the S1-MME control plane interface to the MME and the S1-U user plane interface to the S-GW. The Uu interface defines the radio interface between the eNode B and the user equipment (UE).

In the EPC the S5 (non-roaming) or S8 (roaming) reference point lies between S-GW and PDN-GW. The S11 interface reference point is defined between MME and S-GW.

QoS Control in the EPS

The units of QoS control in the EPS are the EPS bearer between the PDN-GW (sometimes denoted as P-GW) and the UE, and the E-UTRAN radio access bearer (E-RAB) between the S-GW and the UE. Each packet flow mapped to the same EPS bearer receives identical bearer-level packet forwarding treatment and is assigned the same QoS class. Provisioning of different packet forwarding treatments to different packet flows requires the establishment of separate bearers.

Each QoS class and UE IP address combination requires a separate bearer, and each UE IP address is associated with a single access point name (APN). The APN is a reference used to identify a PDN to which the UE may connect. The APN itself is a name that may be used in a DSN query to resolve the IP address of the appropriate PDN-GW. One bearer, known as the default bearer, remains established throughout the lifetime of the PDN connection. Additional EPS bearers, known as dedicated bearers, may be established to the same APN, but with different QoS classes, and are also associated with the same UE IP address. A single UE may connect to multiple APNs and hence may be assigned multiple UE IP addresses.

The indicator of QoS class throughout the EPS is the QoS Class Indicator (QCI). The QCI is a scalar that is associated to each individual bearer assigned to a UE. It establishes, for each network node, the QoS parameters and forwarding handling of the packets within each data flow. The delay budget, packet error loss rate and priority are all characteristics of a flow derived from the QCI associated bearer carrying the data flow. The 3GPP has defined the specific set of supported QCIs, and this QoS classes to be used in the EPS. These QCI values are shown in the following table.

Table 2. Standard QCI values

QCI	Resource Type	Priority	Packet Delay Budget	Packet Error Loss Rate	Example Services
1	GBR	2	100 ms	10-2	Conversational Voice
2		4	150 ms	10-3	Conversational Video (Live Streaming)
3		3	50 ms	10-3	Real Time Gaming
4		5	300 ms	10-6	Non-Conversational Video (Buffered Streaming)
5	Non-GBR	1	100 ms	10-6	IMS Signaling
6		6	300 ms	10-6	Video (Buffered Streaming) TCP-based (For example, www, e-mail, chat, ftp, p2p file sharing, progressive video, and so on.)
7		7	100 ms	10-3	Voice, Video (Live Streaming) Interactive Gaming
8		8	300 ms	10-6	Video (Buffered Streaming) TCP-based (For example, www, e-mail, chat, ftp, p2p file sharing, progressive video, and so on.
9		9			

The EPS supports the following types of bearer:

- guaranteed bit rate (GBR)
- non-guaranteed bit rate (non-GBR)

A GBR bearer is permanently assigned network resources at the time of its establishment or modification by the admission control functions resident in the EPS, for example the eNode B. If the traffic carried over a GBR bearer conforms to the QoS assigned to it, congestion related packet losses are expected to be rare. Congestion related packet loss on a non-GBR bearer, however, would not be unexpected.

Nodes Overview

eNodeB

eNode B functions are summarized below:

- Radio resource management, including the following:
    - Radio bearer control
    - Radio admission control
    - Connection mobility control
    - Scheduling of uplink and downlink radio resources
- Data stream compression and encryption
- MME selection from an MME pool when the UE registers with the EPS
- Routing of user plane data to the assigned S-GW
- Scheduling and transmission of paging messages over the radio interface
- Scheduling and transmission of broadcast information over the radio interface
- Scheduling and transmission of earthquake and tsunami information (ETWS) over the radio interface
- Configuration of measurement reporting by the UE for mobility and scheduling
- Measurement of uplink radio signals

MME

The MME is a control entity that acts as the entry point into the EPC from the eNodeB. Only control plane interfaces and protocols are handled by the MME. It is responsible for:

- NAS signaling and security
- Signaling for iRAT handovers between LTE and 3G (via S3 the interface)
- Reaching the UE when the UE is in IDLE state
- Tracking area list management
- SGW and PGW selection
- Authentication and authorization
- Bearer management, including dedicated bearer establishment
- Lawful intercept

SGW

The Serving Gateway (SGW) is the termination of the user plane interface between the eNodeB and the EPC, as well as a control plane entity towards the MME. It handles both control plane and user plane functions. At any point in time, there is only one SGW serving one specific UE. The SGW is responsible for:

- User plane packet routing and forwarding
- Mobility anchor for inter-eNodeB handovers, as well as iRAT handovers between 3GPP networks
- Accounting for inter-operator charging

The SGW is sometimes incorporated with the PGW into one unit.

PGW

The Packet Data Network (PDN) Gateway (PDN-GW, or PGW) is the gateway between the EPC and the packet data network (PDN). All packets from the PDN destined towards UEs are routed by the PGW, and all packets from the UE are routed to the PDN by the PGW.

The PGW is responsible for:

- User plane packet routing and forwarding
- UE IP address allocation
- Per UE based packet filtering (DPI)
- Accounting for charging, including UL and DL service level charging
- UL and DL service level gating control and rate enforcement

PCRF

The policy and charging rules function (PCRF) is responsible for all policy in the EPS. For all UEs, it is responsible for dynamically installing policy rules in the PGW that determine the QoS and charging that is applied to all services for the UEs. These rules govern the parameters like maximum allowed bandwidth per bearer and per APN for the UE, as well as guide the charging of the services. The PGW is actually responsible for the policing of the rules, but the rules themselves areprovided by the PCRF. Examples of policy rules are the allowed bandwidth over a bearer, the allocation of a dedicated bearer for a specific service to provide better QoS, The PCRF connects to the PGW using the Gx interface, and the Diameter protocol.

HSS

The HSS maintains the subscriber database. It is a stateful database, in the sense that when a UE is attached to the network and active, the HSS knows its state and location. It is also responsible for the authentication of the UEs. The HSS connects to the MME using the S6a interface, and uses the Diameter protocol.

OCS and OFCS

LTE charging is handled by the OCS and OFCS functions. The OFCS is responsible for offline charging, which is typically used for post-paid subscribers. The OCS is responsible for the online charging, which is used for pre-paid subscribers.

For offline charging, the SGW and PGW provide charging information to the OFCS based on the charging rules provided by the PCRF. These charging records can be based on volume of data, time using the service, and even other parameters like time of day and location. The OFCS then collects this charging information and creates charging records for each subscriber, which is forwarded to the billing service.

For online charging, operation is a little different. The PGW requests the OCS for credits as the subscriber performs actions. The OCS is aware of the subscriber’s credit. At a certain time, if the credit runs out, then the OCS responds negatively, and the service is then interrupted. Therefore, the OCS has a more real time focus to it than the OFCS.

Both the OCS and OFCS communicate with the EPC using the Diameter protocol.

SGSN

The SGSN provides 3G connectivity into the EPC. It provides control plane and user plane functionality, and therefore also implements packet routing and forwarding. The SGSN existed in the 3G UMTS system, and used to forward packets to/from the GGSN. Now, in LTE, it communicates to the SGW via the S4 interface.

Concepts

Session creation and deletion

When a UE attaches to the LTE network (that is, it registers for service), a session is created. This session has an end to end meaning, in the sense that bearers are created over the air interface and throughout the EPS network. For EPC, it means that a default bearer (at a minimum) is created and maintained. This default bearer translates into a GTP-U tunnel. The main goal of a session is to provide IP connectivity to the UE, so during this procedure, an IP address is allocated to the UE.

For each APN connection that a UE establishes, a new session is created, and therefore a new default bearer. For each independent session, a distinct IP address is allocated to the UE.

When a UE detaches from an APN connection, or powers off, the sessions are deleted, and no IP connectivity is present.

TAU

A tracking area update (TAU) is a signaling (control plane) procedure that informs the network of the location of the UE. It can be triggered by a number of events, but is typically done when the UE moves from one tracking area to another one.

Idle and connected states

Typically, a UE is in connected state. It means that all bearers belonging to the UE are up and active, from end to end. However, if the UE has no activity for a certain duration of time, the network may put the UE in idle state. In idle state, the UE’s bearers are taken down over the air interface, as well as the bearers on the S1-U interface. However, even when in idle state, the S5/S8 bearers for the UEs remain active. Also, the UE keeps the allocated IP address during idle state.

Paging

When a UE is in connected state, any downlink (DL) packet destined to the UE is simply forwarded to it. However, if the UE is in idle state, the UE has no immediate IP connectivity because of the absent bearers on the air interface and the S1-U interface. In this case, a downlink packet destined for an idle state UE is buffered by the SGW, while the SGW invokes the paging procedure. The paging procedure has the goal of locating and informing the UE, and instructing it to transition to connected state, and re-establish all bearers. Once the UE is in connected state, the downlink packets buffered by the SGW can be forwarded to the UE.

Default and Dedicated bearers

A default bearer is created for each session. Each attached UE has at least one default bearer, but has one default bearer for each APN connection. A default bearer has a QoS setting which is best effort. A UE can also have one or more dedicated bearers. Dedicated bearers are separate bearers that are characterized by a higher QoS. A specific QCI value (see table 2 above) is associated to the dedicated bearer, as well as values for average bandwidth and maximum bandwidth. Some dedicated bearers can also have a guaranteed bit rate. The goal is to deliver a better quality of experience for a specific service to a UE. The policy rules from the PCRF determine the allocation of a dedicated bearer to a UE, and are therefore under full control of the network operator. Examples of a service that would use a dedicated bearer is a video service offered by the operator and VoLTE. Dedicated bearers allow the operator to differentiate the service using QoS.

Dual stack

Connections to a PDN are normally IPv4 or IPv6. However, some PDNs support both IPv4 and IPv6. These PDNs are considered dual IP. When a UE connects to a dual IP PDN, it can obtain an IPv4 address and an IPv6 address, both of which can be used simultaneously. A UE that supports this ability is called a dual stack UE, which is also referred to as IPv4v6.

Multi-APN

Multi-APN refers to the capability of a UE to connect to multiple PDNs simultaneously. Each PDN is identified by the APN. Typically, subscribers are allocated a connection to the internet access APN, but VoLTE is implemented using a separate PDN (and therefore APN). A UE that can connect to both networks simultaneously supports multi-APN.

Handovers

A handover is the procedure where a UE’s air interface connection to the LTE network is transferred from one cell to another. The most common trigger for a handover is the fact that a UE moves in such a way as to degrade the radio connection being used. The UE scans other cells with a better radio connection, and then the network hands it over to the new cell.

S1 Interface Protocol Stacks

The S1 user plane interface (S1-U) is defined between the eNode B and the S-GW and provides non-guaranteed delivery of user plane PDUs between the two network elements. The user plane protocol stack is shown in Figure 7 and consists of the GPRS tunneling protocol user (GTP-U), UDP and IP protocols.

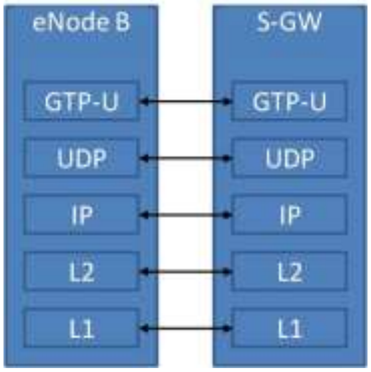


Figure 7. **S1-U Interface Protocol Stack**

The S1 control plane interface (S1-MME) is defined between the eNode B and the MME. The S1 application protocol (S1-AP) is transported over the SCTP protocol, which runs over the IP protocol and provides reliable transport.

The S1-MME protocol stack is shown in Figure 8. The S1-AP protocol transports NAS messages between the UE and the EPC over the S1-MME interface.

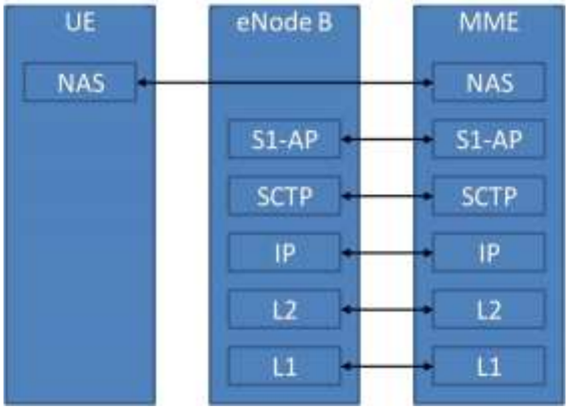


Figure 8. **S1-MME Protocol Stack**

S11 interface

E-UTRAN Mobility

Handover is a procedure handled by E-UTRAN that maintains a call while a user transitions from one cell to another. Handovers generally occur when the UE is near the edge of coverage and a failed handover often results in a dropped call. LTE only supports a very fast break-before-make hard handover procedure. In a break-before-make handover, the UE only has connectivity to a single cell at a time. The soft and softer make-before-break handover procedures used in UMTS systems are eliminated in LTE to simplify the procedures and reduce the need for extra radio and backhaul resources. LTE introduces the X2 interface that provides connectivity between source and target base stations during an intra-E-UTRAN handover. Introduction of the X2 interface reduces load on the EPC and makes the handover procedure faster, reducing the likelihood of failure.

Handover procedures are defined for UEs in the ECM-CONNECTED state. Several types of handover procedures are defined by LTE:

- Intra-eNode B handover between sectors of the same eNode B.
- Inter-eNode B handover between eNode Bs:
  - With MME relocation.
  - Without MME relocation, but with S-GW relocation.
  - With neither MME relocation nor S-GW relocation.
- E-UTRAN to UTRAN inter-radio access technology (inter-RAT) handover.
- UTRAN to E-UTRAN inter-RAT handover.
- E-UTRAN to GSM EDGE radio access network (GERAN) A/Gb mode inter-RAT handover.
- GERAN A/Gb mode to E-UTRAN inter-RAT handover.
- E-UTRAN to high rate packet data (HRPD) inter-RAT handover.
- E-UTRAN to cdma2000 1xRTT inter-RAT handover.

The inter-eNode B handover without MME and S-GW relocation is shown in Figure 9. The case illustrated assumes that IP connectivity is present between the S-GW and both source and target eNode Bs and also requires the presence of the X2 reference point between the eNode Bs. Part of the handover command information comes from the target eNode B and is passed to the UE by the source eNode B, which passes all information necessary to complete the handover to the UE. The UE then accesses the target eNode B using a contention-free RACH procedure, if a dedicated RACH preamble is available. During the execution of the handover procedure, user plane packets are forwarded from the source eNode B to the target eNode B. When the UE has connected to the target eNode B, downlink data that has been forwarded to the target eNode B is delivered to the UE.

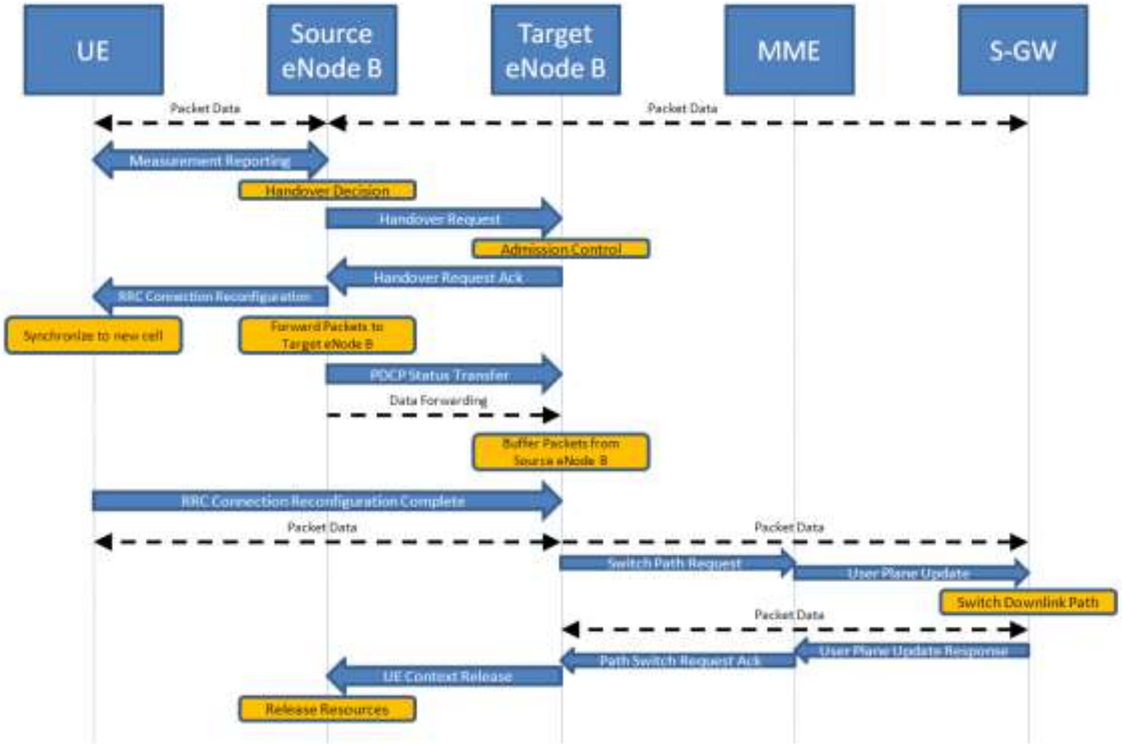


Figure 9. Inter eNode B Handover without MME Rel

EPC Testing Challenges

There are multiple dimensions that are important to test in the EPC. The EPC was designed to handle very large amounts of subscribers moving massive amounts of data. The most important aspects of EPC testing are listed below.

Subscribers

UMTS and HSPA technologies, in conjunction with the development of popular devices that take advantage of the possibilities of wireless data, have led to a rapidly increasing adoption of smartphones and wireless data usage. The worldwide amount of subscribers is growing at a much faster pace than new voice subscribers are. This growth will increase further with the impending deployment of LTE. The trend leads to a core network that must now handle vast amounts of subscribers simultaneously connected to the network. Current testing requirements range from 1 million to 7 million, for one single PDN-GW node. Loading subscribers is one of the most important testing aspects for the core network.

eNodeBs and MMEs

In addition to being able to handle vast amounts of subscribers, the EPC must also support a large amount of radio access network elements to allow for a large scale deployment economically. For LTE especially, NEMs have placed a high importance on being able to support very high counts of MMEs and eNode Bs connected and managed by the same EPC.

Data Throughput

The trend of increasing data adoption not only leads to higher amounts of subscribers, but it also leads to those subscribers using the data services much more than in the past. Furthermore, the applications enabled by ever increasing data rates coupled with fixed pricing models for data usage have encouraged subscribers to use their data plans much more freely. Video over a 3G connection is now commonplace. Current requirements for EPC testing range from 40 Gbps to over 120 Gbps.

Control Plane Load

In addition to the data plane load that the EPC is required to handle, it must also be able to accept all the control plane procedures that allow the data plane to be established, mobility events, QoS changes, and so on. The control plane load rate is critical dimension in all EPC test cases.

Small Packet Sizes

The average packet size in the EPC is approximately 600 octets, because of the nature of the required traffic models in a mobile environment. While testing for throughput objectives using larger packet sizes has value, it is necessary to be able to handle smaller packet sizes, striving to achieve the same throughput values. This means that very high packet/second rate handling by the EPC nodes is expected, and must be tested. Sizes as low as 128 octets have been requested.

Realistic Traffic Models

The subscriber usage patterns witnessed in the field vary depending on the sophistication of the user, the applications used and the devices. For example, browsing the internet on a mobile device results is very different core network activity compared to watching a video. Web browsers typically download a page of about 250KB in size, pause a minute to read it, and then download another page. A video user generates a relatively constant stream of data to be handled quite differently. An EPC system test plan is not complete without a realistic usage, time and application model of the traffic. Configuring this into a test therefore becomes a critical ability and challenge for the test tool.

Deep Packet Inspection (DPI)

There are two levels of DPI that are tested in the EPC.

The first level is part of the 3GPP specifications for traffic handling: when dedicated bearers are used in the EPC, multiple traffic flows coming from and destined to the UE must be mapped onto the appropriate GTP-U bearers that are assigned to the UE. For example, suppose that a UE has two service data flows (SDFs): http and video on demand. Additionally, network policy has allowed this UE to establish a dedicated bearer for the video traffic. In the downlink direction (from network to UE), the PDN-GW must differentiate between both traffic types to map the http traffic to the default bearer, and map the video traffic to the dedicated bearer. This activity is done using DPI technology to recognize the traffic and map it correctly.

The second DPI application is the ability to manage the network traffic and perform policing on traffic types. This, and other related features are offered by the NEMs to the service providers as differentiated features of the EPC equipment. These features are very important, because traffic management is vital in a wireless environment, given the limited spectrum available. The DPI functionality developed by EPC manufacturers is quite sophisticated, and imposes very large requirements on the test equipment, mainly dealing with the ability to simulate vast amounts of different stateful applications, to large amounts of TCP connections.

Combined Objectives

The last category of test case, and the most challenging to support, consists of test cases that combine the objectives listed above into one massive test case. For example, the EPC must not only handle 60 Gbps of throughput, or 1 million subscribers, or 5000 GTP-C transactions/second. It must also support all of these dimensions at the same time: the throughput, the subscribers, and the control plane activity, at the same time. These types of tests take on an infinite number of personalities, because the combinations are endless.

EPC Test Cases

The EPC test cases are run using IxLoad. IxLoad surrounds the system under test, which consists of the SGW and PDN-GW, as shown in Figure 10. Optionally, a PCRF (Policy and Charging Rules Function) may be part of the system under test.

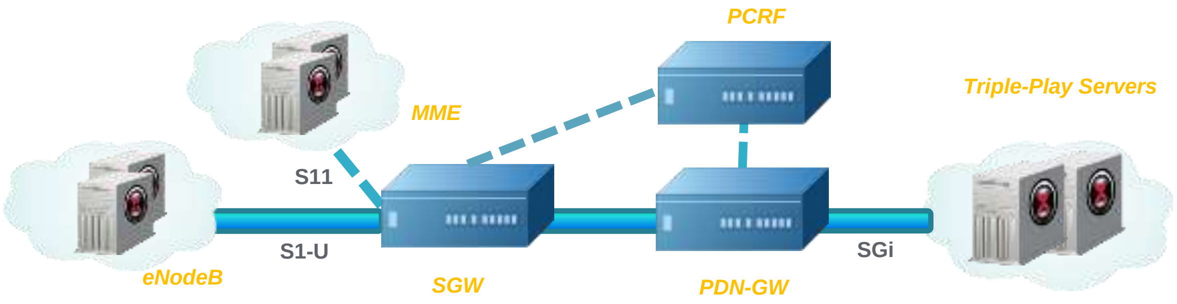


Figure 10. EPC test configuration

IxLoad simulates the MME using the GTP-C protocol on the S11 interface, and the eNodeB using the GTP-U protocol on the S1-U interface. The layer 7 traffic generated by IxLoad uses the S1-U interface, where the traffic is encapsulated in GTP-U bearers. On the right side of the network under test, using the SGi interface, IxLoad also simulates the network servers and peers. This interface does not use special wireless protocols, but rather uses straight UDP and TCP/IP.

EPC Test Case: Throughput Test with High Control Plane (Signaling) Traffic

Overview

The test case performs a dual objective: simulating high throughput while also having high control plane activity. GTP-c transactions represent the control plane activity for the S1-U/S11 interfaces. More precisely, the GTP-c acts on the S11 interface, between the MME and the SGW.

The control plane activity is simulated by having some of the subscribers constantly establishing sessions, performing a short user plane activity (http GET, in this case), and then terminating the session. These subscribers repeat this procedure constantly for the duration of the test.

The bulk of the throughput is simulated by the other group of subscribers, which is configured to establish a session, and perform continuous http GETs without terminating the session. They establish a session at the beginning of the test, and then maintain the same session for the duration of the test.

The reason for separating the subscribers like this is to optimize the usage of the port CPUs of the load modules. The subscribers performing high control plane activity are assigned to a group of port CPUs, while the other group of subscribers is assigned to another group of port CPUs.

By allowing the port CPUs to concentrate on either the throughput or control plane activity exclusively, the power of the CPUs is optimized for maximum traffic.

Objective

The test case is a system test case that has the dual objective of simultaneously generating high throughout user plane data and control plane activity.

Setup

The test case is set up as follows:

- 8 MME + eNodeB pairs, one per port CPU, with 1000 subscribers per pair each generating high throughput http traffic. These subscribers provide the high throughput part of the test.
- 4 MME + eNodeB pairs, one per port CPU, with 5000 subscribers per pair each subscriber establishing a session, downloading a small web page, and deleting the session repeatedly. These subscribers generate the high control plane traffic for the test. The lifetime feature is used to accomplish this setup.
- Multiple configuration parameters depend on the network under test, such as IP addresses for the MMEs and UEs, UE identifier parameters like IMSI and MSISDN, networking parameters, and so on. These parameters are typically obtained by knowing the network configuration.

Step by Step Instructions

1. Insert a new NetTraffic on the server side. Configure it to have a range of 12 IPs, using IP addresses that correspond to the network under test settings.
2. Add an HTTP server activity to the NetTraffic. The default settings can be used.
3. Insert a new NetTraffic on the client side. Select it to configure it, and delete the existing default IP stack by clicking Delete Stack.
4. Add the MME/eNB S11/S1-u stack from the Add Stacks > Wireless menu.

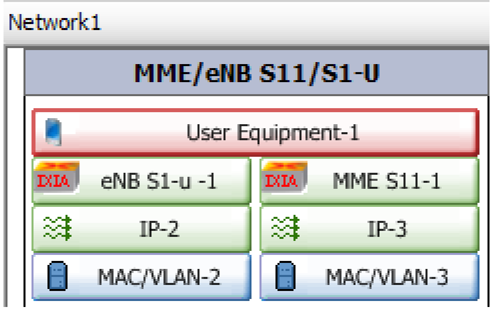
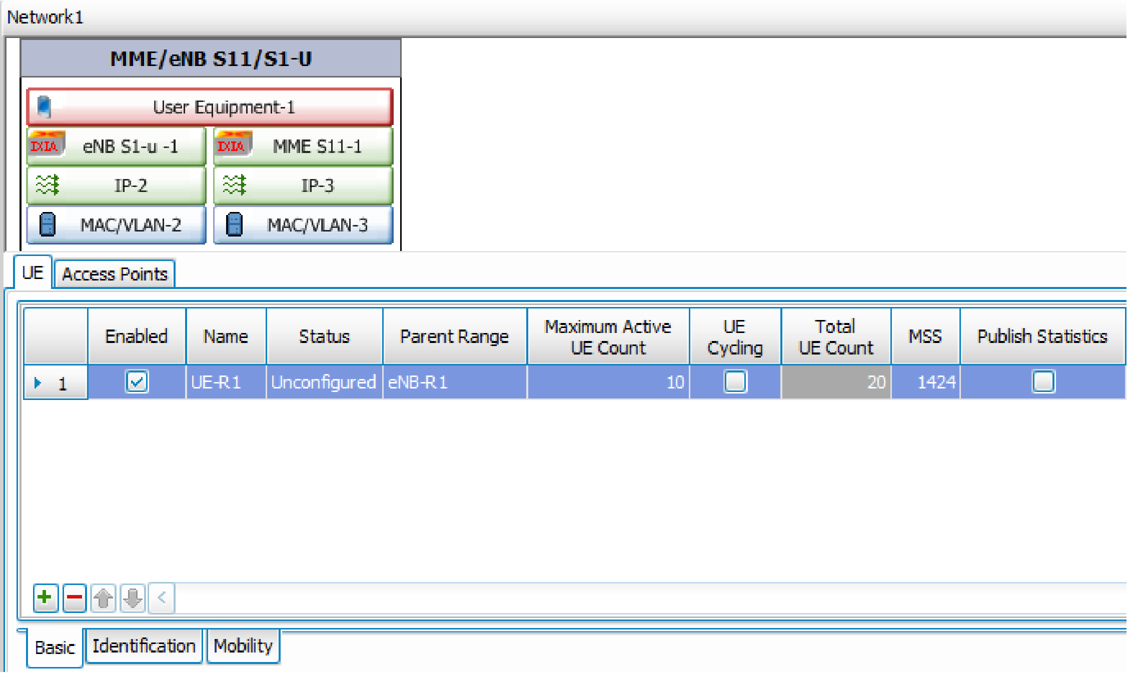


Figure 11. MME/eNB S11/S1-u Stack

5. Select the User Equipment layer to configure the UEs (subscribers) for the test. The UE layer contains two sub-tabs that should be configured as follows:



	Enabled	Name	Status	Parent Range	Maximum Active UE Count	UE Cycling	Total UE Count	MSS	Publish Statistics
1	☑	UE-R1	Unconfigured	eNB-R1	10	☐	20	1424	☐

Figure 12. User Equipment layer

UE Tab

The **UE** tab contains the following additional tabs:

Basic sub-tab:

Configure the Maximum Active UE Count value to match the test variables section.

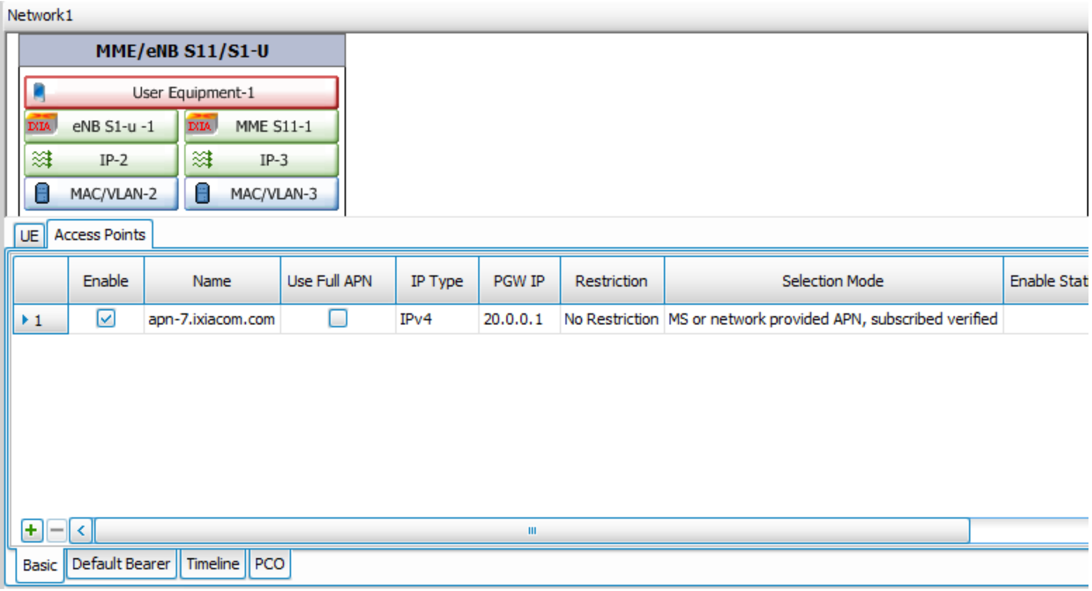
Identification sub-tab:

Configure the appropriate values for IMEI, Software Version, IMSI and MSISDN. These values identify the subscription and equipment, and are usually provided by the customer, and must match the values configured in the system under test.

Mobility sub-tab:

Do not enable mobility for this test.

Access Points tab



	Enable	Name	Use Full APN	IP Type	PGW IP	Restriction	Selection Mode	Enable Stat
1	☑	apn-7.ixiacom.com	☐	IPv4	20.0.0.1	No Restriction	MS or network provided APN, subscribed verified	

Figure 13. Access Points tab

The **Access Points** tab contains the following additional sub-tabs:

Basic sub-tab:

Configure the APN Name and corresponding PGW IP to match the values configured in the system under test. Leave the other values to default values.

Default bearer sub-tab:

The QoS values associated to the default bearer are configured here. Configure the QCI to a value of 8, and leave rest of the values to their default values.

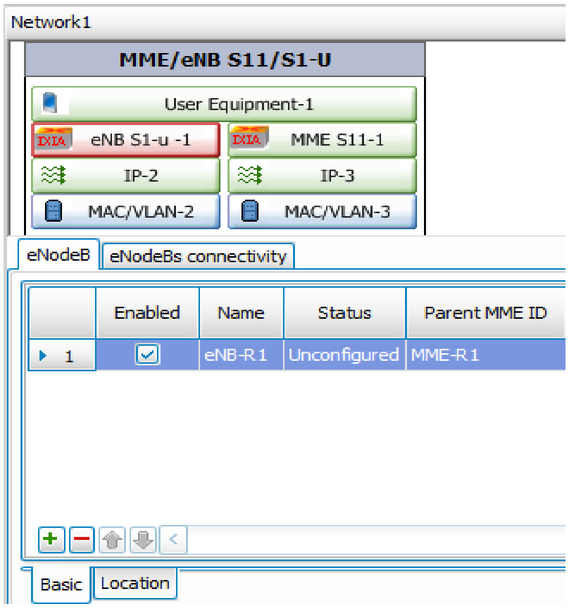
Timeline sub-tab:

In the lifetime configuration, the user can define a precise duration for the subscriber. In this test, lifetime is not used. Leave the values to default values.

PCO sub-tab:

In the PCO configuration, user can enable sending the P-CSCF IP address discovery (IPv4 or IPv6) through PCO IE.

6. Select the **eNB S1-u** layer in the stack to configure the eNodeBs for the test. The e-NodeB layer contains two tabs.



	Enabled	Name	Status	Parent MME ID
1	☑	eNB-R1	Unconfigured	MME-R1

Figure 14. eNB S1-u Basic Tab

E-NodeB Tab

The **E-NodeB** tab contains the following additional sub-tabs:

Basic sub-tab:

No change.

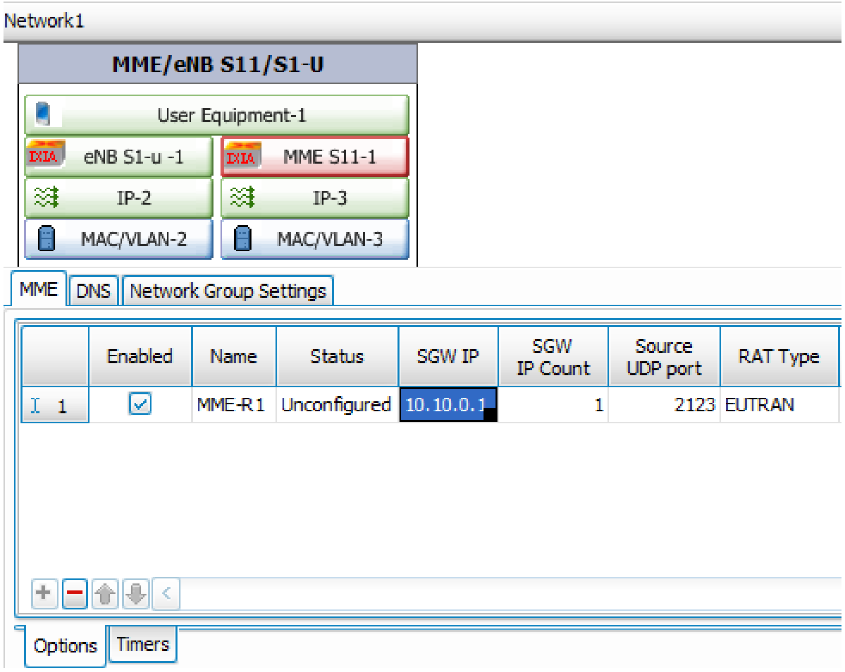
Location sub-tab:

Configure values that match the values from the network under test. The MNC and MCC values are typically selected to match the network's values exactly. The Location Area Code, Routing Area Code, Service Area Code, Tracking Area Code and EUTRAN Cell Identifier values must match values configured in the network under test for the simulated Radio Access Network (RAN).

ENodeBs Connectivity Tab

This tab allows the configuration of the presence/absence of X2 interfaces between eNodeBs. No change is necessary.

7. Select the MME S11 layer to configure the MMEs for the test. This layer contains two sub-tabs that should be configured as follows:



	Enabled	Name	Status	SGW IP	SGW IP Count	Source UDP port	RAT Type
1	☑	MME-R1	Unconfigured	10.10.0.1	1	2123	EUTRAN

Figure 15. MME S11 layer

MME Tab

The **MME** tab contains 2 additional sub-tabs:

Options sub-tab:

Configure the SGW IP address. This is the main IP address to be used for all initial control plane messages destined to the SGW. The SGW may change this IP address during the course of the session signaling, but that is handled by IxLoad dynamically. Multiple IPs are supported, so if this is required by the configuration, increase the Count value to the appropriate value. Typically, this is left to 1. The UDP source port to be used by the MME for the GTP-c signaling can be configured using the Source UDP Port column. Configure the RAT Type column (Radio Access Technology) to EUTRAN, because this is an LTE test.

Timers sub-tab:

These are the GTP protocol timers and counters, which are set to the default values. There is no need to modify them.

DNS Tab

Configure the DNS settings, if needed. This is required in topologies where SGW and PGW IP addresses are resolved by using DNS NAPTR queries.

Network Group Settings tab:

No changes are needed.

8. Select the **IP layer** in the eNB S1-u stack. This IP layer corresponds to the eNodeBs for the test. For each range defined in the eNodeB settings, there is a corresponding range

automatically defined in the IP layer. Configure the appropriate IP range of eNodeBs corresponding to the configuration of the network under test. Configure the **Count** to a value of **8**.

9. Select the IP layer in the MME stack. This IP layer corresponds to the MMEs for the test. For each range defined in the MME settings, there is a corresponding range automatically defined in the IP layer. Configure the appropriate IP range of MME corresponding to the configuration of the network under test. Configure the Count to a value of 8.
10. Click the Settings button for the network plugin. Configure the Interface Behavior selection to be Create interface with user, and select the Teardown interface with user checkbox. This action enables dynamic control plane mode.

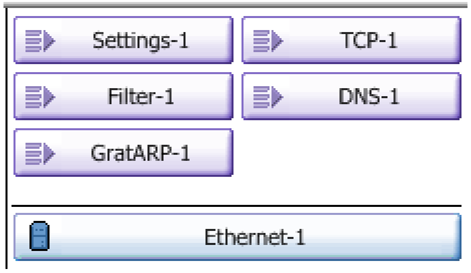
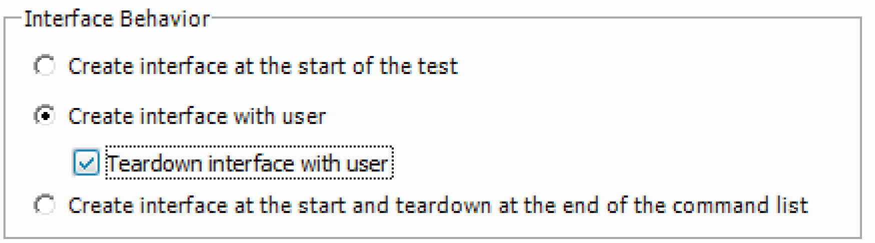


Figure 16. **Settings Button**


Interface Behavior

○ Create interface at the start of the test

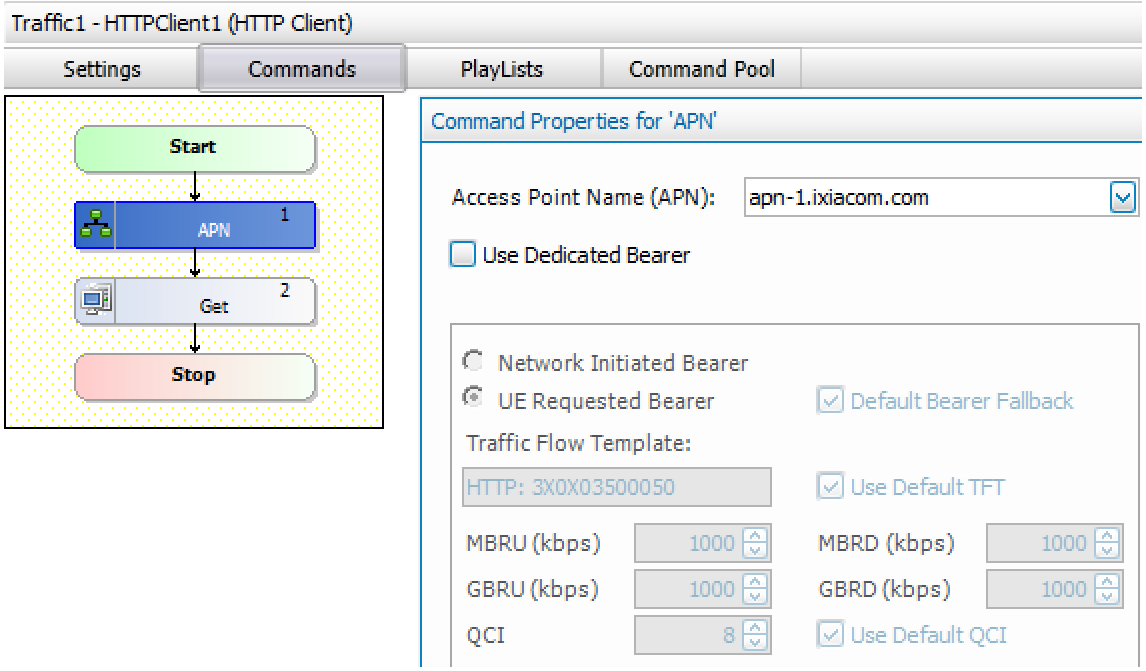
● Create interface with user

☑ Teardown interface with user

○ Create interface at the start and teardown at the end of the command list

Figure 17. **Interface Behavior**

11. Add an HTTP client activity to the NetTraffic. Configure it to have the previously configured HTTP server as a target. Configure one command in the command list: GET the 1024k.html file.
12. Click the Commands tab of the HTTP activity, and select the **APN** command. Make sure to clear the **Use Dedicated Bearer** checkbox. This action causes the http activity to run on the default bearer for each UE.


Traffic1 - HTTPClient1 (HTTP Client)
Settings
Commands
PlayLists
Command Pool
Start
APN
1
Get
2
Stop
Command Properties for 'APN'

Access Point Name (APN): apn-1.ixiacom.com

☐ Use Dedicated Bearer

○ Network Initiated Bearer

● UE Requested Bearer

☑ Default Bearer Fallback

Traffic Flow Template: HTTP: 3X0X03500050

☑ Use Default TFT

MBRU (kbps) 1000

MBRD (kbps) 1000

GBRU (kbps) 1000

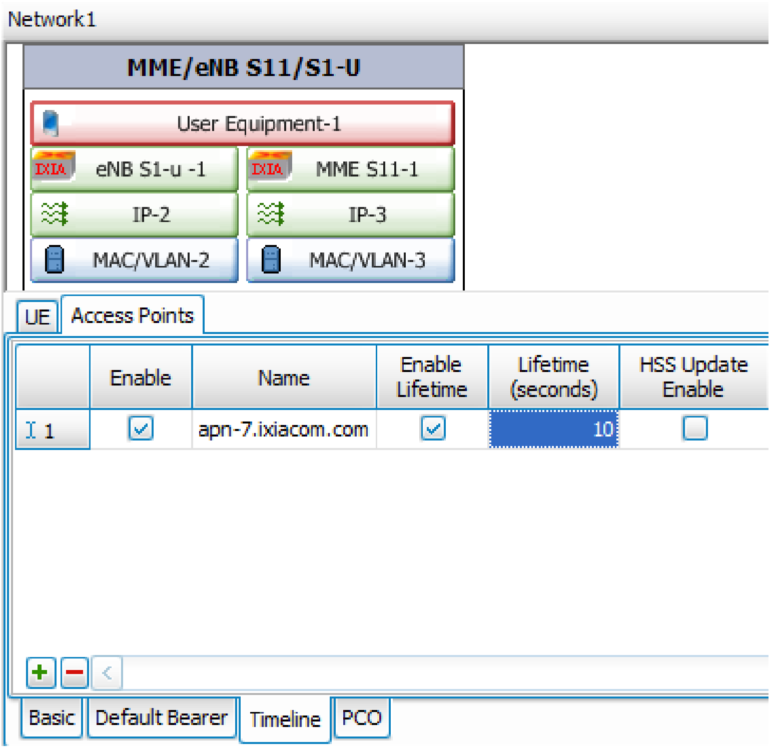
GBRD (kbps) 1000

QCI 8

☑ Use Default QCI

Figure 18. APN command

13. Add a new NetTraffic on the client side. This is the NetTraffic and subscribers responsible for the high control plane traffic. Follow the steps outlined above to configure it to have a range of 4 MMEs and 4 eNodeBs, one range of 20K Ues. Different values for the UE identifiers must be defined, as configured in the network under test.
14. Modify parameters in the User Equipment layer > Access Points > Timeline sub-tab. Select the **Enable Lifetime** checkbox, and enter the Lifetime as 10 seconds.



	Enable	Name	Enable Lifetime	Lifetime (seconds)	HSS Update Enable
1	☑	apn-7.ixiacom.com	☑	10	☐

Figure 19. Lifetime option

15. Add an HTTP client activity to the NetTraffic. Connect it to the same server activity. Configure one command: GET 1b.html, and iterate the command list.
16. In the Timelines and Objectives section, select a throughput objective for the HTTP activity on the throughput network, and configure an objective constraint of Simultaneous Users equal to 8000. Set the throughput objective to 9 Gbps. Configure a 60-minute timeline.
17. Select a Simultaneous Users objective for the HTTP activity for high control plane traffic, and set the objective to 20K. Configure 60 minute timeline duration, with a ramp up value of 1500 users/second.
18. In the Port Assignments section, assign the throughput NetTraffic to the first 8 port CPUs of the Acceleron-NP card.
19. Assign the remaining 4 port CPUs to the control plane NetTraffic.
20. Assign the server NetTraffic to the 12 port CPUs of the second Acceleron-NP load module.
21. Enable 10G aggregation mode for both Acceleron-NP load modules.
22. In the Test Options section, select the Network Diagnostics checkbox to enable the GTP statistics.

Test Variables

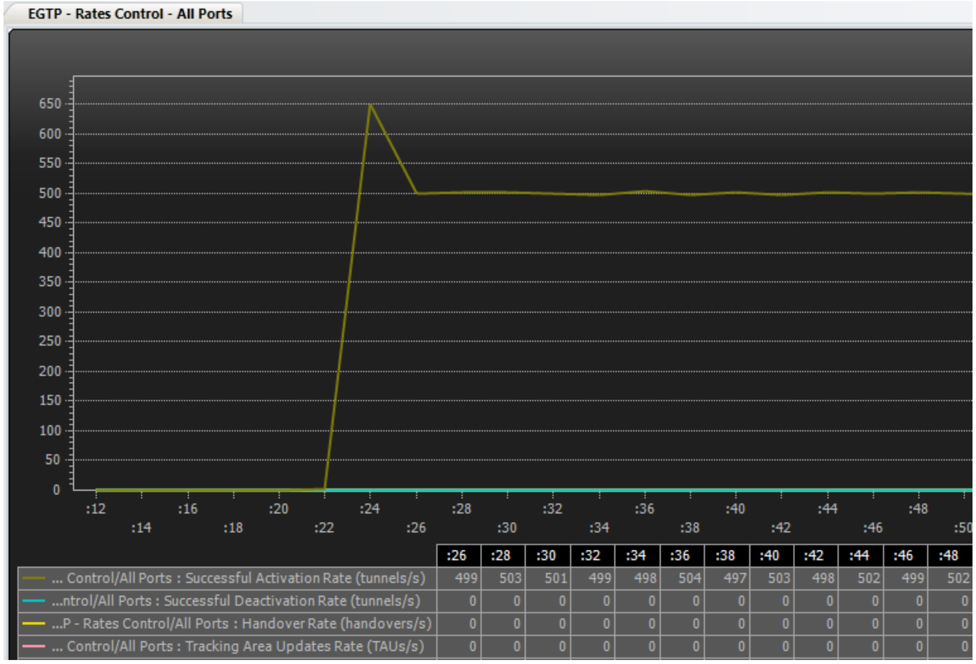
Table 3. Test Variables for Throughput Test with High Control Plane (Signaling) Traffic

Variable	Value
UE Count for throughput network	8000
MME count for throughput network	8
eNodeB count for throughput network	8
UE count for control plane activity network	20000
MME count for throughput network	4
eNodeB count for throughput network	4
Objective for throughput HTTP activity	Throughput = 8 Gbps
Objective for control plane HTTP activity	Simultaneous Users = 20K

Results Analysis

In addition to the normal array of statistics to monitor during this test, the most important are the statistics showing the control plane activity on GTP-C and the HTTP throughput, because they are the objectives of the test.

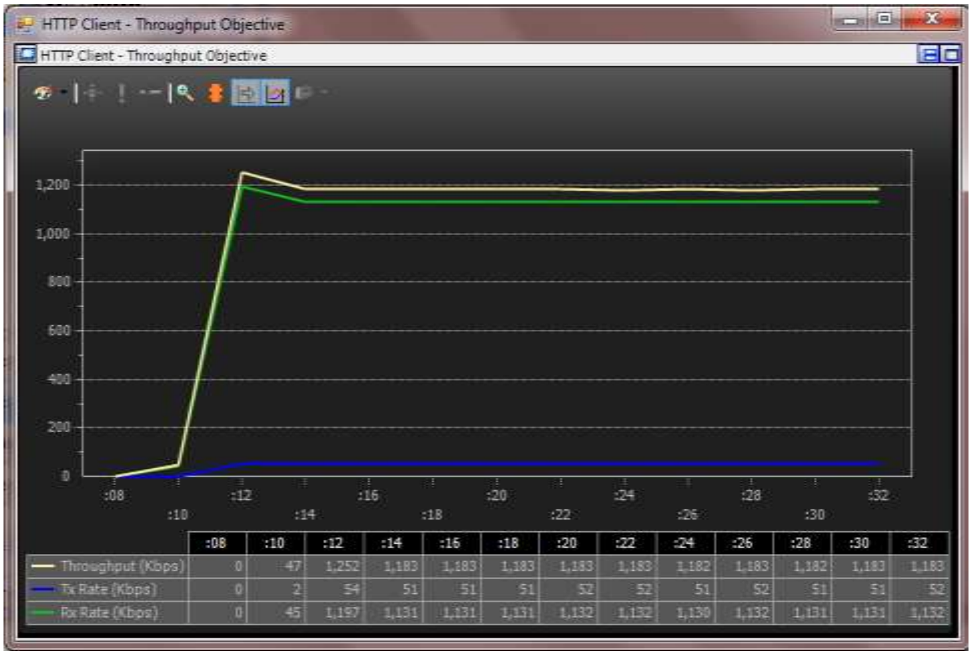
The session activation and deactivation statistics are seen in the *EGTP Rates – All Ports* view, located in the Network folder of the statistics screen. This view clearly shows both the session establishment rate and the session deactivation rate.



	:26	:28	:30	:32	:34	:36	:38	:40	:42	:44	:46	:48
... Control/All Ports : Successful Activation Rate (tunnels/s)	499	503	501	499	498	504	497	503	498	502	499	502
...ntrol/All Ports : Successful Deactivation Rate (tunnels/s)	0	0	0	0	0	0	0	0	0	0	0	0
...P - Rates Control/All Ports : Handover Rate (handovers/s)	0	0	0	0	0	0	0	0	0	0	0	0
... Control/All Ports : Tracking Area Updates Rate (TAUs/s)	0	0	0	0	0	0	0	0	0	0	0	0

Figure 20. Graph of Session Establishment/Termination

The normal *HTTP Throughput* view shows the user plane throughput results for the test.



	:08	:10	:12	:14	:16	:18	:20	:22	:24	:26	:28	:30	:32
Throughput (Kbps)	0	47	1,252	1,183	1,183	1,183	1,183	1,183	1,182	1,183	1,182	1,183	1,183
Tx Rate (Kbps)	0	2	54	51	51	51	52	52	51	52	51	51	52
Rx Rate (Kbps)	0	45	1,197	1,131	1,131	1,131	1,132	1,132	1,130	1,132	1,131	1,131	1,132

Figure 21. Graph of HTTP Throughput

EPC Test Case: Constant BHCA

Overview

This is an EPC test case where the system under test is comprised of the SGW, PGW and possibly the PCRF. The test case is performed using IxLoad by simulating the eNodeBs, MME, and internet servers on the SGi interface. The traffic activity is HTTP.

BHCA is a telephony term meaning Busy Hour Call Attempts. Typical telephony test models incorporate this concept along with a constant call hold time to have a predictable and deterministic test. The amount of active calls at a certain point in time is always constant, given a fixed call hold time, and a fixed BHCA. While this concept does not reflect a practical model when considering data sessions instead of circuit switched voice calls, the requirement to be able to execute this deterministic test still exists.

The formula to follow is as follows:

Simultaneous sessions = BHCA/3600 * SHT

Where SHT = Session Hold Time, and simultaneous sessions refer to the amount of default bearers active at one point in time.

To accomplish this type of test, the time duration of a particular session must be constant, and configurable for the user. The lifetime configuration option of IxLoad is used to accomplish this test.

Objective

The objective of the test case is to provide basic user plane load traffic while maintaining a constant control plane activity and a deterministic amount of sessions being active at a point in time.

Setup

The test case is set up as follows:

- Assign 12 ports of an Acceleron-NP load module as the MMEs/eNodeBs, and assign 12 ports of another Acceleron-NP load module as servers.
- Use 10G aggregation mode.
- Define 12 MME/eNodeB pairs, and use 120K subscribers for the test.

The L7 traffic is itself moderate http traffic, downloading a 100K web page, waiting 10 seconds, and repeating, for each subscriber. The sessions are configured to last 30 seconds, after which the session are deactivated, and a new session are created. This ensures that the constant control plane activity required by the test is achieved. Only default bearers are used for the test.

Step by Step Instructions

1. Insert a new NetTraffic on the server side. Configure it to have a range of **12 IPs**, using IP addresses that correspond to the network under test settings.
2. Add an HTTP server activity to the NetTraffic. Use the default settings.
3. Insert a new NetTraffic on the client side. Select it to configure it, and delete the existing default IP stack by clicking Delete Stack.
4. Add the MME/eNB S11/S1-u stack from the Add Stacks > Wireless menu.

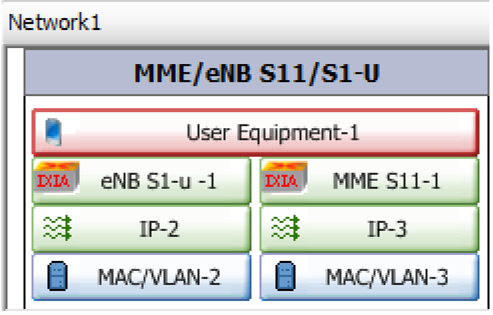
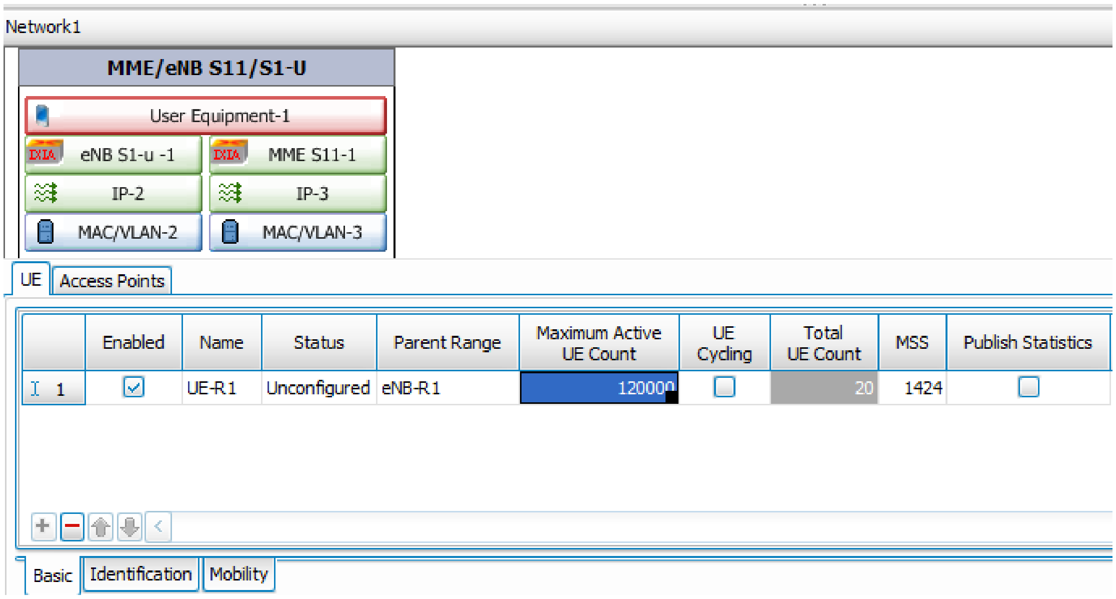


Figure 22. MME/eNB S11/S1-U Stack

5. Click the User Equipment layer to configure the UEs (subscribers) for the test. This layer contains two tabs that are configured as follows:



	Enabled	Name	Status	Parent Range	Maximum Active UE Count	UE Cycling	Total UE Count	MSS	Publish Statistics
1	☑	UE-R1	Unconfigured	eNB-R1	120000	☐	20	1424	☐

Figure 23. User Equipment layer

UE Tab

This tab contains the following additionalsub tabs.

Basic sub-tab:

Configure the Maximum Active UE Count value to match the test variables section.

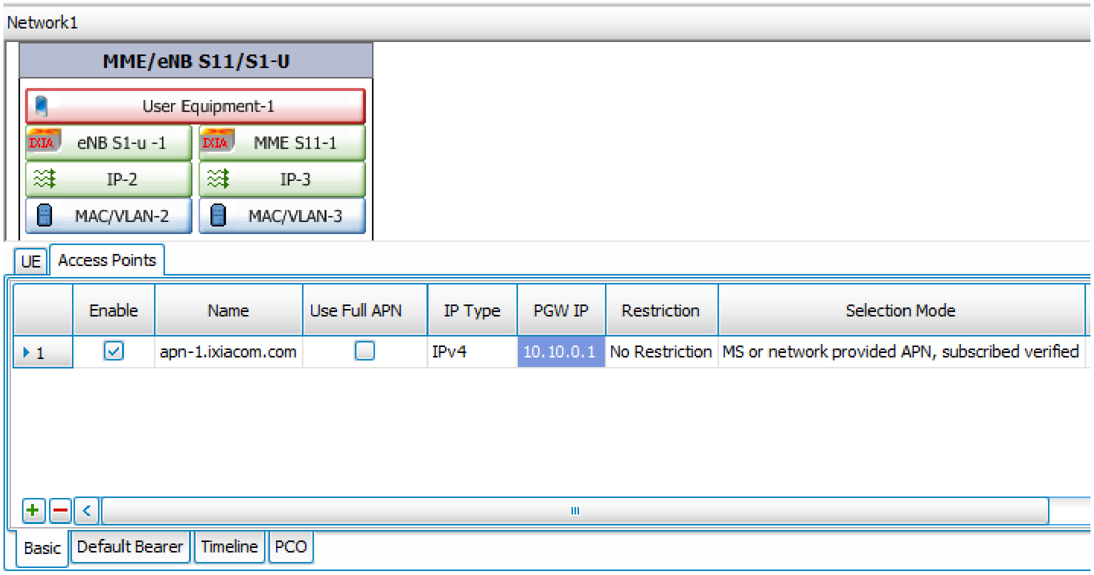
Identification sub-tab:

Configure the appropriate values for IMEI, Software Version, IMSI and MSISDN. These values identify the subscription and equipment, and usually customers provide them. These values must match the values configured in the system under test.

Mobility sub-tab:

Do not enable mobility for this test.

Access Points tab



	Enable	Name	Use Full APN	IP Type	PGW IP	Restriction	Selection Mode
1	☑	apn-1.ixiacom.com	☐	IPv4	10.10.0.1	No Restriction	MS or network provided APN, subscribed verified

Figure 24. Access Points tab

The Access Points tab contains the following additional sub-tabs:

Basic sub-tab:

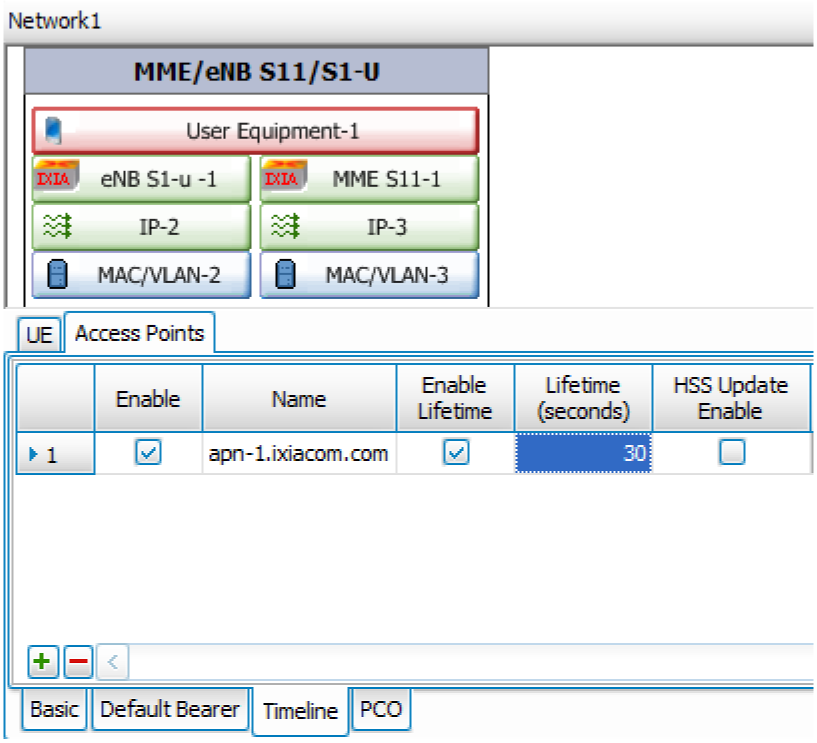
Configure the **APN Name** and corresponding **PGW IP** to match the values configured in the system under test. Leave the other values at default.

Default bearer sub-tab

The QoS values associated to the default bearer are configured here. Configure the QCI to a value of 8, and leave the remaining values to default.

Timeline sub- tab:

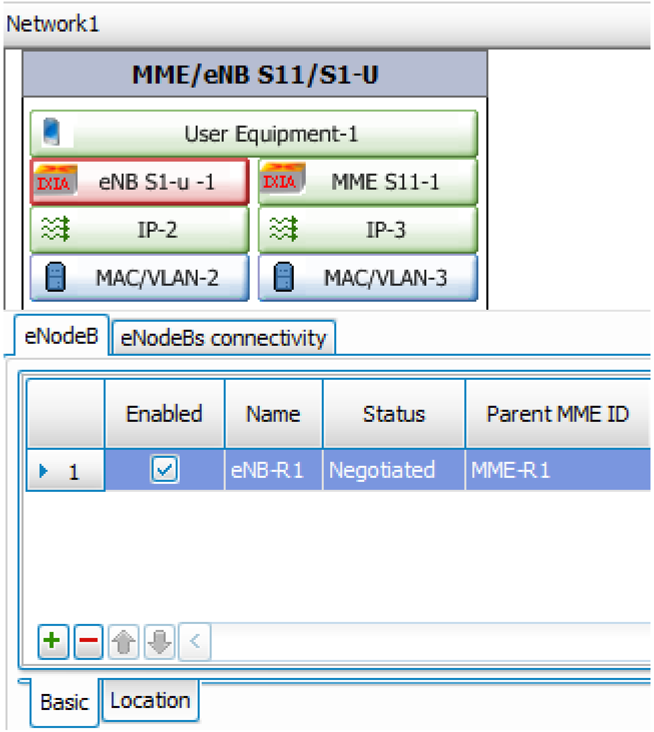
Select the **Enable Lifetime** check box, and set the Lifetime value to 30 seconds. This value causes the default bearer, and therefore the subscriber, to last for exactly 30 seconds, after which the bearer is deleted, and then re-established. This process happens for every iteration of the HTTP command in the list.



	Enable	Name	Enable Lifetime	Lifetime (seconds)	HSS Update Enable
1	☑	apn-1.ixiacom.com	☑	30	☐

Figure 25. Timeline sub-tab

6. Click eNB in the stack to configure the eNodeBs for the test. The eNB layer contains the following tabs:



	Enabled	Name	Status	Parent MME ID
1	☑	eNB-R1	Negotiated	MME-R1

Figure 26. eNodeBBasic Tab

E-NodeB Tab

The E-NodeB tab contains the following additional sub-tabs:

Basic sub-tab:

No change.

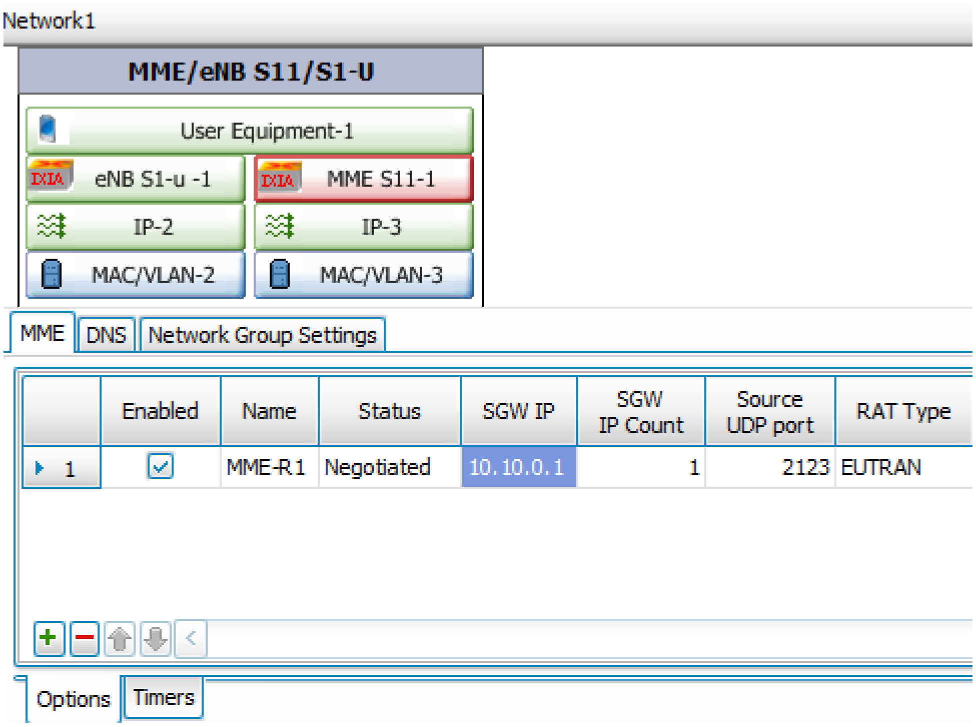
Location sub-tab:

Configure values that match the values from the network under test. The **MNC** and **MCC** values are typically selected to match the network's values exactly. The **Location Area Code**, **Routing Area Code**, **Service Area Code**, **Tracking Area Code** and **EUTRAN Cell Identifier** values must match values configured in the network under test for the simulated Radio Access Network (RAN).

ENodeBs Connectivity Tab

In this tab, the user can configure the presence/absence of X2 interfaces between eNodeBs. No change is necessary.

7. Click MME to configure the MMEs for the test. This layer contains the following additional sub-tabs as shown in the following figure.



	Enabled	Name	Status	SGW IP	SGW IP Count	Source UDP port	RAT Type
1	☑	MME-R1	Negotiated	10.10.0.1	1	2123	EUTRAN

Figure 27. MME layer

MME Tab

The MME tab contains the following additional sub-tabs:

Options sub-tab:

Configure the **SGW IP** addres - the main IP address to be used for all initial control plane messages destined to the SGW. The SGW may change this IP address during the course of the session signaling, but that is handled by IxLoad dynamically. Multiple IPs are supported, so if this is required by the configuration, increase the **Count** value to the appropriate value. Typically, this is left to **1**. Using the Source UDP Port Column, the user can configure the UDP source port to be used by the MME for the GTP-c signalling. Configure the RAT-Type column (Radio Access Technology) to EUTRAN, because this test is an LTE test.

Timers sub-tab:

These timers are the GTP protocol timers and counters, which are set to the default values. There is no need to modify them.

Network Group Settings Tab

No changes are needed.

8. Select the IP layer in the eNB stack. This IP layer corresponds to the eNodeBs for the test. For each range defined in the eNodeB settings, there is a corresponding range automatically defined in the IP layer. Configure the appropriate IP range of eNodeBs corresponding to the configuration of the network under test. Configure the Count to a value of 12.

9. Select the IP layer in the MME stack. This IP layer corresponds to the MMEs for the test. For each range defined in the MME settings, there is a corresponding range automatically defined in the IP layer. Configure the appropriate IP range of MME corresponding to the configuration of the network under test. Confiugre the Count to 12.
10. Click the Settings button for the network plugin. Configure the Interface Behavior selection to Create interface at the start and teardown at the end of the command list. This enables dynamic control plane mode.

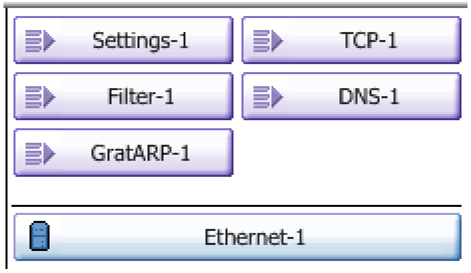
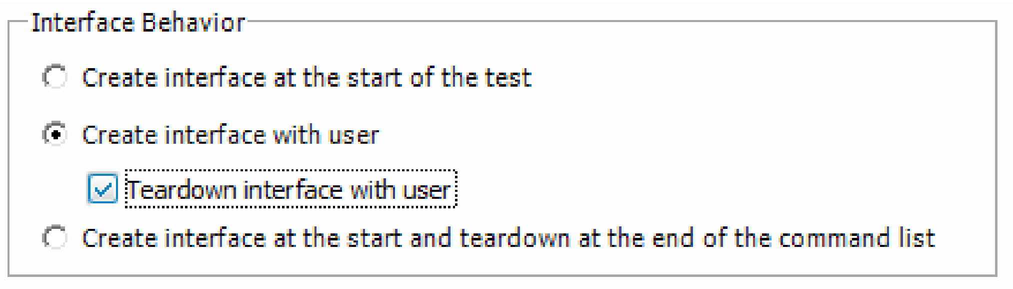


Figure 28. Settings Button


Interface Behavior

○ Create interface at the start of the test

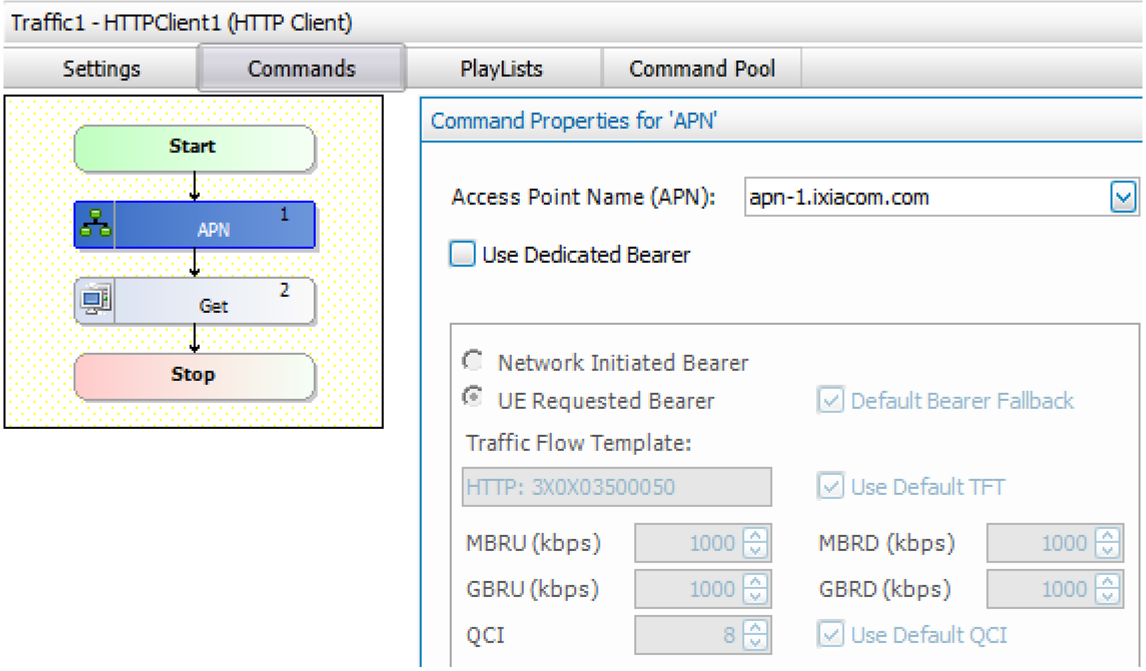
● Create interface with user

☑ Teardown interface with user

○ Create interface at the start and teardown at the end of the command list

Figure 29. Interface Behavior Options

11. Add an HTTP client activity to the NetTraffic. Configure it to have the previously configured HTTP server as a target. Configure two commands in the command list: GET the 128k.html file, and Think for 30s. Make sure the iterate command list is selected.
12. Click the Commands tab of the HTTP activity, and select the APN command. Make sure to select the Use Dedicated Bearer checkbox. This selection causes the http activity to run on the default bearer for each UE.


Traffic1 - HTTPClient1 (HTTP Client)
Settings
Commands
PlayLists
Command Pool
Start
APN
1
Get
2
Stop
Command Properties for 'APN'

Access Point Name (APN): apn-1.ixiacom.com

☐ Use Dedicated Bearer

○ Network Initiated Bearer

● UE Requested Bearer

☑ Default Bearer Fallback

Traffic Flow Template: HTTP: 3X0X03500050

☑ Use Default TFT

MBRU (kbps) 1000

MBRD (kbps) 1000

GBRU (kbps) 1000

GBRD (kbps) 1000

QCI 8

☑ Use Default QCI

Figure 30. APN command

13. In the Timelines and Objectives section, select a Simultaneous Users objective for the HTTP activity. Configure a 60 minute timeline.
14. In the Port Assignments section, assign the client NetTraffic to the 12 port CPUs of the first Acceleron-NP load module.
15. Assign the server NetTraffic to the 12 port CPUs of the second Acceleron-NP load module.
16. Enable 10G aggregation mode for both Acceleron-NP load modules.
17. In the Test Options section, enable the Network Diagnostics check box to enable the GTP statistics.

Test Variables

Table 4. Test Variables for Constant BHCA Test

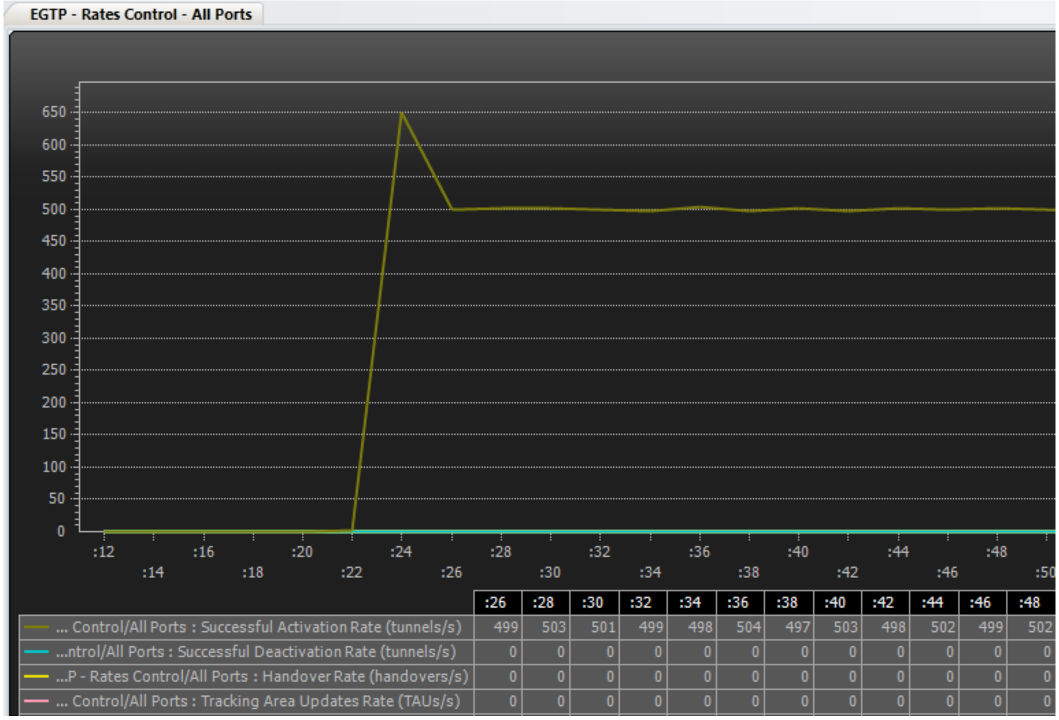
Variable	Value	Comment
UE Count	120000	
MME count	12	
eNodeB count	12	
HTTP activity -> EGTP -> Session Timeout	Enabled	To enable the precise time duration of the default bearer for each UE

Variable	Value	Comment
HTTP activity -> EGTP -> Session Timeout -> Timeout Value	30s	
Objective for HTTP activity	SU = 120K	

Results Analysis

The statistics that are important to monitor for a constant BHCA test are the rates at which the sessions are being activated and deactivated, and how many sessions are active at one point in time.

IxLoad provides the session activate and deactivation rates in the EGTP Rates – All Ports statistics view. Both the activation and deactivation rates are shown in the same view. The example below shows a reduced configuration where the session duration timeout configured for 30s. From second 6 of the test to second 36, sessions are established and maintained. Starting at second 36, the originally established sessions start terminating, because of the session duration timeout. Thus, the session deactivation rate ramps up at the same rate that the sessions were established. Afterwards, both stats maintain the same rate, which corresponds to a constant BHCA.

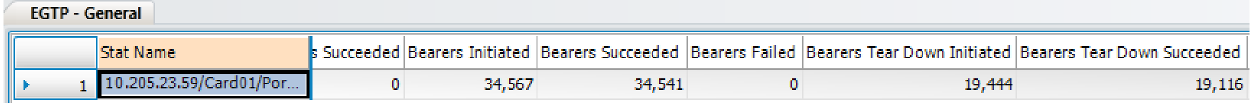


	:26	:28	:30	:32	:34	:36	:38	:40	:42	:44	:46	:48
... Control/All Ports : Successful Activation Rate (tunnels/s)	499	503	501	499	498	504	497	503	498	502	499	502
...ntrol/All Ports : Successful Deactivation Rate (tunnels/s)	0	0	0	0	0	0	0	0	0	0	0	0
...P - Rates Control/All Ports : Handover Rate (handovers/s)	0	0	0	0	0	0	0	0	0	0	0	0
... Control/All Ports : Tracking Area Updates Rate (TAUs/s)	0	0	0	0	0	0	0	0	0	0	0	0

Figure 31. EGTP - Rates Control

To view the amount of active sessions, the *EGTP General* view is used. By selecting the **All Bearers** tab at the bottom of the view, the Active Sessions statistic is immediately available. For a constant BHCA test, it must remain at the same value during the sustain period of the test.

The *Sessions Terminated* stat starts increasing steadily after 30s, the value corresponding to the session time configuration value.



	Stat Name	s Succeeded	Bearers Initiated	Bearers Succeeded	Bearers Failed	Bearers Tear Down Initiated	Bearers Tear Down Succeeded
1	10.205.23.59/Card01/Por...	0	34,567	34,541	0	19,444	19,116

Figure 32. EGTP General View

EPC Test Case: Small Packets and Multiple Bearers

Overview

In an EPC test case, the system under test comprises the SGW, PGW, and possibly the PCRF. The test case is performed using IxLoad by simulating the eNodeBs, MME, and internet servers on the SGi interface. The traffic activity is HTTP.

Mobile environments sometimes result in the user plane traffic being transported using small packets, either because of the nature of the traffic or because of the radio interface itself. The average packet size can be approximately 600 octets. In addition, LTE offers the possibility to have multiple bearers per UE. Multiple bearers are meant to address QoS differences between the traffic types being run by the subscriber. Network policy determines if the subscriber will be allowed dedicated bearers or not, thus allowing a network operator to offer differentiated services.

Objective

The EPC test case has a dual objective:

- Testing the packet switching ability with small packets
- To exercise this functionality with multiple bearers per subscriber.

Setup

The test case will be set up as follows:

- Assign 12 ports of an Acceleron-NP load module as the MMEs/eNodeBs, and assign the 12 ports of another Acceleron-NP load module as servers.
- Use 10G aggregation mode.
- Define 12 MME/eNodeB pairs, and use 120K subscribers for the test.

The L7 traffic itself is the http and ftp traffic, where the http runs over the default bearer, while the ftp downloads are given a dedicated bearer.

Step by Step Instructions

1. Insert a new NetTraffic on the server side. Configure it to have a range of 24 IPs, using IP addresses that correspond to the network under test settings.
2. Add an HTTP server activity to the NetTraffic. Use the default settings except for Effective Send MSS (Tx) under the activity settings, advanced options: set this value to 600.
3. Add an FTP server activity to the NetTraffic. Use the default settings except the Effective Send MSS (Tx): set this value to 600.

4. Insert a new NetTraffic on the client side. Select it to configure it, and delete the existing default IP stack by clicking Delete Stack.
5. Add the MME/eNB S11/S1-u stack from the Add Stacks > Wireless menu.

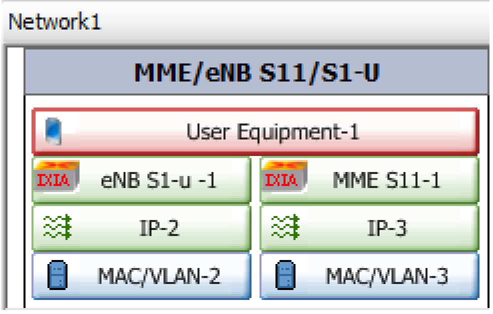
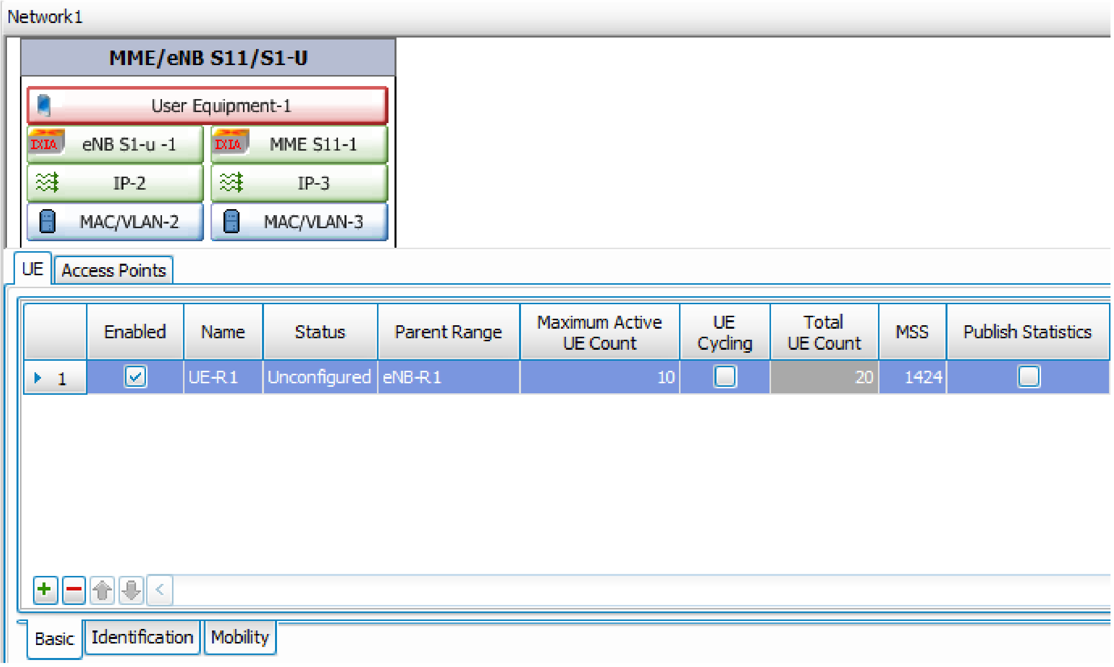


Figure 33. MME/eNB S11/S1-U Stack

6. Click User Equipment to configure the UEs (subscribers) for the test. The **User Equipment** layer contains two tabs that must be configured as follows:



	Enabled	Name	Status	Parent Range	Maximum Active UE Count	UE Cycling	Total UE Count	MSS	Publish Statistics
1	☑	UE-R1	Unconfigured	eNB-R1	10	☐	20	1424	☐

Figure 34. User Equipment layer

UE Tab

The UE tab contains the following additional sub-tabs:

Basic sub-tab:

Configure the **Maximum ActiveTotal UE Count** value to match the test variables section.

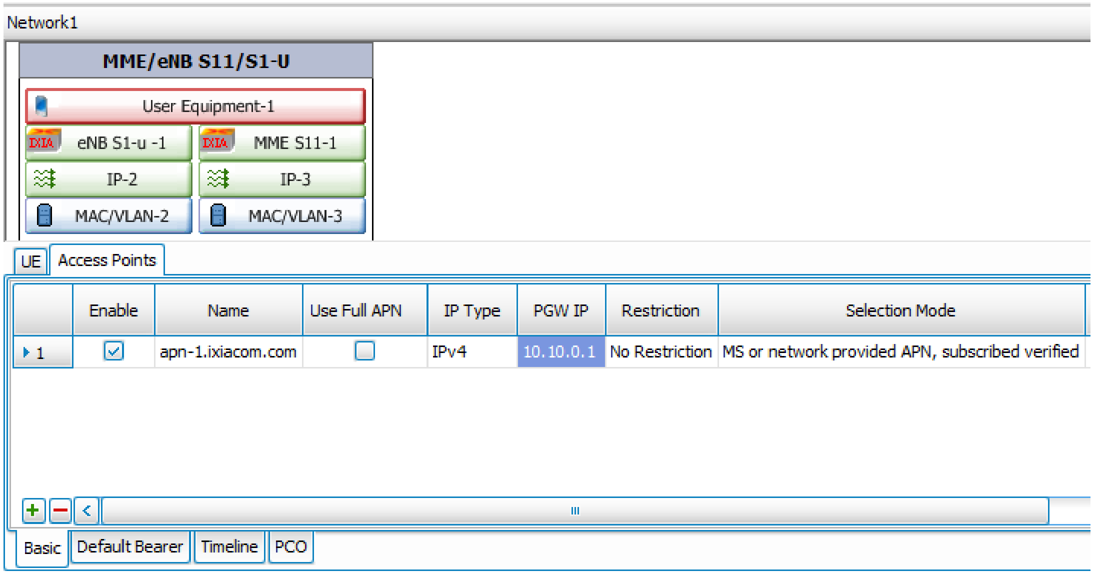
Identification sub-tab:

Configure the appropriate values for **IMEI**, **Software Version**, **IMSI** and **MSISDN**. These values identify the subscription and equipment, and usually customers provide them. These values must match the values configured in the system under test.

Mobility sub-tab:

Do not enable mobility for this test.

Access Points tab



	Enable	Name	Use Full APN	IP Type	PGW IP	Restriction	Selection Mode
▸ 1	☑	apn-1.ixiacom.com	☐	IPv4	10.10.0.1	No Restriction	MS or network provided APN, subscribed verified

Figure 35. Access Points tab

The Access Points tab contains the following additional sub-tabs:

Basic sub-tab:

Configure the **APN Name** and corresponding **PGW IP** to match the values configured in the system under test. Leave the other values to default.

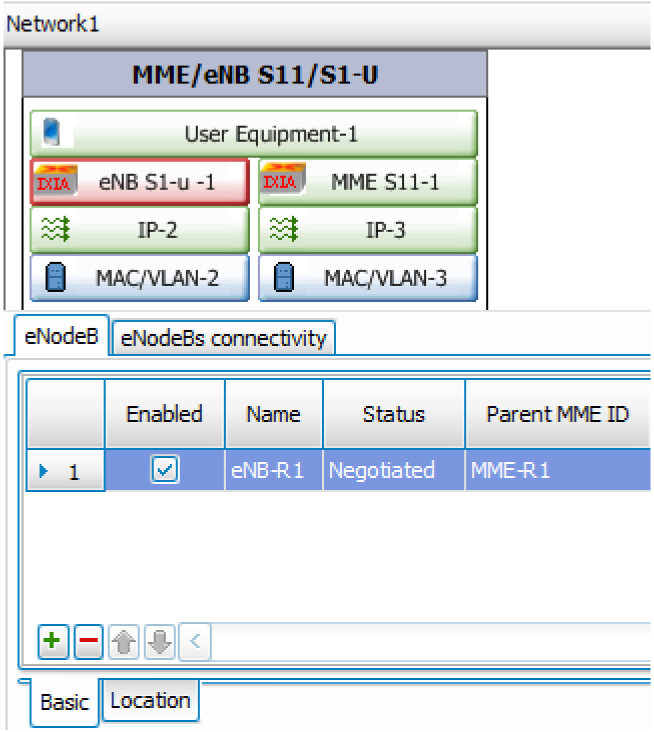
Default bearer sub-tab:

The QoS values associated to the default bearer are configured here. Configure the QCI to a value of 8, and leave the remaining values to default.

Timeline sub-tab:

In the lifetime configuration, the user can define a precise duration for the subscriber. In this test, lifetime is not used. Leave the Enable Lifetime checkbox cleared. Also, leave the **HSS Update Enable** checkbox cleared as well.

7. Click eNB in the stack to configure the eNodeBs for the test. The eNB layer contains 3 tabs.



	Enabled	Name	Status	Parent MME ID
1	☑	eNB-R1	Negotiated	MME-R1

Figure 36. eNB S1-u Basic Tab

E-NodeB Tab

The E-NodeB tab contains the following additional sub-tabs:

Basic sub-tab:

No change.

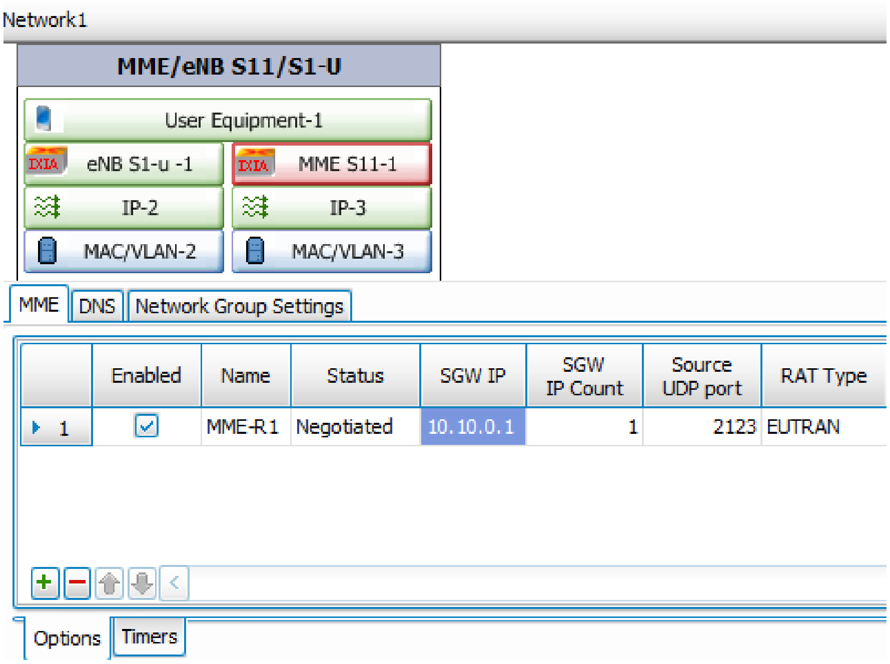
Location sub-tab:

Configure values that match the values from the network under test. The **MNC** and **MCC** values are typically selected to match the network's values exactly. The **Location Area Code**, **Routing Area Code**, **Service Area Code**, **Tracking Area Code** and **EUTRAN Cell Identifier** values must match values configured in the network under test for the simulated Radio Access Network (RAN).

ENodeBs Connectivity Tab

This tab allows the configuration of the presence/absence of X2 interfaces between eNodeBs. No change is necessary.

8. Click the MME layer to configure the MMEs for the test. This layer contains two tabs that must be configured as follows:



	Enabled	Name	Status	SGW IP	SGW IP Count	Source UDP port	RAT Type
1	☑	MME-R1	Negotiated	10.10.0.1	1	2123	EUTRAN

Figure 37. MME S11 layer

MME Tab

The MME tab contains the following additionalsub-tabs:

Options sub-tab:

Configure the **SGW IP** address. This is the main IP address is used for all initial control plane messages destined to the SGW. The SGW may change this IP address during the course of the session signaling, but IxLoad dynamically handles it. Multiple IPs are supported, so if this is required by the configuration, increase the **Count** value to the appropriate value. Typically, this is left to **1**. Users can configure the UDP source port to be used by the MME for the GTP-c signaling using the **Source UDP Port** column. Configure the **RAT Type** column (Radio Access Technology) to **EUTRAN**, because this is an LTE test.

Timers sub-tab:

These timers are the GTP protocol timers and counters that are set to the default values. There is no need to modify them.

Network Group Settings Tab

No changes are needed.

9. Click the IP layer in the eNB stack. This IP layer corresponds to the eNodeBs for the test. For each range defined in the eNodeB settings, there is a corresponding range automatically defined in the IP layer. Configure the appropriate IP range of eNodeBs corresponding to the configuration of the network under test. Configure the Count to a value of 12.

10. Click the IP layer in the MME stack. This IP layer corresponds to the MMEs for the test. For each range defined in the MME settings, there is a corresponding range automatically defined in the IP layer. Configure the appropriate IP range of MME corresponding to the configuration of the network under test. Configure the Count to a value of 12.
11. Click the Settings button for the network plugin. In the Interface Behavior section, click Create interface with user, and select the Teardown interface with user checkbox. This enables dynamic control plane mode.

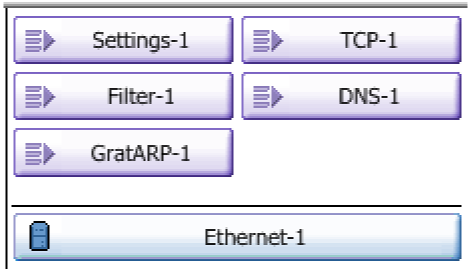
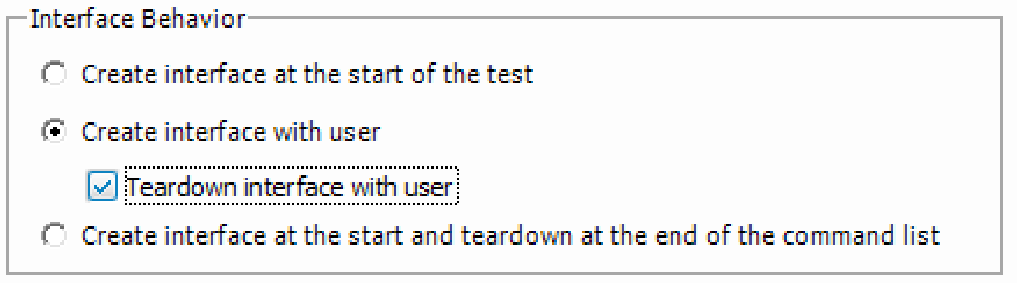


Figure 38. Settings Button



Interface Behavior

○ Create interface at the start of the test

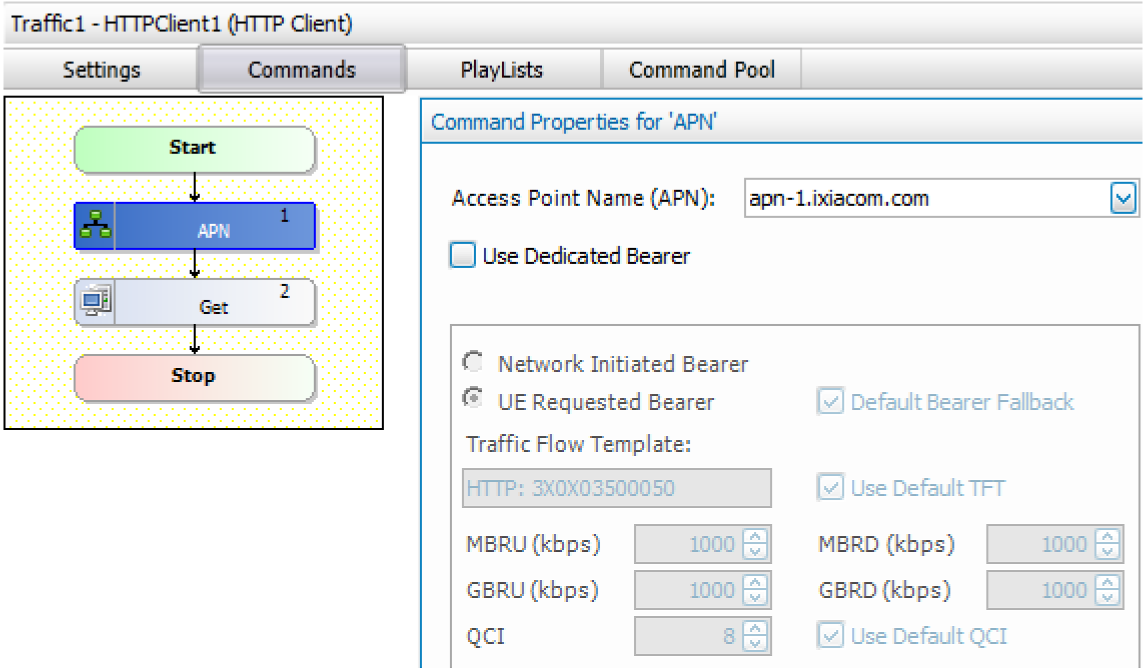
● Create interface with user

☑ Teardown interface with user

○ Create interface at the start and teardown at the end of the command list

Figure 39. Interface Behavior

12. Add an HTTP client activity to the NetTraffic. Configure it to have the previously configured HTTP server as a target. Configure one command in the command list: GET the 1024k.html file, and make sure the iterate command list is selected.
13. Click the Commands tab of the HTTP activity, and select the APN command. Make sure that the Use Dedicated Bearer checkbox is unselected. This selection causes the http activity to run on the default bearer for each UE.



Traffic1 - HTTPClient1 (HTTP Client)

Command Properties for 'APN'

Access Point Name (APN): apn-1.ixiacom.com

☐ Use Dedicated Bearer

○ Network Initiated Bearer

● UE Requested Bearer

☑ Default Bearer Fallback

Traffic Flow Template: HTTP: 3X0X03500050

☑ Use Default TFT

MBRU (kbps): 1000

MBRD (kbps): 1000

GBRU (kbps): 1000

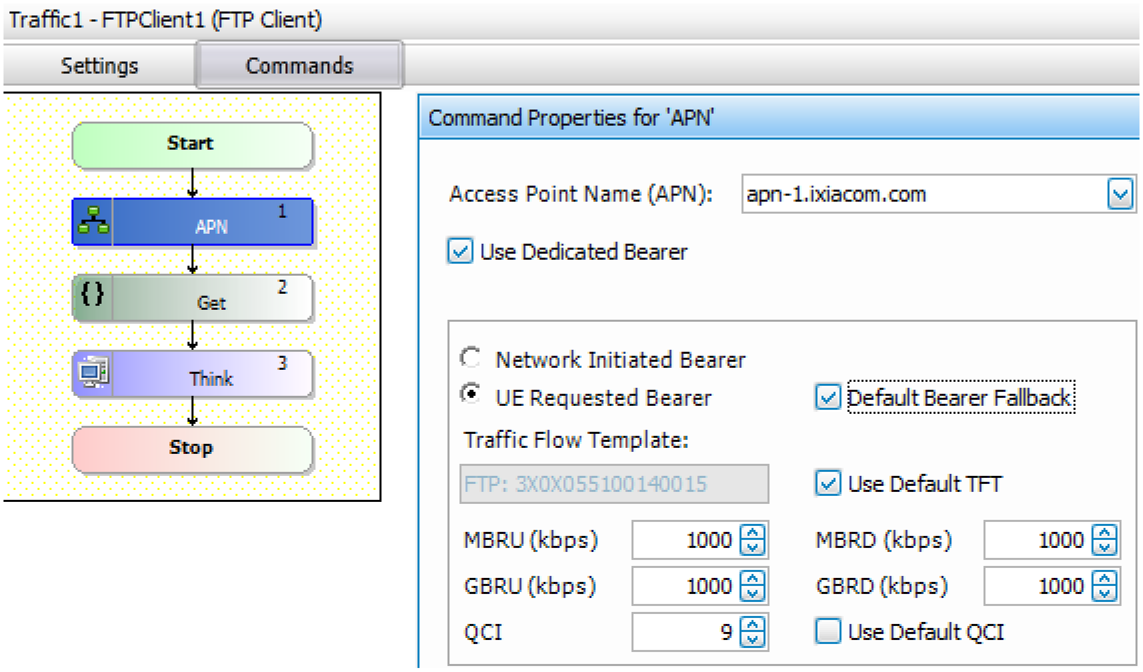
GBRD (kbps): 1000

QCI: 8

☑ Use Default QCI

Figure 40. APN command

14. Add an FTP client activity to the NetTraffic. Configure it to have the previously configured FTP server as a target. Configure two commands in the command list: {get} the /#1048576 file, and Think for 30s. Make sure the iterate command list is selected.
15. Click the Commands tab of the FTP activity, and select the APN command. Select the Use Dedicated Bear check box. This selection causes the http activity to run on the default bearer for each UE. Click MS Initiated Bearer, and clear Use Default QCI. Enter the value for QCI as 9.


Traffic1 - FTPClient1 (FTP Client)
Settings
Commands
Start
APN
1
Get
2
Think
3
Stop
Command Properties for 'APN'

Access Point Name (APN): apn-1.ixiacom.com

☑ Use Dedicated Bearer

○ Network Initiated Bearer

● UE Requested Bearer

☑ Default Bearer Fallback

Traffic Flow Template: FTP: 3X0X055100140015

☑ Use Default TFT

MBRU (kbps) 1000

MBRD (kbps) 1000

GBRU (kbps) 1000

GBRD (kbps) 1000

QCI 9

☐ Use Default QCI

Figure 41. APN Command

16. In the Timelines and Objectives section, select a Simultaneous Users objective for the HTTP client activity, and set the objective to 120K. Configure a 60 minute timeline. Configure the same values for the FTP client activity.
17. In the Port Assignments section, assign the client NetTraffic to the 12 port CPUs of the first Acceleron-NP load module.
18. Assign the server NetTraffic to the 12 port CPUs of the second Acceleron-NP load module.
19. Enable 10G aggregation mode for both Acceleron-NP load modules.
20. In the Test Options section, select the Network Diagnostics checkbox to enable the GTP statistics.

Test Variables

The test variables highlights are shown in the following table.

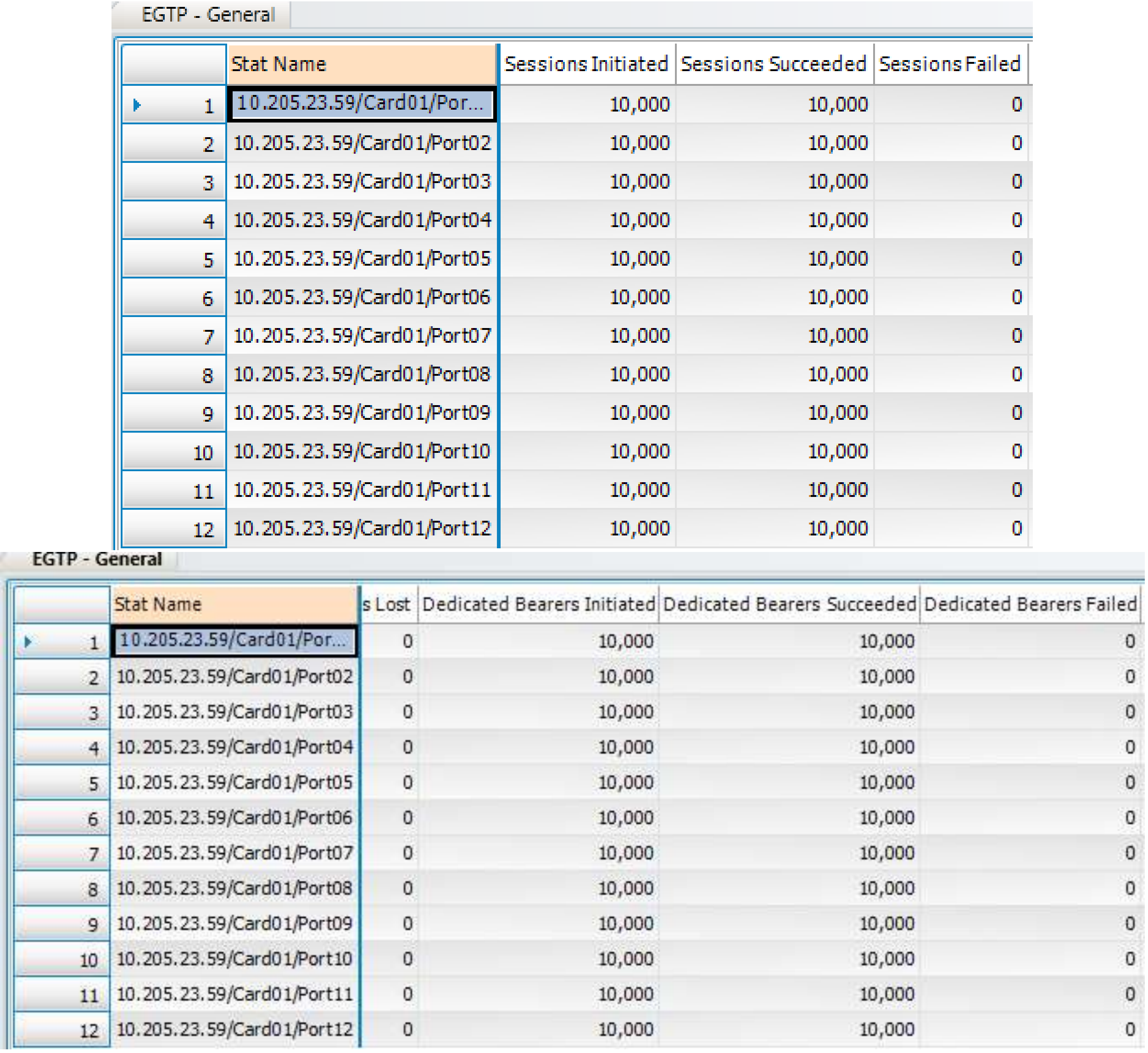
Table 5. Test Variables for Small Packets and Multiple Bearers Test

Variable	Value	Comment
UE Count	120000	
MME count	12	
eNodeB count	12	
Objective for HTTP activity	SU = 120K	
Objective for FTP activity	SU = 120K	
FTP activity -> EGTP -> Use default bearer for this activity	Unselected	This is to ensure that the FTP activity obtains a dedicated bearer
Server MSS	600	This is to ensure that the downlink packets from both the HTTP and FTP servers will not exceed 600 octets.

Results Analysis

The main statistics that you need to track for this test are, the GTP-U packets/second and the session statistics for eGTP.

The session statistics become a highlight for the test results, because this test uses default and dedicated bearers. The view containing these stats is the *EGTP General* view. For each simulated UE, two bearers are established. This is indicated by the *Sessions Initiated*, *Sessions Succeeded* and *Sessions Succeeded(D)* statistics. *Sessions Initiated* corresponds to the total amount of bearers activated during the test, while *Sessions Succeeded* shows how many initiated sessions were successfully established. The *Sessions Succeeded(D)* stat shows the same result for dedicated bearers only.

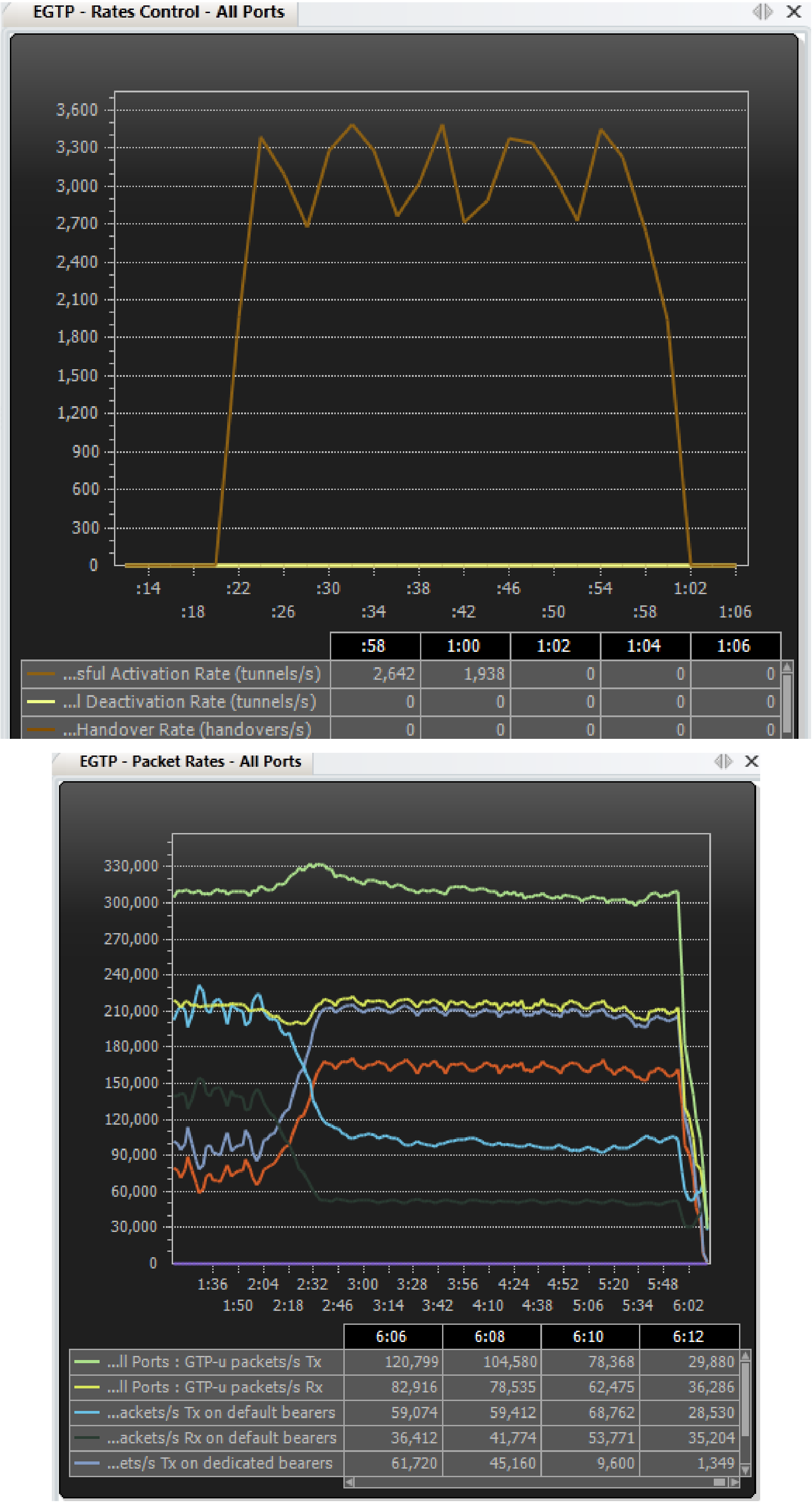


	Stat Name	Sessions Initiated	Sessions Succeeded	Sessions Failed
1	10.205.23.59/Card01/Por...	10,000	10,000	0
2	10.205.23.59/Card01/Port02	10,000	10,000	0
3	10.205.23.59/Card01/Port03	10,000	10,000	0
4	10.205.23.59/Card01/Port04	10,000	10,000	0
5	10.205.23.59/Card01/Port05	10,000	10,000	0
6	10.205.23.59/Card01/Port06	10,000	10,000	0
7	10.205.23.59/Card01/Port07	10,000	10,000	0
8	10.205.23.59/Card01/Port08	10,000	10,000	0
9	10.205.23.59/Card01/Port09	10,000	10,000	0
10	10.205.23.59/Card01/Port10	10,000	10,000	0
11	10.205.23.59/Card01/Port11	10,000	10,000	0
12	10.205.23.59/Card01/Port12	10,000	10,000	0

	Stat Name	s Lost	Dedicated Bearers Initiated	Dedicated Bearers Succeeded	Dedicated Bearers Failed
1	10.205.23.59/Card01/Por...	0	10,000	10,000	0
2	10.205.23.59/Card01/Port02	0	10,000	10,000	0
3	10.205.23.59/Card01/Port03	0	10,000	10,000	0
4	10.205.23.59/Card01/Port04	0	10,000	10,000	0
5	10.205.23.59/Card01/Port05	0	10,000	10,000	0
6	10.205.23.59/Card01/Port06	0	10,000	10,000	0
7	10.205.23.59/Card01/Port07	0	10,000	10,000	0
8	10.205.23.59/Card01/Port08	0	10,000	10,000	0
9	10.205.23.59/Card01/Port09	0	10,000	10,000	0
10	10.205.23.59/Card01/Port10	0	10,000	10,000	0
11	10.205.23.59/Card01/Port11	0	10,000	10,000	0
12	10.205.23.59/Card01/Port12	0	10,000	10,000	0

Figure 42. EGTP - General Statistics

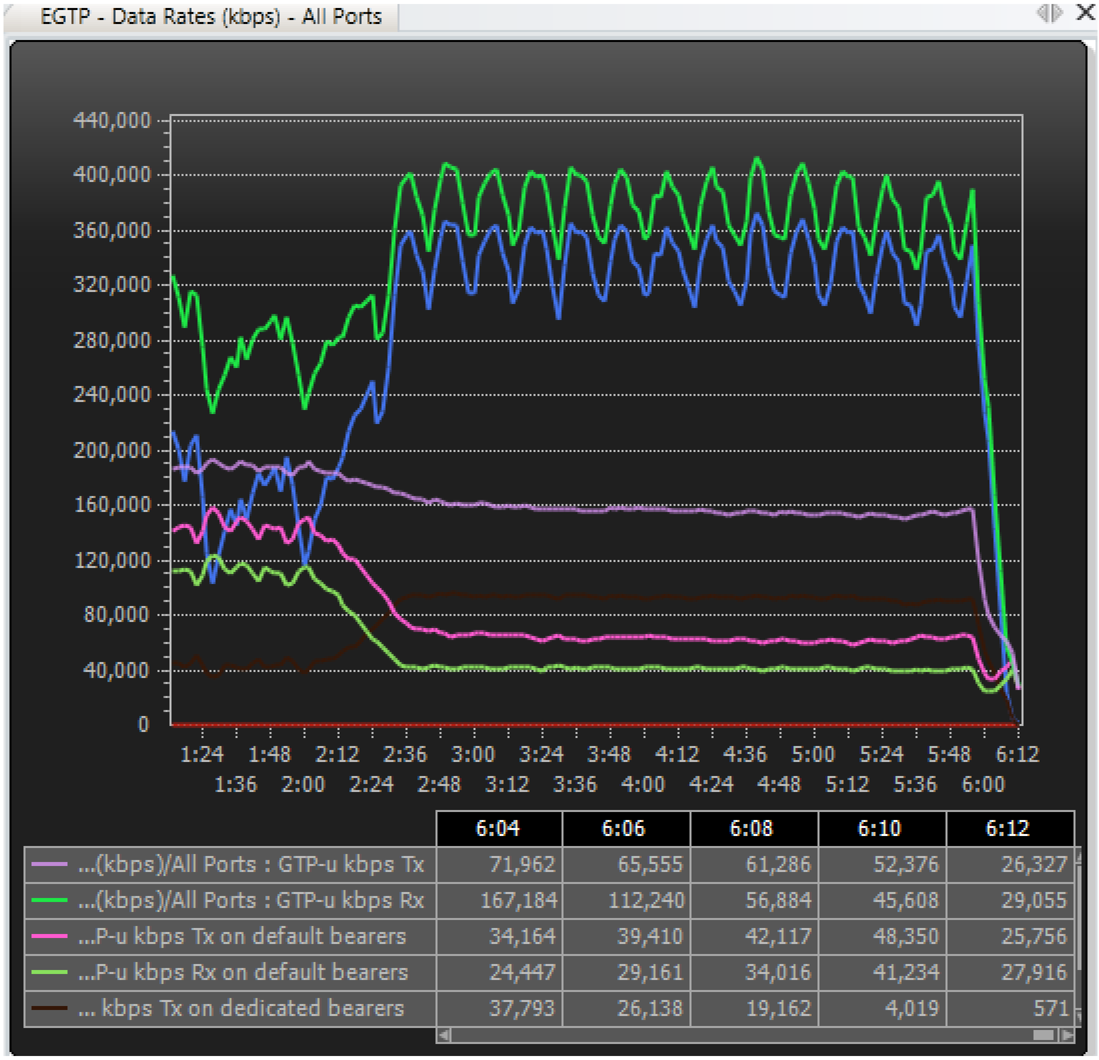
Typically, when a test with small packets is run, a goal of the test is to reach a certain packet/second rate on the GTP-U protocol. It will be stressed harder than usual because of the small packet size. IxLoad provides the GTP-U packets/second stat in the *EGTP-U Rates* view, which shows the Tx and Rx GTP-U packet rates.



	:58	1:00	1:02	1:04	1:06
...sful Activation Rate (tunnels/s)	2,642	1,938	0	0	0
...l Deactivation Rate (tunnels/s)	0	0	0	0	0
...Handover Rate (handovers/s)	0	0	0	0	0

	6:06	6:08	6:10	6:12
...ll Ports : GTP-u packets/s Tx	120,799	104,580	78,368	29,880
...ll Ports : GTP-u packets/s Rx	82,916	78,535	62,475	36,286
...ackets/s Tx on default bearers	59,074	59,412	68,762	28,530
...ackets/s Rx on default bearers	36,412	41,774	53,771	35,204
...ets/s Tx on dedicated bearers	61,720	45,160	9,600	1,349

Figure 43. EGTP- Packet Rates Statistics



	6:04	6:06	6:08	6:10	6:12
...(kbps)/All Ports : GTP-u kbps Tx	71,962	65,555	61,286	52,376	26,327
...(kbps)/All Ports : GTP-u kbps Rx	167,184	112,240	56,884	45,608	29,055
...P-u kbps Tx on default bearers	34,164	39,410	42,117	48,350	25,756
...P-u kbps Rx on default bearers	24,447	29,161	34,016	41,234	27,916
... kbps Tx on dedicated bearers	37,793	26,138	19,162	4,019	571

Figure 44. EGTP – Data Rates Statistics

EPC Test Case: Handovers

Overview

This test case exercises handover capability while forwarding traffic at a high rate. The test simulates 120,000 subscribers browsing Web pages while performing various types of handovers. Specifically, the types of handovers that are performed are as follows:

- X2-based handovers
- S1-based handovers with MME relocation
- S1-based handovers without MME relocation

There are no handovers involving SGW relocation, because this test uses default and dedicated bearers.

Handovers are configured to happen at an interval of 65 s for each individual UE. As there are120,000 UEs active during the test, the amount of handovers executed per second during this test are as follows:

Handover rate = 1/65s * 120K = 1846 handovers/second

Objective

The Handovers test case is a system test case that has the dual objective of simultaneously generating high throughout user plane data combined with a medium rate of constant handovers during the test.

Setup

The test case is set up as follows:

12 MME + eNodeB pairs, one per port CPU, with 10000 subscribers per pair, each generating high throughput http traffic and performing handovers.

Multiple configuration parameters depend on the network under test, such as IP addresses for the MMEs and UEs, UE identifier parameters like IMSI and MSISDN, and networking parameters. These are typically obtained by knowing the network configuration.

Step by Step Instructions

1. Insert a new NetTraffic on the server side. Configure it to have a range of 12 IPs, by using IP addresses that correspond to the network under test settings.
2. Add an HTTP server activity to the NetTraffic. The user can use the default settings.
3. Insert a new NetTraffic on the client side. Select it to configure it, and delete the existing default IP stack by clicking Delete Stack.
4. Add the MME/eNB S11/S1-u stack from the Add Stacks > Wireless menu.

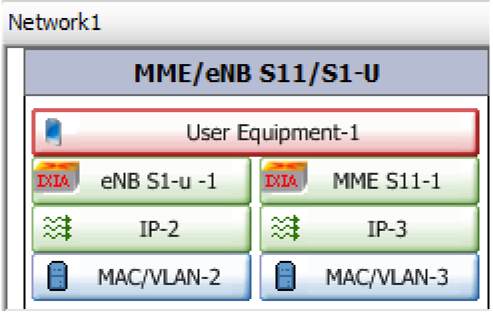
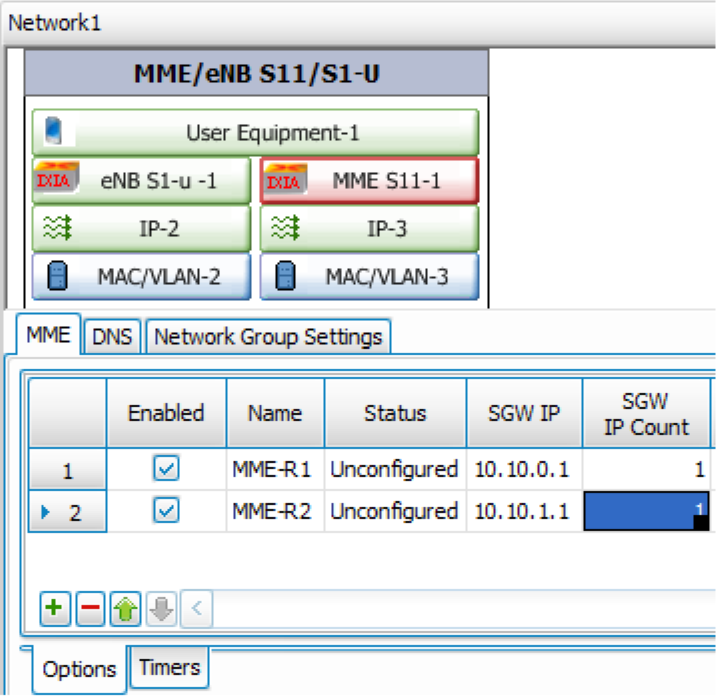


Figure 45. MME/eNB S11/S1-U Stack

5. Click the MME layer to configure the MMEs for the test. This layer contains two tabs that are configured as follows:



	Enabled	Name	Status	SGW IP	SGW IP Count
1	☑	MME-R1	Unconfigured	10.10.0.1	1
2	☑	MME-R2	Unconfigured	10.10.1.1	1

Figure 46. MME layer

MME Tab

The MME tab contains the following additional sub-tabs:

Options sub-tab:

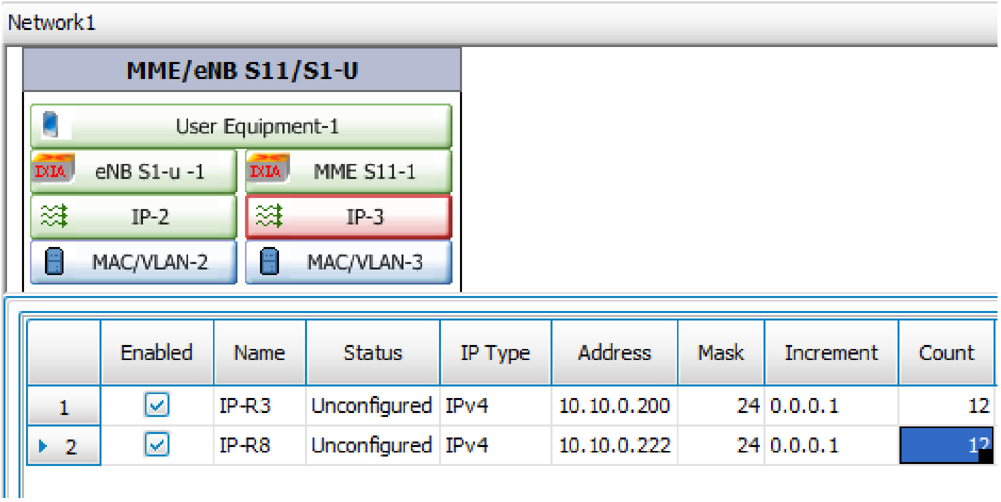
Click the green '+' icon at the bottom left of the pane to add an additional MME.

Configure the **SGW IP** address for each MME range. Assuming that there is only one SGW under test, use the same SGW IP address for both MME ranges. This is the main IP address to be used for all initial control plane messages destined to the SGW. The SGW may change this IP address during the course of the session signaling, but IxLoad dynamically handles it. Multiple IPs are supported, so if this is required by the configuration, increase the **Count** value to the appropriate value. Typically, this is left to **1**. Users can configure the UDP source port to be used by the MME for the GTP-c signaling by using the **Source UDP Port** column. Configure the **RAT Type** column (Radio Access Technology) to **EUTRAN**, because this is an LTE test.

Timers sub-tab:

These are the GTP protocol timers and counters, which are set to the default values. We recommend you not to modify them.

6. Click the IP layer in the MME stack. This IP layer corresponds to the MMEs for the test.

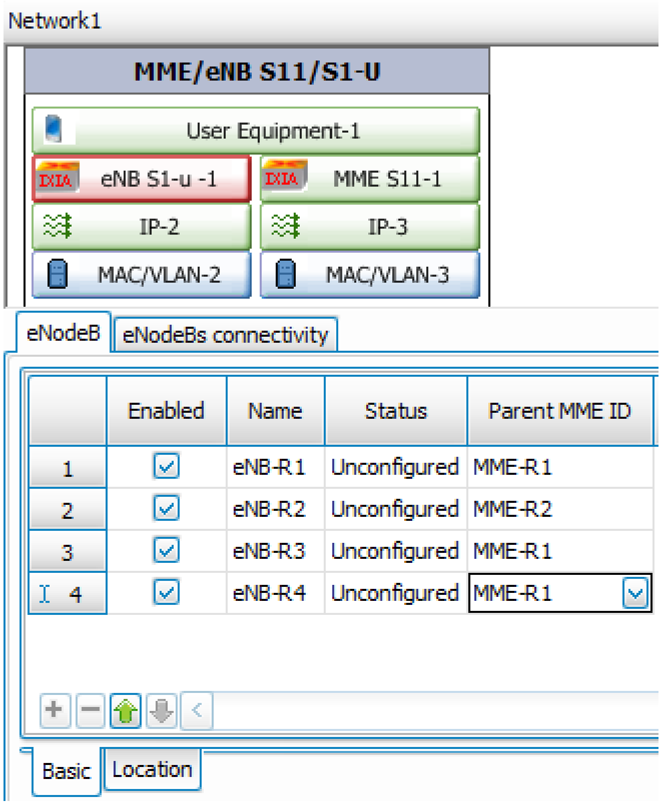


	Enabled	Name	Status	IP Type	Address	Mask	Increment	Count
1	☑	IP-R3	Unconfigured	IPv4	10.10.0.200	24	0.0.0.1	12
2	☑	IP-R8	Unconfigured	IPv4	10.10.0.222	24	0.0.0.1	12

Figure 47. MME IP layer

In this layer, a user can configure the IP address range for the MME ranges. For this test, configure a **Count** of **12** for each MME range (corresponding to one MME per port CPU used for this NetTraffic, for each MME range). Configure the starting IP address, mask, and gateway according to the network under test configurations.

7. Click the eNB layer to configure the eNodeBs for the test. The e-NodeB tab contains three tabs that are configured as follows:



	Enabled	Name	Status	Parent MME ID
1	☑	eNB-R1	Unconfigured	MME-R1
2	☑	eNB-R2	Unconfigured	MME-R2
3	☑	eNB-R3	Unconfigured	MME-R1
4	☑	eNB-R4	Unconfigured	MME-R1

Figure 48. Basic Sub-Tab

E-NodeB Tab

The E-NodeB tab contains the following additional sub-tabs:

Basic sub-tab:

Click '+' icon at the bottom left of the pane to add three more eNodeB ranges (for a total of four ranges). For the eNB-R2 range, select MME-R2 as the parent MME ID.

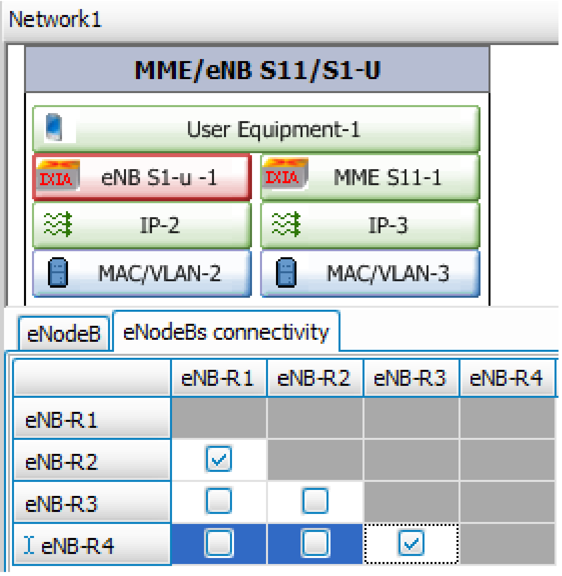
eNodeBs are configured such that each range gets one parent MME.

Location tab:

Configure values that match the values from the network under test. The **MNC** and **MCC** values are typically selected to match the network's values exactly. The **Location Area Code**, **Routing Area Code**, **Service Area Code**, **Tracking Area Code,** and **EUTRAN Cell Identifier** values must match values configured in the network under test for the simulated Radio Access Network (RAN).

ENodeB Connectivity Tab

The **ENodeBs connectivity** tab serves to configure the connections between the eNodeBs for the test. This connectivity matrix represents the presence or absence of the X2 interface between eNodeB ranges. If a check box is selected between two eNodeB ranges, it means that there is an X2 interface connecting those two eNodeB ranges. For this test, select the check boxes between **eNB-R1** and **eNB-R4**, and **eNB-R3** and **eNB-R4**, as indicated in the following figure.

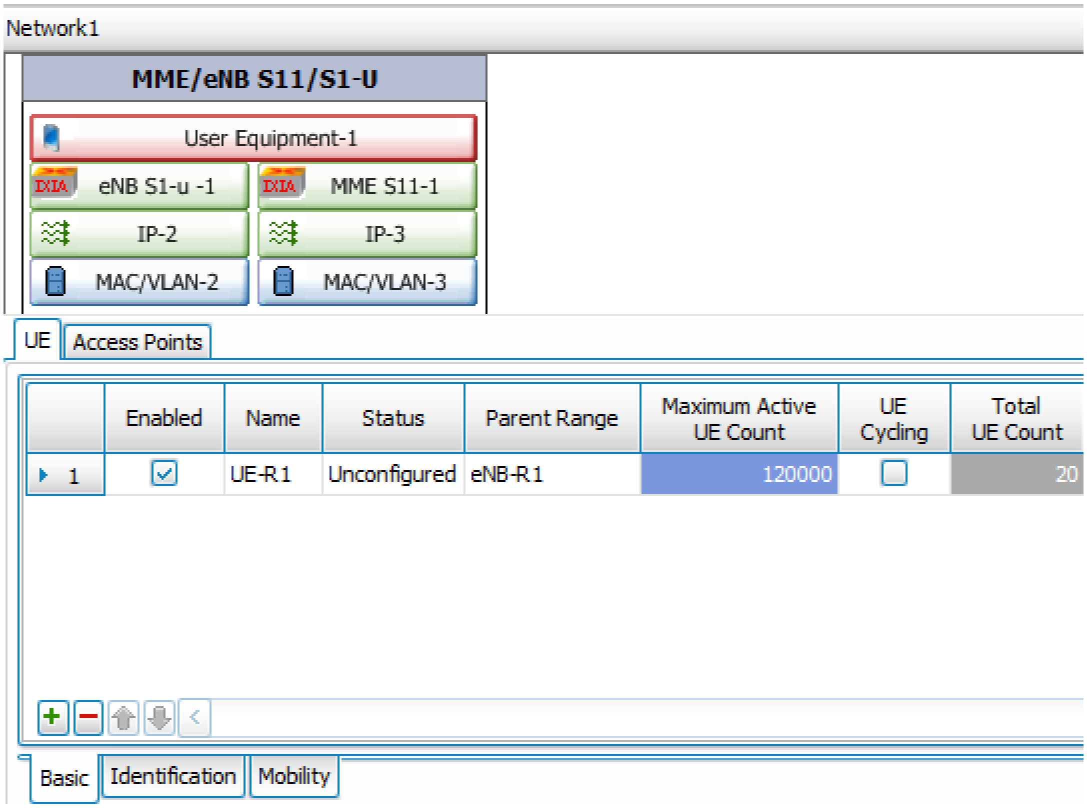


	eNB-R1	eNB-R2	eNB-R3	eNB-R4
eNB-R1				
eNB-R2	☑			
eNB-R3	☐	☐		
eNB-R4	☐	☐	☑	

Figure 49. eNodeBs Connectivity Sub-Tab

If the presence of an X2 interface between two eNodeBs is indicated, this means an X2 handover is possible between those eNodeBs. But if the X2 interface is not present between two eNodeBs, a handover between them is a S1-based handover.

8. Click the IP layer in the eNodeB stack. For each range defined in the eNodeB settings, there is a corresponding range automatically defined in the IP layer. Configure the appropriate IP range of eNodeBs corresponding to the configuration of the network under test. Configure the Count to a value of 12.
9. Click the User Equipment layer to configure the UEs (subscribers) for the test. The User Equipment layer contains two tabs that are configured as follows:



	Enabled	Name	Status	Parent Range	Maximum Active UE Count	UE Cycling	Total UE Count
1	☑	UE-R1	Unconfigured	eNB-R1	120000	☐	20

Figure 50. UE tab

UE Tab

The UE tab contains the following additional sub-tabs:

Basic sub-tab:

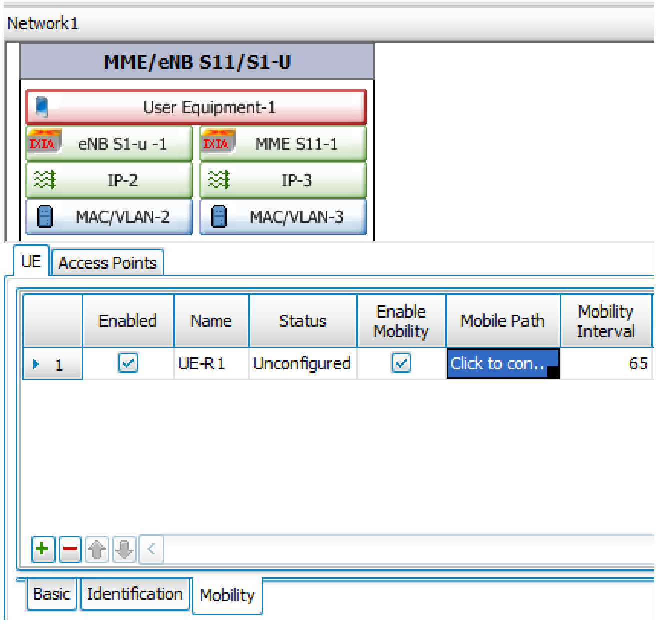
Configure the **Count** value to match the test variables section.

Identification sub-tab:

Configure the appropriate values for **IMEI**, **Software Version**, **IMSI** and **MSISDN**. These values identify the subscription and equipment, and usuallycustomers provide them. The values must match the values configured in the system under test.

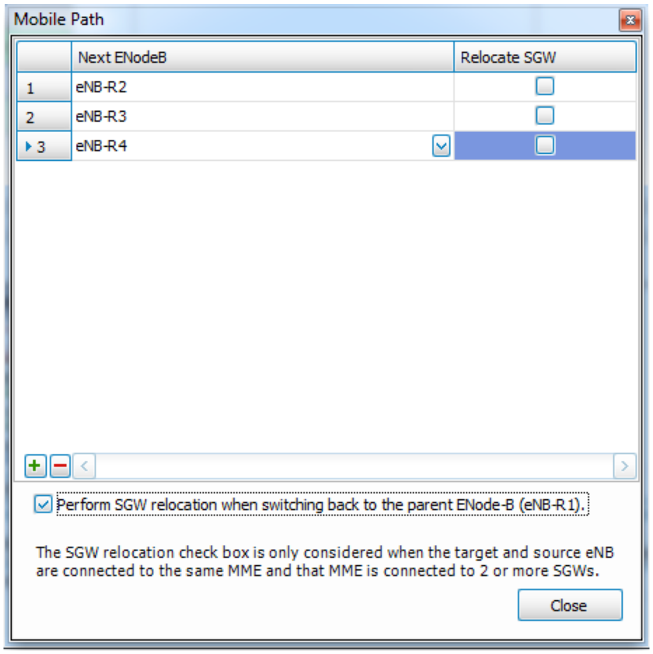
Mobility sub-tab:

The **Mobility** tab is used to configure handovers for the UEs. Select the **Enable Mobility** check box to enable handovers for the UE range. Next, click the ellipsis in the **Mobile Path** column to configure the handover path that the UEs traverse. This configuration determines the exact handovers that each UE performs, moving from one eNodeB to the next.



	Enabled	Name	Status	Enable Mobility	Mobile Path	Mobility Interval
1	☑	UE-R1	Unconfigured	☑	Click to con..	65

Figure 51. Mobility sub-tab



	Next ENodeB	Relocate SGW
1	eNB-R2	☐
2	eNB-R3	☐
3	eNB-R4	☐

☑ Perform SGW relocation when switching back to the parent ENode-B (eNB-R1).

The SGW relocation check box is only considered when the target and source eNB are connected to the same MME and that MME is connected to 2 or more SGWs.

Figure 52. Mobile Path Configuration

Click the green **'+'** icon in the bottom left-pane of the window to add three steps to the mobile path. Knowing that the UE range is configured to be on eNB-R1, to begin the test (from the UE configuration, basic tab), configure the first step to be eNB-R2, the second step to be eNB-R3, and finally the last step to be eNB-R4, as illustrated in the figure.

This activity creates the following handovers to occur, for each UE in the range:

- The UE will handover from eNB-R1 to eNB-R2
- The UE will handover from eNB-R2 to eNB-R3

- The UE will handover from eNB-R3 to eNB-R4
- The UE will handover from eNB-R4 to eNB-R1

This mobile path is then repeated for the entire duration of the test.

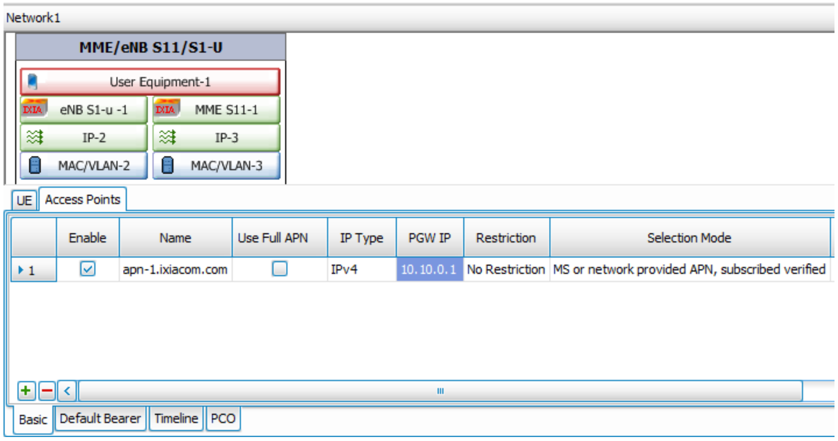
Close the **Mobile Path Configuration** window, and configure the rest of the mobility tab values as follows:

- **Mobility Interval**: 65. This value represents the time (in seconds) between each step of the mobile path, independently for each UE in the range.
- **Maximum Interval Variation**: 5. This value is the variation value for the interval, such that handovers do not occur exactly every 65 s, but happen each 65 +/- 5%.
- **Start Delay**: 120. This value delays the handovers such that no handover occurs until 120 s from the start of the test have elapsed. The delay is to give time for the UEs to ramp up before the handover signaling starts.
- **Maximum delay variation**: 0.

Timeline tab:

Do not enable the timeline for this test. Use the default values.

Access Points Tab



	Enable	Name	Use Full APN	IP Type	PGW IP	Restriction	Selection Mode
1	☑	apn-1.ixiacom.com	☐	IPv4	10.10.0.1	No Restriction	MS or network provided APN, subscribed verified

Figure 53. Access Points tab

The Access Points tab contains the following additional sub-tabs:

Basic sub-tab:

Configure the **APN** and corresponding **PGW IP** to match the values configured in the system under test. Leave the other values to default.

Default bearer sub-tab:

The QoS values associated to the default bearer are configured here. Configure the QCI to a value of 8, and leave the rest of the values to their default values.

Timeline tab:

The lifetime configuration allows the user to define a precise duration for the subscriber. In this test, lifetime is not used. Clear both the **Enable Lifetime** and **The HSS Update Enable** checkboxes.

10. Click Settings for the network plugin. In the Interface Behavior section click Create interface with user, and select the Teardown interface with user check box. This enables dynamic control plane mode.

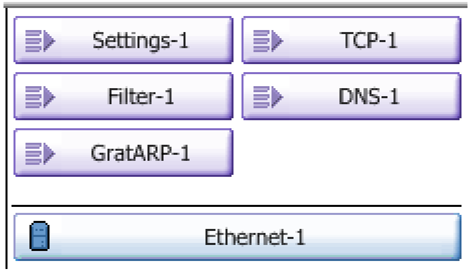
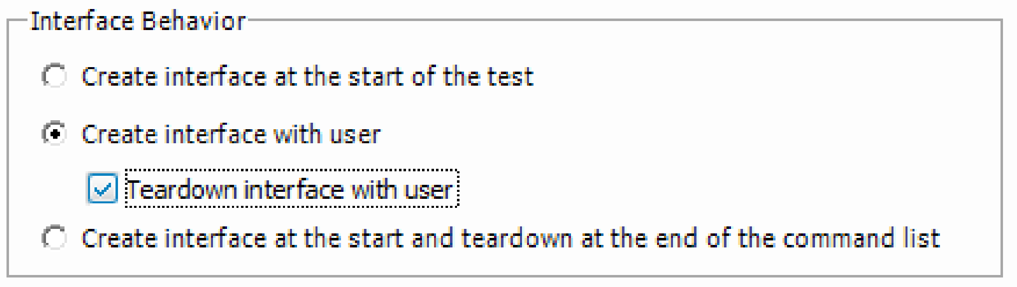


Figure 54. Settings Button



Interface Behavior

○ Create interface at the start of the test

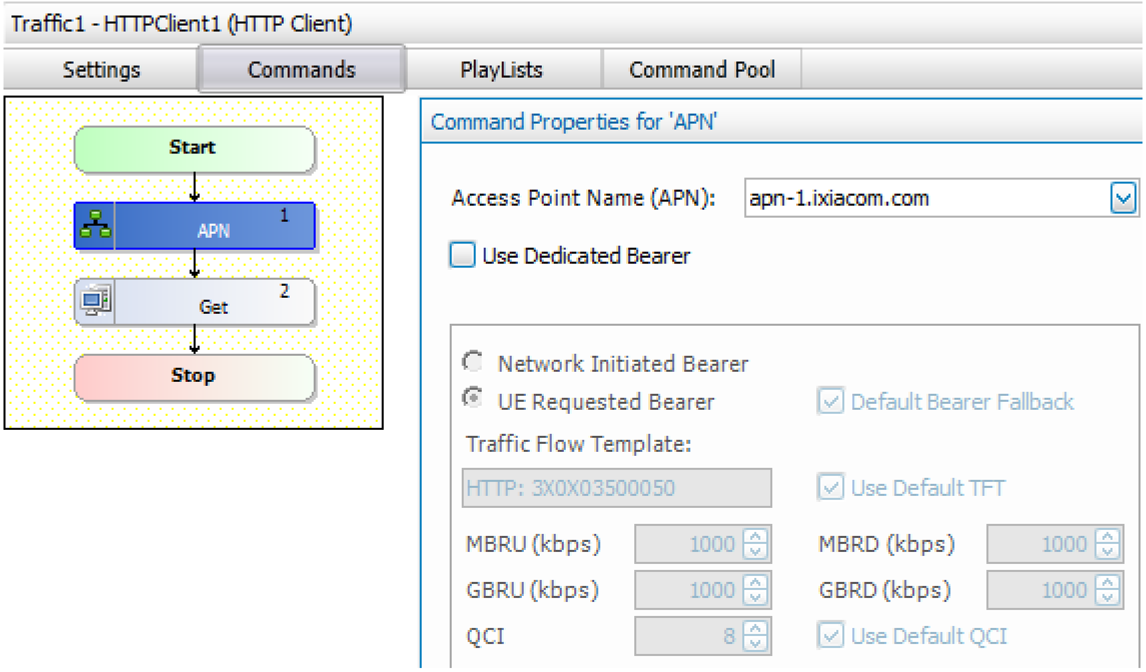
● Create interface with user

☑ Teardown interface with user

○ Create interface at the start and teardown at the end of the command list

Figure 55. Interface Behavior

11. Add an HTTP client activity to the NetTraffic. Configure it to have the previously configured HTTP server as a target. Configure one command in the command list: GET the 1024k.html file, and make sure the iterate command list is selected.
12. Click the Commands tab of the HTTP activity, and select the APN command. Make sure that the Use Dedicated Bearer checkbox is cleared. This action causes the http activity to run on the default bearer for each UE.


Traffic1 - HTTPClient1 (HTTP Client)
Settings
Commands
PlayLists
Command Pool
Start
APN
1
Get
2
Stop
Command Properties for 'APN'

Access Point Name (APN): apn-1.ixiacom.com

☐ Use Dedicated Bearer

○ Network Initiated Bearer

● UE Requested Bearer ☑ Default Bearer Fallback

Traffic Flow Template: HTTP: 3X0X03500050 ☑ Use Default TFT

MBRU (kbps) 1000 MBRD (kbps) 1000

GBRU (kbps) 1000 GBRD (kbps) 1000

QCI 8 ☑ Use Default QCI

Figure 56. APN command

13. In the Timelines and Objectives section, select a Simulated Users objective for the HTTP activity on the client network, and configure an objective value of 120000. Configure a 60-minute timeline duration, with a ramp up value of 1000 users/second.
14. In the Port Assignments section, assign the client NetTraffic to the 12 port CPUs of the first Acceleron-NP card.
15. Assign the server NetTraffic to the 12 port CPUs of the second Acceleron-NP load module.
16. Enable 10G aggregation mode for both Acceleron-NP load modules.
17. In the Test Options section, select the Network Diagnostics check box to enable the GTP statistics.

Test Variables

Table 6. Test Variables for Throughput Test with High Control Plane (Signaling) Traffic

Variable	Value	Comment
UE Count	120K	
MME count for client network (eNodeB and MME)	12	
eNodeB count for client network (eNodeB and MME)	12	
Objective for HTTP activity	SU = 120K	
Mobility interval	65s	
Maximum interval variation	5%	
Start delay	120s	
Start delay variation	0s	

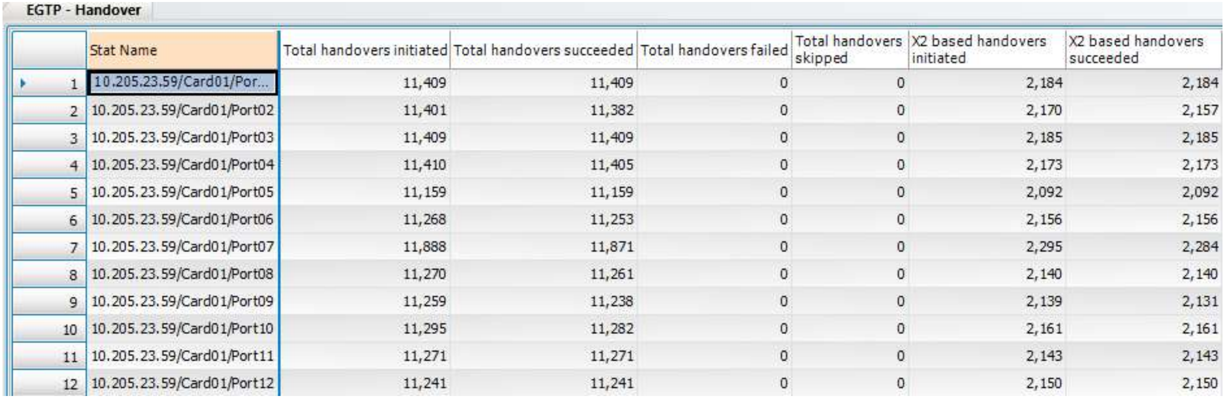
Results Analysis

The statistics here to watch are the handovers, because this is a handover focused test. All handover related statistics are available in the same view called eGTP – Handover.

The view contains five tabs:

- **All**: Contains all the statistics related to all the different types of handovers.
- **Total**: Contains totals initiated and failed for all handover types.
- **X2 Based Handovers**: Contains statistics that only relate to X2-based handovers.
- **S1 Based Handovers**: Direct Forwarding: Contains the statistics related to S1-based handovers by using direct forwarding.
- **S1 Based Handovers**: Indirect Forwarding: Contains the statistics related to S1-based handovers that do not make use of direct forwarding.

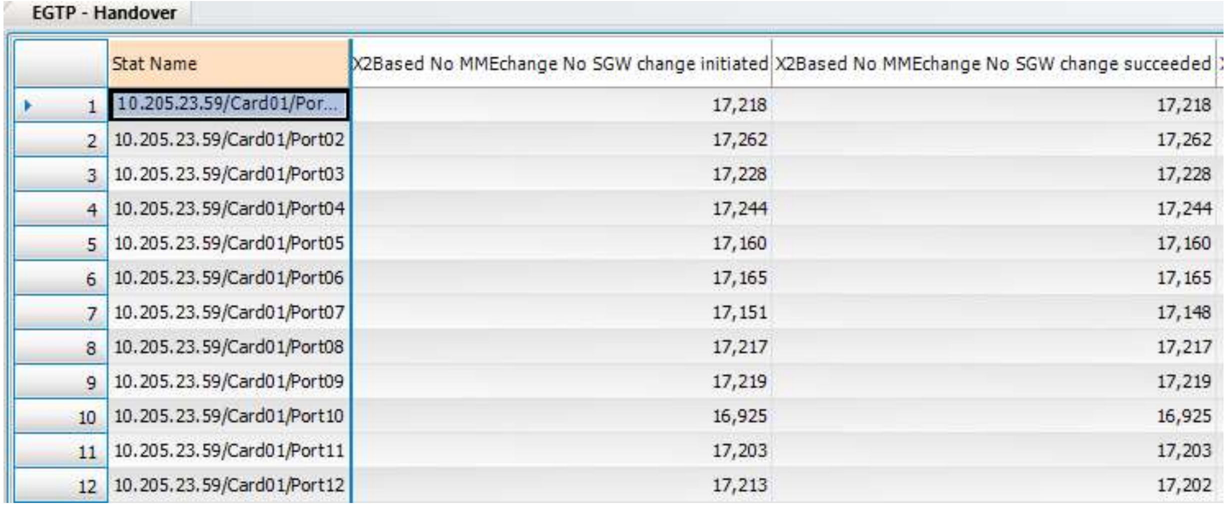
All the tabs will be interesting to monitor during the test, because this test contains handovers of all types as outlined earlier.



	Stat Name	Total handovers initiated	Total handovers succeeded	Total handovers failed	Total handovers skipped	X2 based handovers initiated	X2 based handovers succeeded
1	10.205.23.59/Card01/Por...	11,409	11,409	0	0	2,184	2,184
2	10.205.23.59/Card01/Port02	11,401	11,382	0	0	2,170	2,157
3	10.205.23.59/Card01/Port03	11,409	11,409	0	0	2,185	2,185
4	10.205.23.59/Card01/Port04	11,410	11,405	0	0	2,173	2,173
5	10.205.23.59/Card01/Port05	11,159	11,159	0	0	2,092	2,092
6	10.205.23.59/Card01/Port06	11,268	11,253	0	0	2,156	2,156
7	10.205.23.59/Card01/Port07	11,888	11,871	0	0	2,295	2,284
8	10.205.23.59/Card01/Port08	11,270	11,261	0	0	2,140	2,140
9	10.205.23.59/Card01/Port09	11,259	11,238	0	0	2,139	2,131
10	10.205.23.59/Card01/Port10	11,295	11,282	0	0	2,161	2,161
11	10.205.23.59/Card01/Port11	11,271	11,271	0	0	2,143	2,143
12	10.205.23.59/Card01/Port12	11,241	11,241	0	0	2,150	2,150

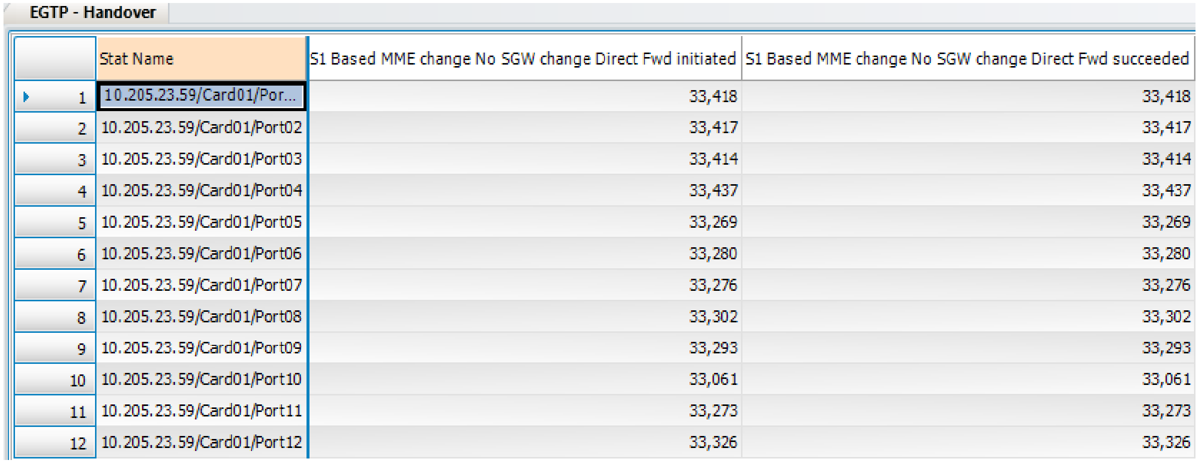
Figure 57. The Handover Statistics View, All tab

The preceding figure shows the **Total** tab. It summarizes the various handovers types that were attempted, and shows how many succeeded, and also if any have failed to complete.



	Stat Name	X2Based No MMEchange No SGW change initiated	X2Based No MMEchange No SGW change succeeded
1	10.205.23.59/Card01/Por...	17,218	17,218
2	10.205.23.59/Card01/Port02	17,262	17,262
3	10.205.23.59/Card01/Port03	17,228	17,228
4	10.205.23.59/Card01/Port04	17,244	17,244
5	10.205.23.59/Card01/Port05	17,160	17,160
6	10.205.23.59/Card01/Port06	17,165	17,165
7	10.205.23.59/Card01/Port07	17,151	17,148
8	10.205.23.59/Card01/Port08	17,217	17,217
9	10.205.23.59/Card01/Port09	17,219	17,219
10	10.205.23.59/Card01/Port10	16,925	16,925
11	10.205.23.59/Card01/Port11	17,203	17,203
12	10.205.23.59/Card01/Port12	17,213	17,202

Figure 58. The Handover Statistics View, X2 Based Handovers tab



	Stat Name	S1 Based MME change No SGW change Direct Fwd initiated	S1 Based MME change No SGW change Direct Fwd succeeded
1	10.205.23.59/Card01/Por...	33,418	33,418
2	10.205.23.59/Card01/Port02	33,417	33,417
3	10.205.23.59/Card01/Port03	33,414	33,414
4	10.205.23.59/Card01/Port04	33,437	33,437
5	10.205.23.59/Card01/Port05	33,269	33,269
6	10.205.23.59/Card01/Port06	33,280	33,280
7	10.205.23.59/Card01/Port07	33,276	33,276
8	10.205.23.59/Card01/Port08	33,302	33,302
9	10.205.23.59/Card01/Port09	33,293	33,293
10	10.205.23.59/Card01/Port10	33,061	33,061
11	10.205.23.59/Card01/Port11	33,273	33,273
12	10.205.23.59/Card01/Port12	33,326	33,326

Figure 59. Handover Statistics View, S1 Based Handovers – Direct Forwarding

The above figure shows more details related to the X2 based handovers executed during the test.

EPC Test Case: eNodeB Plugin IDLE/Paging Procedure Using Subscriber Model

Overview

In an EPC test case, the system under test comprises of the MME, SGW, PGW, and possibly the PCRF. The test case is performed using IxLoad by simulating the eNodeBs and internet servers on the SGi interface. The traffic activity is StatelessPeer (UDP).

Objective

This is a system test case that has the objective of simulating UEs going into IDLE mode and receiving Downlink traffic which triggers Paging procedure.

Setup

1 eNodeB, one port CPU, with 1 subscriber, using Subscriber mode on eNodeB side and 1 host (IP) on SGi side (internet), using NetTraffic mode, one port CPU.

Multiple configuration parameters depend on the network under test, such as IP addresses for the MMEs and eNodeB, UE identifier parameters like IMSI and MSISDN, and networking parameters. These are typically obtained by knowing the network configuration.

Step by Step Instructions

1. Insert a new NetTraffic on the Terminate side. Configure it to have a range of 1 IP, by using IP address that corresponds to the network under test settings (PGW SGi interface).
2. Add a StatelessPeer activity to the NetTraffic. Refer to below section detailing activity settings.
3. Insert a new Subscriber on the Originate side.

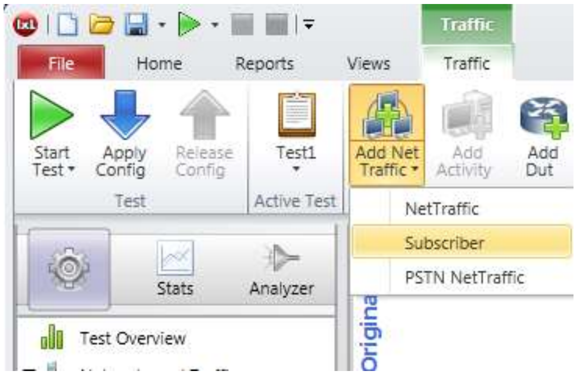


Figure 60. Adding Subscriber

4. Select it to configure, and delete the existing default IP stack (Delete Stack).
5. Add the eNodeB S1-MME/S1-U stack.

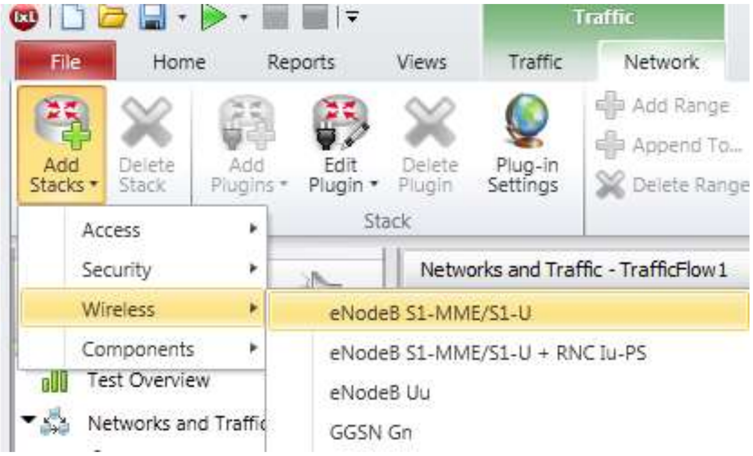


Figure 61. eNodeB S1-MME/S1-U stack

UE Tab

The UE tab contains the following additional sub-tabs:

Basic sub-tab:

Configure the **Count** value to match the test variables section.

Details sub-tab:

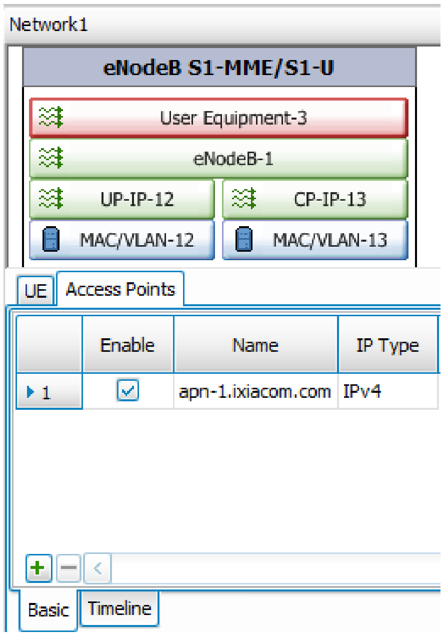
Configure the appropriate values for **MCC**, **MNC**, **IMEI**, **Software Version**, **Auth K Value** and **Auth OP Value**. These values, usually provided by the customers, identify the subscription and equipment and must match the values configured in the system under test (MME).

Mobility sub-tab:

Do not enable mobility for this test.

Access Points Tab

The Access Points tab contains the following additional sub-tabs:



	Enable	Name	IP Type
1	☑	apn-1.ixiacom.com	IPv4

Figure 62. Access Points tab

Basic sub-tab:

Configure the **APN Name** and **IP Type** to match the values configured in the system under test. Leave the other values at default.

Timeline sub-tab:

Timeline configuration is disabled when running in Subscriber mode.

eNodeB Tab

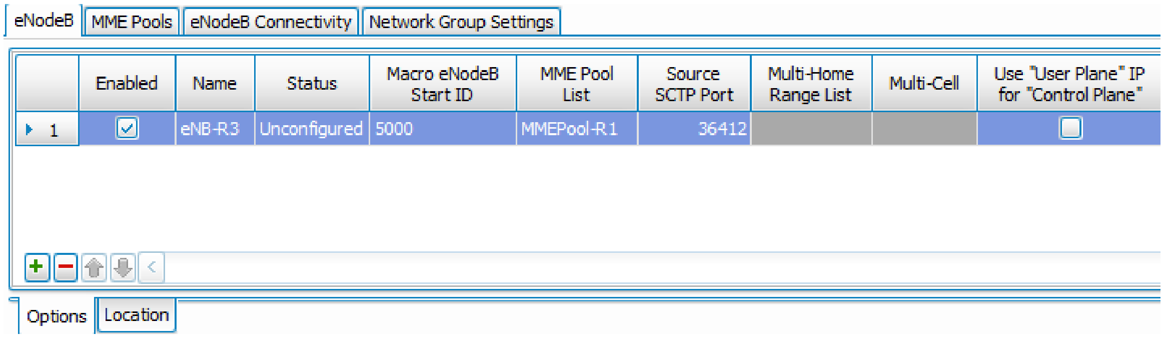
The eNodeB tab contains the following additional sub-tabs:

Options sub-tab:

eNodeBs are configured such that each range gets one parent MME.

Configure the **Macro eNodeB Start ID** and **Source SCTP Port** to match the value configured in the system under test. Leave the other values to default.

Select **Use “User Plane” IP for “Control Plane” IP** if your configuration uses a single IP address for both Control and User Planes. Active IP address is the one configured under **UP-IP** range.



	Enabled	Name	Status	Macro eNodeB Start ID	MME Pool List	Source SCTP Port	Multi-Home Range List	Multi-Cell	Use "User Plane" IP for "Control Plane"
1	☑	eNB-R3	Unconfigured	5000	MMEPool-R1	36412			☐

Figure 63. eNodeB tab

Location tab:

Configure values that match the values from the network under test. The **Home MCC, Home MNC,** and **TAC** values must match the system under test values exactly. Leave the other values to default.

MME Pools Tab

Configure the values that match the values from the network under test: MME **IP Address** and **IP Type**.

eNodeB Connectivity Tab

No change needed.

Network Group Settings Tab

No change needed.

eNB S1-MME CP Tab

Select Control Plane section (**eNB S1-MME CP**) to add network commands.

6. Add the following: Think, Enter Idle State, Wait For Paging, Think. Each UE executes this command list after Initial Attach until Sustain Time lapses.

   Leave default value for both Think commands (1000 ms). The main purpose of Think is to synchronize Control Plane with L7 commands.

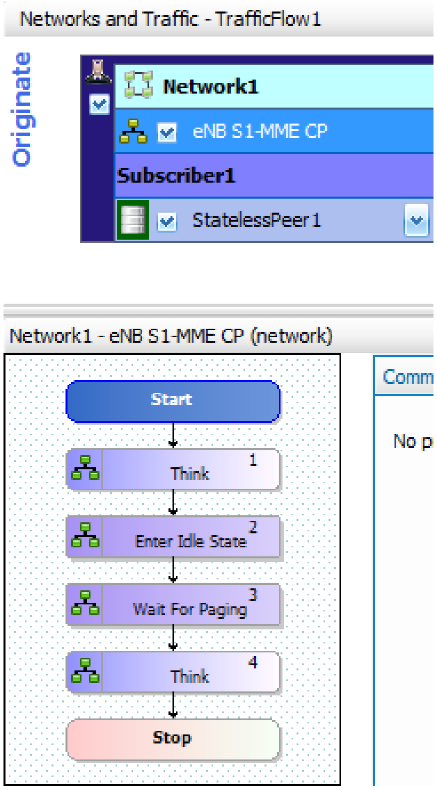


Figure 64. eNB S1-MME CP Network commands section

StatelessPeer activity

Click the green + button on the Subscriber ribbon to add StatelessPeer activity to the Subscriber.

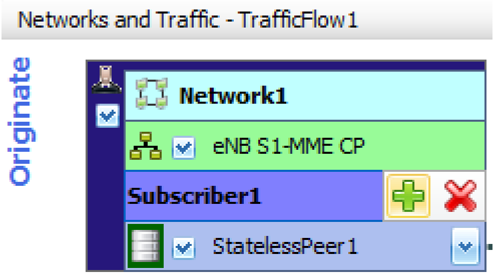


Figure 65. Add StatelessPeer to Subscriber

StatelessPeer command list

Add StatelessPeer commands by selecting Subscriber layer and using green + button available in StatelessPeer Command Editor window.

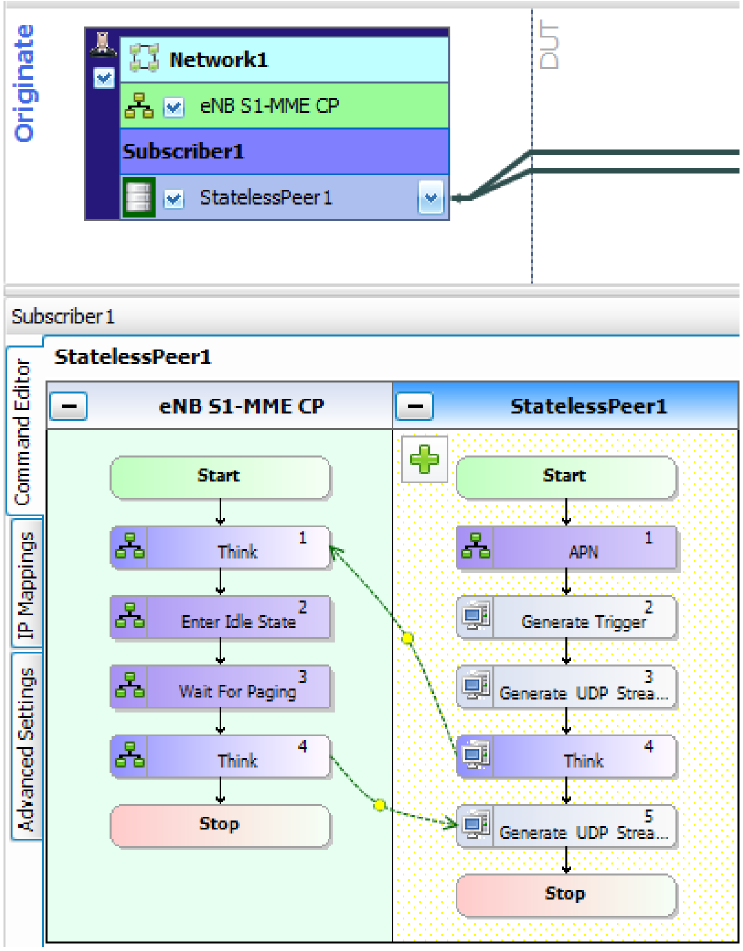
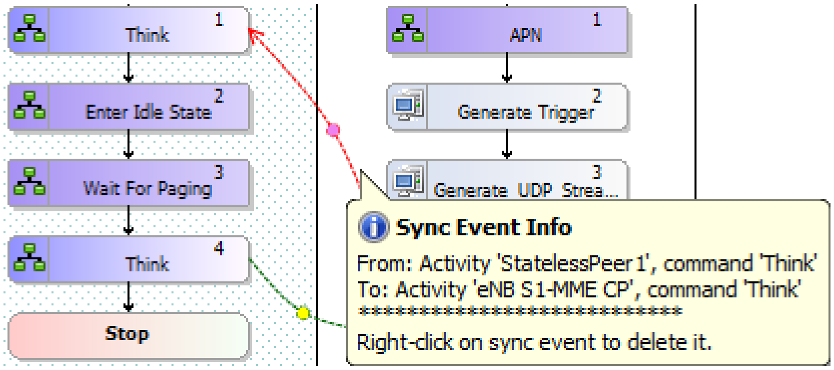


Figure 66. StatelessPeer commands

StatelessPeer commands

Configure the following commands: **Generate Trigger** (needed for Terminating side to learn UE's IP address dynamically allocated during Attach procedure), **Generate UDP Stream**, **Think**, **and Generate UDP Stream**. First the system runs **Generate UDP Stream** immediately after attach, before UE going into IDLE state. Enter Idle State is triggered by the subsequent Think command from the StatelessPeer activity through Sync Event.

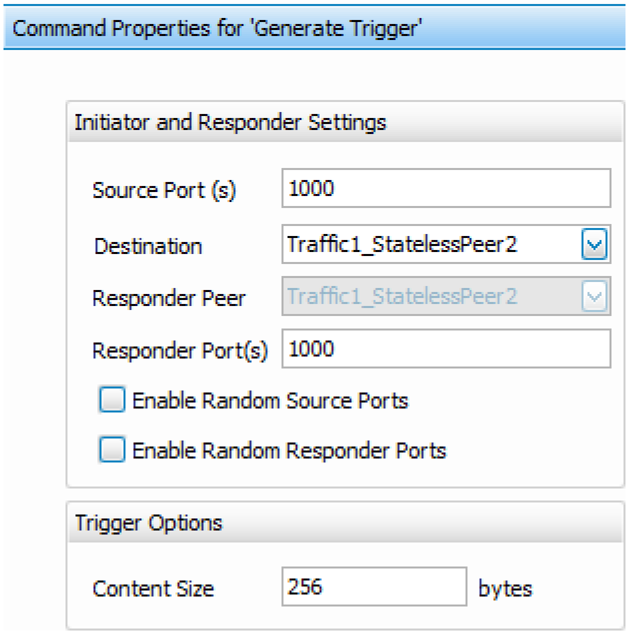


Sync Event Info

From: Activity 'StatelessPeer1', command 'Think'
To: Activity 'eNB S1-MME CP', command 'Think'
****
Right-click on sync event to delete it.

Figure 67. Sync Event used for Control – User Plane synchronization

7. Configure the following parameters for Generate Trigger command:



Command Properties for 'Generate Trigger'

Initiator and Responder Settings

Source Port (s): 1000

Destination: Traffic1_StatelessPeer2

Responder Peer: Traffic1_StatelessPeer2

Responder Port(s): 1000

☐ Enable Random Source Ports

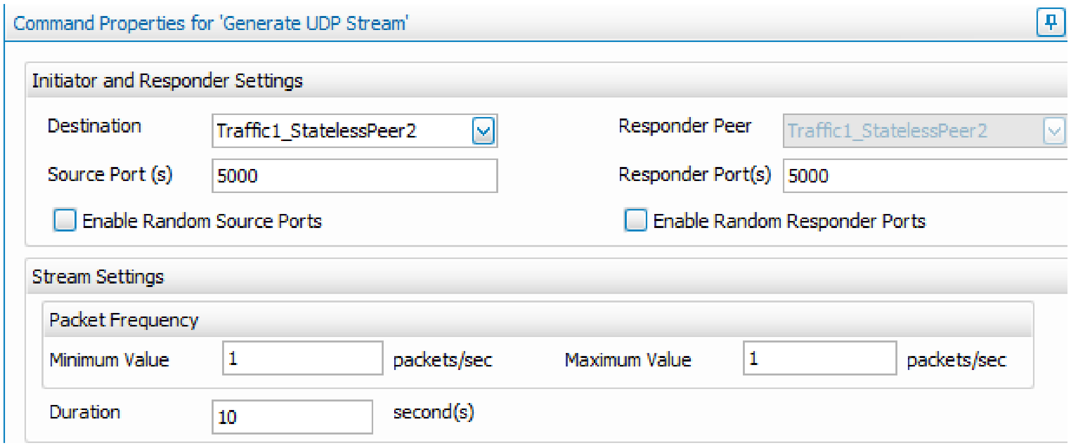
☐ Enable Random Responder Ports

Trigger Options

Content Size: 256 bytes

Figure 68. Generate Trigger parameters

8. Configure the following parameters for Generate UDP Stream commands; by setting different values for port and payload size the user can easily identify packets in the flow and capture:



Command Properties for 'Generate UDP Stream'

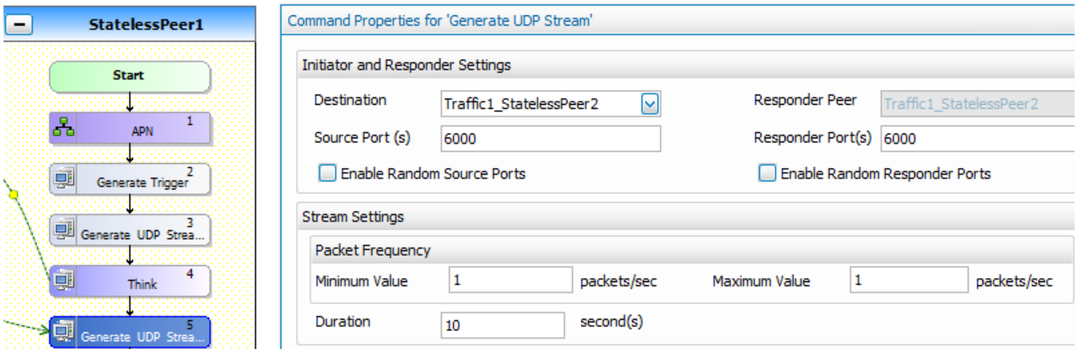
Initiator and Responder Settings

Destination: Traffic1_StatelessPeer2
Responder Peer: Traffic1_StatelessPeer2
Source Port (s): 5000
Responder Port(s): 5000
☐ Enable Random Source Ports
☐ Enable Random Responder Ports

Stream Settings

Packet Frequency
Minimum Value: 1 packets/sec
Maximum Value: 1 packets/sec
Duration: 10 second(s)

1st Generate UDP Stream command



Command Properties for 'Generate UDP Stream'

Initiator and Responder Settings

Destination: Traffic1_StatelessPeer2
Responder Peer: Traffic1_StatelessPeer2
Source Port (s): 6000
Responder Port(s): 6000
☐ Enable Random Source Ports
☐ Enable Random Responder Ports

Stream Settings

Packet Frequency
Minimum Value: 1 packets/sec
Maximum Value: 1 packets/sec
Duration: 10 second(s)

Figure 69. 2nd Generate UDP Stream command

Terminating side StatelessPeer

Add the following commands to SGi StatelessPeer activity: **Wait for Trigger** and **Generate UDP Stream**.

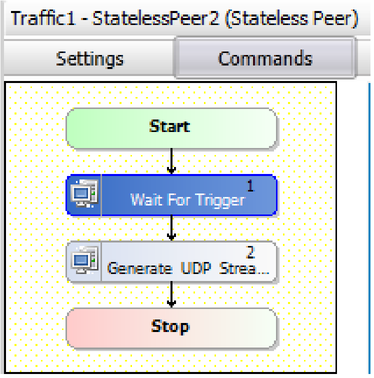
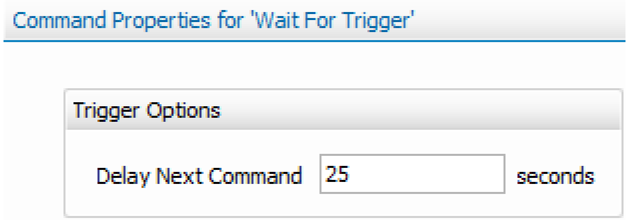


Figure 70. Terminating side StatelessPeer

9. Configure the Delay Next Command parameter with a value of 25 seconds. This configuration allows enough time for other commands to run and for Paging to occur while UE is in IDLE state.



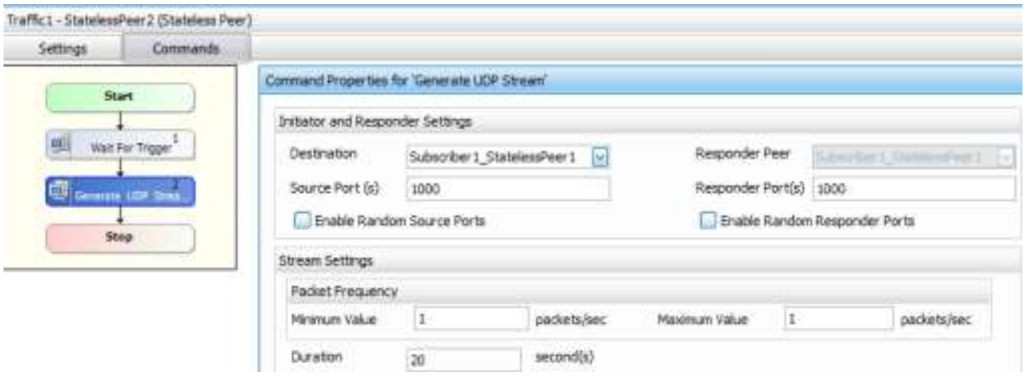
Command Properties for 'Wait For Trigger'

Trigger Options

Delay Next Command 25 seconds

Figure 71. Wait For Trigger settings

10. Configure the following parameters for Generate UDP Stream command. The Source and Responder Port(s) must match with the values configured for Generate Trigger on eNodeB side



Command Properties for 'Generate UDP Stream'

Initiator and Responder Settings

Destination Subscriber1_StatelessPeer1

Responder Peer Subscriber1_StatelessPeer1

Source Port (s) 1000

Responder Port(s) 1000

☐ Enable Random Source Ports

☐ Enable Random Responder Ports

Stream Settings

Packet Frequency

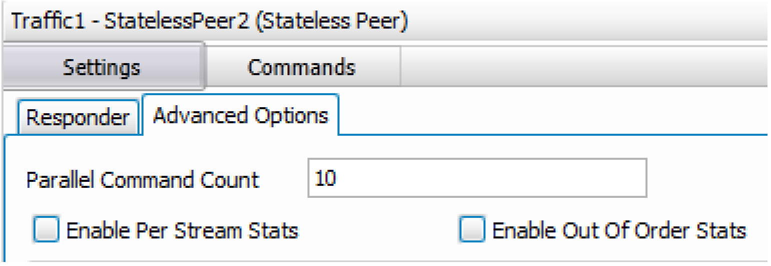
Minimum Value 1 packets/sec

Maximum Value 1 packets/sec

Duration 20 second(s)

Figure 72. Generate UDP Stream settings

11. Configure Parallel Stream Count (Settings – Advanced Options) with a value of 10. This parameter must match the number of active UEs, because the number of IP hosts on Terminate (SGi) side must be kept to a minimum (that is, value of 1) to generate symmetrical traffic.



Parallel Command Count 10

☐ Enable Per Stream Stats

☐ Enable Out Of Order Stats

Figure 73. Parallel Command Count

General Settings

Click the **Settings** button for the network plugin. In the **Interface Behavior** section, click **Create interface at the start and teardown at the end of the command list**. This selection enables dynamic control plane mode.

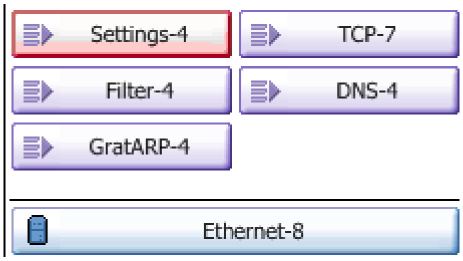
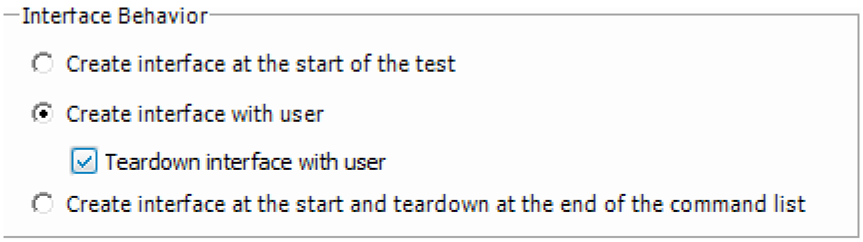


Figure 74. Interface Behavior settings


Interface Behavior

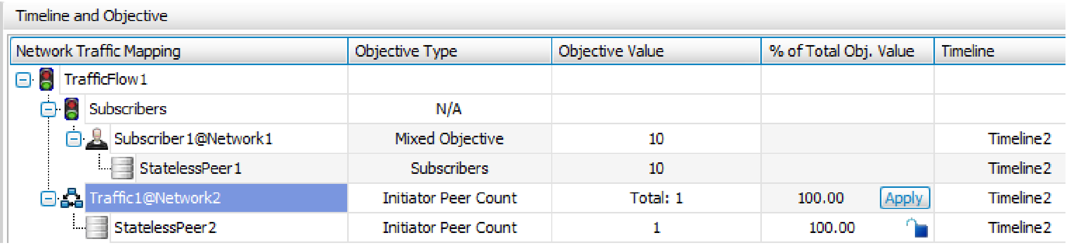
○ Create interface at the start of the test

● Create interface with user

☑ Teardown interface with user

○ Create interface at the start and teardown at the end of the command list

12. In the Timelines and Objectives section, select Subscribers objective for the StatelessPeer activity on the client network, and configure an objective value of 10. Configure a 3-minute timeline duration, with a ramp up value of 1 users/second.


Timeline and Objective

Network Traffic Mapping	Objective Type	Objective Value	% of Total Obj. Value	Timeline
TrafficFlow1				
Subscribers	N/A			
Subscriber1@Network1	Mixed Objective	10		Timeline2
StatelessPeer1	Subscribers	10		Timeline2
Traffic1@Network2	Initiator Peer Count	Total: 1	100.00 Apply	Timeline2
StatelessPeer2	Initiator Peer Count	1	100.00	Timeline2

Figure 75. Timeline and Objective

13. In the Port Assignments section, assign 1 port CPUs of the first Xcellon -NP card to the Subscriber on Originate side.

14. Assign 1 port CPU of the second Xcellon-NP to the NetTraffic on Terminate side.

15. In the Test Options section, select the Network Diagnostics check box to enable the GTP statistics.

Test Variables

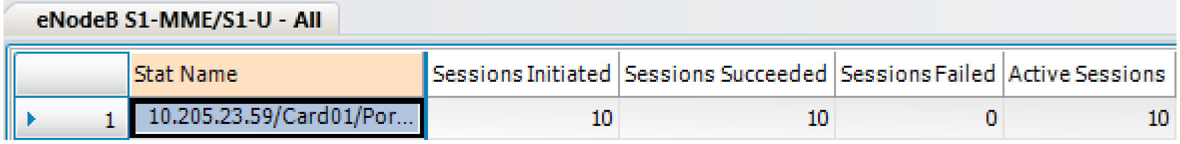
Table 7. Test Variables for eNodeB IDLE/Paging test

Variable	Value	Comment
UE Count	10	
eNodeB count for client network	1	
IP count on SGi (Terminate) side	1	
Objective for Subscriber StatelessPeer activity (eNodeB)	Subscriber = 10	
Objective for NetTraffic StatelessPeer activity (SGi)	1	
Parallel Stream Count	10	

Results Analysis

As this is a Control Plane procedure test, the statistics to watch are the Sessions and Messages.

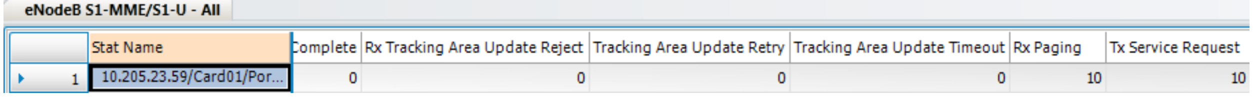
In the **eNodeB S1-MME/S1-U Sessions** view user needs to validate that all sessions were successful and active:



eNodeB S1-MME/S1-U - All

	Stat Name	Sessions Initiated	Sessions Succeeded	Sessions Failed	Active Sessions
1	10.205.23.59/Card01/Por...	10	10	0	10

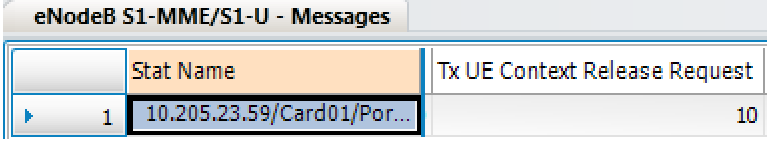
Same view displays counter for Paging events followed by an equal number of Service Requests (counter should be a multiple of active UEs):



eNodeB S1-MME/S1-U - All

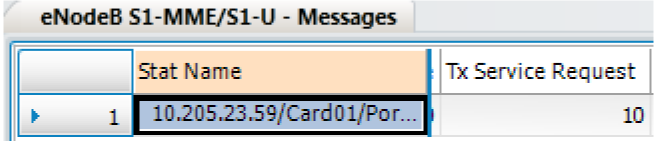
	Stat Name	Complete	Rx Tracking Area Update Reject	Tracking Area Update Retry	Tracking Area Update Timeout	Rx Paging	Tx Service Request
1	10.205.23.59/Card01/Por...	0	0	0	0	10	10

In the **eNodeB S1-MME/S1-U Messages** view, user should validate number of transmitted UE Context Release Request (sent when entering IDLE state) to match the Service Request (sent when exiting IDLE as a consequence of Paging):



eNodeB S1-MME/S1-U - Messages

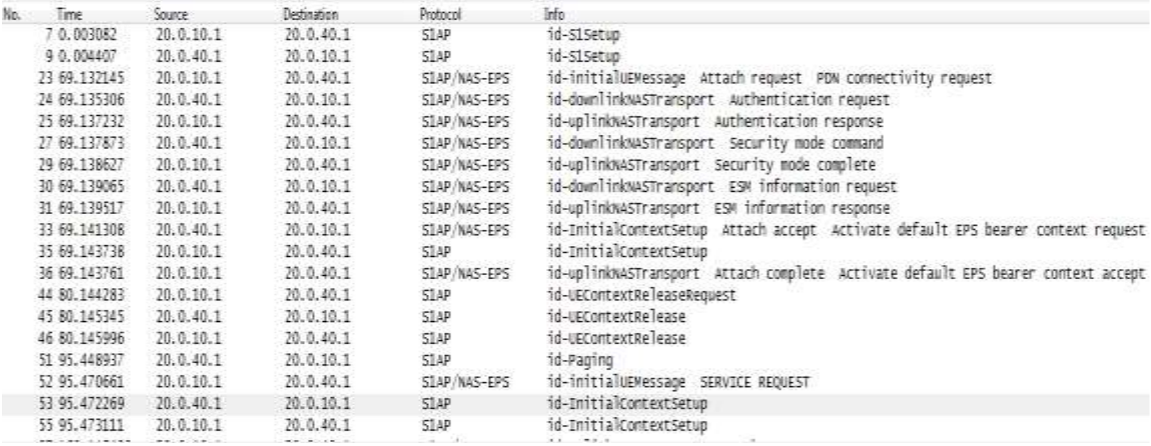
	Stat Name	Tx UE Context Release Request
1	10.205.23.59/Card01/Por...	10



eNodeB S1-MME/S1-U - Messages

	Stat Name	Tx Service Request
1	10.205.23.59/Card01/Por...	10

Next figure shows typical call flow for this procedure (S1AP messages captured on S1-MME interface, including S1-Setup which establishes link between eNB and MME):



```
No.  Time       Source      Destination  Protocol      Info
  7 0.003082   20.0.10.1   20.0.40.1    S1AP          id-S1Setup
  9 0.004407   20.0.40.1   20.0.10.1    S1AP          id-S1Setup
 23 69.132145  20.0.10.1   20.0.40.1    S1AP/NAS-EPS  id-initialUEMessage  Attach request  PDN connectivity request
 24 69.135306  20.0.40.1   20.0.10.1    S1AP/NAS-EPS  id-downlinkNASTransport  Authentication request
 25 69.137232  20.0.10.1   20.0.40.1    S1AP/NAS-EPS  id-uplinkNASTransport  Authentication response
 27 69.137873  20.0.40.1   20.0.10.1    S1AP/NAS-EPS  id-downlinkNASTransport  Security mode command
 29 69.138627  20.0.10.1   20.0.40.1    S1AP/NAS-EPS  id-uplinkNASTransport  Security mode complete
 30 69.139065  20.0.40.1   20.0.10.1    S1AP/NAS-EPS  id-downlinkNASTransport  ESM information request
 31 69.139517  20.0.10.1   20.0.40.1    S1AP/NAS-EPS  id-uplinkNASTransport  ESM information response
 33 69.141308  20.0.40.1   20.0.10.1    S1AP/NAS-EPS  id-InitialContextSetup  Attach accept  Activate default EPS bearer context request
 35 69.143738  20.0.10.1   20.0.40.1    S1AP          id-InitialContextSetup
 36 69.143761  20.0.10.1   20.0.40.1    S1AP/NAS-EPS  id-uplinkNASTransport  Attach complete  Activate default EPS bearer context accept
 44 80.144283  20.0.10.1   20.0.40.1    S1AP          id-UEContextReleaseRequest
 45 80.145345  20.0.40.1   20.0.10.1    S1AP          id-UEContextRelease
 46 80.145996  20.0.10.1   20.0.40.1    S1AP          id-UEContextRelease
 51 95.448937  20.0.40.1   20.0.10.1    S1AP          id-Paging
 52 95.470661  20.0.10.1   20.0.40.1    S1AP/NAS-EPS  id-initialUEMessage  SERVICE REQUEST
 53 95.472269  20.0.40.1   20.0.10.1    S1AP          id-InitialContextSetup
 55 95.473111  20.0.10.1   20.0.40.1    S1AP          id-InitialContextSetup
```

VoLTE Test Case: Measuring Quality of Experience for Voice Calls in LTE

Overview

With the migration of mobile networks to all IP networks defined by the LTE specification, there is a need to migrate the voice and sms services as well. Today, there are several options for carrying voice over LTE, using different technologies:

- **CSFB, Circuit Switched Fall Back**: The circuit switched fallback, CSFB option for providing voice over LTE has been standardized under 3GPP specification 23.272. Essentially LTE CSFB uses a variety of processes and network elements to enable the circuit to fall back to the 2G or 3G connection (GSM, UMTS, CDMA2000 1x) before a circuit switched call is initiated.
- The specification also allows for SMS to be carried as this is essential for very many set-up procedures for cellular telecommunications. To achieve this, the handset uses an interface known as SGs which allows messages to be sent over an LTE channel.
- **SV-LTE - simultaneous voice LTE**: SV-LTE allows running packet switched LTE services simultaneously with a circuit switched voice service. SV-LTE facility provides the facilities of CSFB at the same time as running a packet switched data service. This is an option that many operators will opt for. However, it has the disadvantage that it requires two radios to run at the same time within the handset. This has a serious impact on battery life.
- **VoLGA, Voice over LTE via GAN**: The VoLGA standard was based on the existing 3GPP Generic Access Network (GAN) standard, and the goal was to enable LTE users to receive a consistent set of voice, SMS (and other circuit-switched) services as they transition between GSM, UMTS and LTE access networks.
- **Voice over LTE, VoLTE (initially called One Voice)**: The Voice over LTE, VoLTE aims for providing voice over an LTE system utilizes IMS enabling it to become part of a rich media solution.

One additional approach which is not initiated by operators is the usage of Over-the-top (OTT) content services, using applications like Skype and Google Talk to provide LTE voice service. However, handing the LTE voice service over completely to the OTT actors is expected to not receive too much support in the telecom industry, while the voice call service is, and will still be, the main revenue source for the mobile operators.

The typical topology for VoLTE is shown below. The SIP registration and call control messages are sent from the User Endpoint (UE) over the default bearer in EPC to the Proxy Call Session Control Function (P-CSCF), the entry point in the IMS domain. In some networks a Session Border Controller (SBC) is used for this function. The Serving Call Session Control Function (S-CSCF) is the central node of the signaling plane. It is a SIP server that communicates to the Home Subscriber Server to download the users' profiles. S-CSCF controls over the Mr or Mg interfaces the Media Server and Media Gateway for voice routing.

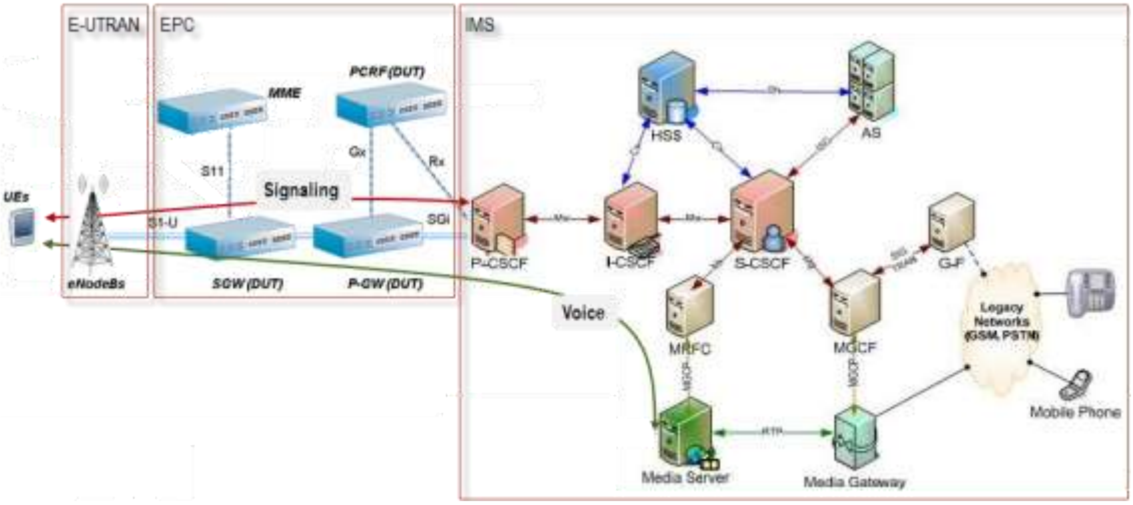


Figure 76. VoLTE Topology

To assure a good quality of voice, a dedicated bearer with high QoS is used for conversational speech in the EPC domain. The allocation of the dedicated bearer is requested by the P-CSCF to the Policy and Charging Rules Function (PCRF) over the Rx interface (this is a Diameter interface).

SMS-over-IP is also a functionality specified by VoLTE. The UE submits a short message via a SIP MESSAGE request that follows the same path to the S-CSCF. From this point, depending on the user profile (obtained by S-CSCF from HSS) the SIP request is sent to the IP-SM-GW (IP Short Message Gateway); for simplicity this server is not represented in the topology shown in the figure above. The submission report is sent by the IP-SM-GW to the UE as a SIP MESSAGE Request. The SMS submit and submission report requests use the same SIP Method, but with different content-body.

Objective

The goal of this test methodology is to determine the capacity of the EPC to handle a specific volume of calls without degradation of voice quality.

Setup

The EPC isolation test configuration is used for this test, where IxLoad will emulate:

- the User Endpoints over eNodeBs and MME (the left side of the topology diagram in the diagram below)
- the IMS network; that is the P-CSCF and all the devices behind it

Voice calls originate from the UEs (eNodeB /MME) and are terminated by user agents behind in the IMS network.

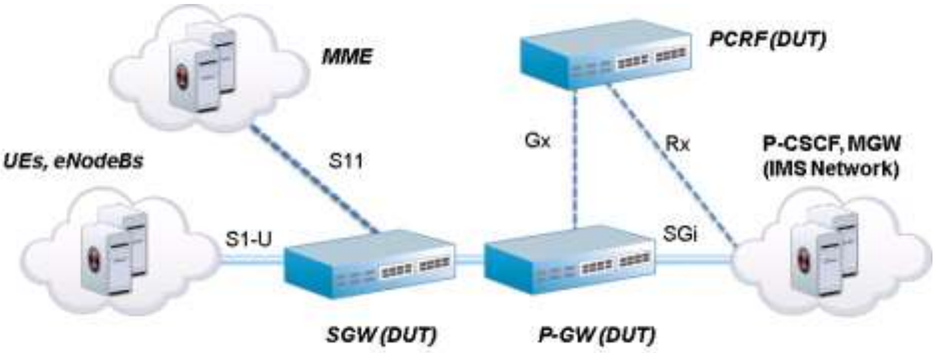


Figure 77. EPC Isolation Test Configuration

Step by Step Instructions

The step-by-step instructions highlight how to set the essential parameters of this configuration and explain additional options, which may be used to change the behavior of the test.

The final IxLoad configuration as a result of these steps is provided in the blackbook.ixiacom.com Web site - see *VoIP-VoLTE-IxLoad6.0.crf*. The configuration consists in two files: the test repository, a file with .rxf extension, and the test scenario for the SIP call flow, a file with the .tst extension. These two files are archived in a single .crf file. To import a Compressed Repository File (.crf) in IxLoad, use the command **Import** under the **File** menu.

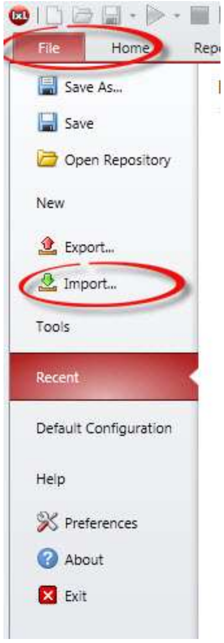


Figure 78. Option to Import a Compressed Repository File into IxLoad

Create the Network Traffic for UEs

1. Open the IxLoad GUI
2. Add the Originate **Net Traffic**

   The menu is context sensitive; to have access to **Add Net Traffic** button first select the Networks and Traffic in the navigation pane.

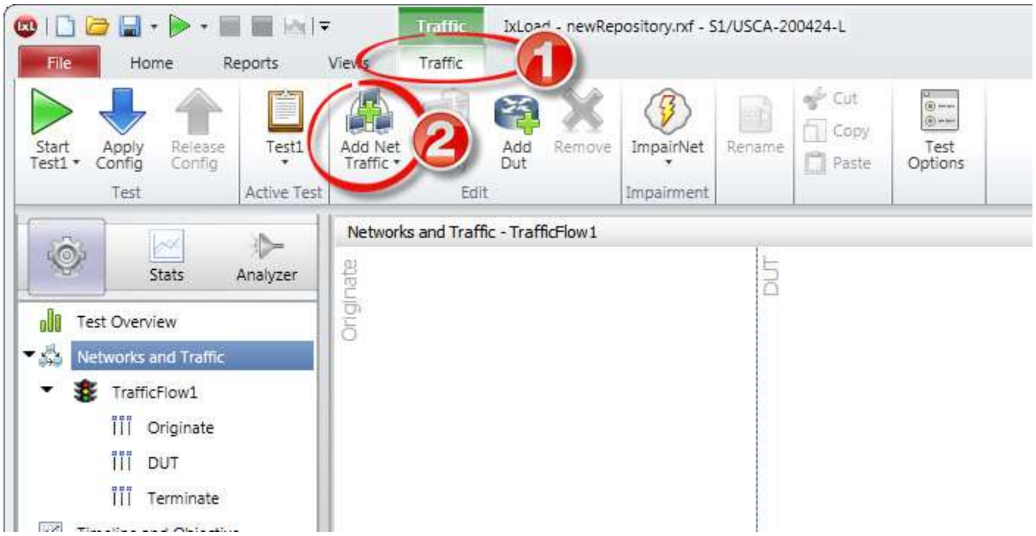


Figure 79. Add Net Traffic

3. Add the MME/eNB S11/S1-U Stack Manager interface to the Originate Net Traffic.

   By default, the Net Traffic added in step 2 contains a range of IPv4 addresses. The intention in this configuration is to emulate User Endpoints over MME and eNodeB that are connected through S11 and S1-U interfaces to the S-Gateway. These interfaces are provided by the MME/eNB S11/S1-U stack manager component. Select the Network1, right click on the IP-1, select Add above, and then MME/eNB S11/S1-u

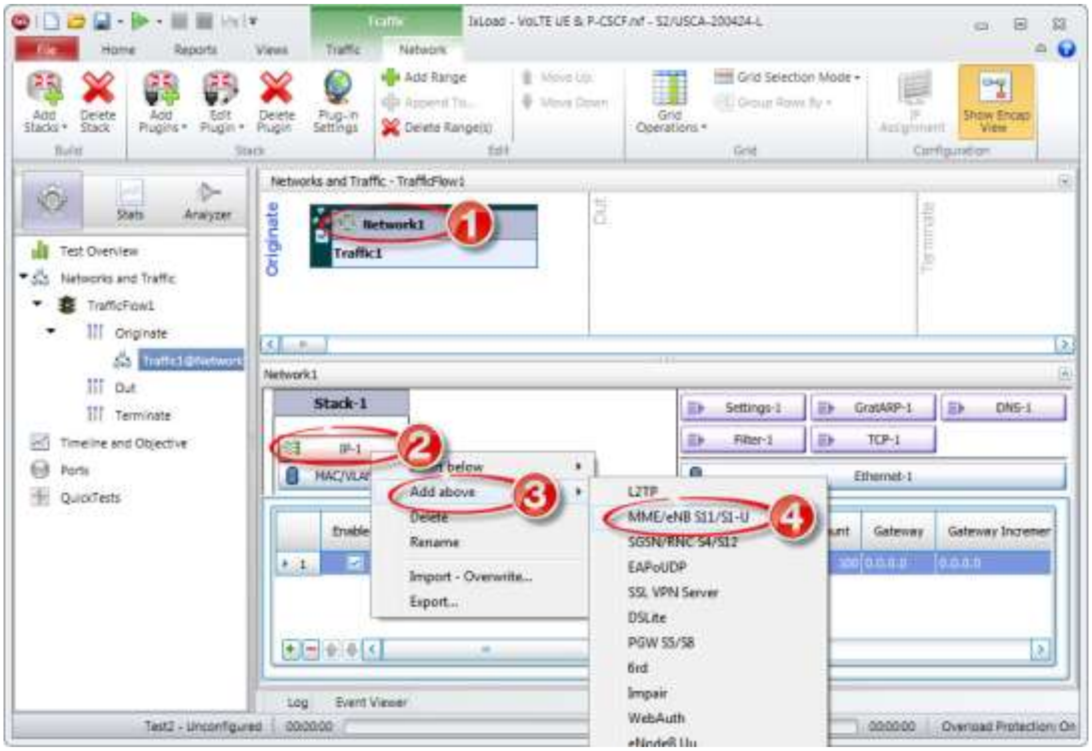
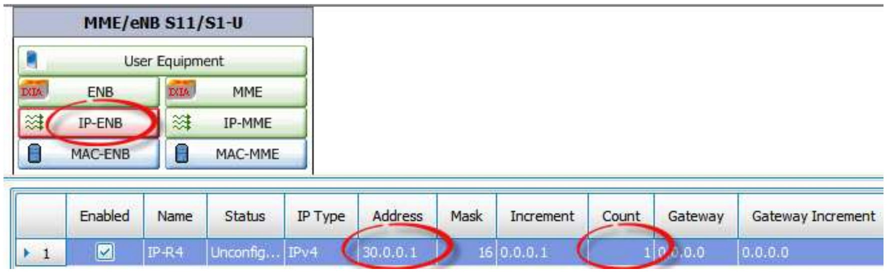


Figure 80. Add MME/eNB S11/S1-U Stack

4. Configure the IP addresses for the emulated eNodeB and emulated MME:

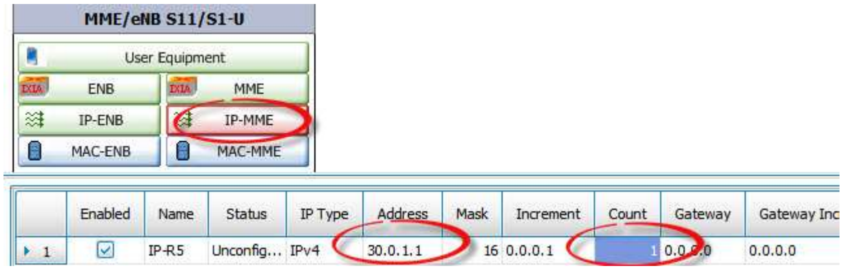
   a. One eNodeB with the IP address 30.0.0.1 is emulated by this configuration. Select the **IP-ENB** element and set the **Address** and the **Count**



	Enabled	Name	Status	IP Type	Address	Mask	Increment	Count	Gateway	Gateway Increment
1	☑	IP-R4	Unconfig...	IPv4	30.0.0.1	16	0.0.0.1	1	0.0.0.0	0.0.0.0

Figure 81. Setting the eNodeB IP address

b. One MME with the IP address 30.0.1.1 is emulated by this configuration. Select the IP-MME element and set the Address and the Count



	Enabled	Name	Status	IP Type	Address	Mask	Increment	Count	Gateway	Gateway Inc
1	☑	IP-R5	Unconfig...	IPv4	30.0.1.1	16	0.0.0.1	1	0.0.0.0	0.0.0.0

Figure 82. Setting the MME IP address

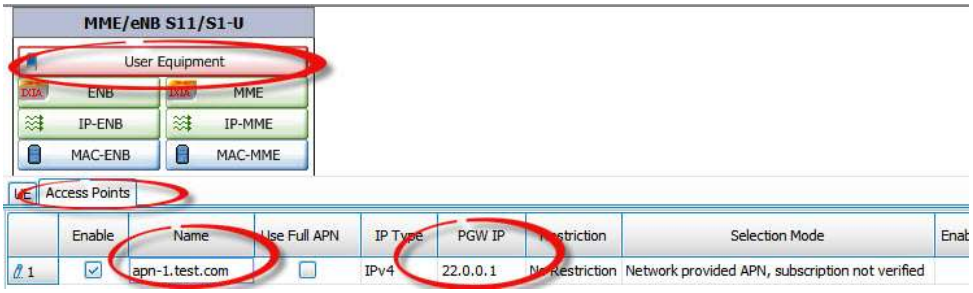
5. Configure the emulated User Equipment parameters:

    a. the APN (Access Point Name) must match the name configured on the system under test; for this example the APN is set to apn-1.test.com

    b. The IP address of the PGW to which the APN refers must be set in the PGW IP; for this case the real PGW has the IP address 22.0.0.1.

    Select the User Equipment element and, in the Access Points tab, set the APN name and the PGW IP.

    Note: The PGW IP address can be resolved by DNS query if the option Resolve DNS is enabled in the MME DNS tab; in that case there is no need to fill the PGW IP field.



	Enable	Name	Use Full APN	IP Type	PGW IP	Restriction	Selection Mode	Enab
1	☑	apn-1.test.com	☐	IPv4	22.0.0.1	No Restriction	Network provided APN, subscription not verified	

Figure 83. User Equipment Settings

Create the Network Traffic for emulated P-CSCF

6. Add a Net Traffic on the Terminate side

   Click Terminate in the Navigation Pane or in the Terminate column in the Networks and Traffic pane; then click the Add Net Traffic button in the Toolbar, or right click and select Add Net Traffic

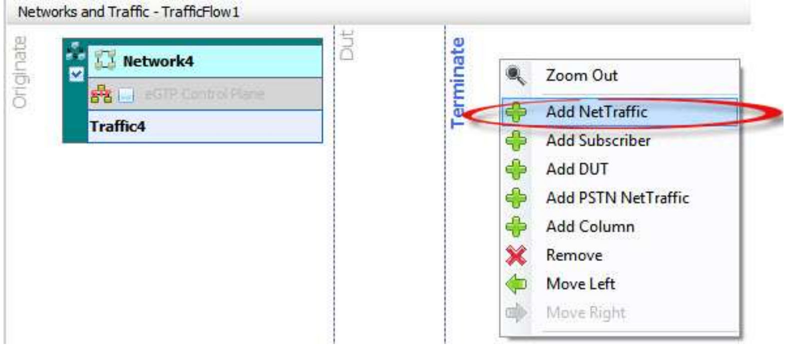
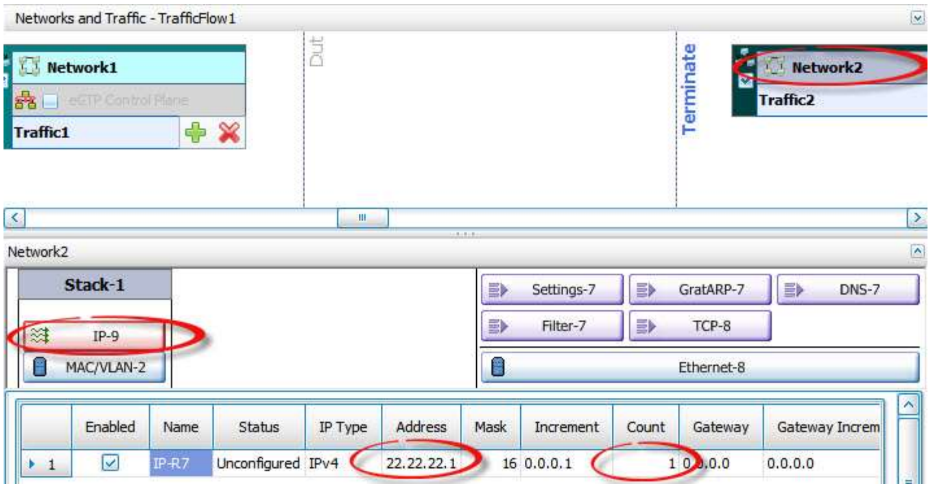


Figure 84. Add Net Traffic by right click on the Network and Traffic pane

7. Set the IP address of the emulated P-CSCF

   One P-CSCF server is emulated in this configuration. Set its IP Address to 22.22.22.1 and the Count to 1



	Enabled	Name	Status	IP Type	Address	Mask	Increment	Count	Gateway	Gateway Increm
1	☑	IP-R7	Unconfigured	IPv4	22.22.22.1	16	0.0.0.1	1	0.0.0.0	0.0.0.0

Figure 85. Table 8. IP Address of the emualted P-CSCF

Add the emulated P-CSCF

8. Add the SIP Cloud activity

   Move the mouse pointer over the Traffic element. A plus sign appears. Click on it and select the VoIPSIPCloud activity

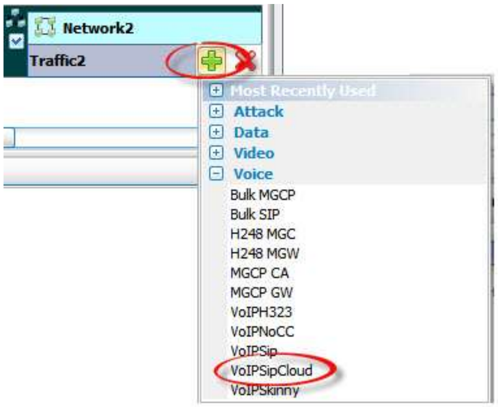
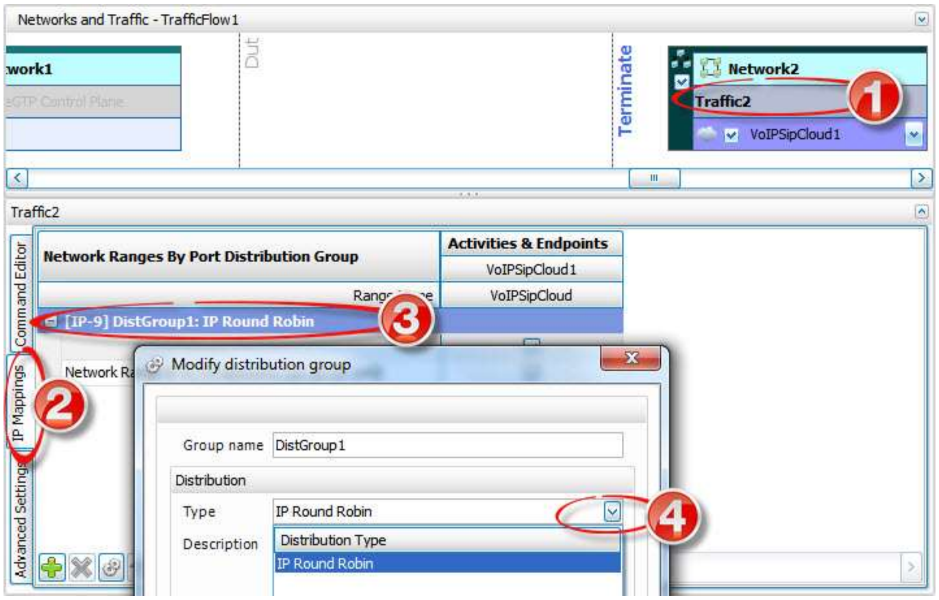


Figure 86. Add a SIP Cloud activity - this is the emulated P-CSCF

9. Set the Distribution Group of the IP address range to IP Round Robin

   The SIP Cloud requires that the distribution of the network ranges by port to be set to IP Round Robin.

   Select the Traffic element in the Net Traffic, select the IP Mappings tab, double click the Distribution Group and select the IP Round Robin distribution type.



Group name: DistGroup1

Type: IP Round Robin

Description

Figure 87. Distribution Type of Network Ranges

Add and configure the SIP Peer activities

In this moment, the configuration contains all the network elements. The next steps are to add the definition of the application traffic. The intention of this configuration is to emulate SIP UEs on the eNodeB/MME side that originate calls routed by the emulated P-CSCF to emulated SIP endpoints placed behind the P-CSCF. This is emulated by adding a SIP activity to originate calls on the **MME/eNB S11/S1-u** network and a SIP activity to receive calls under the **SIP Cloud**.

10. Add a SIP peer activity on the Originate side

    Move the mouse pointer over the Traffic element of the Originate network; a plus sign will be shown; click on it and select the VoIPSIP Peer activity.

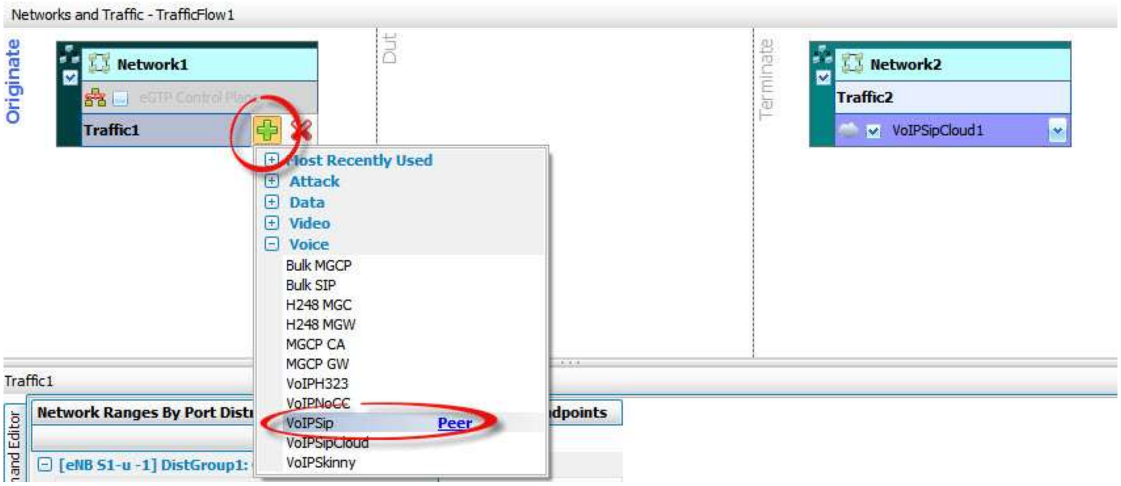


Figure 88. Add the VoIPSIP Peer activity

11. Add a SIP peer activity on the Terminate side.

    Repeat the operation of adding a SIP peer activity on the terminate Net Traffic.

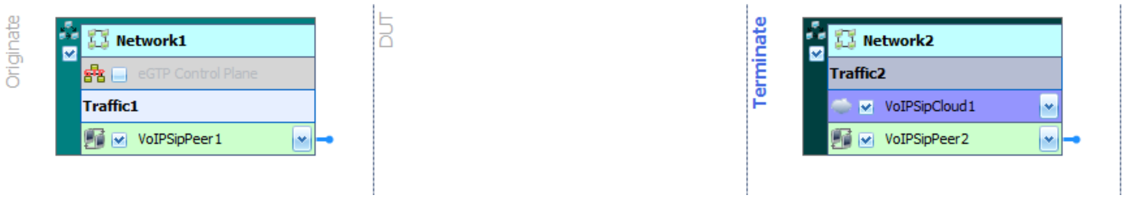


Figure 89. SIP Peer activities on both Originate and Terminate Network Traffics

12. Use one of SIP Sample message flows as the call flows for VoIPSIPPeer1 and 2 activities.

    Drag and drop the lollipop of the VoIPSIPPeer1 over VoIPSIPPeer2. Select the SIP EP – Registration and Call with Voice message flow from the drop down list.

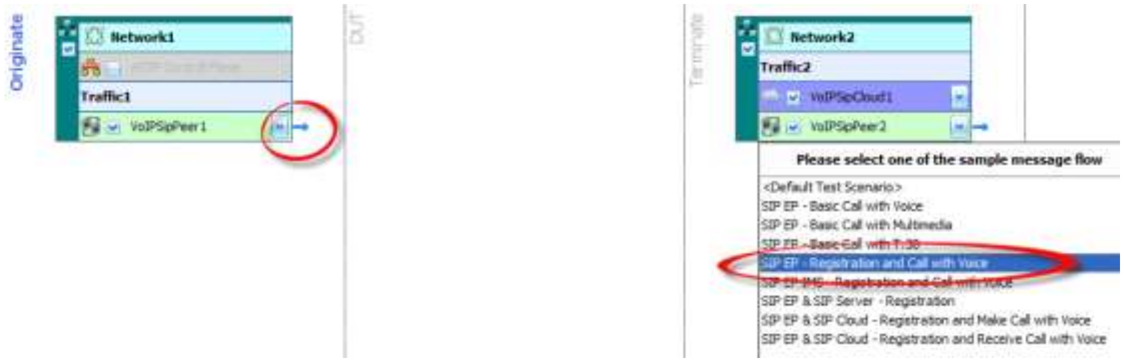

Originate
Network1
Traffic1
VoIPSipPeer1
DUT
Terminate
Network2
Traffic2
VoIPSipCloud1
VoIPSipPeer2
Please select one of the sample message flow
<Default Test Scenario>
SIP EP - Basic Call with Voice
SIP EP - Basic Call with Multimedia
SIP EP - Basic Call with T.38
SIP EP - Registration and Call with Voice
SIP EP IMS - Registration and Call with Voice
SIP EP & SIP Server - Registration
SIP EP & SIP Cloud - Registration and Make Call with Voice
SIP EP & SIP Cloud - Registration and Receive Call with Voice

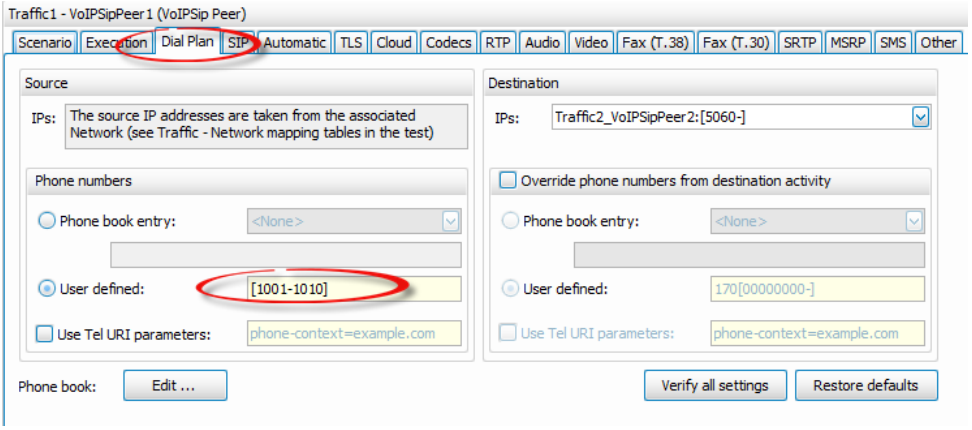
Figure 90. Add SIP Call flow to the SIP activities

13. Set the parameters of VoIPSIPPeer1 activity.

    Select the VoIPSIPPeer1 activity

    a. Set the Dial Plan

       In this example, we emulate 10 UEs with Phone Numbers 1001 to 1010. Click the Dial Plan tab and edit the sequence [1001-1010] in the Source / Phone Numbers field of the Dial Plan. Leave the Destination as the Symbolic Link to the Terminate VoIP activity; the phone numbers defined there are used in building the SIP Invite requests.



Source

IPs: The source IP addresses are taken from the associated Network (see Traffic - Network mapping tables in the test)

Phone numbers

○ Phone book entry: <None>

● User defined: [1001-1010]

☐ Use Tel URI parameters: phone-context=example.com

Destination

IPs: Traffic2_VoIPSipPeer2:[5060-]

☐ Override phone numbers from destination activity

○ Phone book entry: <None>

● User defined: 170[00000000-]

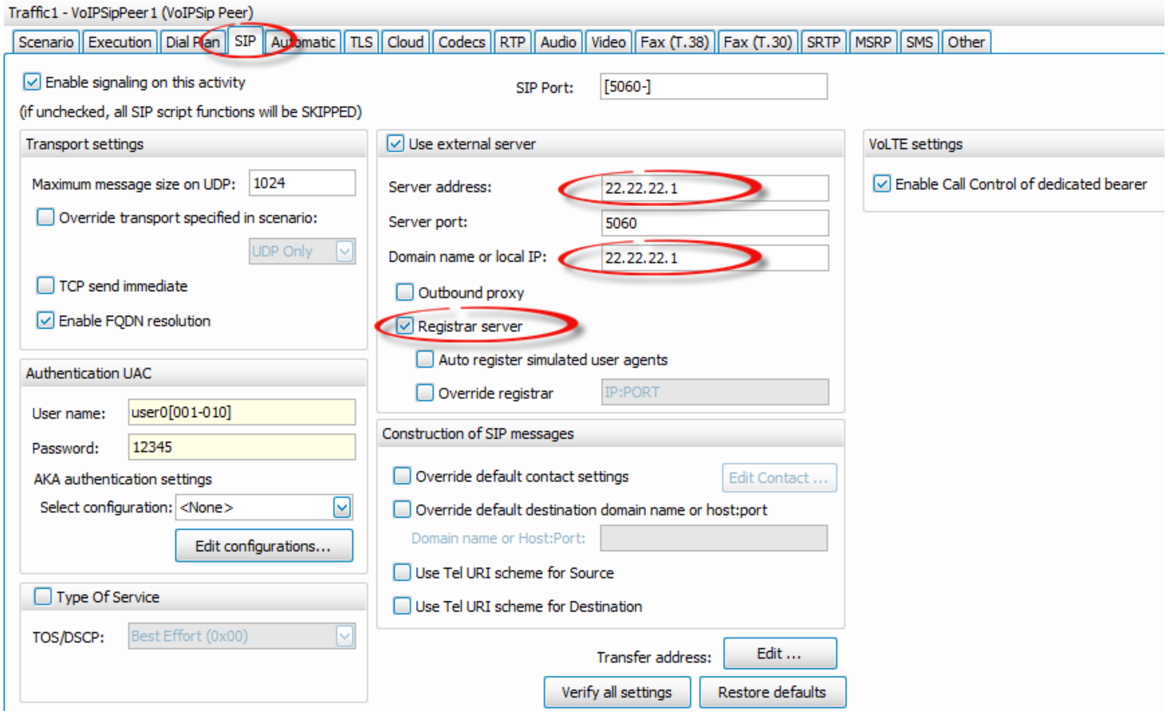
☐ Use Tel URI parameters: phone-context=example.com

Figure 91. Dial Plan

b. Set the SIP Server Address

The UE must know the IP address of the P-CSCF; it can be configured as an IP address or as a domain name in the SIP Tab. In this case, while the P-CSCF is the entry point to the IMS network, the IP address of the registrar server is the same. The P-CSCF knows how to route the registration and call setup requests. But for the UEs this is transparent; it sends all the SIP requests to the same P-CSCF.

Click the SIP Tab, and select Use External Server checkbox. Set the Server address and Domain name or local IP to the IP address of the P-CSCF (22.22.22.1 in this example) and select the Registrar server checkbox.


Traffic1 - VoIPSipPeer1 (VoIPSip Peer)

☑ Enable signaling on this activity

(if unchecked, all SIP script functions will be SKIPPED)

SIP Port: [5060-]

Transport settings

Maximum message size on UDP: 1024

☐ Override transport specified in scenario: UDP Only

☐ TCP send immediate

☑ Enable FQDN resolution

Authentication UAC

User name: user0[001-010]

Password: 12345

AKA authentication settings

Select configuration: <None>

☐ Type Of Service

TOS/DSCP: Best Effort (0x00)

☑ Use external server

Server address: 22.22.22.1

Server port: 5060

Domain name or local IP: 22.22.22.1

☐ Outbound proxy

☑ Registrar server

☐ Auto register simulated user agents

☐ Override registrar IP:PORT

Construction of SIP messages

☐ Override default contact settings

☐ Override default destination domain name or host:port

Domain name or Host:Port:

☐ Use Tel URI scheme for Source

☐ Use Tel URI scheme for Destination

Transfer address:

VoLTE settings

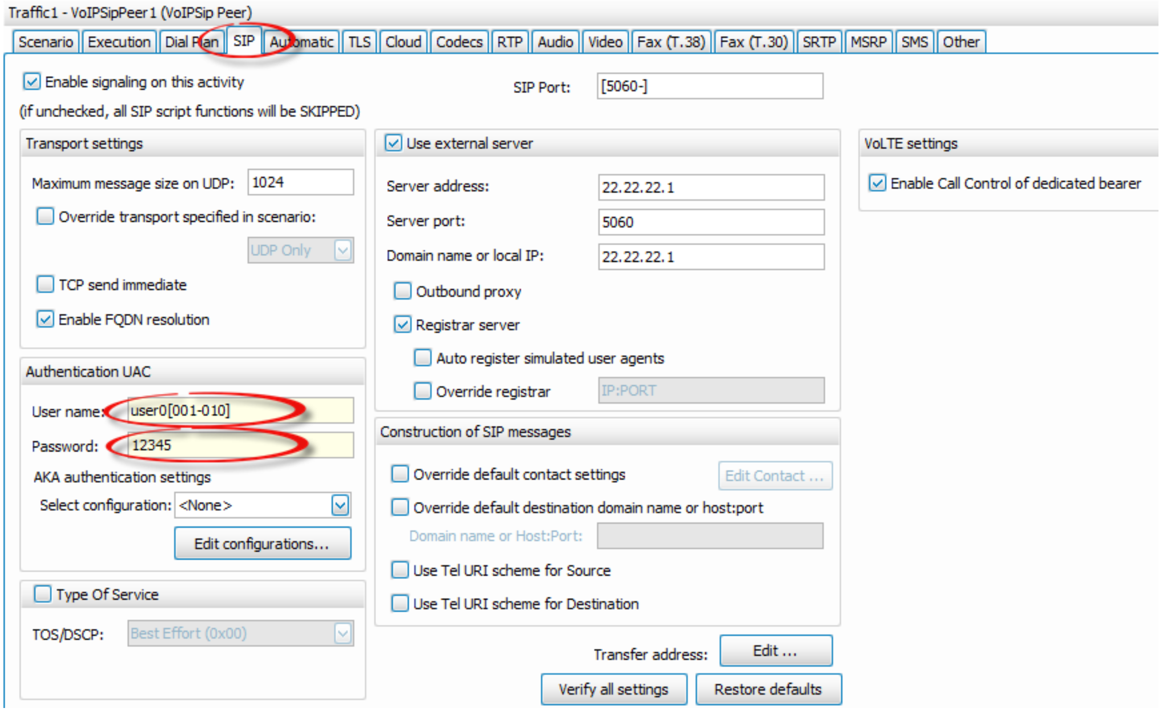
☑ Enable Call Control of dedicated bearer

Figure 92. Set the SIP Server IP address

c. Set the Authentication credentials

In the practical deployments, the SIP requests for registration or call setup are authenticated by the server. The UE must use the proper credentials to have access to the service. Several authentication methods are defined for SIP, IxLoad supporting all of them. In this example, we use digest MD5, that requests each user to have a username and a password. We use the sequence user0001 to user0010 for the username and the same password 12345 for all users; it is possible also to use a sequence for the password also. In cases where the phone numbers, usernames or passwords of the emulated UEs are not in sequence, a phonebook can be used.

In the **SIP** tab edit the Username and Password fields.



☑ Enable signaling on this activity

(if unchecked, all SIP script functions will be SKIPPED)

SIP Port: [5060-]

Maximum message size on UDP: 1024

☐ Override transport specified in scenario: UDP Only

☐ TCP send immediate

☑ Enable FQDN resolution

User name: user0[001-010]

Password: 12345

Select configuration: <None>

☐ Type Of Service

TOS/DSCP: Best Effort (0x00)

☑ Use external server

Server address: 22.22.22.1

Server port: 5060

Domain name or local IP: 22.22.22.1

☐ Outbound proxy

☑ Registrar server

☐ Auto register simulated user agents

☐ Override registrar IP:PORT

☐ Override default contact settings

☐ Override default destination domain name or host:port

Domain name or Host:Port:

☐ Use Tel URI scheme for Source

☐ Use Tel URI scheme for Destination

Transfer address:

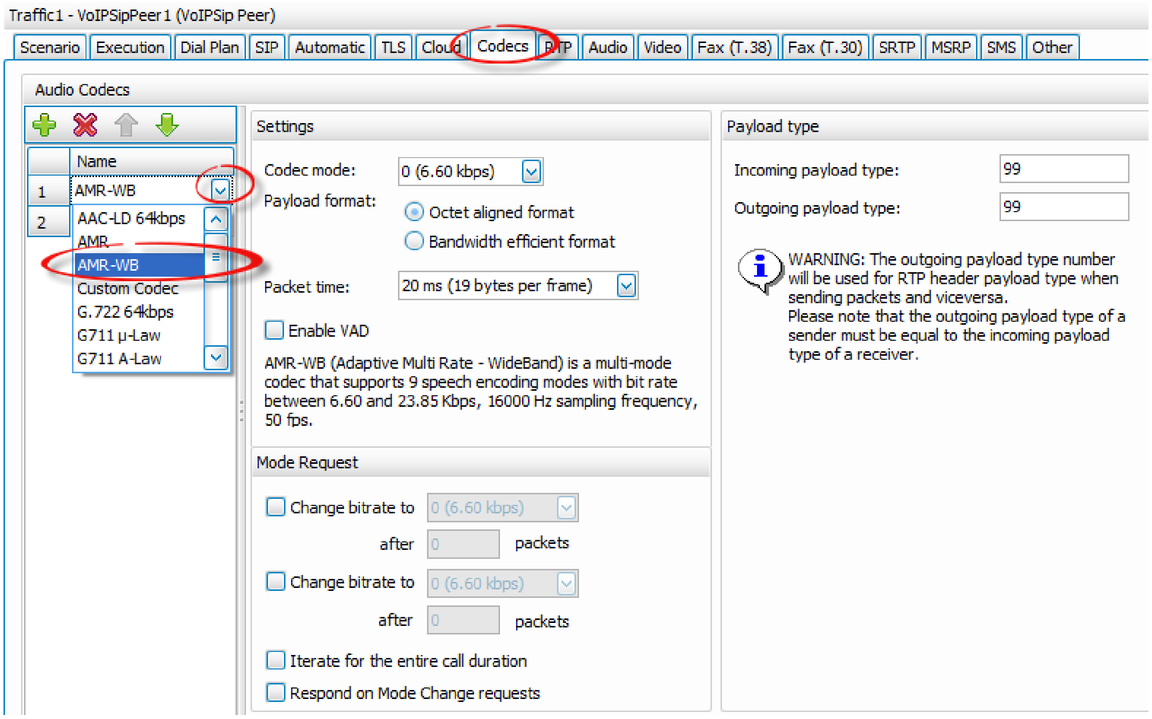
☑ Enable Call Control of dedicated bearer

Figure 93. Authentication Credentials

d. Set the Audio Codec to AMR-WB

VoLTE requires AMR codec for the speech communication. This is a multi-rate codec optimized for speech with capability to adapt to variations of network conditions. IxLoad supports both AMR-NB and WB versions.

Click the **Codecs** tab; in the table of audio codecs, select the first one, and choose AMR-WB codec from the drop down list. The user can change the order of preferred codecs. The SDP is automatically built with the parameters configured in this window.



	Name
1	AMR-WB
2	

Codec mode: 0 (6.60 kbps)

Payload format:

● Octet aligned format

○ Bandwidth efficient format

Packet time: 20 ms (19 bytes per frame)

☐ Enable VAD

AMR-WB (Adaptive Multi Rate - WideBand) is a multi-mode codec that supports 9 speech encoding modes with bit rate between 6.60 and 23.85 Kbps, 16000 Hz sampling frequency, 50 fps.

☐ Change bitrate to 0 (6.60 kbps) after 0 packets

☐ Change bitrate to 0 (6.60 kbps) after 0 packets

☐ Iterate for the entire call duration

☐ Respond on Mode Change requests

Incoming payload type: 99

Outgoing payload type: 99

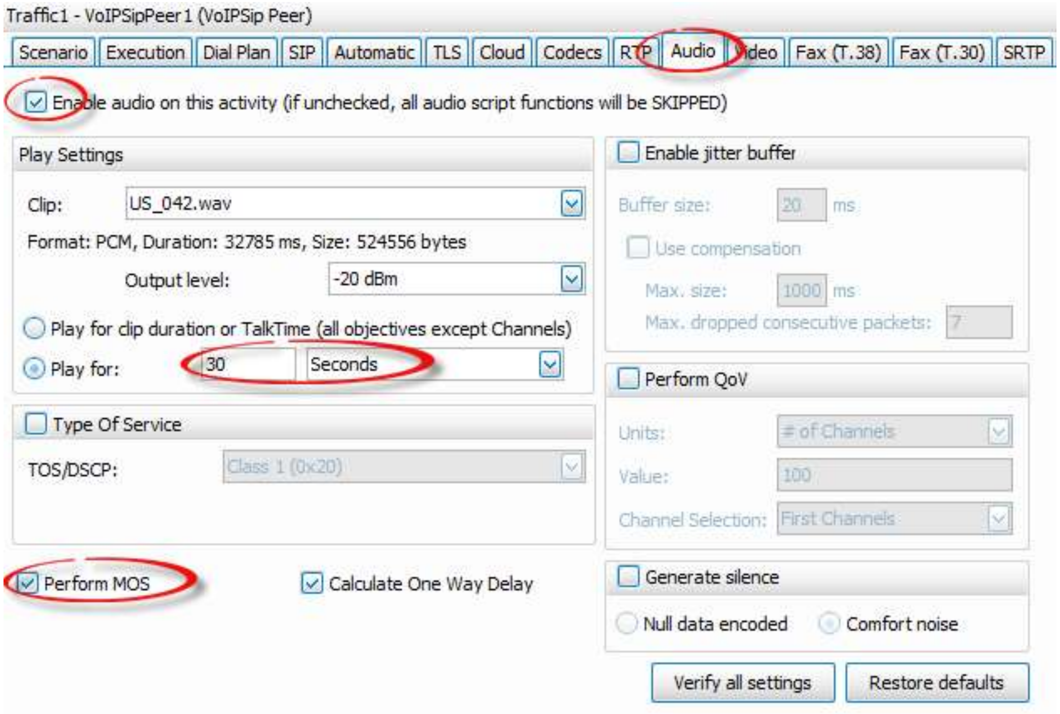
WARNING: The outgoing payload type number will be used for RTP header payload type when sending packets and viceversa.
Please note that the outgoing payload type of a sender must be equal to the incoming payload type of a receiver.

Figure 94. Set the AMR-WB as preferred codec

e. Set the Audio parameters

To have media during an established SIP call, the call flow must contain a media function and that type of media to be enabled on the activity. The call flow contains the function Voice Session that plays and listen audio clips in the same type; it implements the full duplex audio functionality. In the **Audio** tab, enable the Audio Activity. In the same window, specify the duration of the voice session and implicit the duration of the call (assuming only voice session function is executed during the call).

Click the Audio tab, Select the Enable audio on this activity check box. Set the Play for to 30 seconds, and enable the Perform MOS checkbox.



☑ Enable audio on this activity (if unchecked, all audio script functions will be SKIPPED)

Play Settings

Clip: US_042.wav

Format: PCM, Duration: 32785 ms, Size: 524556 bytes

Output level: -20 dBm

○ Play for clip duration or TalkTime (all objectives except Channels)

● Play for: 30 Seconds

☐ Type Of Service

TOS/DSCP: Class 1 (0x20)

☑ Perform MOS

☑ Calculate One Way Delay

☐ Enable jitter buffer

Buffer size: 20 ms

☐ Use compensation

Max. size: 1000 ms

Max. dropped consecutive packets: 7

☐ Perform QoV

Units: # of Channels

Value: 100

Channel Selection: First Channels

☐ Generate silence

○ Null data encoded ○ Comfort noise

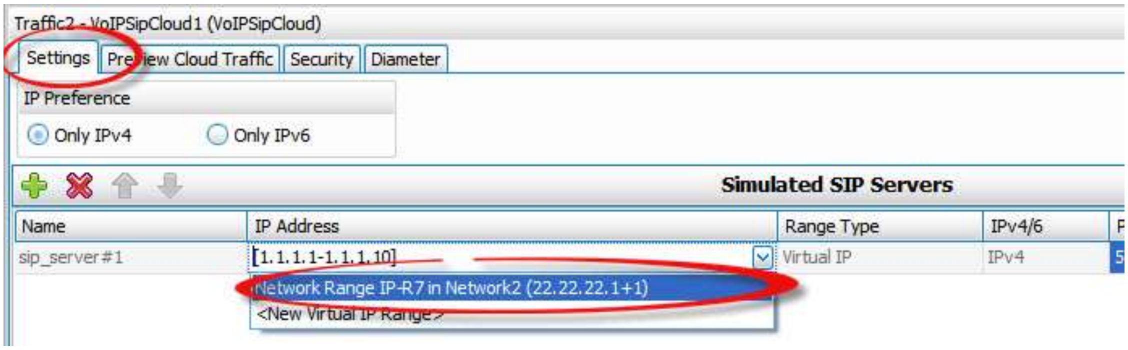
Figure 95. Audio Settings

14. Set the parameters of VoIPSipCloud1 activity

    Select the VoIPSipCloud1 activity

    a. Map the SIP cloud activity to the IP address defined for the Terminate Network

       In the **Settings** tab, select the IP address from the list. Only the Network Ranges with the Distribution Group Round Robin are shown.



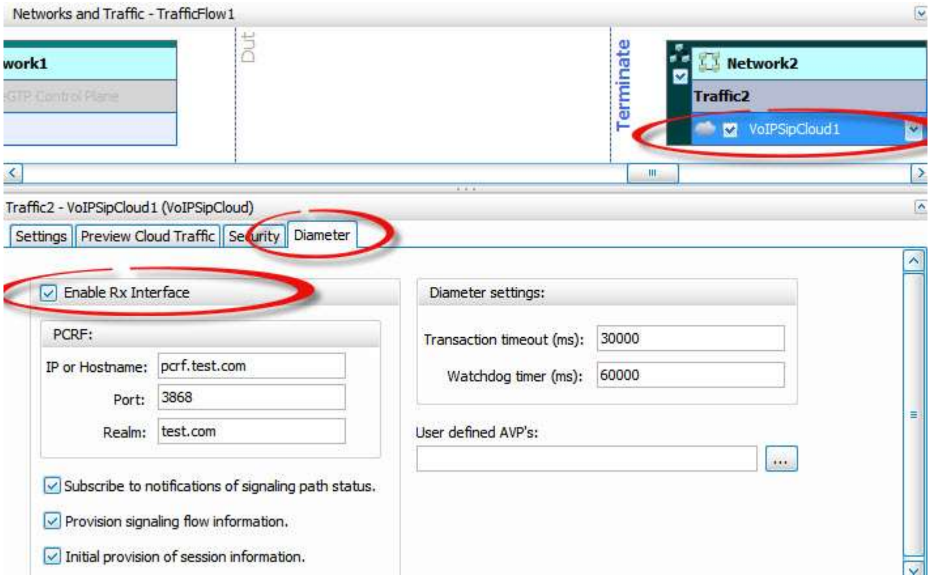
Name	IP Address	Range Type	IPv4/6
sip_server#1	[1.1.1.1-1.1.1.10]	Virtual IP	IPv4

Figure 96. Map the SIP cloud to an IP address

b. Enable the Rx interface on the emulated P-CSCF

The P-CSCF and the PCRF are connected through the Rx interface – see image below. The interface confirms that call media requests conform to the appropriate policy, open gates and pinholes in the media route and specifies the appropriate QoS, requests per-flow charging information when needed, inform the P-CSCF of media-plane events. The Rx interface uses the Diameter protocol and can be emulated by the SIP Cloud module in IxLoad.

In the **VoIPSIPCloud1** activity click the **Diameter** tab, and check the **Enable Rx Interface** check box.



☑ Enable Rx Interface

PCRF:

IP or Hostname: pcrf.test.com

Port: 3868

Realm: test.com

☑ Subscribe to notifications of signaling path status.

☑ Provision signaling flow information.

☑ Initial provision of session information.

Diameter settings:

Transaction timeout (ms): 30000

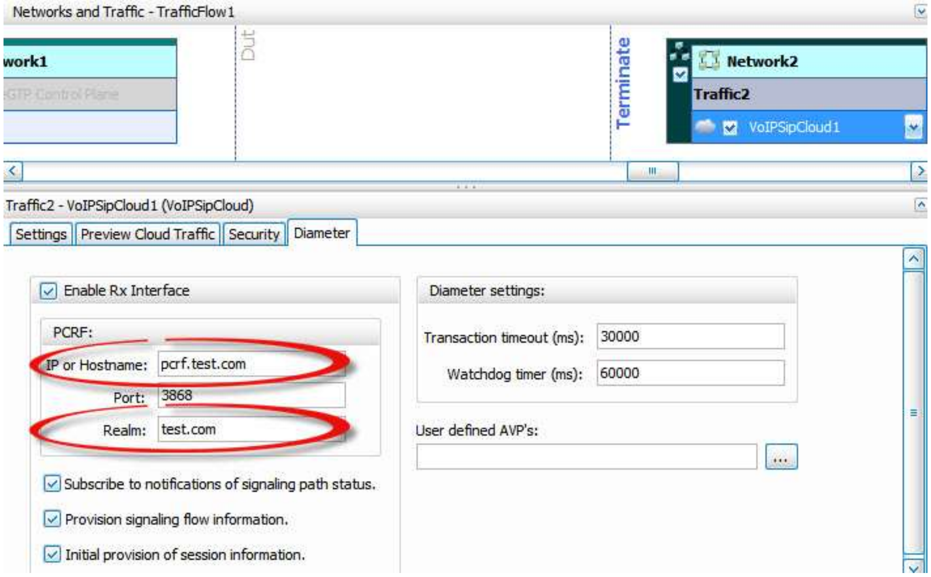
Watchdog timer (ms): 60000

User defined AVP's:

Figure 97. Enable the Rx interface for the emulated P-CSCF

c. Set the PCRF parameters

The P-CSCF must communicate with the PCRF. The IP address of the Hostname and the realm of the PCRF are parameters of the Diameter configuration window. In this example, the PCRF hostname is pcrf.test.com, and the realm is test.com (these are configuration parameters of the system under test)



☑ Enable Rx Interface

PCRF:

IP or Hostname: pcrf.test.com

Port: 3868

Realm: test.com

☑ Subscribe to notifications of signaling path status.

☑ Provision signaling flow information.

☑ Initial provision of session information.

Diameter settings:

Transaction timeout (ms): 30000

Watchdog timer (ms): 60000

User defined AVP's:

Figure 98. PCRF parameters

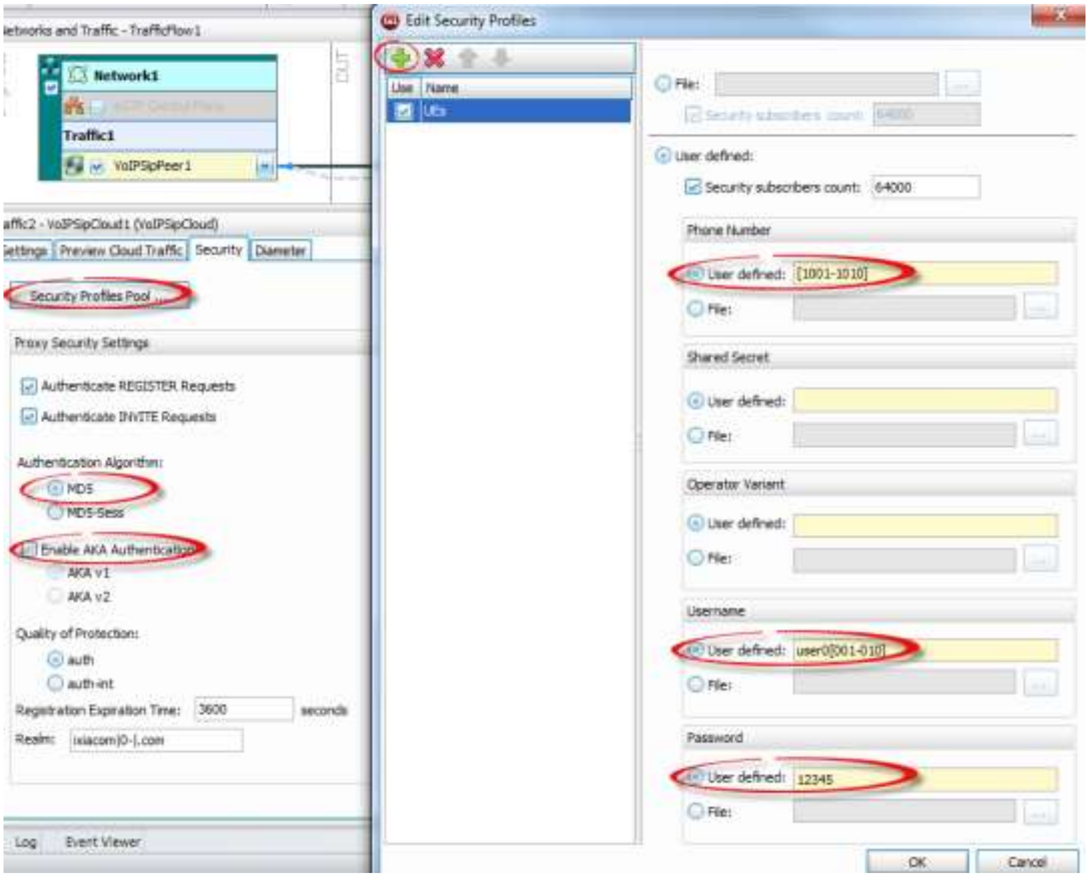
Note: the PCRF implementations have variations in supported AVPs (Attribute Value Pair). To interoperate with a specific PCRF, use custom AVPs in the Diameter messages on Rx interface. This is possible in IxLoad by loading a file with the description of custom AVPs (the field User defined AVPs allows this).

d. Set the SIP Security parameters on the Server

The SIP Cloud acts as the P-CSCF; a real P-CSCF does the authentication of the SIP requests. The emulated P-CSCF can do the same functionality. In the **Security** tab, the user can define the type of requests for authentication, as well as the Authentication algorithm and the credentials for each UE.

Click the Security tab, select MD5 Authentication Algorithm and clear the AKA Authentication check boxes.

Click on **Security Profiles Pool** button. Create a new profile; and make sure you set the same values for the Phone Number, Username, and Password as for the emulated UEs (on the originate side)



Proxy Security Settings

☑ Authenticate REGISTER Requests

☑ Authenticate INVITE Requests

Authentication Algorithm:

● MD5

○ MD5-Sess

☐ Enable AKA Authentication

○ AKA v1

○ AKA v2

Quality of Protection:

● auth

○ auth-int

Registration Expiration Time: 3600 seconds

Realm: ixiacom|0-|.com

○ File:

☑ Security subscribers count: 64000

● User defined:

☑ Security subscribers count: 64000

Phone Number

● User defined: [1001-1010]

○ File:

Shared Secret

● User defined:

○ File:

Operator Variant

● User defined:

○ File:

Username

● User defined: user0[001-010]

○ File:

Password

● User defined: 12345

○ File:

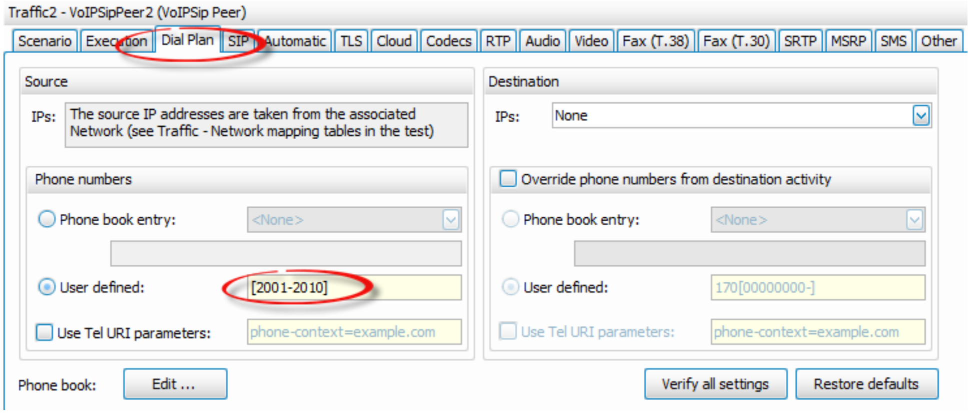
Figure 99. Security profile on the SIP Server

15. Set the parameters of VoIPSipPeer2 activity

    Select the VoIPSipPeer2 activity

    a. Set the Dial Plan

       In this example, we emulate 10 User Agents with Phone Numbers 2001 to 2010. Click the **Dial Plan** tab and edit the sequence [2001-2010] in the Source / Phone Numbers field of the Dial Plan. Leave the Destination as none; this activity is only receiving calls, so it does not need destination phone numbers.



Source

IPs: The source IP addresses are taken from the associated Network (see Traffic - Network mapping tables in the test)

Phone numbers

○ Phone book entry: <None>

● User defined: [2001-2010]

☐ Use Tel URI parameters: phone-context=example.com

Destination

IPs: None

☐ Override phone numbers from destination activity

○ Phone book entry: <None>

● User defined: 170[00000000-]

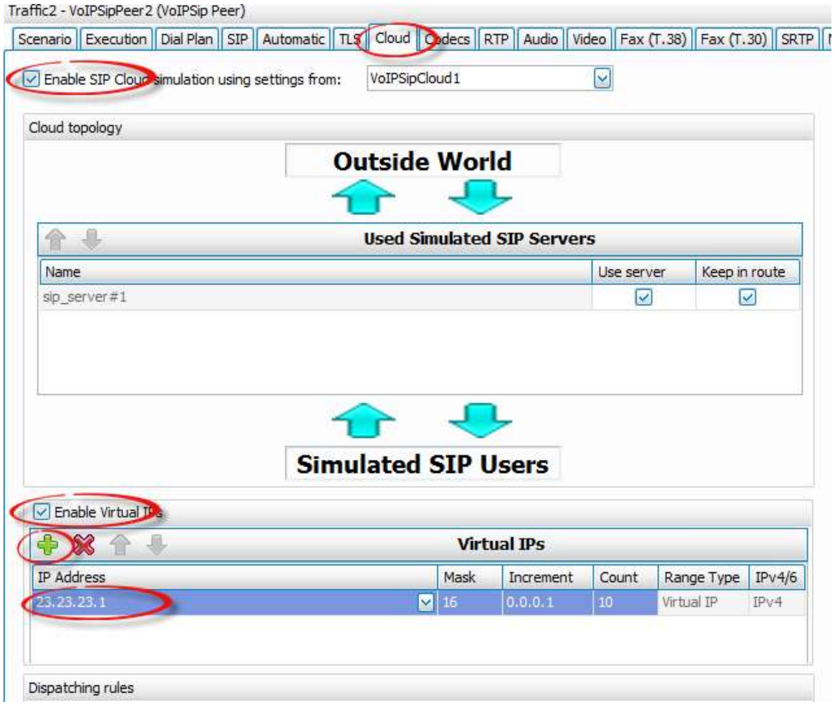
☐ Use Tel URI parameters: phone-context=example.com

Figure 100. Dial Plan

    b. Enable this activity with the SIP Cloud

       The VoIPSipPeer2 activity emulates SIP User Agents in the IMS core, behind the P-CSCF that is emulated by the SIP Cloud activity. It means that all the traffic between EPC and the IMS core goes through the P-CSCF (VoIPSipCloud1 activity) that receives the SIP Requests, and forwards them to the User Agents behind it.

       Click the **Cloud** tab. Select the **SIP Cloud simulation** and **Virtual IPs** checkboxes, and a range of 10 **Virtual IPs** with the staring IP Address 23.23.23.1.



Traffic2 - VoIPSipPeer2 (VoIPSip Peer)

☑ Enable SIP Cloud simulation using settings from: VoIPSipCloud1

Cloud topology

Used Simulated SIP Servers

Name	Use server	Keep in route
sip_server#1	☑	☑

☑ Enable Virtual IPs

Virtual IPs

IP Address	Mask	Increment	Count	Range Type	IPv4/6
23.23.23.1	16	0.0.0.1	10	Virtual IP	IPv4

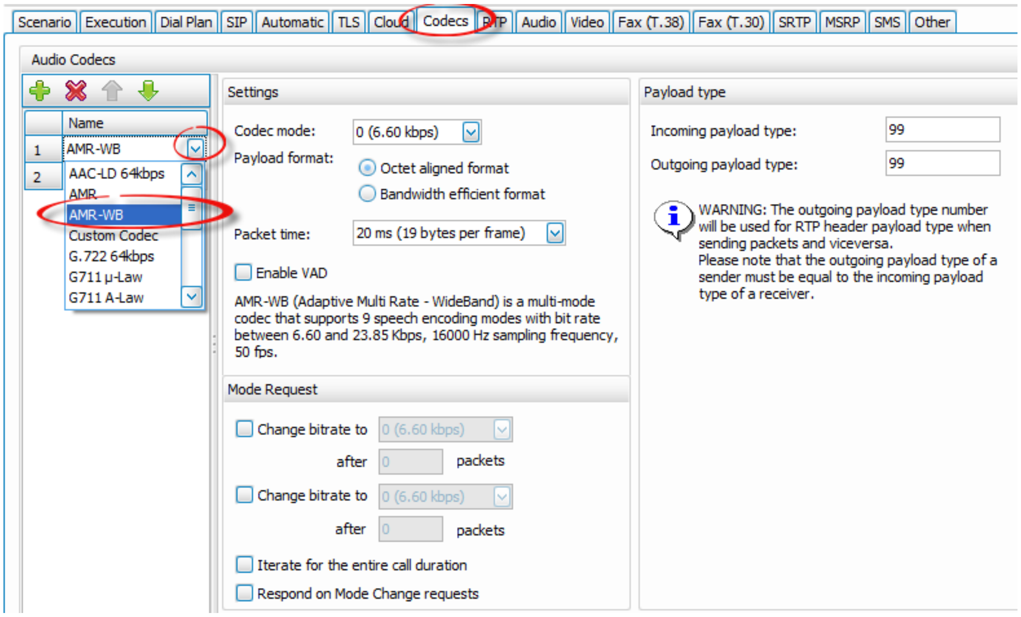
Dispatching rules

Figure 101. Associate a SIP Peer Activity with a SIP Cloud activity to emulate SIP User Agents behind a SIP Proxy

There is no need to set the SIP Server IP address or the Credentials for Authentication for this activity as it communicates internally to the emulated P-CSCF.

c. Set the Audio Codec to AMR-WB

Click the Codecs tab. in the audio codecs table, select the first one, and choose AMR-WB codec from the drop down list. The user can change the order of preferred codecs. The SDP is automatically built with the parameters configured in this window.



	Name
1	AMR-WB
2	

Codec mode: 0 (6.60 kbps)

Payload format:
● Octet aligned format
○ Bandwidth efficient format

Packet time: 20 ms (19 bytes per frame)

☐ Enable VAD

AMR-WB (Adaptive Multi Rate - WideBand) is a multi-mode codec that supports 9 speech encoding modes with bit rate between 6.60 and 23.85 Kbps, 16000 Hz sampling frequency, 50 fps.

Incoming payload type: 99

Outgoing payload type: 99

WARNING: The outgoing payload type number will be used for RTP header payload type when sending packets and viceversa.
Please note that the outgoing payload type of a sender must be equal to the incoming payload type of a receiver.

☐ Change bitrate to 0 (6.60 kbps)
after 0 packets

☐ Change bitrate to 0 (6.60 kbps)
after 0 packets

☐ Iterate for the entire call duration

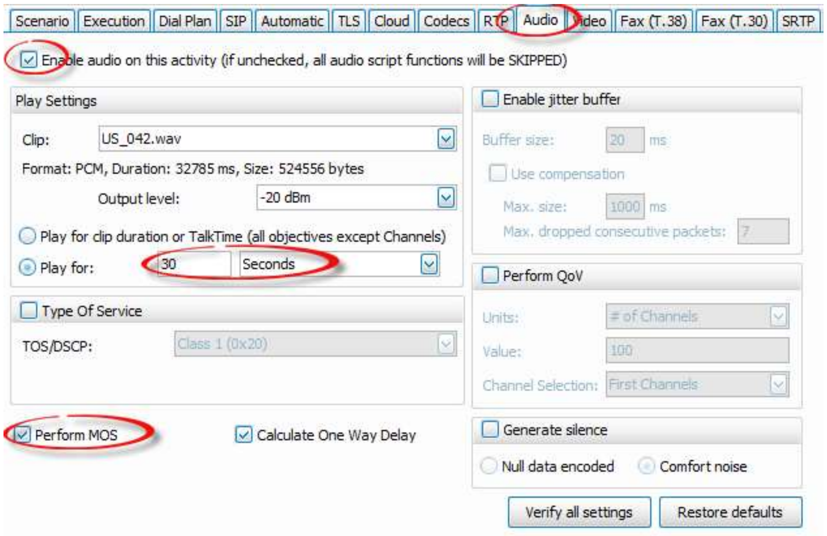
☐ Respond on Mode Change requests

Figure 102. Set the AMR-WB as preferred codec

d. Set the Audio parameters

As on the originating side, the terminating side must have the Audio settings on to play and receive audio.

Click the **Audio** tab. Select the **Enable audio on this activity** checkbox. Set the **Play for** to 30 seconds, and select the **Perform MOS** checkbox.



☑ Enable audio on this activity (if unchecked, all audio script functions will be SKIPPED)

Play Settings

Clip: US_042.wav

Format: PCM, Duration: 32785 ms, Size: 524556 bytes

Output level: -20 dBm

○ Play for clip duration or TalkTime (all objectives except Channels)

● Play for: 30 Seconds

☐ Type Of Service

TOS/DSCP: Class 1 (0x20)

☑ Perform MOS

☑ Calculate One Way Delay

☐ Enable jitter buffer

Buffer size: 20 ms

☐ Use compensation

Max. size: 1000 ms

Max. dropped consecutive packets: 7

☐ Perform QoV

Units: # of Channels

Value: 100

Channel Selection: First Channels

☐ Generate silence

○ Null data encoded ○ Comfort noise

Figure 103. Audio Settings

16. Set the Timeline and Objective

For the capacity test, a test objective type is set to Channels. The specified number of channels is concurrently active executing the call flow defined in the activities. Set the Objective Value to 10. If you want to increase the test objective, then:

- Increase the number of Maximum Active UE Count in the User Equipment plugin under Network1
- Extend the sequence of Phone Numbers in the VoIPSIPPeer1 dial plan
- Extend the sequence of User names for the VoIPSipPeer1 Authentication
- Extend the sequence of Phone Numbers in the VoIPSIPPeer2 dial plan
- Increase the number of virtual IP Addresses for VoIPSipPeer2 activity (under Cloud tab).
- Set the Sustain Time to 5 min.

17. Ports mapping

Map ports to the Traffic Networks. You need a pair of ports, connected to the EPC system (the DUT)

Running the test

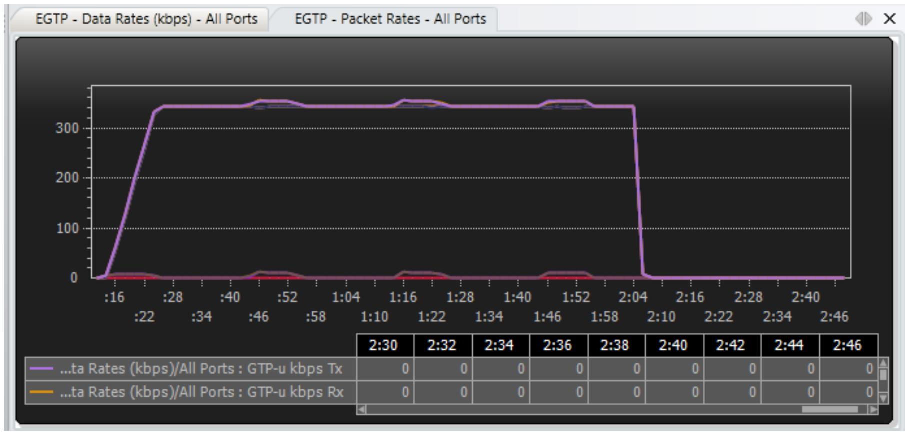
18. Save the configuration

    Click Save in the Quick Access Tool Bar to save the configuration. Users can also save using the keyboard shortcut CTRL+s or through the menu, File > Save. To save for the first time, the system prompts you to enter a name for the rxf configuration and a name for the tst file. The .tst file contains the SIP call flow.

19. Run the test.

Result Analysis

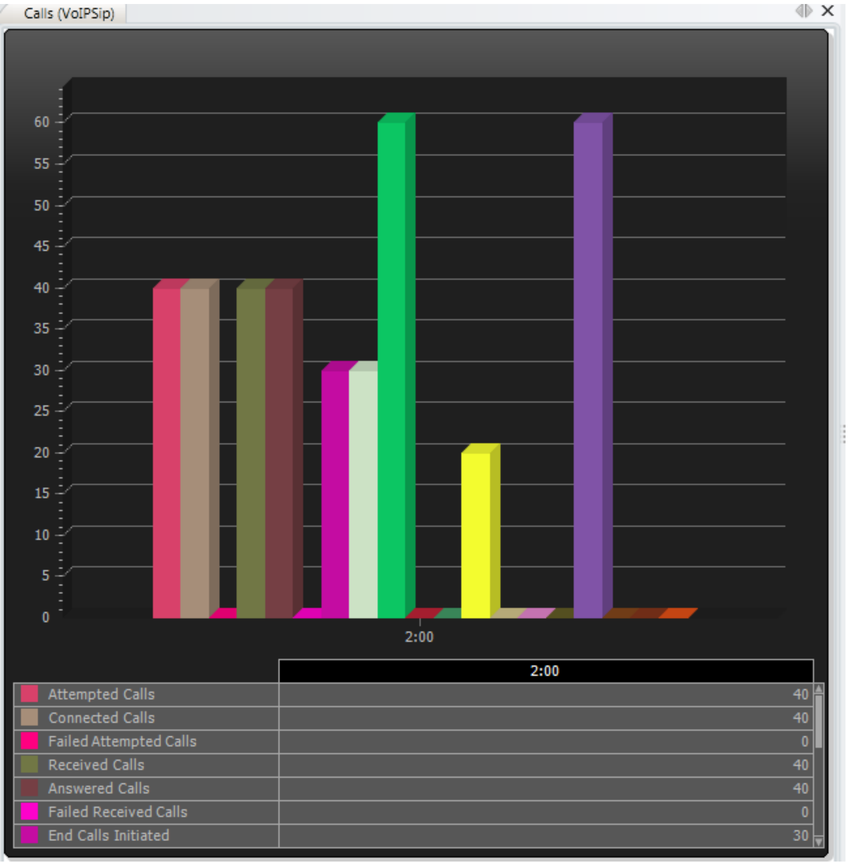
The EPC, SIP, and RTP stats must be analyzed in this configuration.



	2:30	2:32	2:34	2:36	2:38	2:40	2:42	2:44	2:46
...ta Rates (kbps)/All Ports : GTP-u kbps Tx	0	0	0	0	0	0	0	0	0
...ta Rates (kbps)/All Ports : GTP-u kbps Rx	0	0	0	0	0	0	0	0	0

Figure 104. EPC Packet Rates

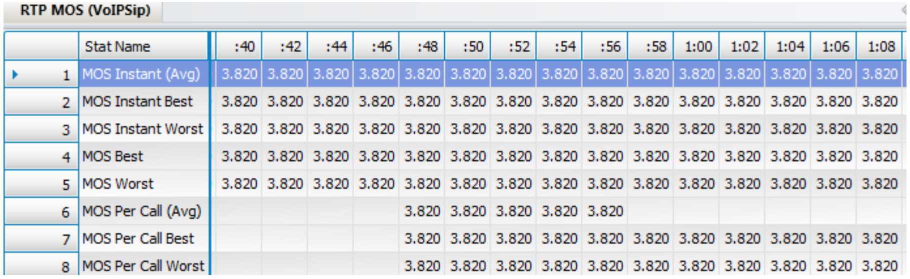
The Packet Rate increases when new calls are established, but majorities of packets are RTP.



	2:00
Attempted Calls	40
Connected Calls	40
Failed Attempted Calls	0
Received Calls	40
Answered Calls	40
Failed Received Calls	0
End Calls Initiated	30

Figure 105. VoIP Calls

The number of Attempted / Connected calls (on the Originating side) and the number of Received / Answered calls (on the Terminating side) must be equal in a successful test. Any difference means the calls fail; and the reasons for failure are available in the Event Viewer.


RTP MOS (VoIPSip)

	Stat Name	:40	:42	:44	:46	:48	:50	:52	:54	:56	:58	1:00	1:02	1:04	1:06	1:08
1	MOS Instant (Avg)	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820
2	MOS Instant Best	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820
3	MOS Instant Worst	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820
4	MOS Best	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820
5	MOS Worst	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820
6	MOS Per Call (Avg)					3.820	3.820	3.820	3.820	3.820						
7	MOS Per Call Best					3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820
8	MOS Per Call Worst					3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820	3.820

Figure 106. Quality of Voice

Quality of voice is the final goal of this test. Even the calls can be established, it is important to measure quality of experience for the voice service. In this case, the measure MOS is as expected (for AMR-WB codec mode 0, the expected MOS is 3.82).

Troubleshooting and Diagnostics

When issues are present, a deep down analysis can be done using various features provided by IxLoad:

- Stats drilldown per activity / port
- Event viewer for SIP, SDP, and RTP related issues. When an error occurs on VoIP, an error is logged in the Even Viewer window indicating the endpoint ID. The error type and description, and hints to resolve the error.
- Analyzer and Traffic Packet Viewer: User can enable traffic capture per port. To save memory, the RTP outbound packets are not captured. To minimize the size of the capture, apply filters using the tcpdump syntax.

Test Variables

Table 9. Voice QoE Test Variables

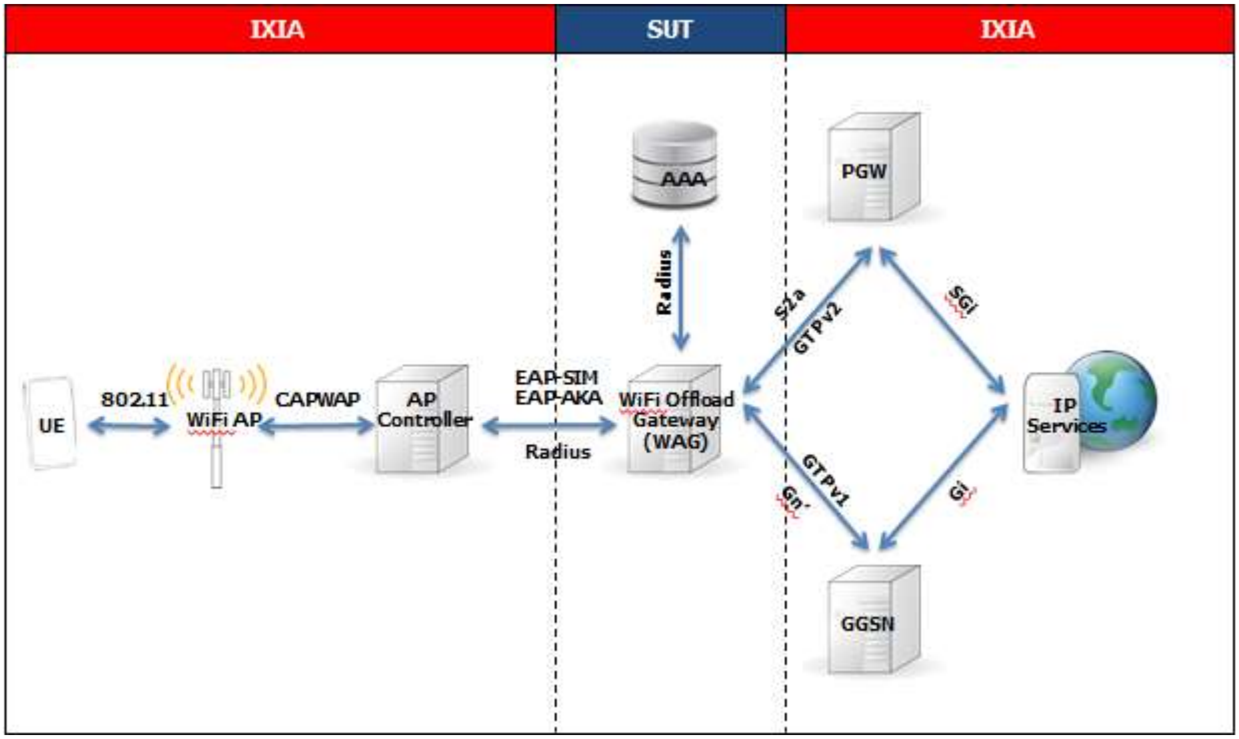
Parameter Name	Current Value	Additional Options
IP Version	IPv4	IPv6
Concurrent Calls	10	Users can emulate up to 8,000 concurrent active endpoints in calls with audio streams by a single 1G port of an Xcellon-Ultra-NP card. To increase the number of channels, you have to allocate enough resources in terms of IP Addresses and Phone Numbers/User Names (see section 16 Set the Timeline and Objective)
Test Objective	Channels	The configuration is created for capacity testing. Other test objectives are available: for testing the rate of call setup supported by the access network, the CPS test objective can be used. Besides the value of Call Per Second Rate, you have to specify the number of emulated endpoints or the call duration (the talk time). These three parameters are correlated: CPS = Number_of_Endpoints / Call_Duration where Call_Duration = Talk_Time + Call_Setup_Time + Overhead_Time To increase the CPS, use more endpoints or reduce the Talk Time.

Wi-Fi Offload Test Case: Testing WAG/Wi-Fi Gateway in Isolation

Overview

The need to offload the data traffic for the mobile phones through the Wi-Fi network is the main drive for the Internet Service Providers who want to send as little traffic as possible through the 3G/4G devices.

This test case describes the methodology of testing in isolation a Trusted Wi-Fi Access Gateway (also known as WAG or TWAG), being surrounded by Ixia equipment which emulates access and core sides.



Objective

This is a system test case that has a dual objective of simultaneously generating high throughput user plane data combined with a medium rate of constant handovers. The test simulates 120,000 active UEs on the access side authenticating with RADIUS EAP-SIM, using DHCP to obtain the IP addressess and running L4/7 traffic once user plane is established. S2a PGW (GTPv2 based) is being simulated on the core side. The WAG also acts as a RADIUS proxy, so the test setup needs an AAA Server – this one is a FreeRadius server configured on a Linux computer.

The rates performed by the test are as follows:

- 1200 RADIUS authentications per second

- 1200 DHCP transactions per second
- 1200 GTPv2 session establishments per second on the PGW

Setup

The test case is setup with 12 Access Points, each having associated 10,000 subscribers (UEs), each UE generating high throughput HTTP traffic.

Multiple configuration parameters depend on the network under test, such as IP addresses for the WiFi Access Gateway and RADIUS proxy, UE identifier parameters like Calling Station Id (MAC address). These are typically obtained by knowing the network configuration.

Step by Step Instructions

1. Insert a new NetTraffic on the server side. Select it to configure it, and delete the existing default IP stack by clicking **Delete Stack**.
2. Add the PGW S5/S8/S2a stack from the Add Stacks > Wireless menu.

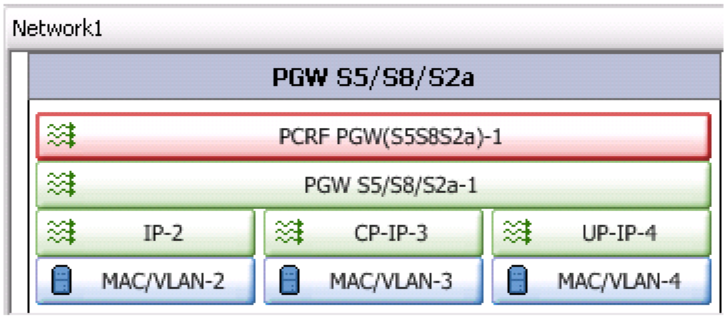
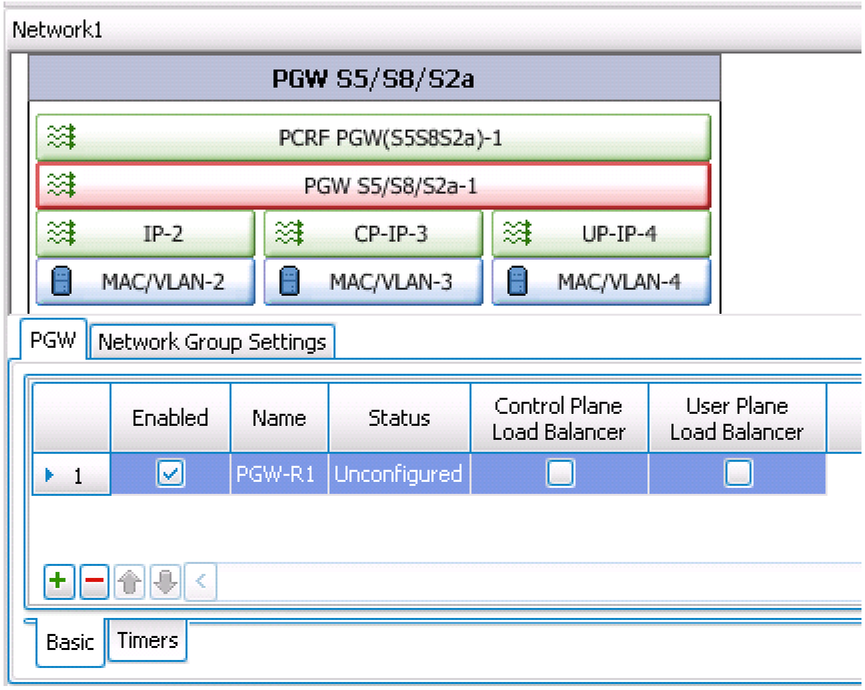


Figure 107. PGW S5/S8/S2a Stack

3. Click the **PGW** layer to configure the PGW details. This layer contains two tabs that are configured as follows:



	Enabled	Name	Status	Control Plane Load Balancer	User Plane Load Balancer
1	☑	PGW-R1	Unconfigured	☐	☐

Figure 108. PGW layer

PGW Tab

The PGW tab contains the following additional sub-tabs:

Basic sub-tab:

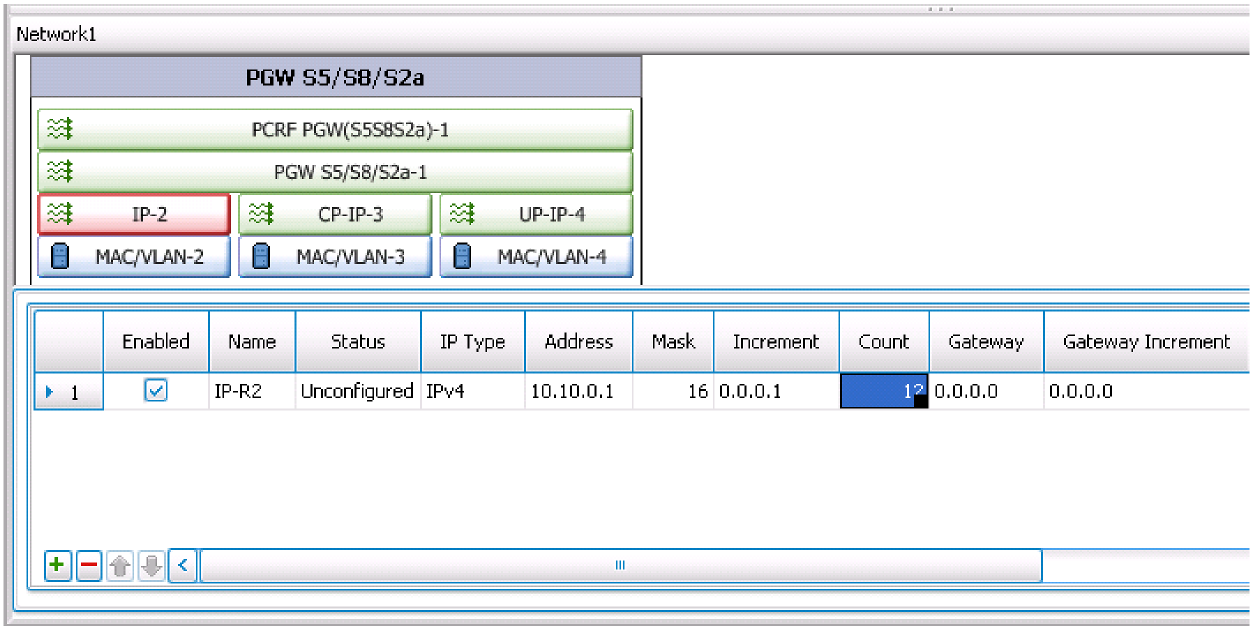
Click the green + icon at the bottom left of the pane to add an additional PGW range.

This tab can be used to enable PGW load balancing on control plane and/or user plane.

Timers sub-tab:

These are the GTP protocol timers and counters set to the default values. No need to modify them.

4. Click the left **IP layer** in the PGW stack. This IP layer corresponds to the PGWs for the test. If load balancing is needed for the PGW, it can be configured using options in the **CP-IP** and **UP-IP** layers.

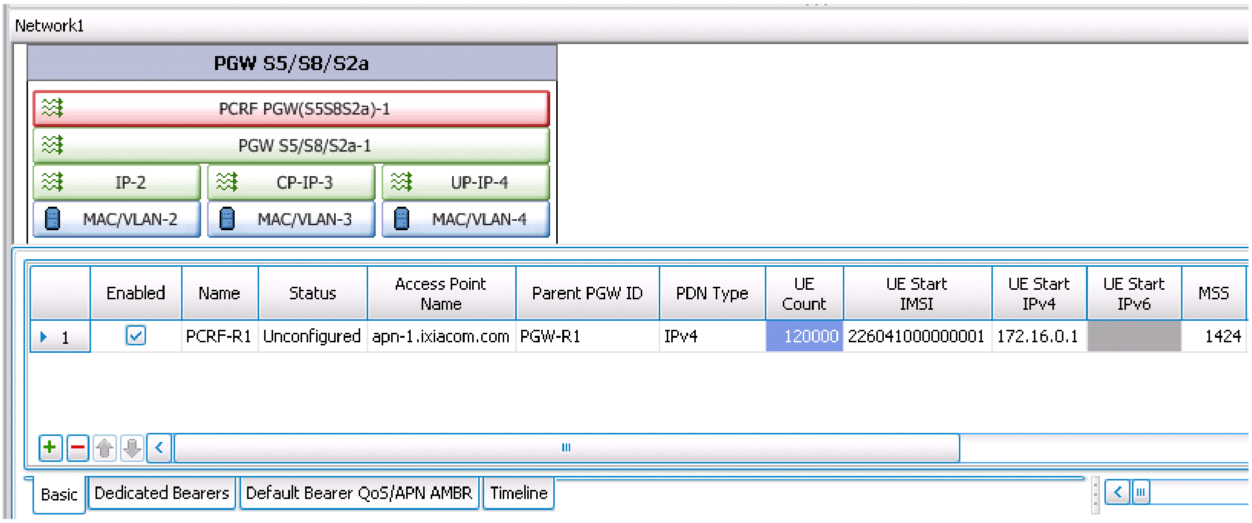


	Enabled	Name	Status	IP Type	Address	Mask	Increment	Count	Gateway	Gateway Increment
1	☑	IP-R2	Unconfigured	IPv4	10.10.0.1	16	0.0.0.1	12	0.0.0.0	0.0.0.0

Figure 109. PGW IP layer

This layer is used to configure the IP address range for the PGWs. Configure a **Count** of **12**. Configure the starting IP address, mask, and default gateway according to the system under test configurations.

5. Click the **PCRF** layer to configure the UE ranges. The **PCRF** layer contains four tabs configured as follows:



	Enabled	Name	Status	Access Point Name	Parent PGW ID	PDN Type	UE Count	UE Start IMSI	UE Start IPv4	UE Start IPv6	MSS
1	☑	PCRF-R1	Unconfigured	apn-1.ixiacom.com	PGW-R1	IPv4	120000	226041000000001	172.16.0.1		1424

Figure 110. PCRF Basic Tab

Basic Tab

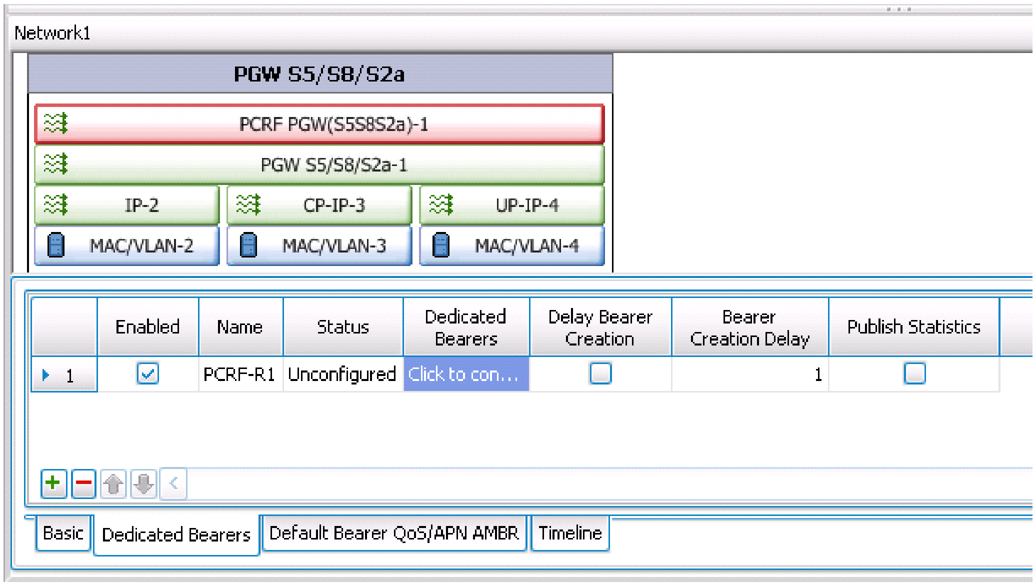
The **Basic** tab contains the information that identifies the UE range: **Access Point Name, PDN Type, IMSI, UE Start IP, MSS.**

Configure a count of 120000 for the PCRF range in this test.

Click + icon at the bottom left of the pane if more PCRF ranges are needed.

Dedicated Bearers Tab

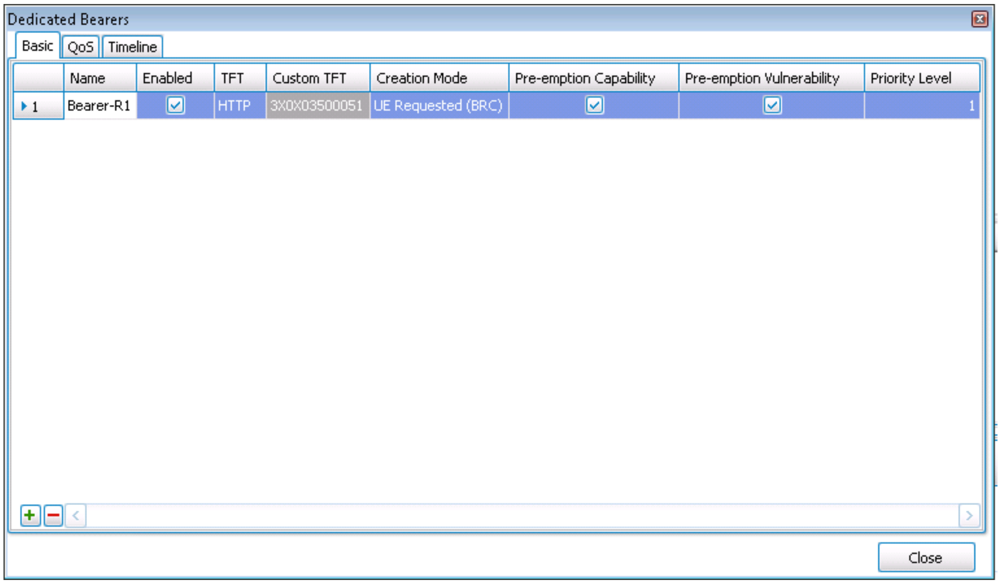
The **Dedicated Bearers** tab is used for configuring network initiated dedicated bearers for the S2a stack.



	Enabled	Name	Status	Dedicated Bearers	Delay Bearer Creation	Bearer Creation Delay	Publish Statistics
1	☑	PCRF-R1	Unconfigured	Click to con...	☐	1	☐

Figure 111. PCRF Dedicated Bearers tab

By clicking **Dedicated Bearers** field, a pop-up window appears for configuring the dedicated bearer parameters. Not used in this test.



	Name	Enabled	TFT	Custom TFT	Creation Mode	Pre-emption Capability	Pre-emption Vulnerability	Priority Level
1	Bearer-R1	☑	HTTP	3X0X03500051	UE Requested (BRC)	☑	☑	1

Figure 112. Dedicated Bearers configuration

Default Bearer QoS/APN AMBR and Timeline tabs:

Leave default values for these tabs.

6. Add a HTTP server activity to the NetTraffic. Leave the default settings.
7. Insert a new NetTraffic on the client side. Select it to configure it, and delete the existing default IP stack by clicking Delete Stack.
8. Add the Trusted WiFi Client stack from the Add Stacks > Wireless menu.

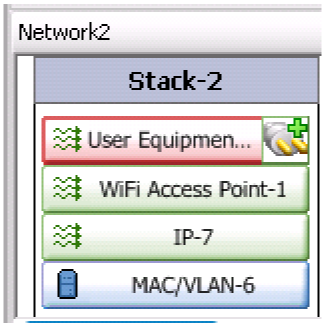
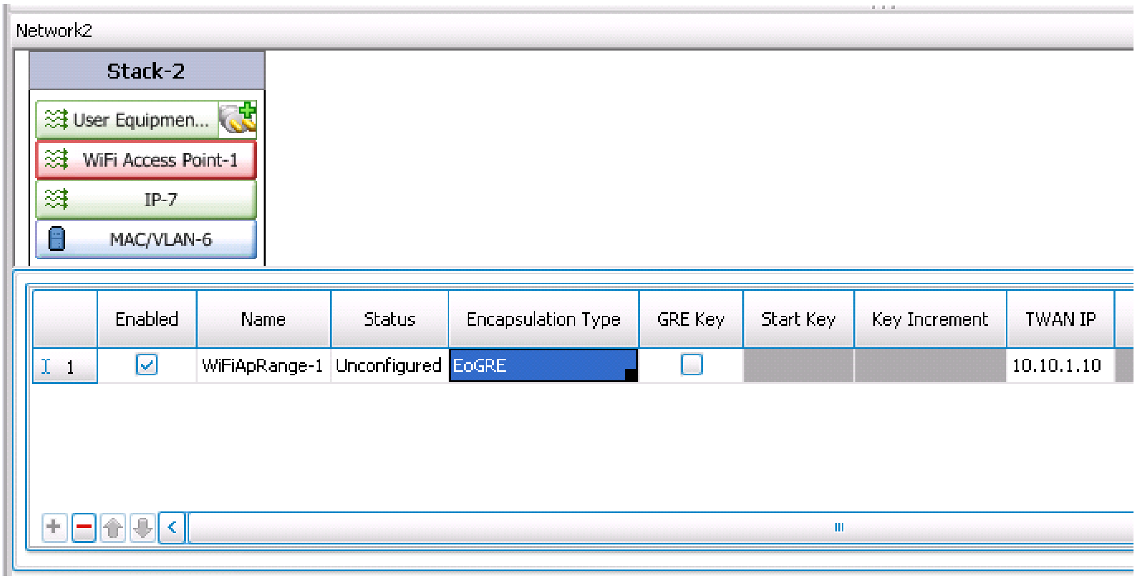


Figure 113. Trusted WiFi Client Stack

9. Click the **WiFi Access Point** layer to configure the APs.



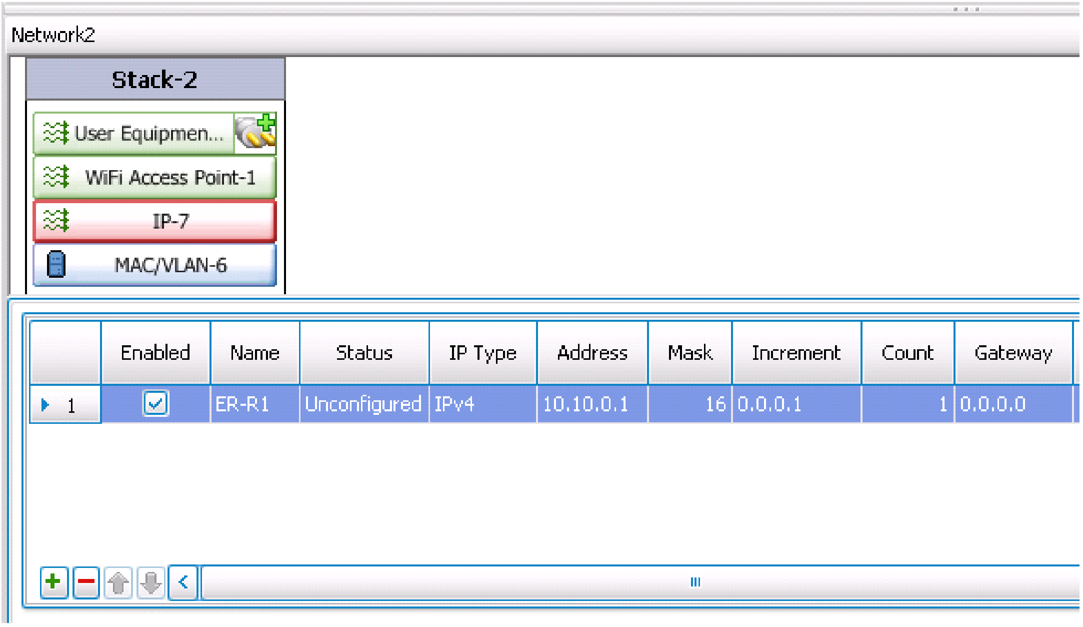
	Enabled	Name	Status	Encapsulation Type	GRE Key	Start Key	Key Increment	TWAN IP
1	☑	WiFiApRange-1	Unconfigured	EoGRE	☐			10.10.1.10

Figure 114. WiFi Access Point Layer

Test scenario uses an EoGRE encapsulation without a GRE key between the Access Point and the WiFi Gateway for DHCP and traffic.

Set the **TWAN IP** to the IP address of the Wi-Fi Access Gateway.

10. Click the **IP layer** in the Trusted WiFi stack. This IP layer corresponds to the APs to be used in the test.

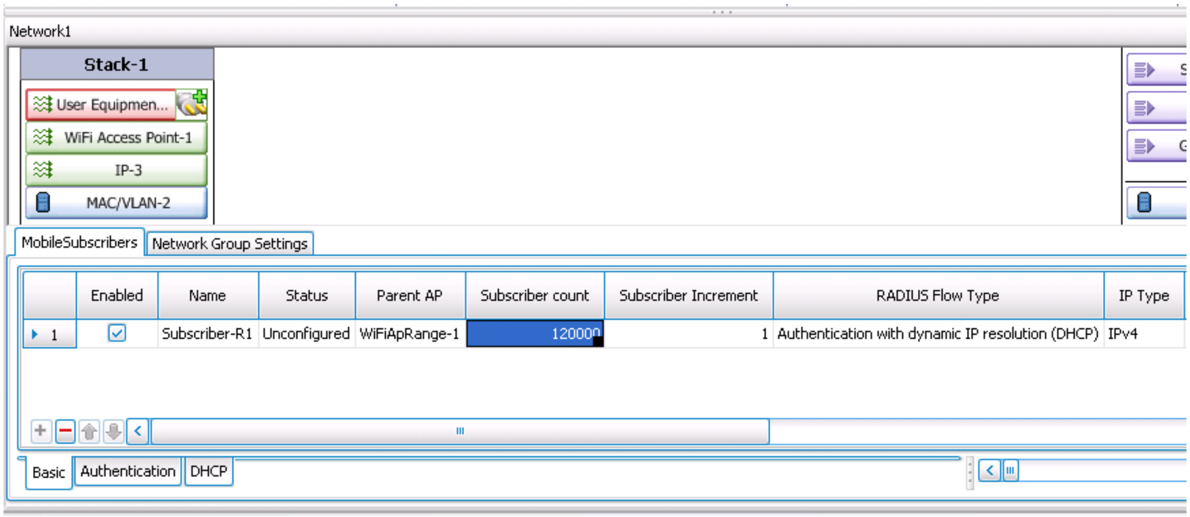


	Enabled	Name	Status	IP Type	Address	Mask	Increment	Count	Gateway
1	☑	ER-R1	Unconfigured	IPv4	10.10.0.1	16	0.0.0.1	1	0.0.0.0

Figure 115. Access Point IP Layer

In this layer, the user can configure the IP address range for the Access Point ranges. For this test, configure a **Count** of **12** for the Access Point range. Configure the starting IP address, mask, and gateway according to the network under test configuration.

11. Click the **User Equipment** layer to configure the UEs (subscribers) for the test. The User Equipment layer contains two tabs that are configured as follows:



	Enabled	Name	Status	Parent AP	Subscriber count	Subscriber Increment	RADIUS Flow Type	IP Type
1	☑	Subscriber-R1	Unconfigured	WiFiApRange-1	120000	1	Authentication with dynamic IP resolution (DHCP)	IPv4

Figure 116. UE tab

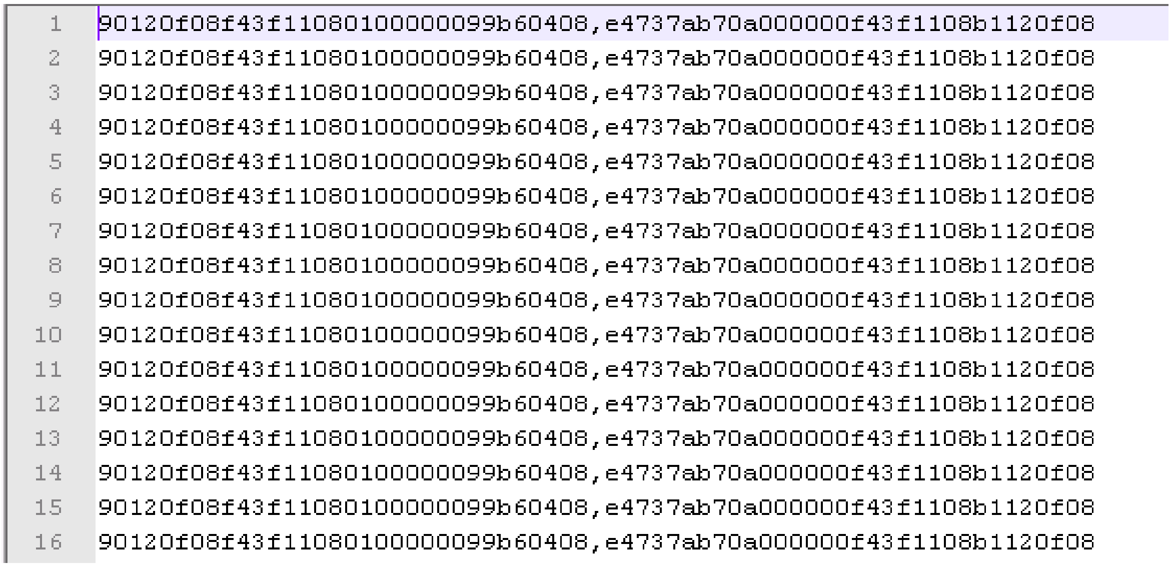
Mobile Subscribers Tab

The Mobile subscribers tab contains the following additional sub-tabs:

Basic sub-tab:

Configure the **Subscriber Count** value to match the test variables section. Here you must also configure the **Calling Station Id (MAC)** for the UE range.

Authentication sub-tab:



```
90120f08f43f11080100000099b60408,e4737ab70a000000f43f1108b1120f08
90120f08f43f11080100000099b60408,e4737ab70a000000f43f1108b1120f08
90120f08f43f11080100000099b60408,e4737ab70a000000f43f1108b1120f08
90120f08f43f11080100000099b60408,e4737ab70a000000f43f1108b1120f08
90120f08f43f11080100000099b60408,e4737ab70a000000f43f1108b1120f08
90120f08f43f11080100000099b60408,e4737ab70a000000f43f1108b1120f08
90120f08f43f11080100000099b60408,e4737ab70a000000f43f1108b1120f08
90120f08f43f11080100000099b60408,e4737ab70a000000f43f1108b1120f08
90120f08f43f11080100000099b60408,e4737ab70a000000f43f1108b1120f08
90120f08f43f11080100000099b60408,e4737ab70a000000f43f1108b1120f08
90120f08f43f11080100000099b60408,e4737ab70a000000f43f1108b1120f08
90120f08f43f11080100000099b60408,e4737ab70a000000f43f1108b1120f08
90120f08f43f11080100000099b60408,e4737ab70a000000f43f1108b1120f08
90120f08f43f11080100000099b60408,e4737ab70a000000f43f1108b1120f08
90120f08f43f11080100000099b60408,e4737ab70a000000f43f1108b1120f08
90120f08f43f11080100000099b60408,e4737ab70a000000f43f1108b1120f08
```

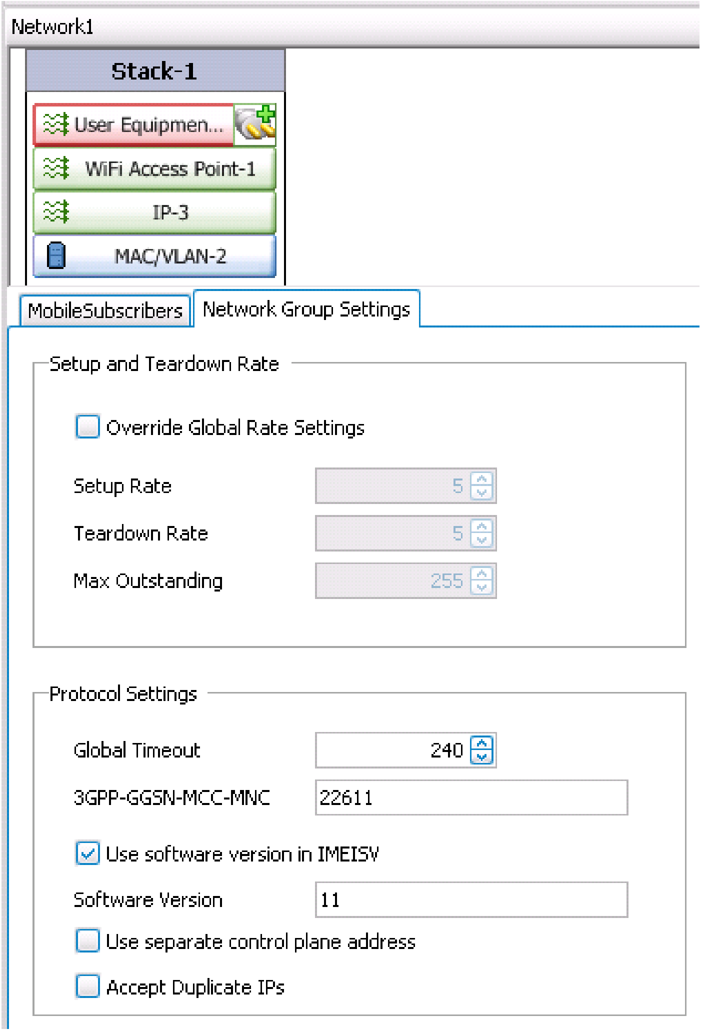
Figure 117. EAP File

Configure the **Authentication Mode** to **EAP-SIM**. You must also load the file containing the OPc and K values for the subscribers, one line per subscriber, separated by a comma.

DHCP sub-tab:

Users can configure to accept DHCP offers only from a specific DHCP server. Keep the default settings for these tabs.

Network Group Settings Tab



Setup and Teardown Rate

☐ Override Global Rate Settings

Setup Rate 5

Teardown Rate 5

Max Outstanding 255

Protocol Settings

Global Timeout 240

3GPP-GGSN-MCC-MNC 22611

☑ Use software version in IMEISV

Software Version 11

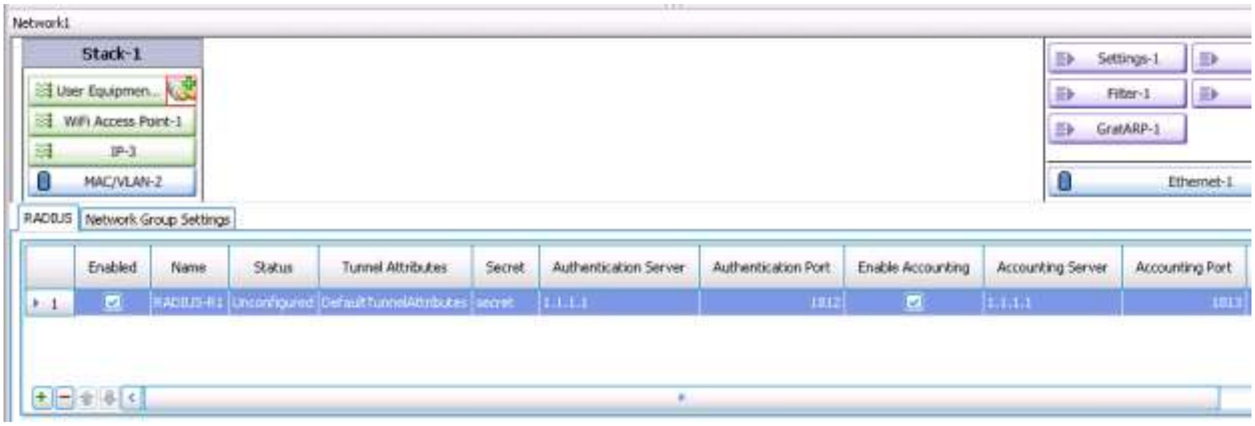
☐ Use separate control plane address

☐ Accept Duplicate IPs

Figure 118. Network Group Settings tab

The **Network Group Settings** tab contains global options for this specific network group. Leave these options set to their default values.

12. Click the **Radius** extension to configure the Radius options for the test.



	Enabled	Name	Status	Tunnel Attributes	Secret	Authentication Server	Authentication Port	Enable Accounting	Accounting Server	Accounting Port
1	☑	RADIUS-R1	Unconfigured	DefaultTunnelAttributes	secret	1.1.1.1	1812	☑	1.1.1.1	1813

Figure 119. Radius extension

For the Radius extension, you must configure the IP addresses for the **Authentication Server** and **Accounting Server**. Also, configure the **Authentication Port** and **Accounting Port** for the servers.

Shared Secret must match the value configured in Device Under Test.

13. Click **Settings** for the network plugin. In the **Interface Behavior** section click **Create interface with user**, and select the **Teardown interface with user** check box. This enables dynamic control plane mode.

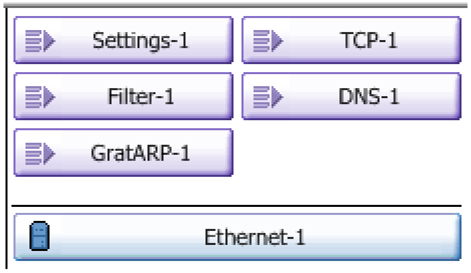
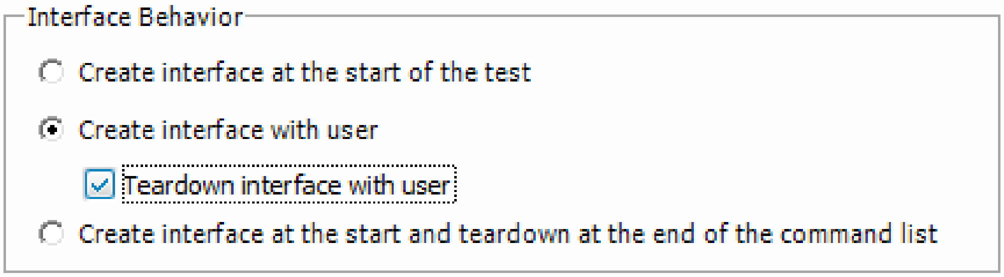


Figure 120. Settings Button



Interface Behavior

○ Create interface at the start of the test

● Create interface with user

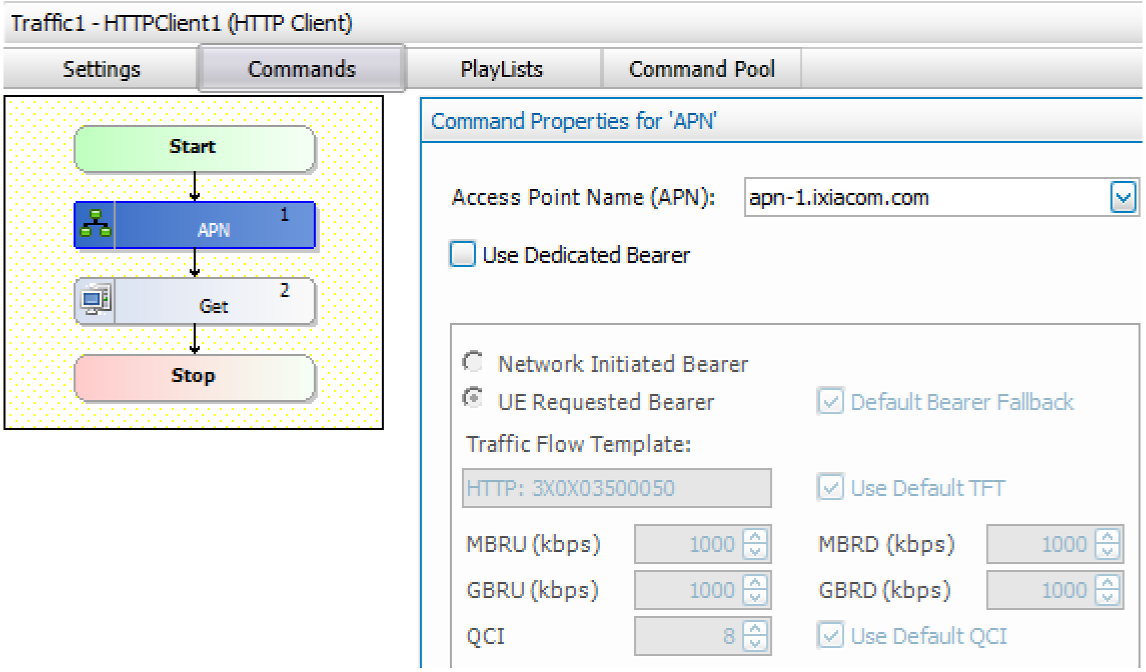
☑ Teardown interface with user

○ Create interface at the start and teardown at the end of the command list

Figure 121. Interface Behavior

14. Add an **HTTP client** activity to the NetTraffic. Configure it to have the previously configured **HTTP server** as a target. Configure one command in the command list: **GET** the **1024k.html** file.

15. Click the **Commands** tab of the **HTTP activity,** and select the **APN** command. Make sure that the **Use Dedicated Bearer** checkbox is cleared. This action causes the http activity to run on the default bearer for each UE.


Traffic1 - HTTPClient1 (HTTP Client)
Settings
Commands
PlayLists
Command Pool
Start
APN
1
Get
2
Stop
Command Properties for 'APN'

Access Point Name (APN): apn-1.ixiacom.com

☐ Use Dedicated Bearer

○ Network Initiated Bearer

● UE Requested Bearer

☑ Default Bearer Fallback

Traffic Flow Template: HTTP: 3X0X03500050

☑ Use Default TFT

MBRU (kbps) 1000

MBRD (kbps) 1000

GBRU (kbps) 1000

GBRD (kbps) 1000

QCI 8

☑ Use Default QCI

Figure 122. APN command

16. In the **Timelines and Objectives** section, select a **Simulated Users** objective for the HTTP activity on the client network, and configure an objective value of **120000.** Configure a **60-minute timeline** duration, with a ramp up value of **1200 users/second**.
17. In the Port Assignments section, assign the client NetTraffic to the 12 port CPUs of the first Acceleron-NP card.
18. Assign the server NetTraffic to the 12 port CPUs of the second Acceleron-NP load module.
19. Enable 10G aggregation mode for both Acceleron-NP load modules.
20. In the Test Options section, select the Network Diagnostics check box to enable the Radius and DHCP statistics.

Test Variables

Table 10. Test Variables for WiFi Test

Variable	Value	Comment
UE Count	120K	
AP count for client network	12	
Objective for HTTP activity	SU = 120K	
TPS for Radius EAP/SIM Authentications	1200	
TPS for DHCP Transactions	1200	
TPS for S2a PGW	1200	

Results Analysis

Validate the results from **DHCPv4** and **RADIUS** views. Following messages must match: the DHCP Discovers/Offers/Requests/Acks/Nacks and the Radius Access Request/Challenge/Accept/Reject messages.

EPC Test Case: Single Radio Voice Call Continuity (SRVCC) with IR94

Overview

This use case simulates the Single Radio Voice Call Continuity (SRVCC) procedure while in a call with both audio and video sessions active. The test has 100 subscribers attaching in 4G and initiating a VoLTE call with audio and video (IR94). After a configured amount of time, the subscribers will initiate a SRVCC procedure to handoff the session from 4G to 3G, while maintaining the active sessions. The SRVCC handover is anchored in the IMS core network, and the circuit-packet function in the IMS core performs the necessary inter-working functions. The CS part is not visible in this scenario. Figure 124 below shows a high level overview of the SRVCC procedure.

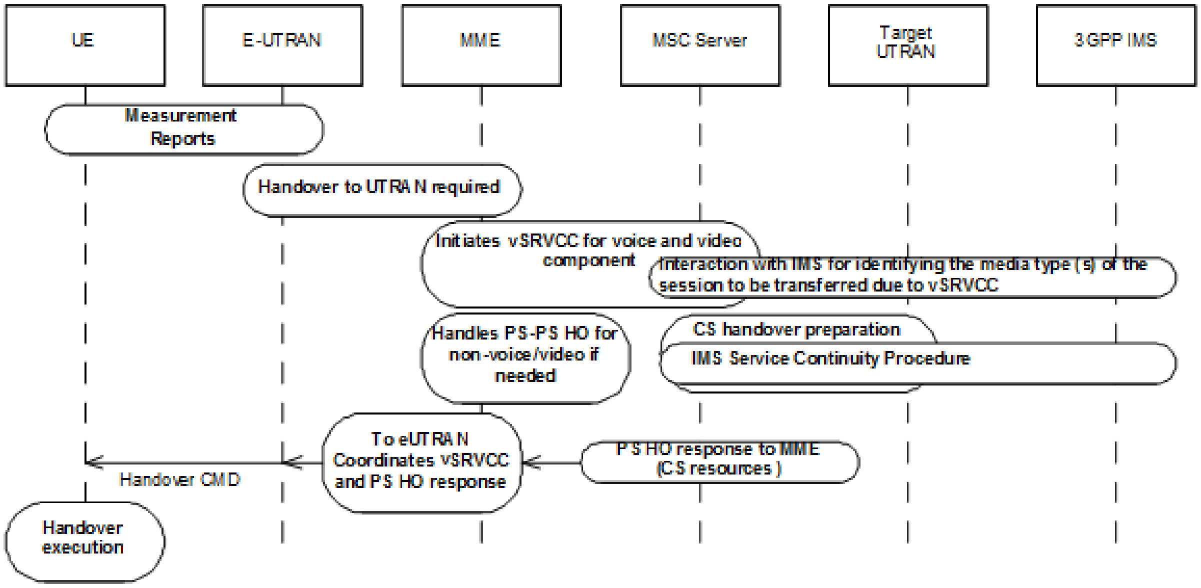

UE
E-UTRAN
MME
MSC Server
Target UTRAN
3GPP IMS
Measurement Reports
Handover to UTRAN required
Initiates vSRVCC for voice and video component
Interaction with IMS for identifying the media type (s) of the session to be transferred due to vSRVCC
Handles PS-PS HO for non-voice/video if needed
CS handover preparation
IMS Service Continuity Procedure
To eUTRAN Coordinates vSRVCC and PS HO response
PS HO response to MME (CS resources)
Handover CMD
Handover execution

Figure 123. Overall high level concepts for vSRVCC from E-UTRAN to UTRAN

Objective

The IR94 SRVCC test case has the objective of generating audio and video RTP traffic while testing the conformance of the Single Radio Voice Call Continuity procedure for both IR92 and IR94 scenarios in the SGW and the IMS Core.

Setup

The test is set up as follows:

One eNB, one MME, one SGSN, and one RNC with 100 subscribers, attaching in 4G to the eNB and initiating a VoLTE Call that also has video enabled. After a preconfigured time interval, the UEs will initiate a SRVCC procedure to continue the calls in 3G.

After a SRVCC procedure, if the UE is performing handover back from 3G to 4G, the audio and video dedicated bearers will be re-created at the start of a new voice loop while the RTP traffic is sent on the default bearer until then.

Multiple configuration parameters depend on the network under test, such as IP addresses for the MMEs and UEs, UE identifier parameters like IMSI and MSISDN, and networking parameters. These are typically obtained by knowing the network configuration.

Step by Step instructions

1. Insert **a new NetTraffic** on the **Terminate side**. Configure it to have a range of **1 IP** by using an IP addresses that correspond to the network under test settings. This NetTraffc will be used to simulate the SGi interface and the Landline users.
2. Add a VoIPSip activity to the NetTraffic. Use the default settings.

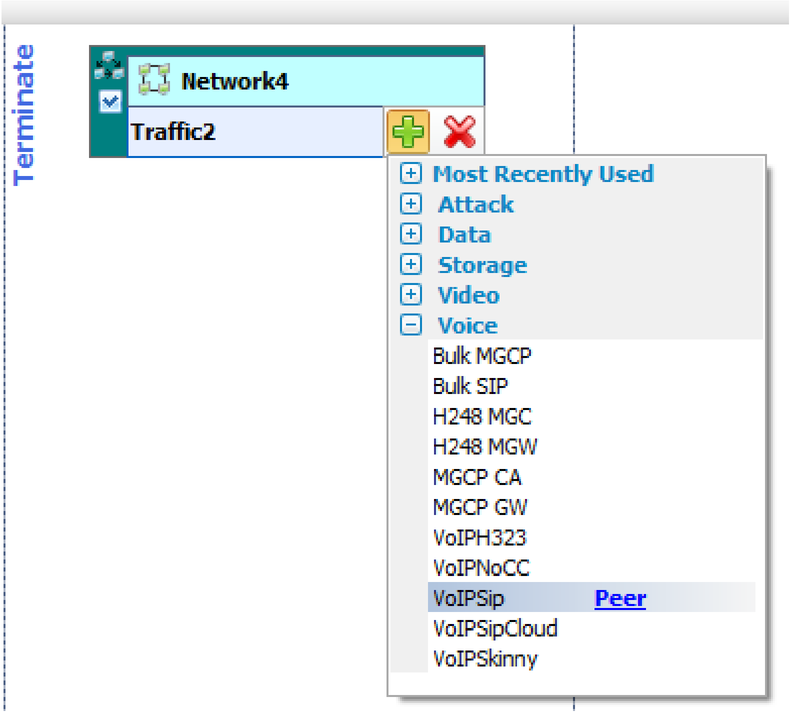


Figure 124. Adding a new VoIPSiP activity

3. Insert a new Subscriber on the Originate side. While having the Originate side selected, click on **Add NetTraffic** and select **Subscriber**.

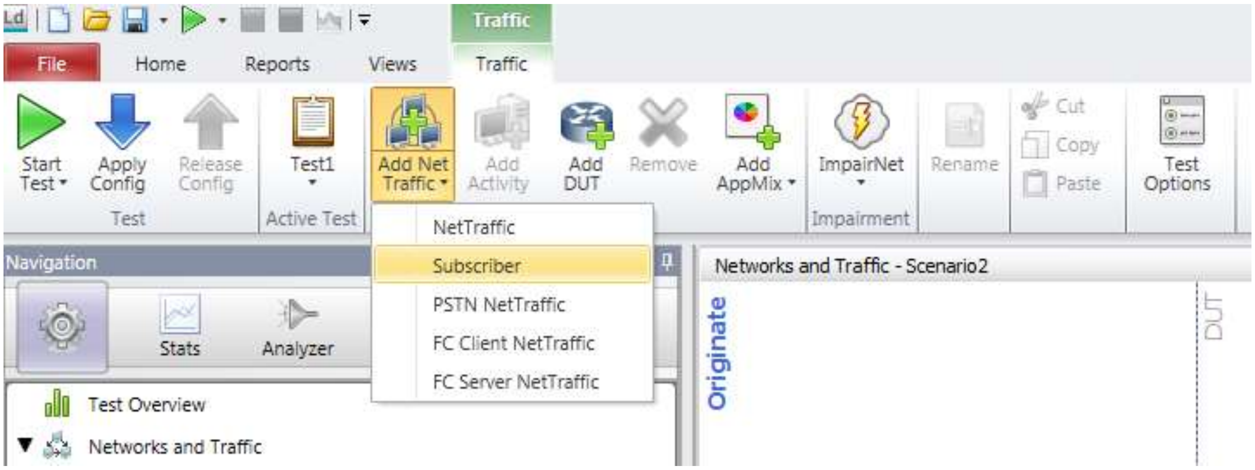


Figure 125. Adding a Subscriber

Select to configure it, and **delete** the existing default IP stack by clicking **Delete Stack**.

4. Add a **VoIPSip** activity to this NetTraffic. Drag from the activity blue lollipop and drop it on the Server side VoIP activity. A window with sample message flows should appear.

   Select the Basic Call with Multimedia sample.

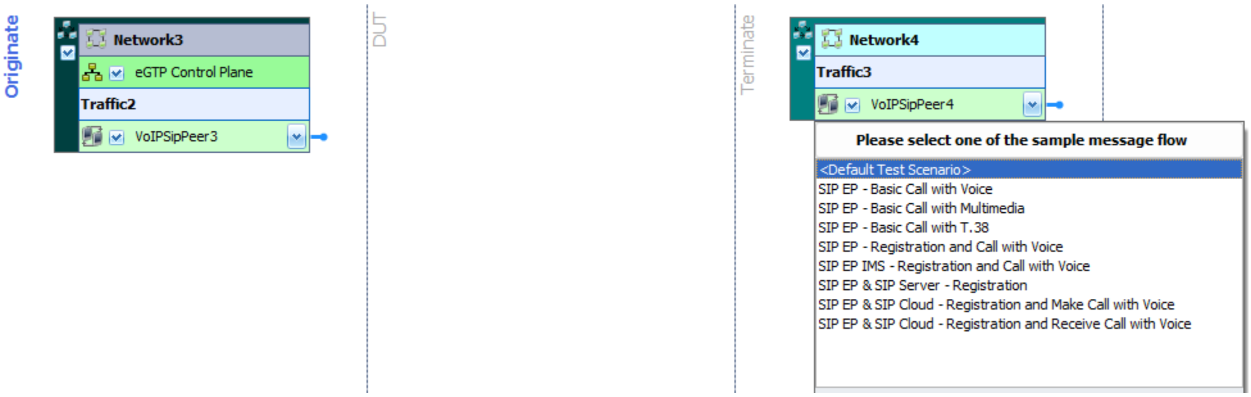

Originate
Network3
eGTP Control Plane
Traffic2
VoIPSipPeer3
DUT
Terminate
Network4
Traffic3
VoIPSipPeer4
Please select one of the sample message flow
<Default Test Scenario>
SIP EP - Basic Call with Voice
SIP EP - Basic Call with Multimedia
SIP EP - Basic Call with T.38
SIP EP - Registration and Call with Voice
SIP EP IMS - Registration and Call with Voice
SIP EP & SIP Server - Registration
SIP EP & SIP Cloud - Registration and Make Call with Voice
SIP EP & SIP Cloud - Registration and Receive Call with Voice

Figure 126. Sample message Flows

This adds a scenario to the Voice activity that contains both audio and video calls setup and RTP functions. Click on the VoIPSipPeer activity to see or modify the scenario in Scenario Editor.

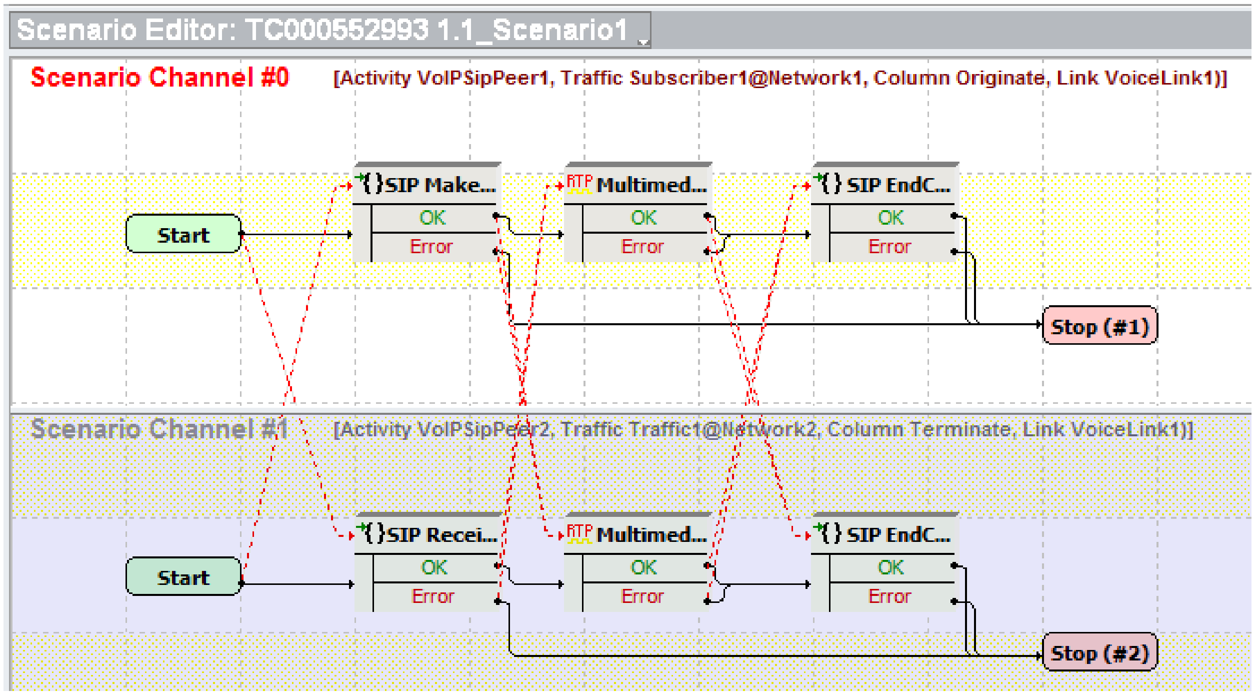
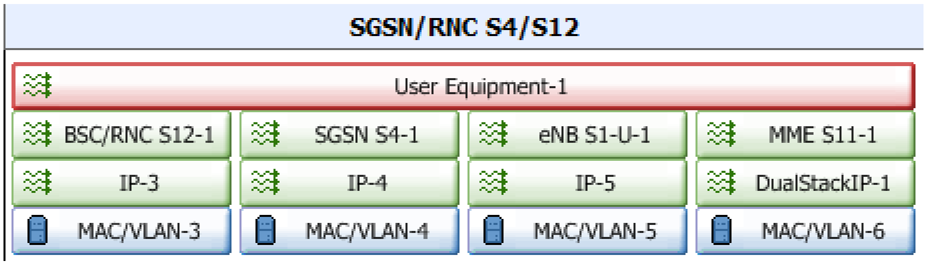

Scenario Editor: TC000552993 1.1_Scenario1
Scenario Channel #0
[Activity VoIPSipPeer1, Traffic Subscriber1@Network1, Column Originate, Link VoiceLink1)]
Start
SIP Make...
OK
Error
Multimed...
OK
Error
SIP EndC...
OK
Error
Stop (#1)
Scenario Channel #1
[Activity VoIPSipPeer2, Traffic Traffic1@Network2, Column Terminate, Link VoiceLink1)]
Start
SIP Recei...
OK
Error
Multimed...
OK
Error
SIP EndC...
OK
Error
Stop (#2)

Figure 127. VoIP scenario in the Scenario Editor

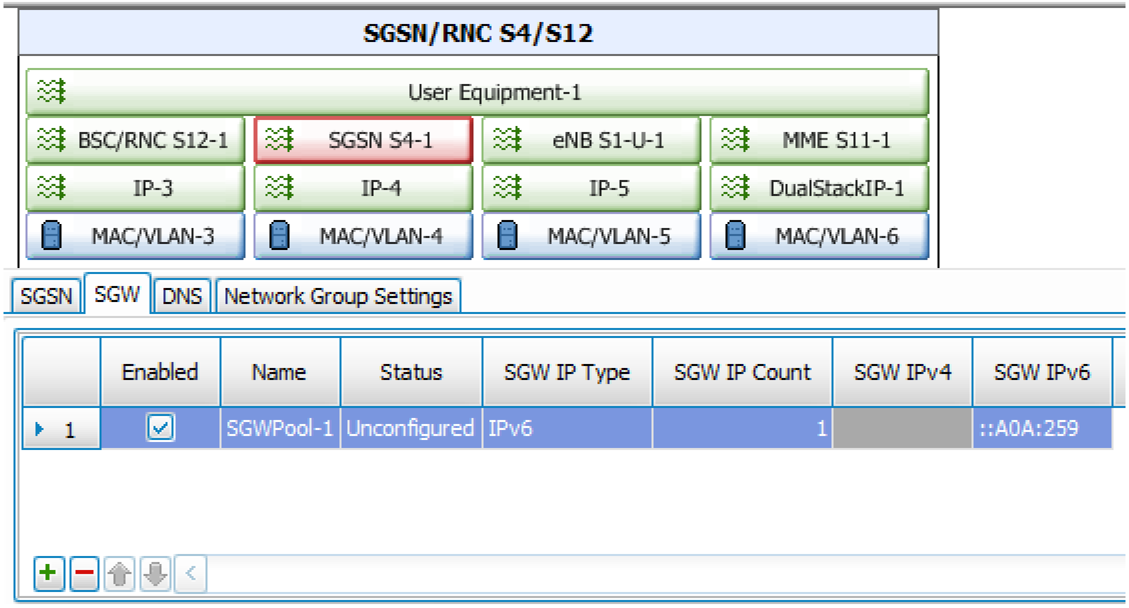
5. Select the Subscriber on the Originate side and add the **SGSN/RNC S4/S12 + eNB/MME S11/S1-u** stack from the **Add Stacks > Wireless** menu.



SGSN/RNC S4/S12			
User Equipment-1			
BSC/RNC S12-1	SGSN S4-1	eNB S1-U-1	MME S11-1
IP-3	IP-4	IP-5	DualStackIP-1
MAC/VLAN-3	MAC/VLAN-4	MAC/VLAN-5	MAC/VLAN-6

Figure 128. SGSN/RNC S4/S12 + eNB/MME S11/S1-u stack

6. Click the **SGSN** layer to configure the SGSNs for the test.

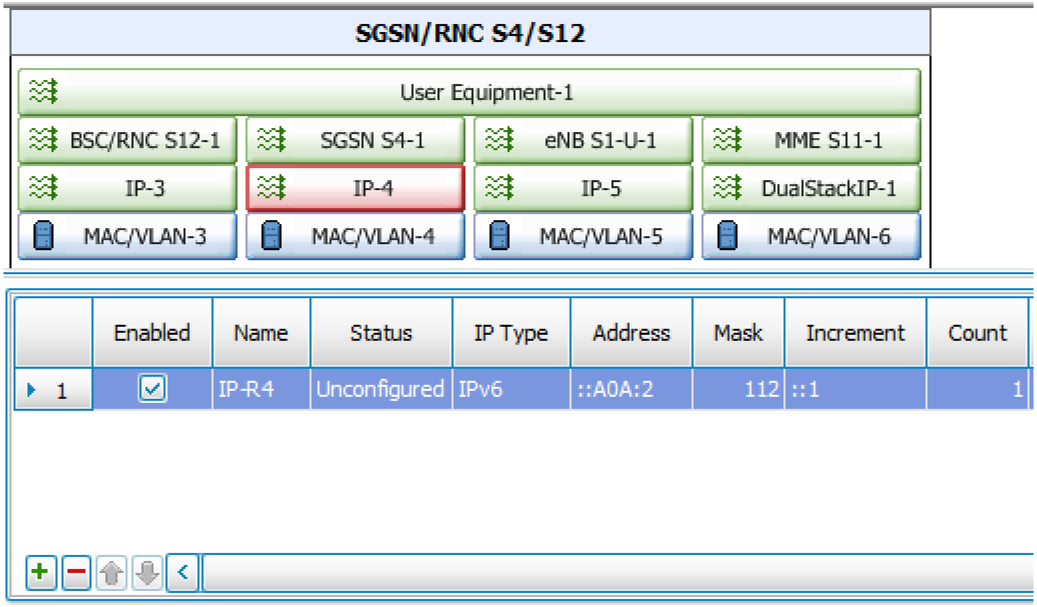


	Enabled	Name	Status	SGW IP Type	SGW IP Count	SGW IPv4	SGW IPv6
1	☑	SGWPool-1	Unconfigured	IPv6	1		::A0A:259

Figure 129. SGSN - SGW IP Configuration

Configure the SGW IP for the SGW that will be connected to the SGSN (using the S4 interface).

7. Click the **IP layer** in the SGSN stack. This IP layer corresponds to the simulated SGSNs for the test. Use an IP address that corresponds to the network under test settings.

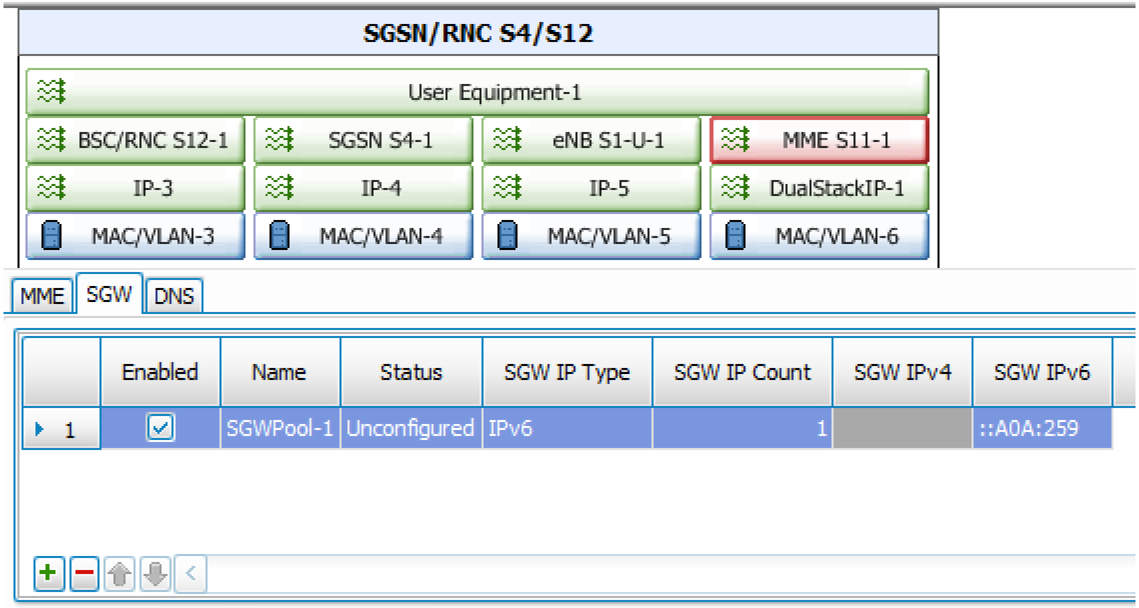


	Enabled	Name	Status	IP Type	Address	Mask	Increment	Count
1	☑	IP-R4	Unconfigured	IPv6	::A0A:2	112	::1	1

Figure 130. SGSN IP Configuration

In this layer, user can configure the IP address range for the SGSN ranges. Configure the IP for the SGSN and configure the count to at least 1 (SGSNs).

8. Click the MME layer to configure the MMEs for the test.

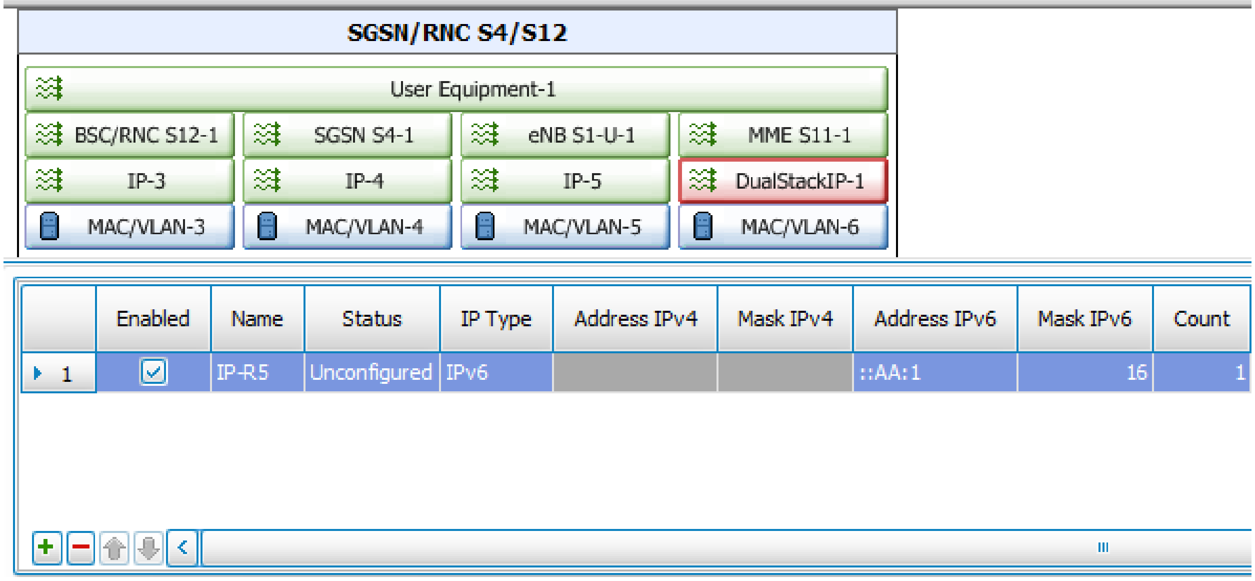


	Enabled	Name	Status	SGW IP Type	SGW IP Count	SGW IPv4	SGW IPv6
1	☑	SGWPool-1	Unconfigured	IPv6	1		::A0A:259

Figure 131. MME - SGW IP Configuration

Configure the SGW IP of he SGW that will be connected to the simulated MMEs (using the S11 interface).

9. Click the IP layer in the MME stack. This IP layer corresponds to the MMEs for the test.

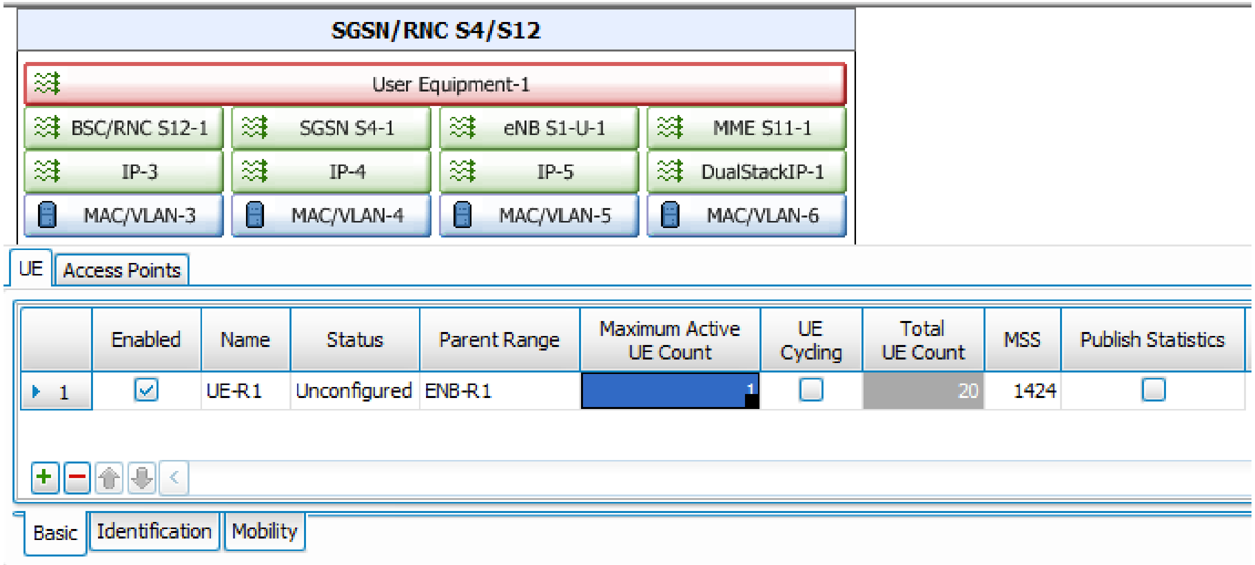


	Enabled	Name	Status	IP Type	Address IPv4	Mask IPv4	Address IPv6	Mask IPv6	Count
1	☑	IP-R5	Unconfigured	IPv6			::AA:1	16	1

Figure 132. MME IP configuration

In this layer, the user can configure the IP address range for the MME ranges. Configure the IP for the MME and configure the count to at least 1 (MMEs).

10. Click the **User Equipment** layer. This layer has two tabs.



	Enabled	Name	Status	Parent Range	Maximum Active UE Count	UE Cycling	Total UE Count	MSS	Publish Statistics
1	☑	UE-R1	Unconfigured	ENB-R1	1	☐	20	1424	☐

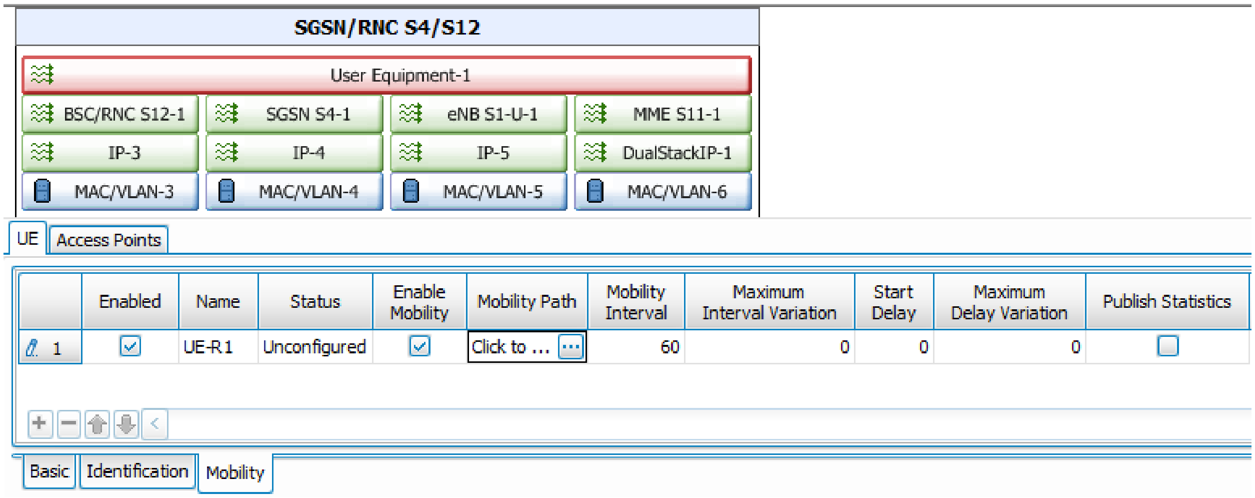
Figure 133. UE tab

UE Tab

Set the **Maximum Active UE Count** to 100. Select eNB-R1 as the **Parent Range** for this UE. By doing this, the UE will attach in 4G.

Mobility tab:

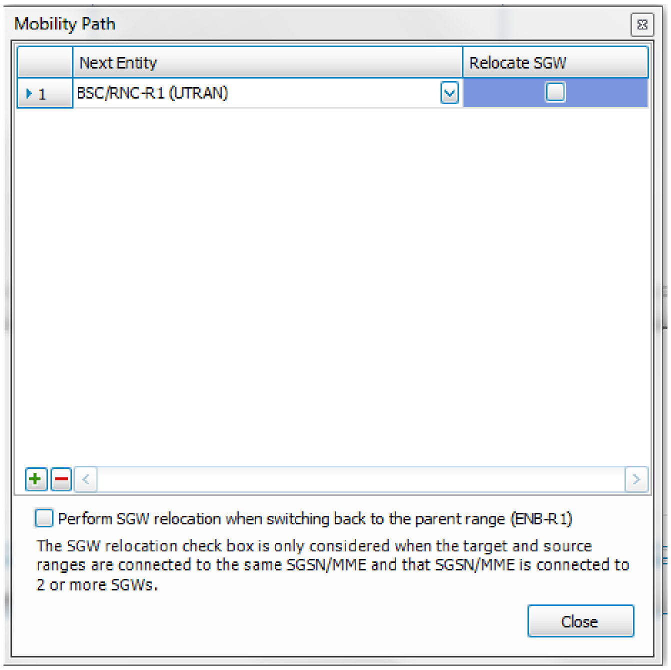
The user can configure the mobility path that will be followed by the UEs when doing Handover events. Enable the Mobility Path by clicking on **Enable Mobility**. Do not configure the Mobility Interval as this parameter will be ignored in ubscriber tests with active commands. The time between mobilities will be adjusted by controlling the Think intervals between **eGTP Commands** in the **eGTP Control Plane Command List**



	Enabled	Name	Status	Enable Mobility	Mobility Path	Mobility Interval	Maximum Interval Variation	Start Delay	Maximum Delay Variation	Publish Statistics
1	☑	UE-R1	Unconfigured	☑	Click to ...	60	0	0	0	☐

Figure 134. Mobility sub-tab

Click on **Mobility Path** to make the **(…)** button visible. Click to configure the mobility path.



	Next Entity	Relocate SGW
1	BSC/RNC-R1 (UTRAN)	☐

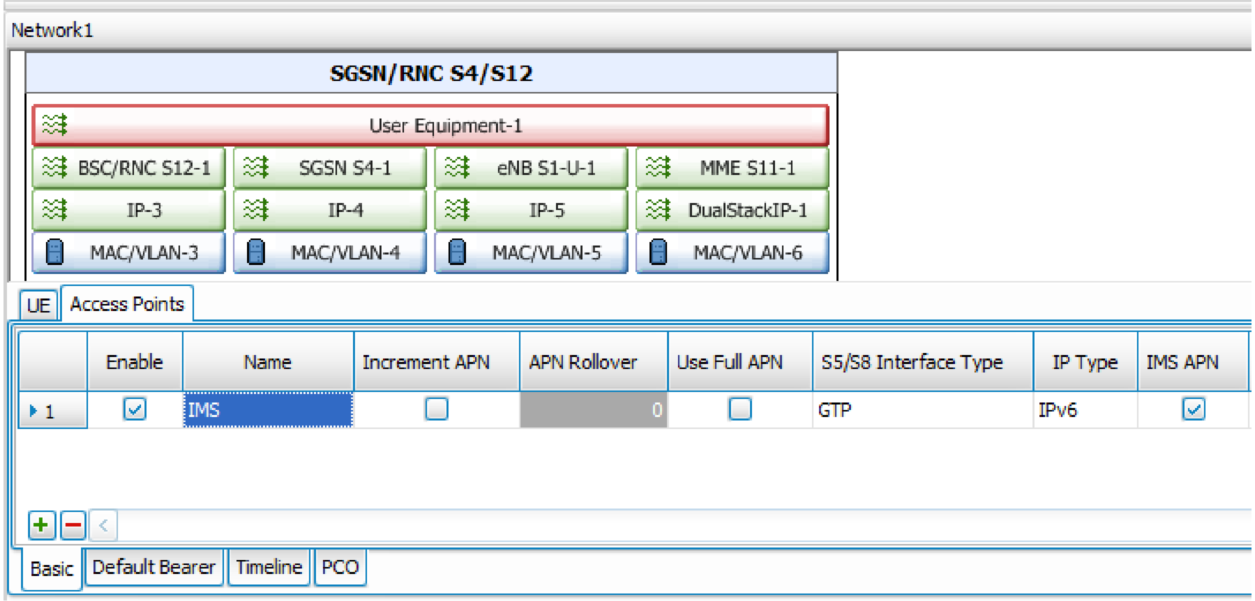
☐ Perform SGW relocation when switching back to the parent range (ENB-R1)

The SGW relocation check box is only considered when the target and source ranges are connected to the same SGSN/MME and that SGSN/MME is connected to 2 or more SGWs.

Figure 135. Mobile Path Configuration

Click on the **+** sign to add a new node in the path and from the drop down menu select the BSC/RNC-R1 node. By doing this you will configure a handover from the source node of the UE (that is ENB-R1), to the BSC/RNC-R1 node.

11. Click the **Access Points** tab in the User Equipment layer to configure the IMS APN.



	Enable	Name	Increment APN	APN Rollover	Use Full APN	S5/S8 Interface Type	IP Type	IMS APN
1	☑	IMS	☐	0	☐	GTP	IPv6	☑

Figure 136. Access Points tab

Configure the APN name that will be used by the VoIP activity, IP type for this APN and PGW IP.

The **IMS APN** checkbox needs to be checked to mark the APN as an IMS APN and to enable the SRVCC behavior in case of handover from 4G to 3G.

12. Click on **Subscriber1** and configure the **Egtp Control Plane Network Commands** as seen below. Configure all the **Think** command to 2000ms. By varying the Think commands duration user can control the time between procedures.

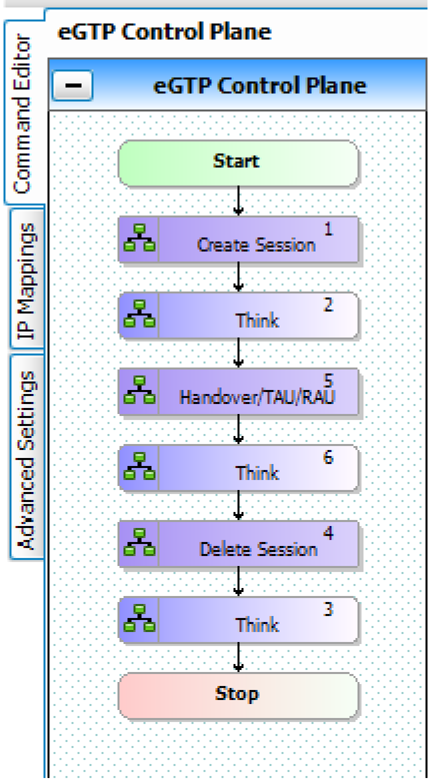


Figure 137. eGTP Control Plane command list

13. Synchronize the VoIPSipPeer activity with the eGTP Control Plane as follows:

Drag and drop from the OK event in the SIP MakeCall procedure to the **Think** located after the Create Session command and from the OK and Error events in the SIP EndCall Initiate procedure to the last **Think** in the eGTP Control Plane command list.

This is needed to ensure that SIP MakeCall command is not executed until the session has been created, and that Delete Session command is not executed until the SIP EndCall Initiate command has completed the execution.

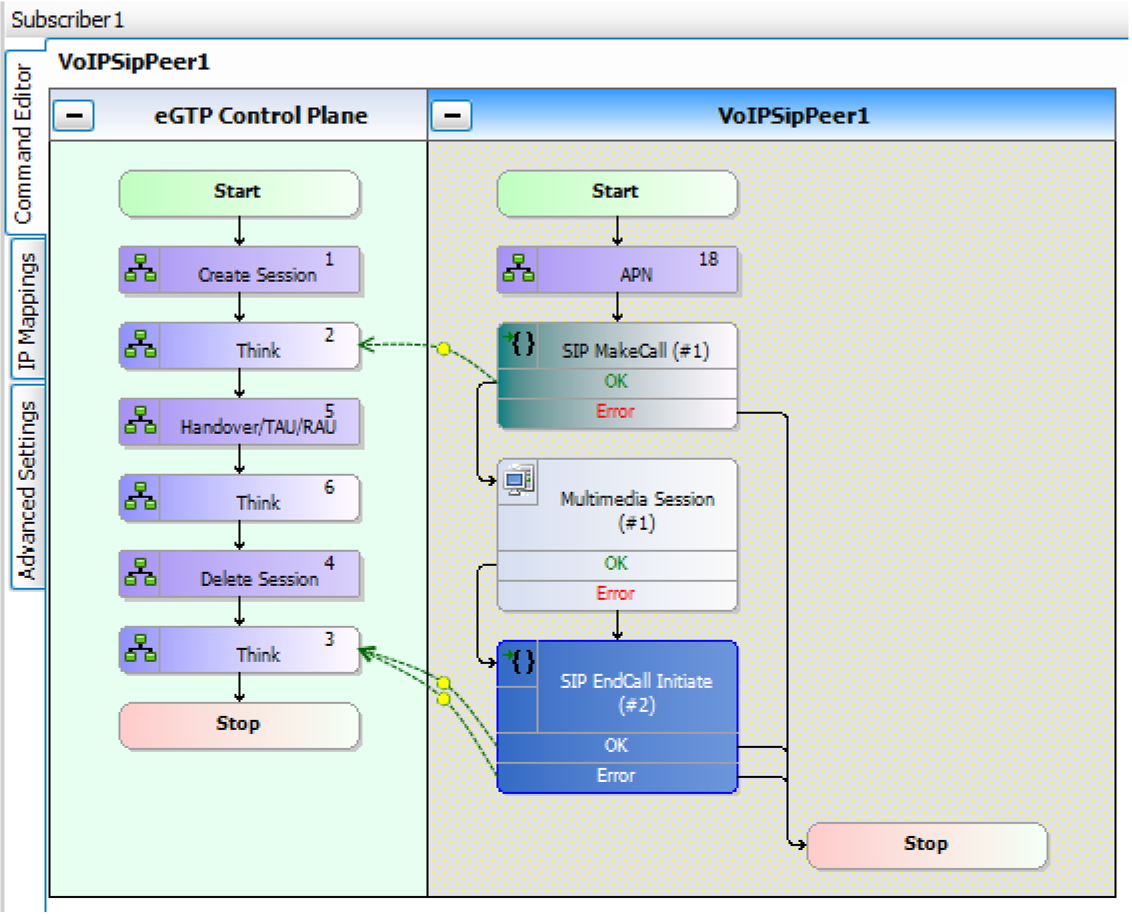
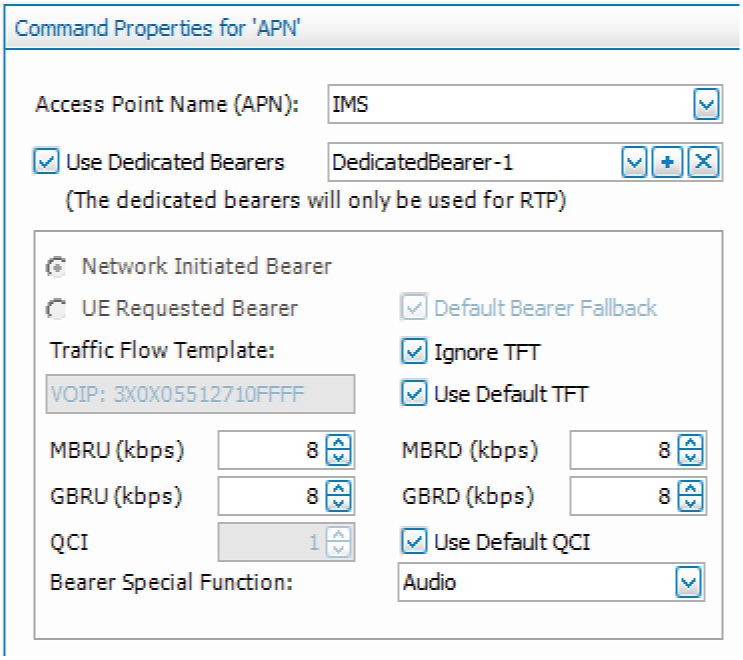


Figure 138. Synchronization between eGTP Control Plane and the VoIPSip activity

This configuration will simulate Subscribers attaching to the network, then executing a handover procedure and after some more time disconnecting from the network.

14. Click on Subscriber1 and then on the APN command.



Command Properties for 'APN'

Access Point Name (APN): IMS

☑ Use Dedicated Bearers: DedicatedBearer-1

(The dedicated bearers will only be used for RTP)

● Network Initiated Bearer

○ UE Requested Bearer

☑ Default Bearer Fallback

Traffic Flow Template: VOIP: 3X0X05512710FFFF

☑ Ignore TFT

☑ Use Default TFT

MBRU (kbps): 8

MBRD (kbps): 8

GBRU (kbps): 8

GBRD (kbps): 8

QCI: 1

☑ Use Default QCI

Bearer Special Function: Audio

Figure 139. APN command

Since this is a VoLTE test, the voice and video traffic needs to have dedicated resources allocated. For this we need to configure the voice and video traffic to use dedicated bearers.

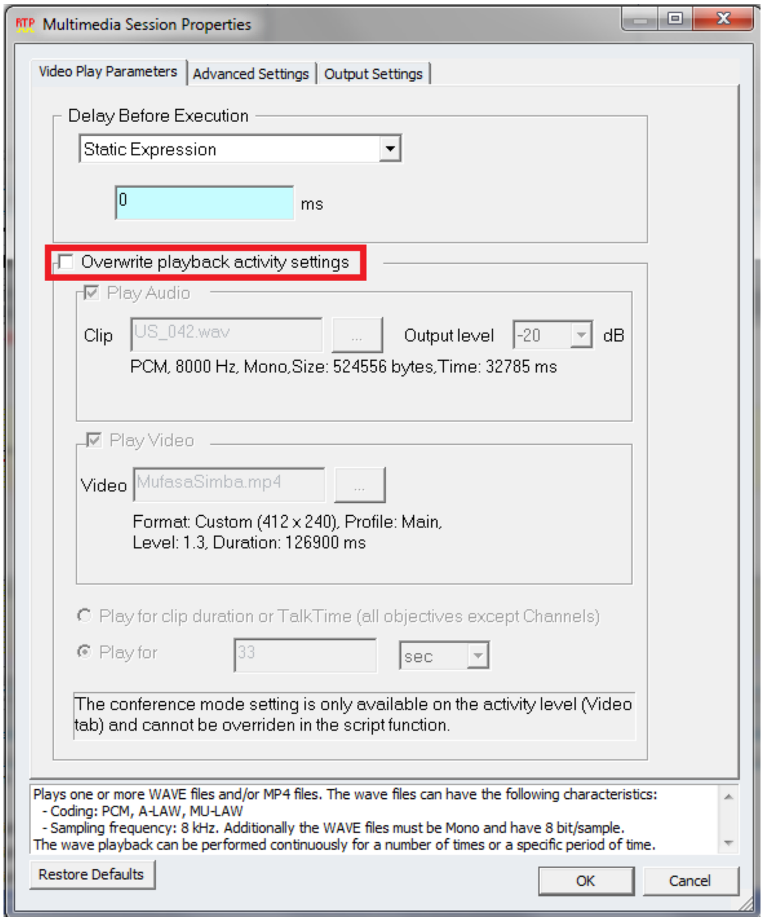
Configure the VoIP traffic item to use the dedicated bearer by clicking on **Use Dedicated Bearers.**

Set the **Bearer Special Function** for the dedicated bearer to **Audio.**

Click on the **+** sign to add another bearer to the VoIPSip Activity. This will be the dedicated bearer used for video. Configure the **Bearer Special Function** for the second bearer to **Video**. Users can navigate between bearers using the drop down menu.

Use the default value for QCI and MBRU/MBRD/GBRU/GBRD and ensure that the Ignore TFT option is enabled. These default values are the recommended values specified by the technical specifications.

15. From the Scenario Editor, click on both multimedia blocks and disable **Overwrite playback activity settings.** By doing this, the multimedia block will receive the audio and video configurations from the configuration in the rxf.



Delay Before Execution: Static Expression

0 ms

☐ Overwrite playback activity settings

☑ Play Audio

Clip: US_042.wav ... Output level: -20 dB

PCM, 8000 Hz, Mono,Size: 524556 bytes,Time: 32785 ms

☑ Play Video

Video: MufasaSimba.mp4 ...

Format: Custom (412 x 240), Profile: Main,
Level: 1.3, Duration: 126900 ms

○ Play for clip duration or TalkTime (all objectives except Channels)

● Play for 33 sec

The conference mode setting is only available on the activity level (Video tab) and cannot be overriden in the script function.

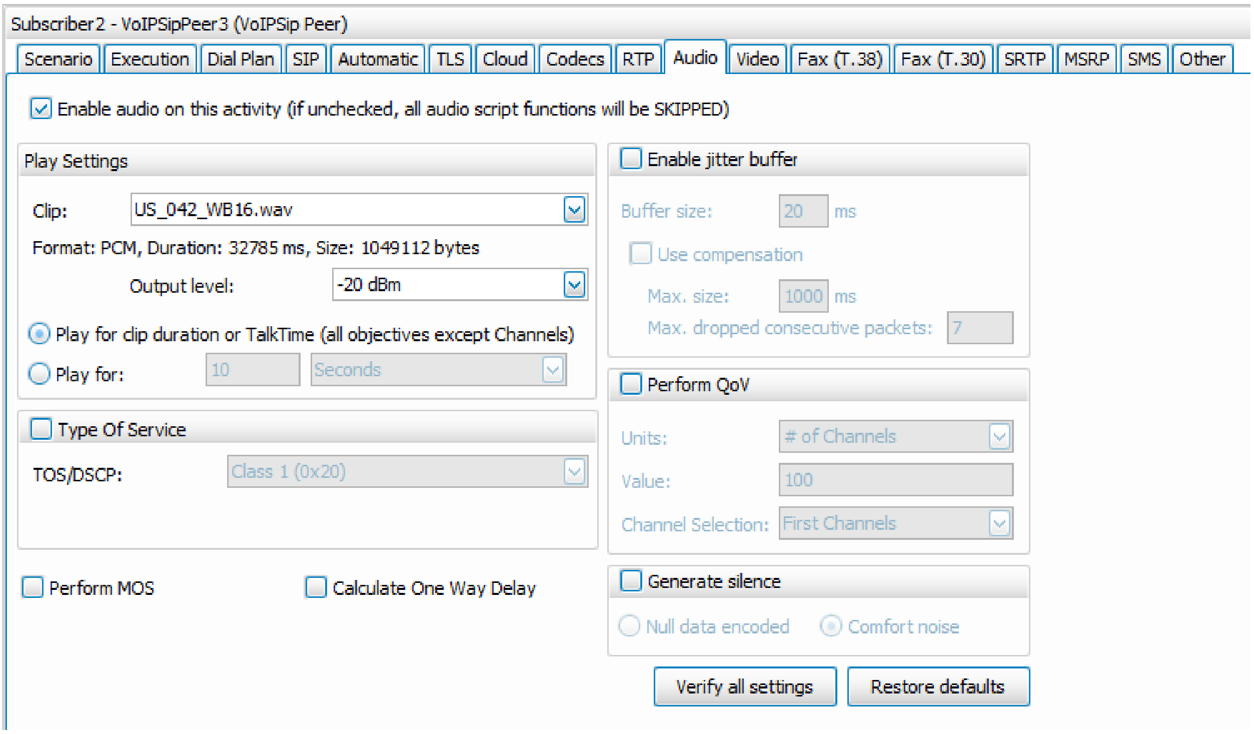
Plays one or more WAVE files and/or MP4 files. The wave files can have the following characteristics:
- Coding: PCM, A-LAW, MU-LAW
- Sampling frequency: 8 kHz. Additionally the WAVE files must be Mono and have 8 bit/sample.

The wave playback can be performed continuously for a number of times or a specific period of time.

Figure 140. Multimedia function

16. Select the VoIP Activity on the Originate side. Go on the Audio tab and click on **Enable audio on this activity.** Select the **US_042_WB16.wav** clip from the list of predefined clips. Use default value for the rest of the parameters in this tab.

    Repeat the same steps on the VoIP activity on the Terminate side.



☑ Enable audio on this activity (if unchecked, all audio script functions will be SKIPPED)

Play Settings

Clip: US_042_WB16.wav

Format: PCM, Duration: 32785 ms, Size: 1049112 bytes

Output level: -20 dBm

● Play for clip duration or TalkTime (all objectives except Channels)

○ Play for: 10 Seconds

☐ Type Of Service

TOS/DSCP: Class 1 (0x20)

☐ Perform MOS

☐ Calculate One Way Delay

☐ Enable jitter buffer

Buffer size: 20 ms

☐ Use compensation

Max. size: 1000 ms

Max. dropped consecutive packets: 7

☐ Perform QoV

Units: # of Channels

Value: 100

Channel Selection: First Channels

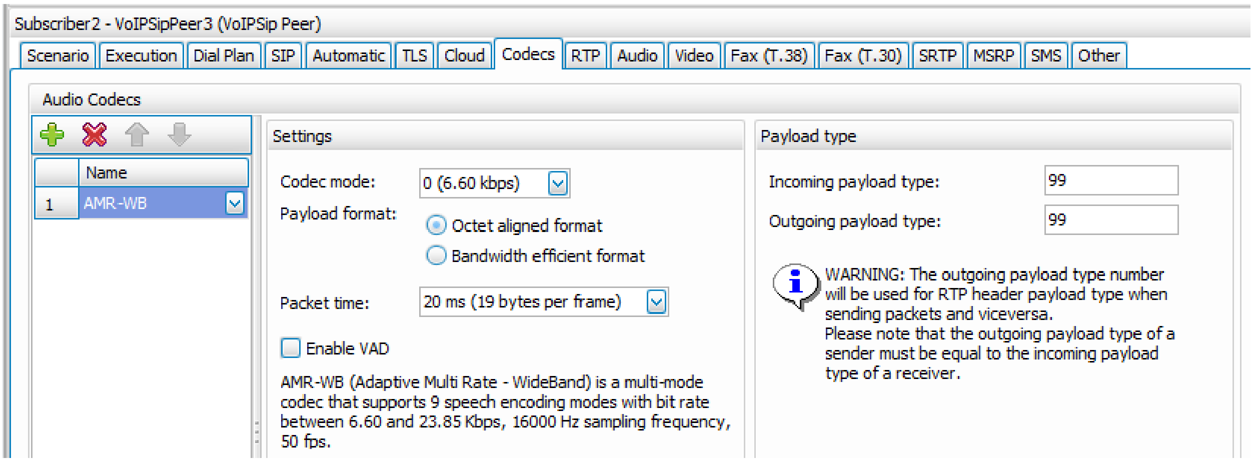
☐ Generate silence

○ Null data encoded ● Comfort noise

Figure 141. Audio settings for the VoIP activity

17. Select the VoIPSip activity on the Originate side. Click on the **Codecs** tab. In the Audio Codecs sections, delete the default values by using the **X** button and add another new value using the **+** sign. From the dropdown menu select **AMR-WB** codec. Keep the default configuration for this codec.

    Repeat the same steps on the VoIP activity on the Terminate side.



Audio Codecs

	Name
1	AMR-WB

Settings

Codec mode: 0 (6.60 kbps)

Payload format:
● Octet aligned format
○ Bandwidth efficient format

Packet time: 20 ms (19 bytes per frame)

☐ Enable VAD

AMR-WB (Adaptive Multi Rate - WideBand) is a multi-mode codec that supports 9 speech encoding modes with bit rate between 6.60 and 23.85 Kbps, 16000 Hz sampling frequency, 50 fps.

Payload type

Incoming payload type: 99

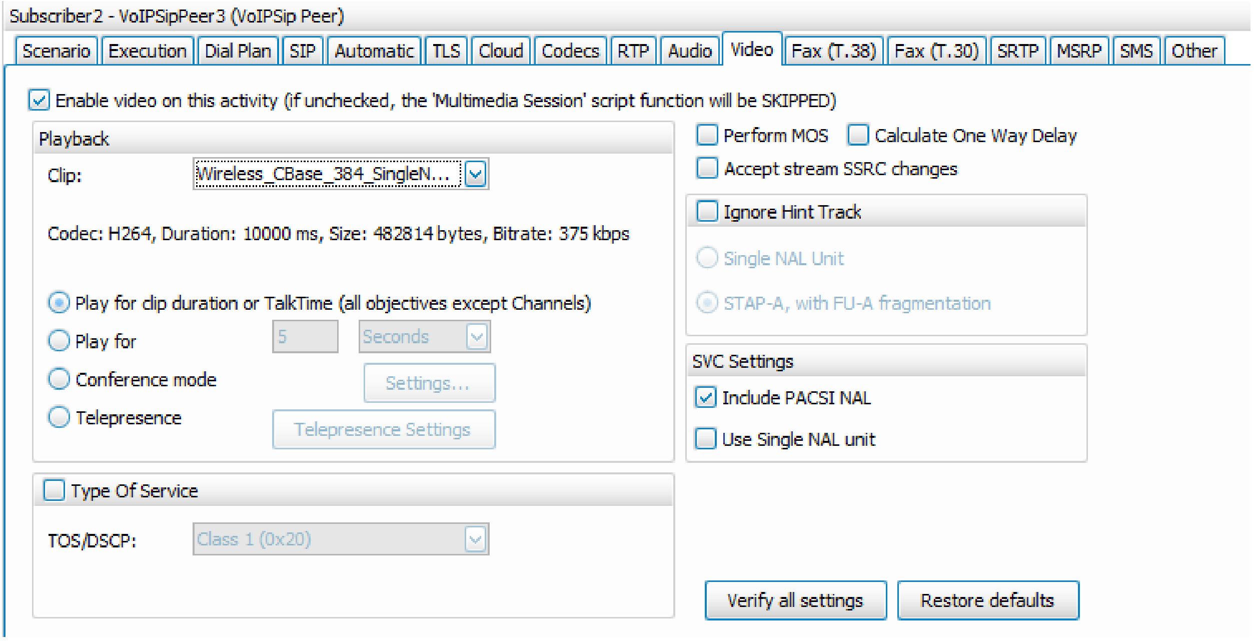
Outgoing payload type: 99

WARNING: The outgoing payload type number will be used for RTP header payload type when sending packets and viceversa.
Please note that the outgoing payload type of a sender must be equal to the incoming payload type of a receiver.

Figure 142. Audio Codecs settings

18. Select the VoIP Activity on the Originate side. Go on the Audio tab and click on **Enable video on this activity.** Select the **Wireless_CBase_384_SingleNalUnit.mp4** clip from the list of predefined clips. Use default value for the rest of the parameters in this tab.

    Repeat the same steps on the VoIP activity on the Terminate side.



☑ Enable video on this activity (if unchecked, the 'Multimedia Session' script function will be SKIPPED)

Playback

Clip: Wireless_CBase_384_SingleN...

Codec: H264, Duration: 10000 ms, Size: 482814 bytes, Bitrate: 375 kbps

● Play for clip duration or TalkTime (all objectives except Channels)
○ Play for 5 Seconds
○ Conference mode
○ Telepresence

☐ Type Of Service

TOS/DSCP: Class 1 (0x20)

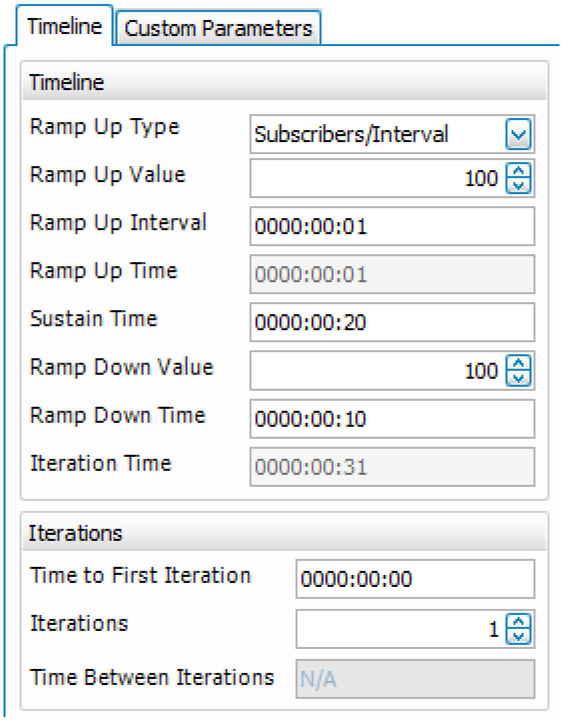
☐ Perform MOS ☐ Calculate One Way Delay
☐ Accept stream SSRC changes

☐ Ignore Hint Track
○ Single NAL Unit
○ STAP-A, with FU-A fragmentation

SVC Settings
☑ Include PACSI NAL
☐ Use Single NAL unit

Figure 143. Video Codecs settings

19. From **Timeline and Objectives,** set the Objective Type for the VoIPPeer activity to Subscribers and the Objective Value to 100. Set the **Ramp Up Value** and **Ramp Down Value** to 100, and **Sustain time** to at least 20 sec.



Timeline

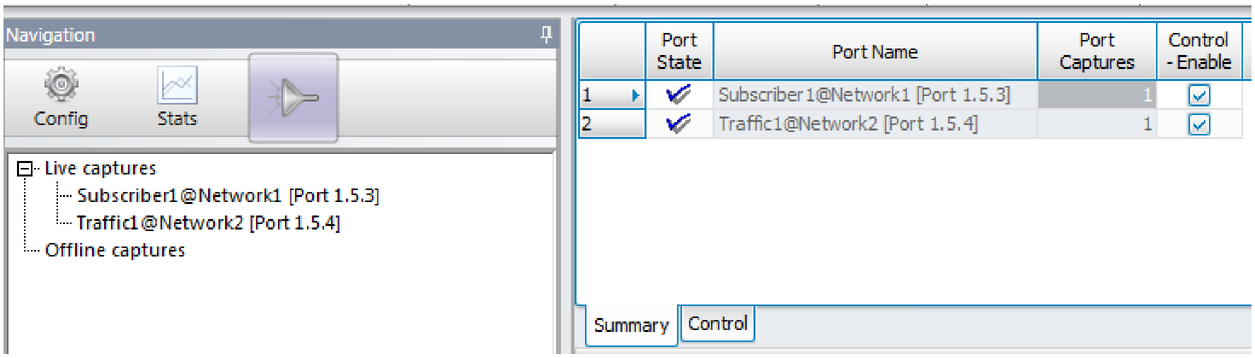
Ramp Up Type	Subscribers/Interval
Ramp Up Value	100
Ramp Up Interval	0000:00:01
Ramp Up Time	0000:00:01
Sustain Time	0000:00:20
Ramp Down Value	100
Ramp Down Time	0000:00:10
Iteration Time	0000:00:31

Iterations

Time to First Iteration	0000:00:00
Iterations	1
Time Between Iterations	N/A

Figure 144. Timeline configuration

20. Click on **Analyzer** and enable the packet capture on both ports by enabling the **Control-Enable** corresponding to each port.



- Live captures
  - Subscriber1@Network1 [Port 1.5.3]
  - Traffic1@Network2 [Port 1.5.4]
- Offline captures

	Port State	Port Name	Port Captures	Control - Enable
1	✓	Subscriber1@Network1 [Port 1.5.3]	1	☑
2	✓	Traffic1@Network2 [Port 1.5.4]	1	☑

Figure 145. Analyzer configuration

21. Click **Settings** for the network plugin. In the **Interface Behavior** section click **Create interface with user** and select the **Teardown interface with user** check box. This enables dynamic control plane mode.

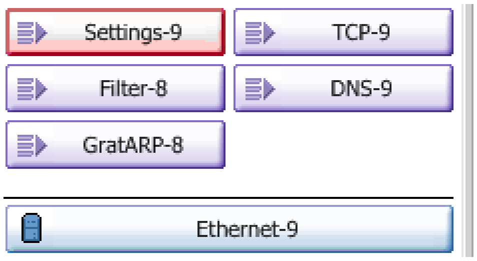
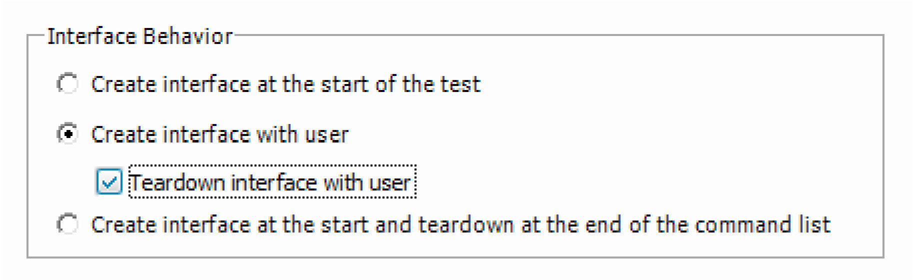


Figure 146. Settings Button



Interface Behavior

○ Create interface at the start of the test

● Create interface with user

☑ Teardown interface with user

○ Create interface at the start and teardown at the end of the command list

Figure 147. Interface Behavior

Test Variables

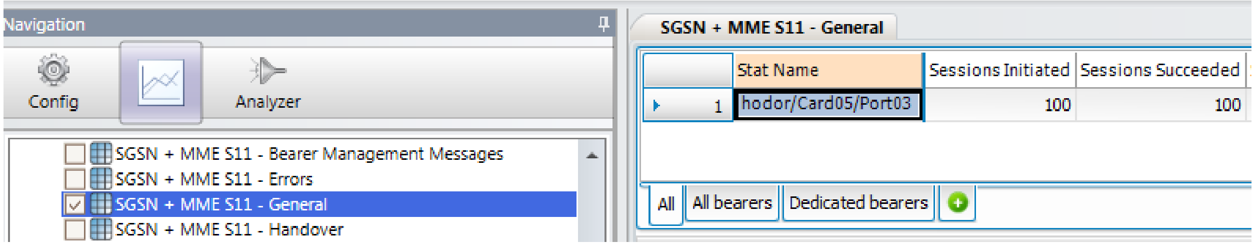
Variables	Values
UE Count	100
Mobility interval	2 sec
Objective for VoIPSip Activity	Subscriber

Results Analysis

The statistics to watch are the handovers, because this is a handover focused test. The statistics are divided in two sections: **SGSN +MME S11** statistics that count events triggered while the UE is attached in 4G and **SGSN S4** statistics that count events triggered while in 3G.

The handover statistics are counted at the destination of the handover, so, for a Handover from 4G to 3G, the handover will be counted in the **SGSN S4 –Handover** view.

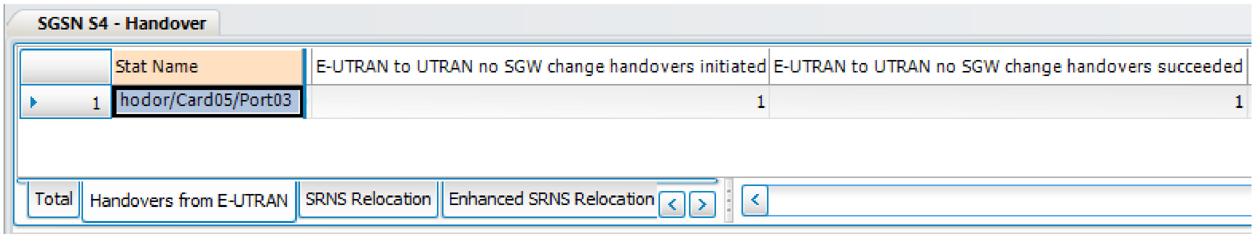
1. First we need to verify that the eGTP session has been successfully created. To do this, check the **SGSN+MME S11 – General** statistics view and check if all the users are successfully attached.


Navigation
Config
Analyzer
☐ SGSN + MME S11 - Bearer Management Messages
☐ SGSN + MME S11 - Errors
☑ SGSN + MME S11 - General
☐ SGSN + MME S11 - Handover
SGSN + MME S11 - General
All
All bearers
Dedicated bearers

	Stat Name	Sessions Initiated	Sessions Succeeded
1	hodor/Card05/Port03	100	100

Figure 1. SGSN + MME S11 – General view

2. After 2 seconds from the start of the test, when the Handover command is executed, check the **SGSN S4 – Handover** view, in the **Handover from E-UTRAN** tab to see if the handover has been executed successfully.



	Stat Name	E-UTRAN to UTRAN no SGW change handovers initiated	E-UTRAN to UTRAN no SGW change handovers succeeded
1	hodor/Card05/Port03	1	1

Figure 148. 3G to 4G statistics view

3. Check the **Calls (VoIPSip)** statistic to verify that all the calls have been set up correctly

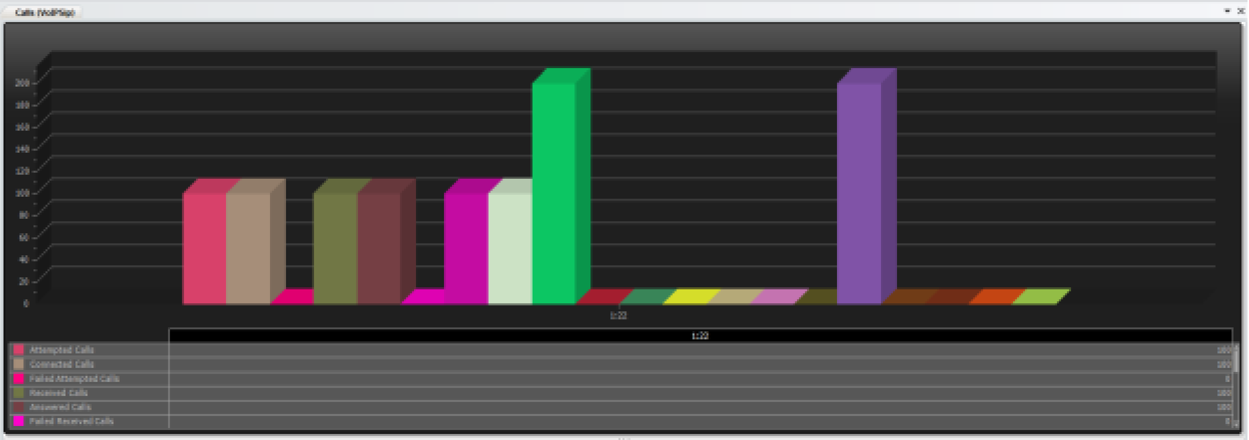
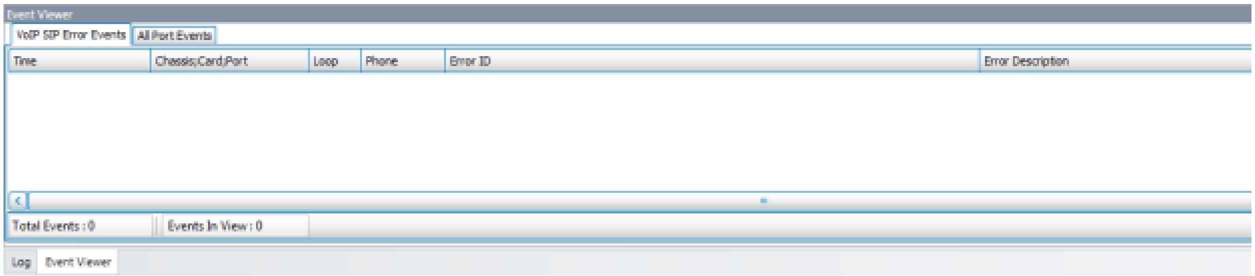


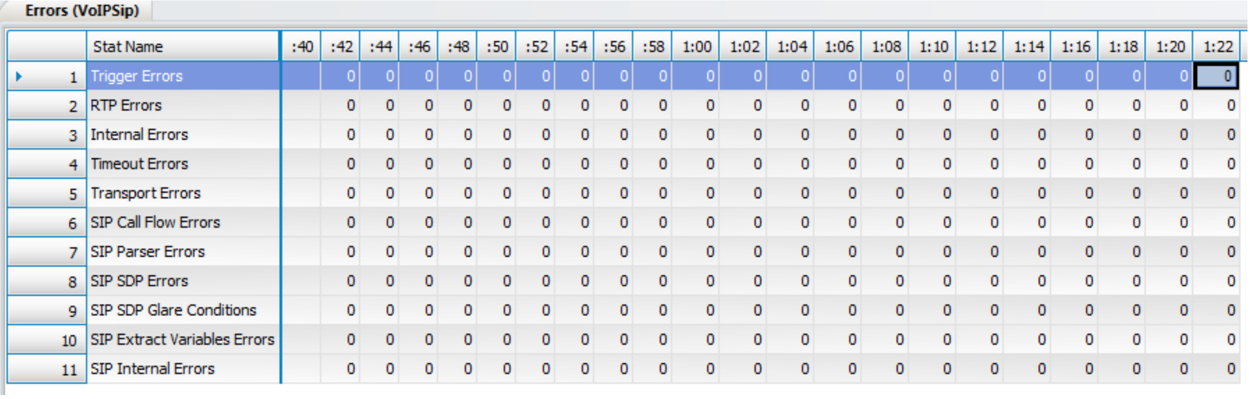
Figure 149. Calls (VoIPSip) statistic

Also, check the **RTP QoS (VoIPSip)** and **Video RTP QoS (VoIPSip)** statistics view to see the Throughput of the RTP audio and video streams.

4. Check the Event Viewer log to see that there where no errors reported during the test run.



5. Check the **Errors (VoIPSip)** statistics view to verify that there are no SIP errors.

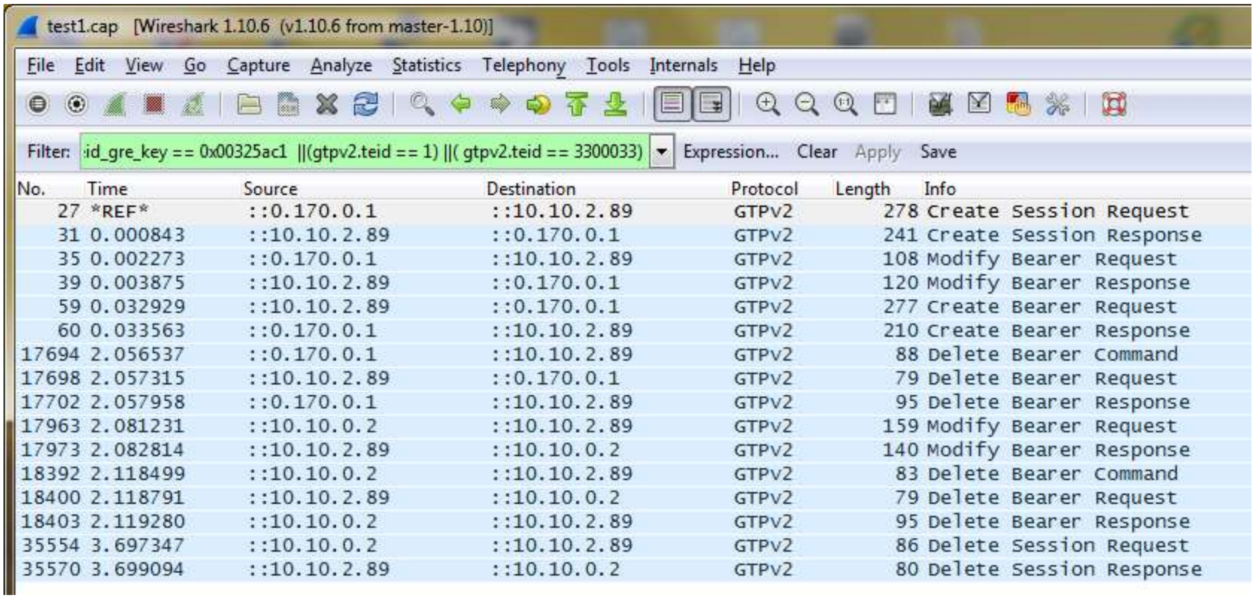


Errors (VoIPSip)

	Stat Name	:40	:42	:44	:46	:48	:50	:52	:54	:56	:58	1:00	1:02	1:04	1:06	1:08	1:10	1:12	1:14	1:16	1:18	1:20	1:22
1	Trigger Errors		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	RTP Errors		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Internal Errors		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Timeout Errors		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	Transport Errors		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	SIP Call Flow Errors		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	SIP Parser Errors		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	SIP SDP Errors		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	SIP SDP Glare Conditions		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	SIP Extract Variables Errors		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	SIP Internal Errors		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

6. Save the packet capture from Analyzer and open it in Wireshark. Apply the following filter to the packet capture to filter out the GTPv2 control plane packets for the first UE:

   gtpv2.f_teid_gre_key == 0x00325ac1 ||(gtpv2.teid == 1) ||(gtpv2.teid == 3300033)


test1.cap [Wireshark 1.10.6 (v1.10.6 from master-1.10)]
File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
Expression... Clear Apply Save

Filter: id_gre_key == 0x00325ac1 ||(gtpv2.teid == 1) ||(gtpv2.teid == 3300033)

```
No.    Time      Source        Destination   Protocol  Length Info
   27 *REF*     ::0.170.0.1   ::10.10.2.89  GTPv2        278 Create Session Request
   31 0.000843  ::10.10.2.89  ::0.170.0.1   GTPv2        241 Create Session Response
   35 0.002273  ::0.170.0.1   ::10.10.2.89  GTPv2        108 Modify Bearer Request
   39 0.003875  ::10.10.2.89  ::0.170.0.1   GTPv2        120 Modify Bearer Response
   59 0.032929  ::10.10.2.89  ::0.170.0.1   GTPv2        277 Create Bearer Request
   60 0.033563  ::0.170.0.1   ::10.10.2.89  GTPv2        210 Create Bearer Response
17694 2.056537  ::0.170.0.1   ::10.10.2.89  GTPv2         88 Delete Bearer Command
17698 2.057315  ::10.10.2.89  ::0.170.0.1   GTPv2         79 Delete Bearer Request
17702 2.057958  ::0.170.0.1   ::10.10.2.89  GTPv2         95 Delete Bearer Response
17963 2.081231  ::10.10.0.2   ::10.10.2.89  GTPv2        159 Modify Bearer Request
17973 2.082814  ::10.10.2.89  ::10.10.0.2   GTPv2        140 Modify Bearer Response
18392 2.118499  ::10.10.0.2   ::10.10.2.89  GTPv2         83 Delete Bearer Command
18400 2.118791  ::10.10.2.89  ::10.10.0.2   GTPv2         79 Delete Bearer Request
18403 2.119280  ::10.10.0.2   ::10.10.2.89  GTPv2         95 Delete Bearer Response
35554 3.697347  ::10.10.0.2   ::10.10.2.89  GTPv2         86 Delete Session Request
35570 3.699094  ::10.10.2.89  ::10.10.0.2   GTPv2         80 Delete Session Response
```

Figure 150. Control Plane messages for the first UE

The figure below shows the complete call flow of the Single Radio Voice Call Continuity (SRVCC) procedure. Please note that in our configured scenario, only the S4/S11 and S12/S1-U interfaces are exposed and only messages on these interfaces will be visible in the packet capture.

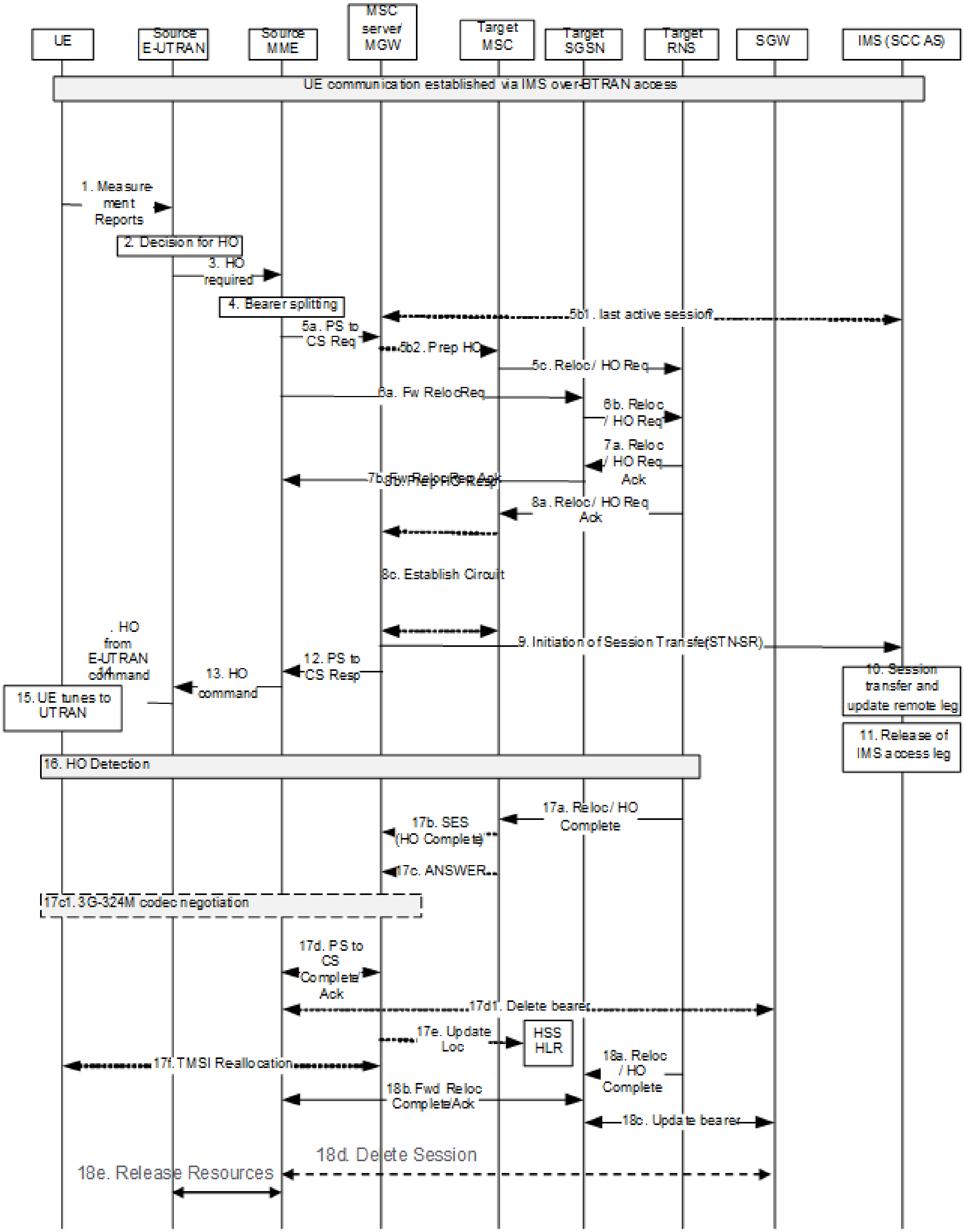
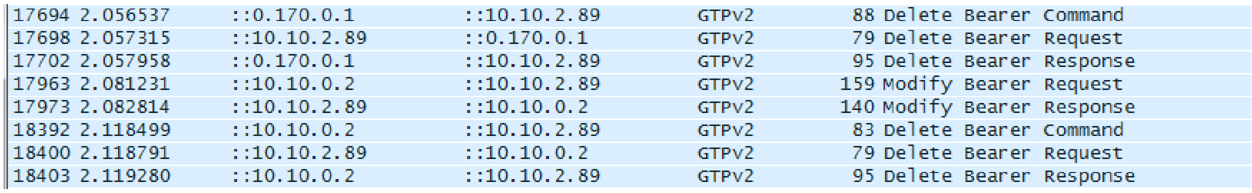


Figure 151. SRVCC call flow

The following messages are part of the GTPv2 control plane signaling related to the SRVCC procedure.



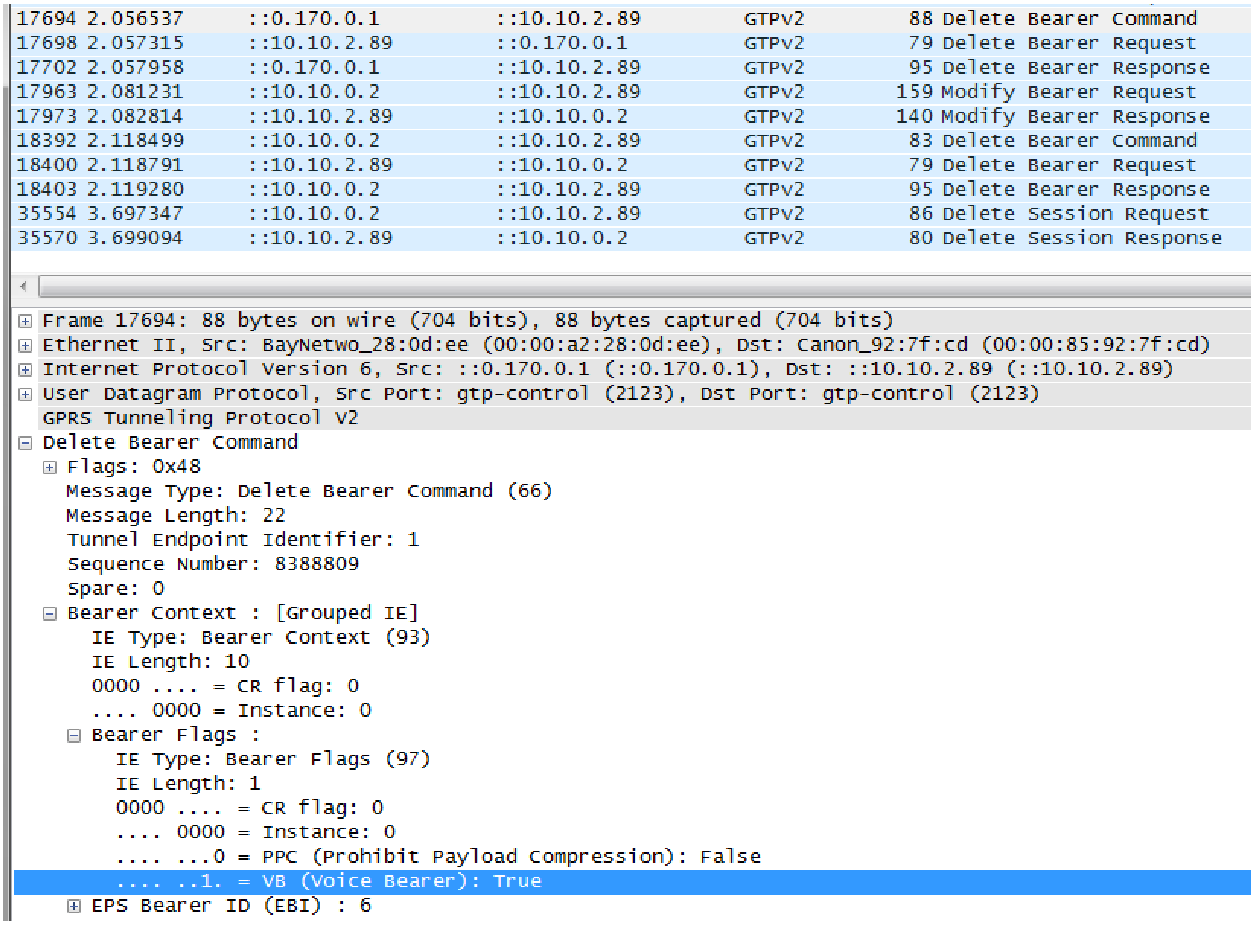
```
17694 2.056537     ::0.170.0.1        ::10.10.2.89       GTPv2       88 Delete Bearer Command
17698 2.057315     ::10.10.2.89       ::0.170.0.1        GTPv2       79 Delete Bearer Request
17702 2.057958     ::0.170.0.1        ::10.10.2.89       GTPv2       95 Delete Bearer Response
17963 2.081231     ::10.10.0.2        ::10.10.2.89       GTPv2      159 Modify Bearer Request
17973 2.082814     ::10.10.2.89       ::10.10.0.2        GTPv2      140 Modify Bearer Response
18392 2.118499     ::10.10.0.2        ::10.10.2.89       GTPv2       83 Delete Bearer Command
18400 2.118791     ::10.10.2.89       ::10.10.0.2        GTPv2       79 Delete Bearer Request
18403 2.119280     ::10.10.0.2        ::10.10.2.89       GTPv2       95 Delete Bearer Response
```

Figure 152. Signaling for the SRVCC IR94 procedure

After moving the audio and video on CS, the voice bearer is deleted and all other bearers are moved from 3G to 4G (if PS support is available). The SIP part of the voice activity is continued until the end of the activity command list. This is done to ensure proper closing of the current call.

Single Radio Voice Call Continuity (SRVCC) provides continuity for a VoIP/IMS call when that call moves from the LTE packet domain to a legacy circuit domain (GSM/UMTS or CDMA 1x).

The Delete Bearer Command for the voice bearer is marked with Bearer Flag - VB (Voice Bearer).



```
17694 2.056537    ::0.170.0.1        ::10.10.2.89       GTPv2          88 Delete Bearer Command
17698 2.057315    ::10.10.2.89       ::0.170.0.1        GTPv2          79 Delete Bearer Request
17702 2.057958    ::0.170.0.1        ::10.10.2.89       GTPv2          95 Delete Bearer Response
17963 2.081231    ::10.10.0.2        ::10.10.2.89       GTPv2         159 Modify Bearer Request
17973 2.082814    ::10.10.2.89       ::10.10.0.2        GTPv2         140 Modify Bearer Response
18392 2.118499    ::10.10.0.2        ::10.10.2.89       GTPv2          83 Delete Bearer Command
18400 2.118791    ::10.10.2.89       ::10.10.0.2        GTPv2          79 Delete Bearer Request
18403 2.119280    ::10.10.0.2        ::10.10.2.89       GTPv2          95 Delete Bearer Response
35554 3.697347    ::10.10.0.2        ::10.10.2.89       GTPv2          86 Delete Session Request
35570 3.699094    ::10.10.2.89       ::10.10.0.2        GTPv2          80 Delete Session Response

⊞ Frame 17694: 88 bytes on wire (704 bits), 88 bytes captured (704 bits)
⊞ Ethernet II, Src: BayNetwo_28:0d:ee (00:00:a2:28:0d:ee), Dst: Canon_92:7f:cd (00:00:85:92:7f:cd)
⊞ Internet Protocol Version 6, Src: ::0.170.0.1 (::0.170.0.1), Dst: ::10.10.2.89 (::10.10.2.89)
⊞ User Datagram Protocol, Src Port: gtp-control (2123), Dst Port: gtp-control (2123)
  GPRS Tunneling Protocol V2
⊟ Delete Bearer Command
  ⊞ Flags: 0x48
    Message Type: Delete Bearer Command (66)
    Message Length: 22
    Tunnel Endpoint Identifier: 1
    Sequence Number: 8388809
    Spare: 0
  ⊟ Bearer Context : [Grouped IE]
      IE Type: Bearer Context (93)
      IE Length: 10
      0000 .... = CR flag: 0
      .... 0000 = Instance: 0
    ⊟ Bearer Flags :
        IE Type: Bearer Flags (97)
        IE Length: 1
        0000 .... = CR flag: 0
        .... 0000 = Instance: 0
        .... ...0 = PPC (Prohibit Payload Compression): False
        .... ..1. = VB (Voice Bearer): True
    ⊞ EPS Bearer ID (EBI) : 6
```

Figure 153. The Voice Bearer is deleted before moving the session

After the session is moved from the eNB to the SGSN the video bearer is also deactivated.

EPC Diameter Test Case: S6a Procedures for Attach and AVP Modification

Overview

The S6a interface enables the transfer of subscriber related data (subscription and authentication) between the MME and the HSS as described in the 3GPP TS 23.401 for authenticating/ authorizing user access to the evolved system.

The S6 application implements the following 3GPP procedures:

- Update Location
- Cancel Location
- Purge UE
- Insert Subscriber Data
- Delete Subscriber Data
- Authentication Information Retrieval
- Reset
- Notification

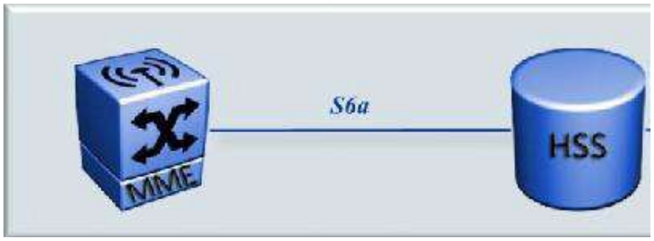


Figure 154. S6a interface: Server (HSS) and Client (MME)

Objective

This test case provides step-by-step instructions on how to use the S6a MME and HSS simulations.

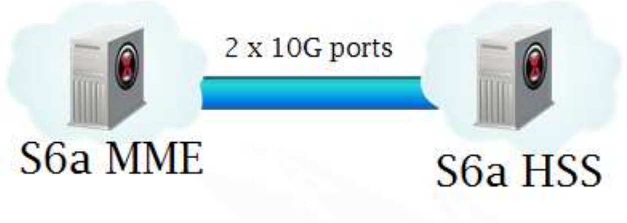
The objectives of the lab are:

- To introduce the IxLoad Diameter configuration editor and current feature support
- To configure the test for specific scenarios and call flows: S6a MME – HSS with AIR/AIA, ULR/ULA messages
- To configure IxLoad to perform specific AVP manipulation
- To understand statistics and packet capture

Setup

The test will be executed in back2back configuration using two separate plugins for MME and HSS S6a.

Two 10G ports from XT80 appliance will be used for the test.



The test will use one subscriber and the following message flow: AIR/AIA, ULR/ULA

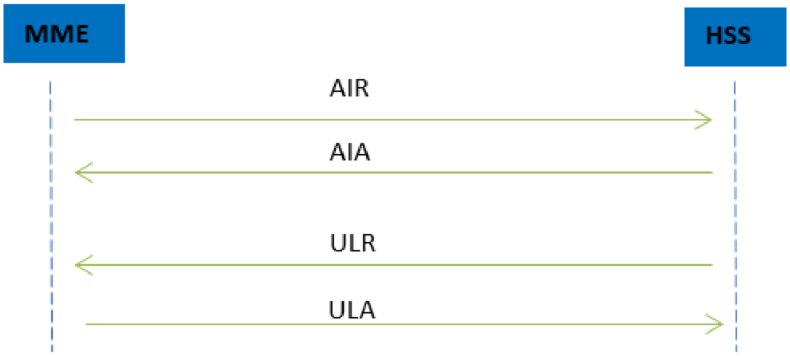
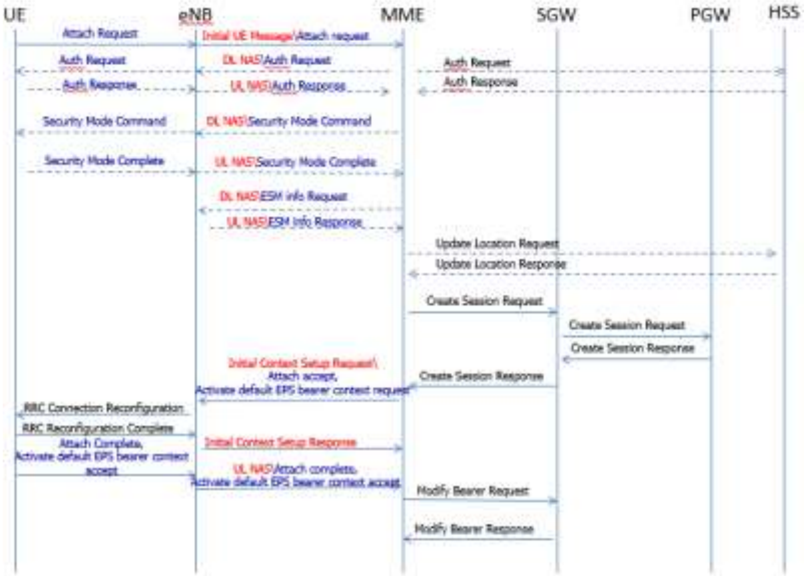


Figure 155. S6a messages

Test goal is to have one subscriber executing the above message flow. The reason the message flow is important is because it is part of Attach procedure:


UE
eNB
MME
SGW
PGW
HSS
Attach Request
Initial UE Message\Attach request
Auth Request
DL NAS\Auth Request
Auth Request
Auth Response
UL NAS\Auth Response
Auth Response
Security Mode Command
DL NAS\Security Mode Command
Security Mode Complete
UL NAS\Security Mode Complete
DL NAS\ESM info Request
UL NAS\ESM Info Response
Update Location Request
Update Location Response
Create Session Request
Create Session Request
Create Session Response
Initial Context Setup Request\ Attach accept, Activate default EPS bearer context request
Create Session Response
RRC Connection Reconfiguration
RRC Reconfiguration Complete
Attach Complete, Activate default EPS bearer context accept
Initial Context Setup Response
UL NAS\Attach complete, Activate default EPS bearer context accept
Modify Bearer Request
Modify Bearer Response

Step by Step instructions

1. Start IxLoad. From the File Menu create a new Diameter scenario by using the built-in templates provided with the IxLoad installation. Load one template as shown below.

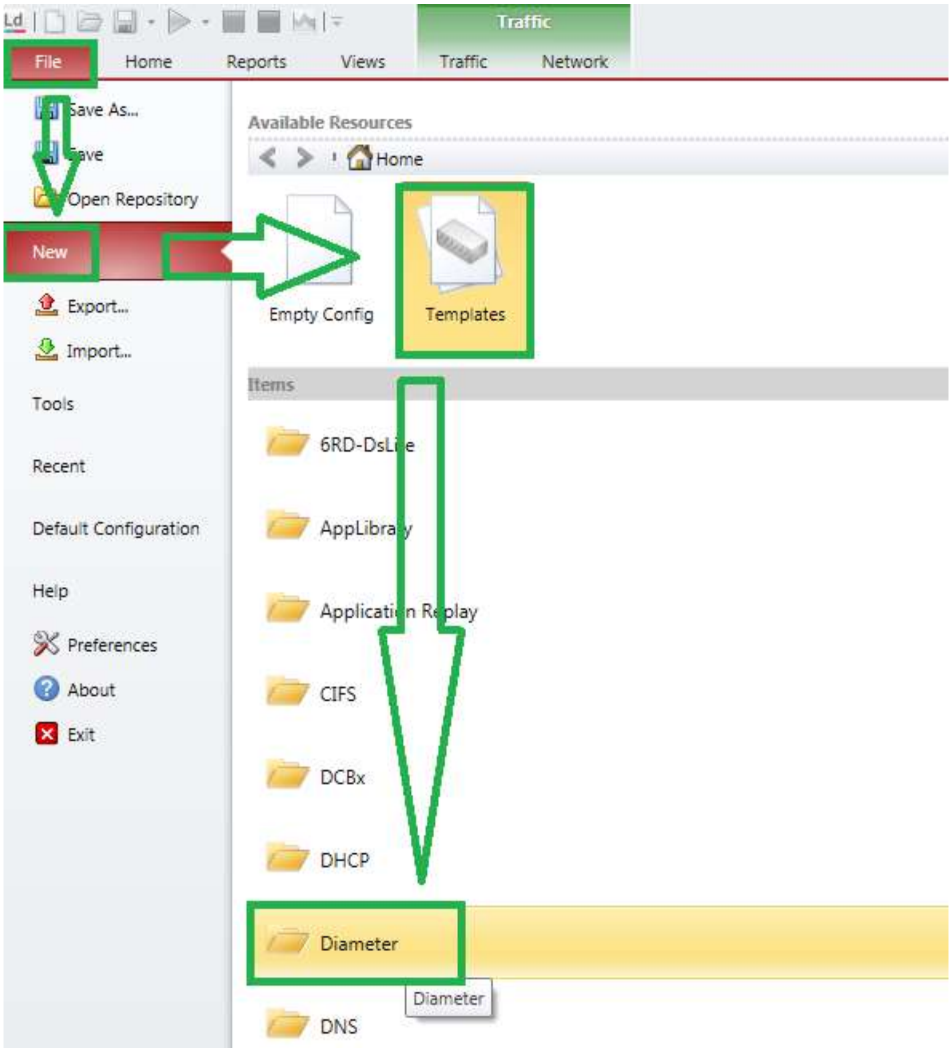
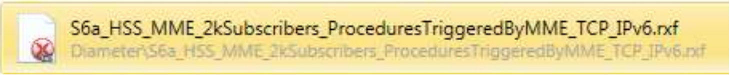
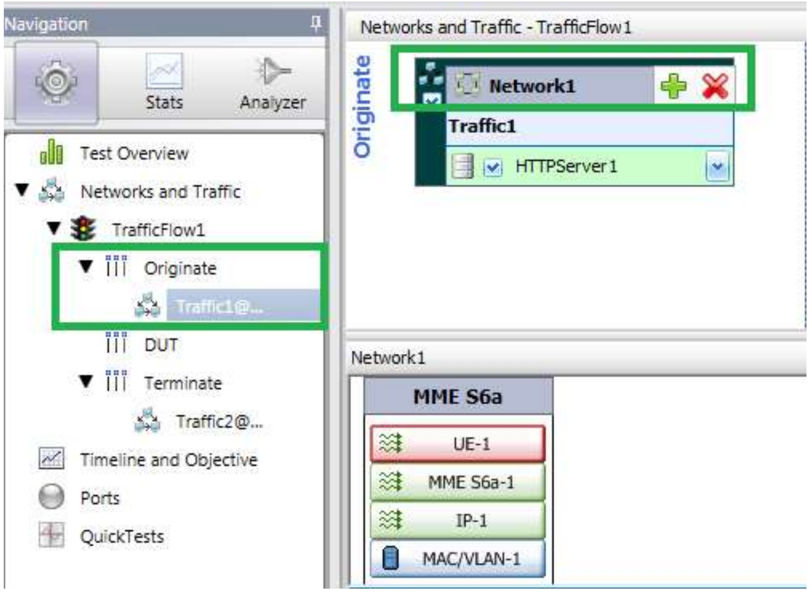


Figure 156. Selecting S6a RXF from Templates section

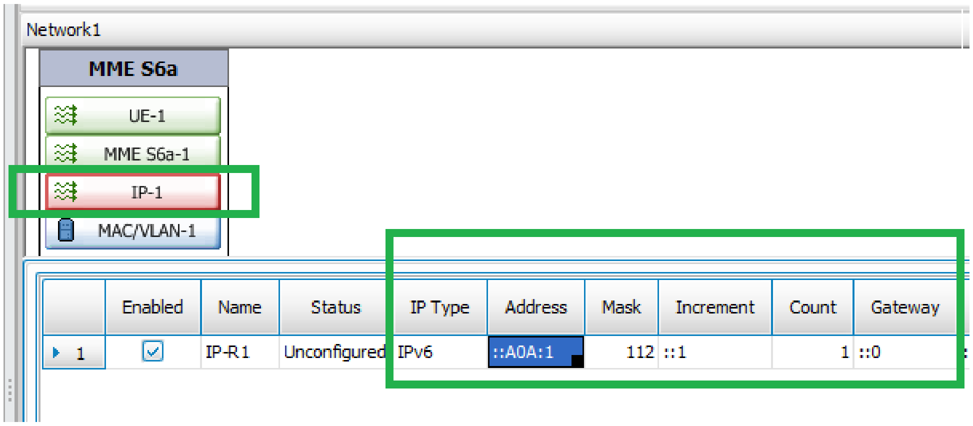
2. Select the S6a config shown below:


S6a_HSS_MME_2kSubscribers_ProceduresTriggeredByMME_TCP_IPv6.rxf
Diameter\S6a_HSS_MME_2kSubscribers_ProceduresTriggeredByMME_TCP_IPv6.rxf

3. Go to the S6a MME simulation



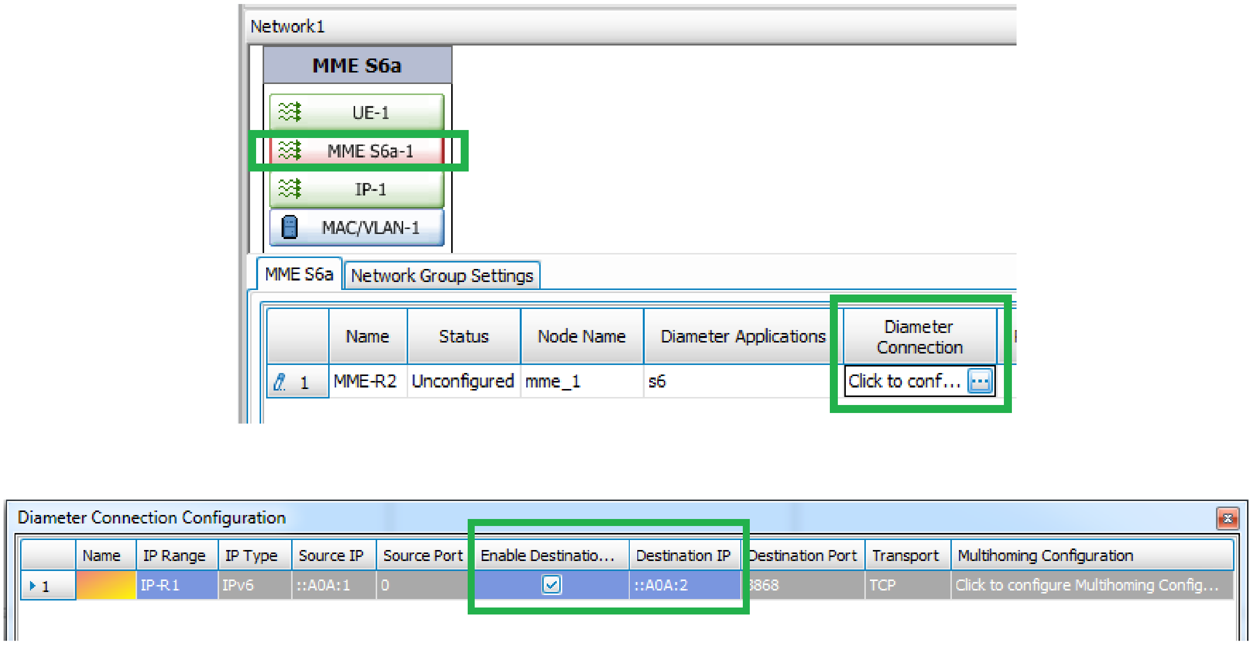
4. The IP of the MME node and gateway information can be changed from the IP Layer as shown below. For our test we'll use the default values:



	Enabled	Name	Status	IP Type	Address	Mask	Increment	Count	Gateway
1	☑	IP-R1	Unconfigured	IPv6	::A0A:1	112	::1	1	::0

Figure 157. Configuring MME IP address

5. To change the destination IP (the IP of the HSS to which the MME is connecting to) you have to select the MME S6a layer -> Diameter connection. This will open a pop-up window where the destination IP can be configured.



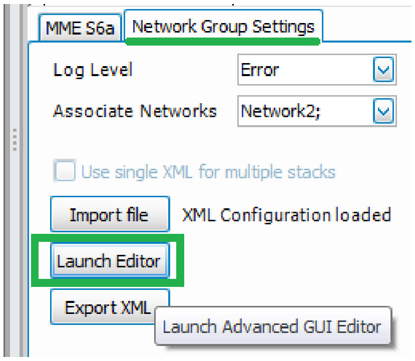
	Name	Status	Node Name	Diameter Applications	Diameter Connection
1	MME-R2	Unconfigured	mme_1	s6	Click to conf…

Diameter Connection Configuration

	Name	IP Range	IP Type	Source IP	Source Port	Enable Destinatio…	Destination IP	Destination Port	Transport	Multihoming Configuration
1		IP-R1	IPv6	::A0A:1	0	☑	::A0A:2	3868	TCP	Click to configure Multihoming Config…

Figure 2. **Configuring Destination IP address for MME**

6. To configure the node details, go to MME Layer -> Network Group Settings and open the advanced GUI editor. Another window will pop-up.



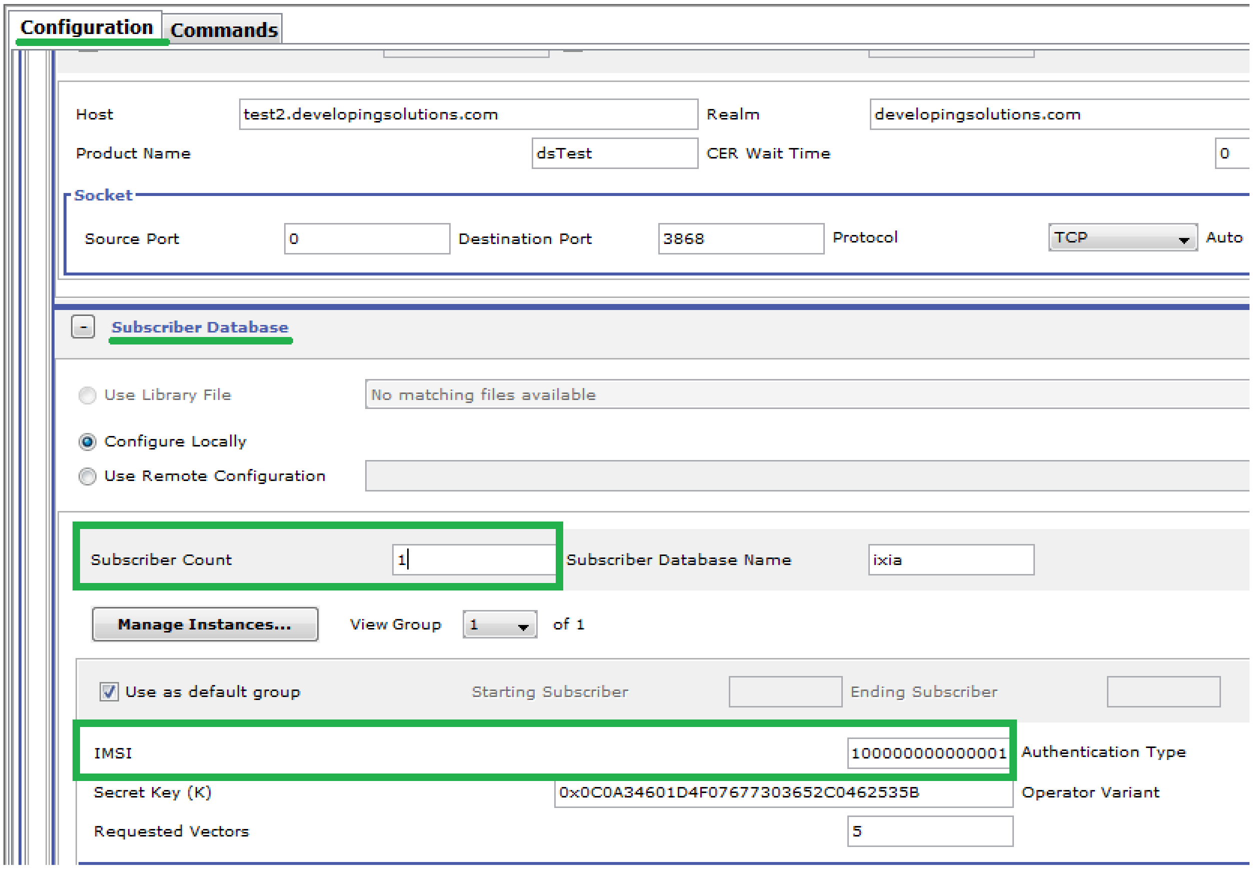
Log Level: Error

Associate Networks: Network2;

☐ Use single XML for multiple stacks

XML Configuration loaded

7. Under the configuration pane, scroll down to the Subscriber database. Here, users can configure the subscriber count and define identification info relevant for their test. In our test we will use one subscriber and the default IMSI value.



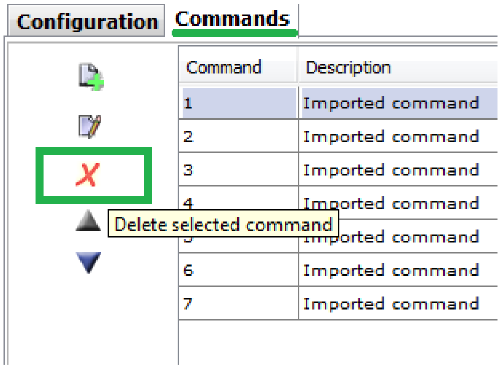
Host: test2.developingsolutions.com
Realm: developingsolutions.com
Product Name: dsTest
CER Wait Time: 0
Source Port: 0
Destination Port: 3868
Protocol: TCP
Auto

○ Use Library File — No matching files available
● Configure Locally
○ Use Remote Configuration

Subscriber Count: 1
Subscriber Database Name: ixia
View Group: 1 of 1
☑ Use as default group
Starting Subscriber
Ending Subscriber
IMSI: 100000000000001
Authentication Type
Secret Key (K): 0x0C0A34601D4F07677303652C0462535B
Operator Variant
Requested Vectors: 5

Figure 158. Subscriber Database section: Subscriber count and authentication parameters

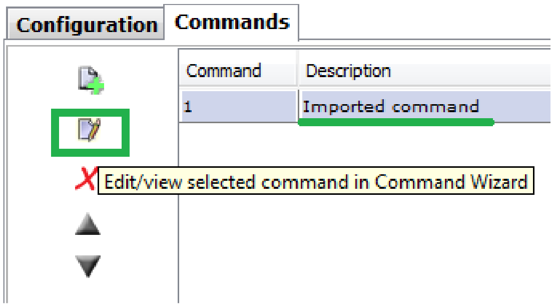
8. Next step is to define the subscriber behavior. Go to the commands tab. In this template users will find some predefined commands. **Delete all** except the first one and we will edit that first one to match our intended message flow.



Command	Description
1	Imported command
2	Imported command
3	Imported command
4	Imported command
5	Imported command
6	Imported command
7	Imported command

Figure 159. Command list for MME node

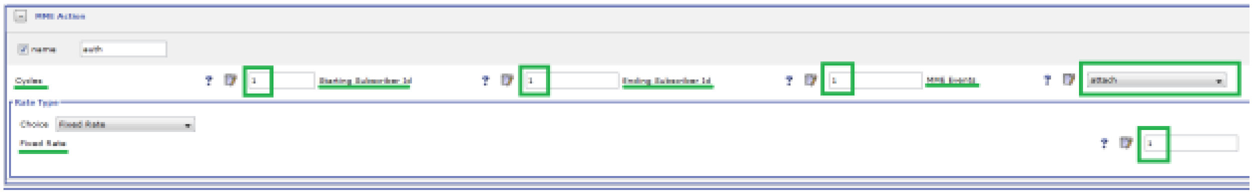
9. Select the first command (and the only one left) and click the “Edit” button. This will open the command editor window.



Command	Description
1	Imported command

Figure 160. Edit button for MME command

10. We will configure the test to run for one cycle, only for the one subscriber we have defined and execute “attach” procedures at a rate of 1 TPS. Important to mention here is that userscan define an infinite number of cycles by setting “Cycles” value to “-1”. This will have the test running until manually stopped or until the Timeline set at step 15 ends. But we will use one cycle for our test.



☑ name auth
Cycles 1
Starting Subscriber Id 1
Ending Subscriber Id 1
MME Event attach
Choice Fixed Rate
Fixed Rate 1

Figure 161. MME Action parameters

An “Attach” event is triggering an **AIR (Authentication Information Request)** followed by an **ULR (Update Location Request),** which is the goal of this test.

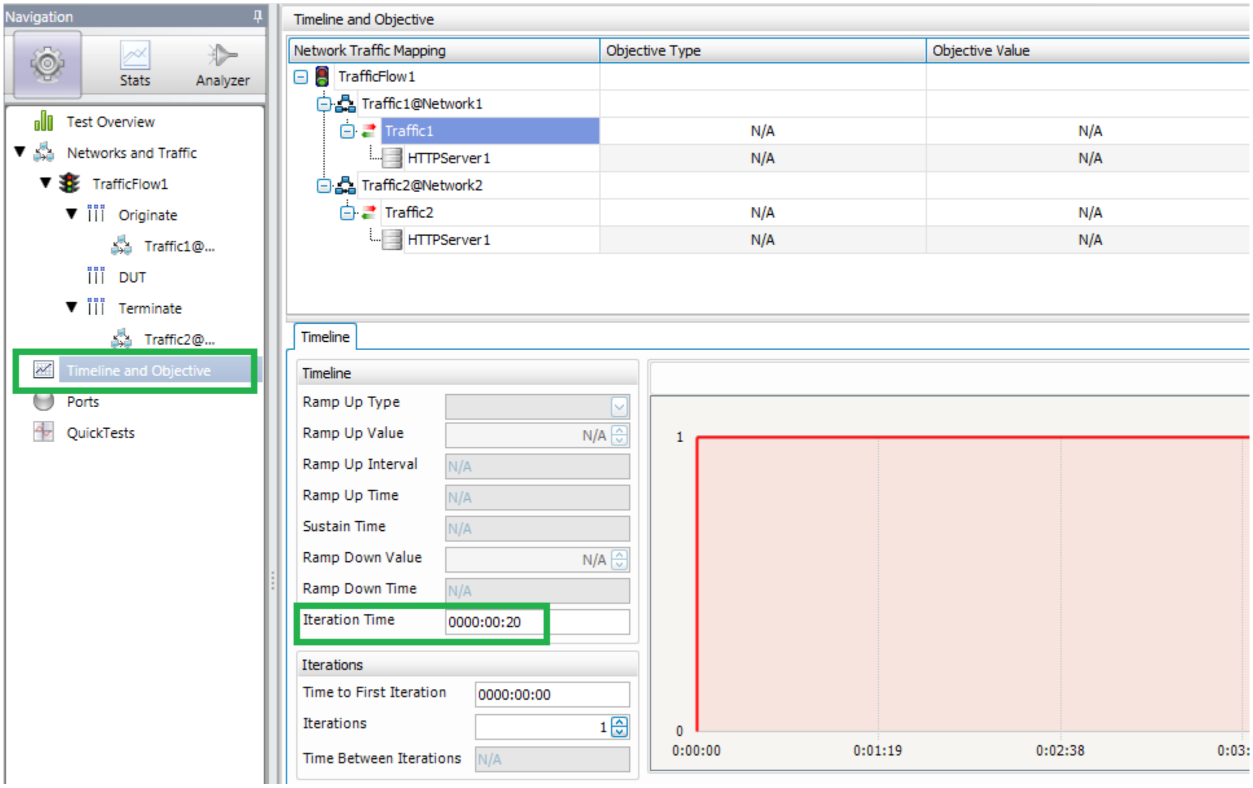
11. Once are done with editing the command click the **Update Command** button to complete command editing and then the **Save** button to save the advanced configuration. Now you can close the advanced GUI and return to the main IxLoad GUI.

12. At this point we can move to the HSS configuration. Users can repeat the steps similar to steps 3 thru 5 to configure IP connectivity for the HSS.

    Also, you will launch the advanced GUI editor for the HSS similar to how you did it in step 6. For this test we can use the default values from the template. Users will have to make sure subscriber information is the same on both ends.

    Note: HSS simulation will reply by default to MME requests, so there is no need to configure any command or state machine, we only need to start the node

13. Next step is to configure test duration:



Timeline and Objective

Network Traffic Mapping	Objective Type	Objective Value
TrafficFlow1		
Traffic1@Network1		
Traffic1	N/A	N/A
HTTPServer1	N/A	N/A
Traffic2@Network2		
Traffic2	N/A	N/A
HTTPServer1	N/A	N/A

Timeline

Ramp Up Type
Ramp Up Value: N/A
Ramp Up Interval: N/A
Ramp Up Time: N/A
Sustain Time: N/A
Ramp Down Value: N/A
Ramp Down Time: N/A
Iteration Time: 0000:00:20

Iterations

Time to First Iteration: 0000:00:00
Iterations: 1
Time Between Iterations: N/A

Figure 162. Test duration (Timeline and Objective)

14. Assign ports to the MME and HSS Network (from XT80 appliance or from VirtualMachine):

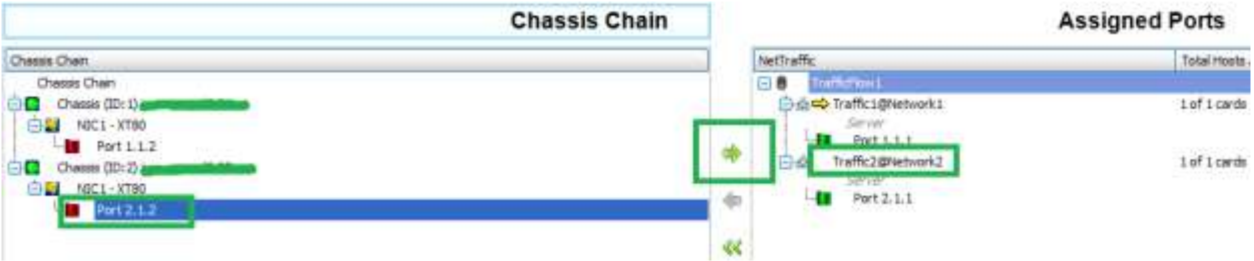
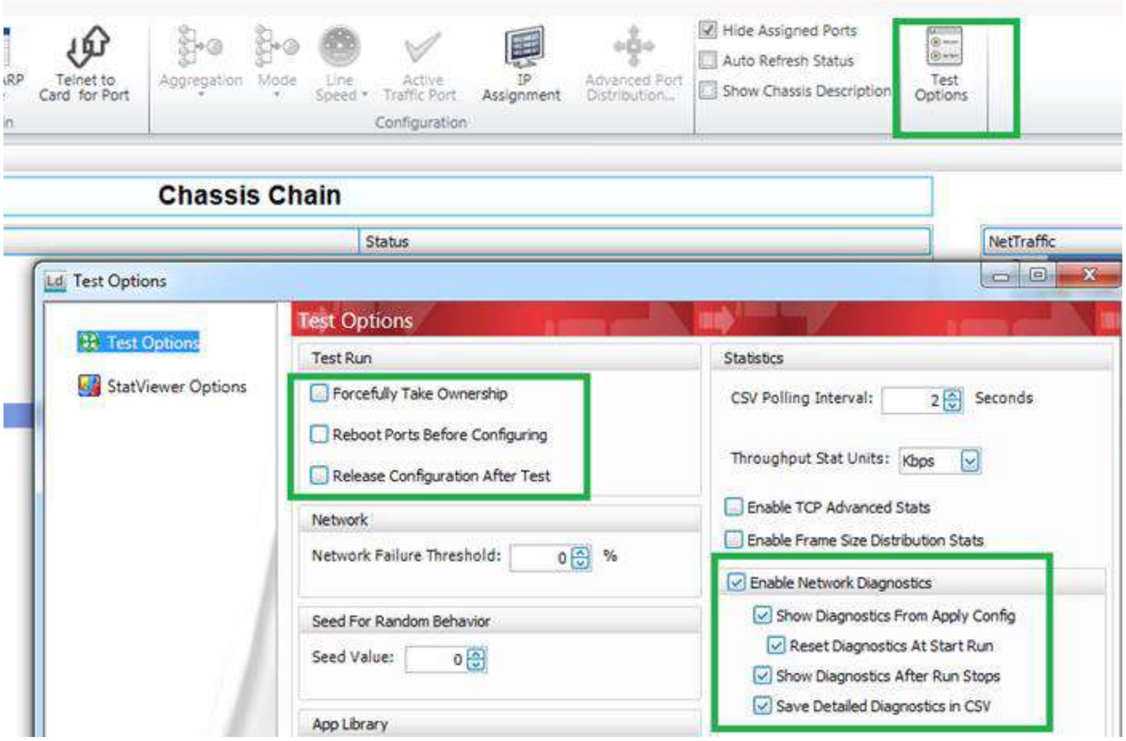


Figure 1. Assigning ports to Network

15. Enable statistics in the rxf.



☑ Hide Assigned Ports
☐ Auto Refresh Status
☐ Show Chassis Description

Test Options

Test Run

☐ Forcefully Take Ownership
☐ Reboot Ports Before Configuring
☐ Release Configuration After Test

Network

Network Failure Threshold: 0 %

Seed For Random Behavior

Seed Value: 0

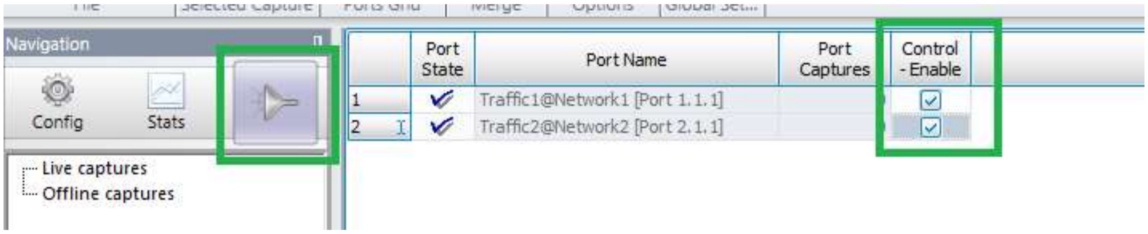
App Library

Statistics

CSV Polling Interval: 2 Seconds
Throughput Stat Units: Kbps
☐ Enable TCP Advanced Stats
☐ Enable Frame Size Distribution Stats
☑ Enable Network Diagnostics
☑ Show Diagnostics From Apply Config
☑ Reset Diagnostics At Start Run
☑ Show Diagnostics After Run Stops
☑ Save Detailed Diagnostics in CSV

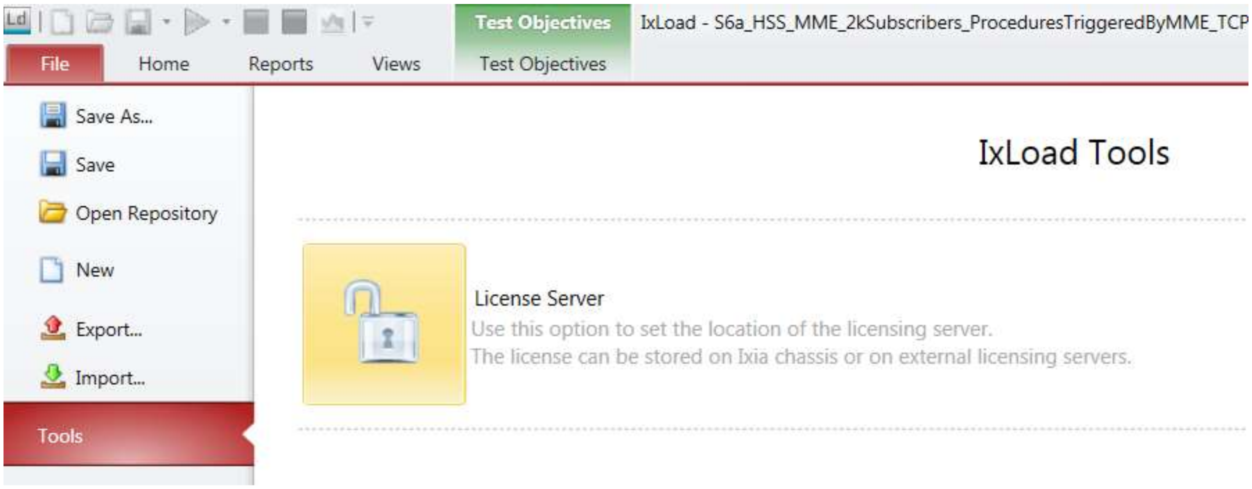
Figure 2. Enabling Statistics

16. Enable capture on ports.



	Port State	Port Name	Port Captures	Control - Enable
1	✓	Traffic1@Network1 [Port 1.1.1]		☑
2	✓	Traffic2@Network2 [Port 2.1.1]		☑

17. For XT80, the license server resides outside the appliance/port. So you have to configure and external license server.



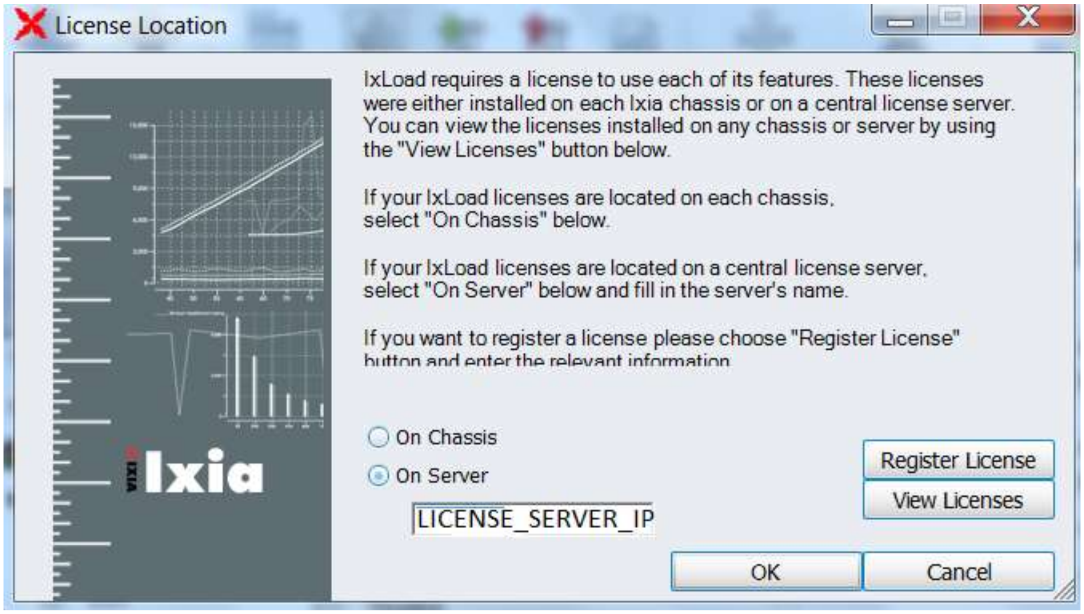
License Server

Use this option to set the location of the licensing server.

The license can be stored on Ixia chassis or on external licensing servers.

Figure 3. License Server configuration

18. Input here the IP of the license server (it can be localhost):



IxLoad requires a license to use each of its features. These licenses were either installed on each Ixia chassis or on a central license server. You can view the licenses installed on any chassis or server by using the "View Licenses" button below.

If your IxLoad licenses are located on each chassis, select "On Chassis" below.

If your IxLoad licenses are located on a central license server, select "On Server" below and fill in the server's name.

If you want to register a license please choose "Register License" button and enter the relevant information.

○ On Chassis

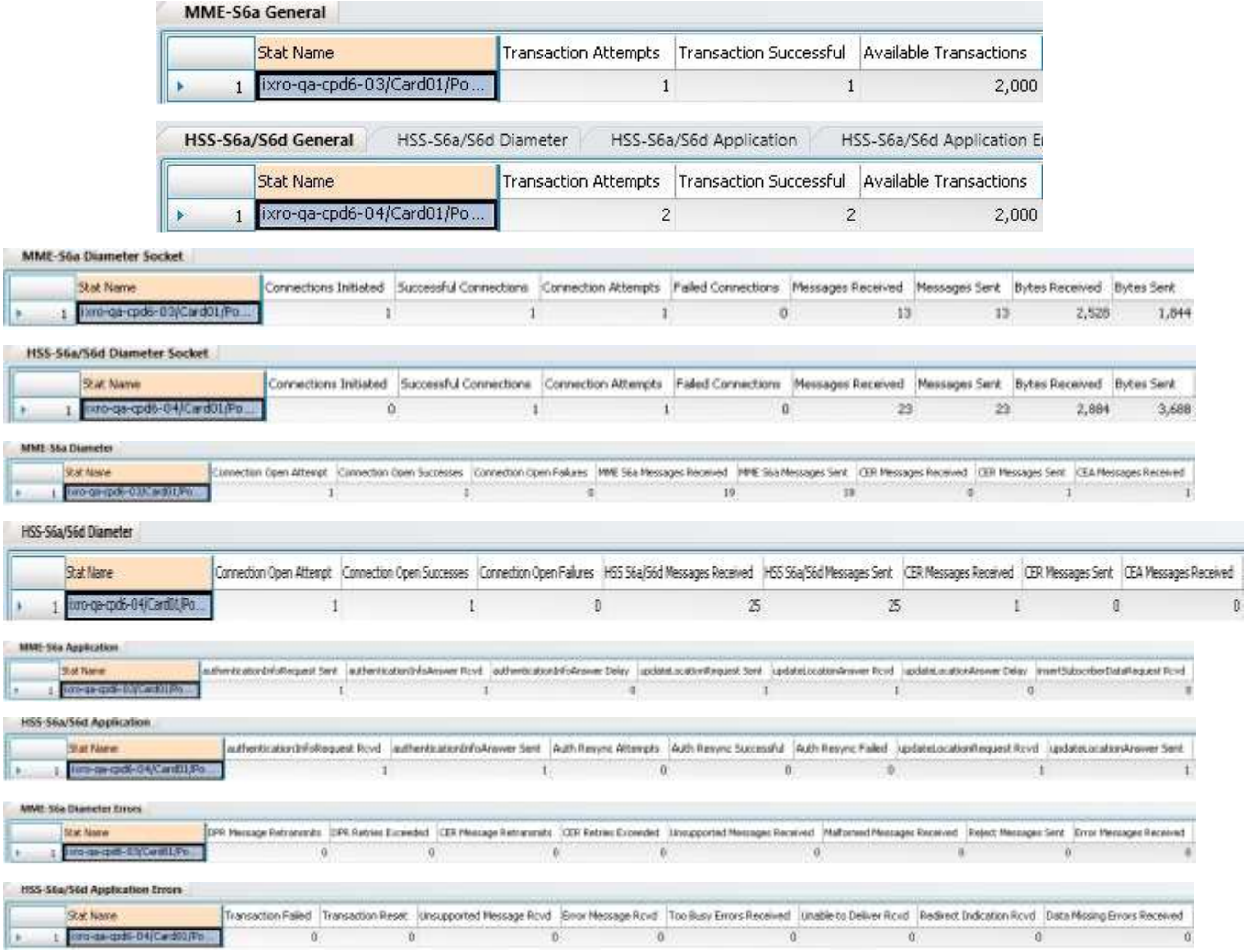
● On Server

LICENSE_SERVER_IP

Results Analysis

Run the test and check the results:

- Rates per second for each procedure
- All procedures should be successful
- No errors should appear
- The capture should be as per the desired message flow
- Statistics should indicate the desired behavior.



MME-S6a General

	Stat Name	Transaction Attempts	Transaction Successful	Available Transactions
1	ixro-qa-cpd6-03/Card01/Po...	1	1	2,000

	Stat Name	Transaction Attempts	Transaction Successful	Available Transactions
1	ixro-qa-cpd6-04/Card01/Po...	2	2	2,000

MME-S6a Diameter Socket

	Stat Name	Connections Initiated	Successful Connections	Connection Attempts	Failed Connections	Messages Received	Messages Sent	Bytes Received	Bytes Sent
1	ixro-qa-cpd6-03/Card01/Po...	1	1	1	0	13	13	2,528	1,844

HSS-S6a/S6d Diameter Socket

	Stat Name	Connections Initiated	Successful Connections	Connection Attempts	Failed Connections	Messages Received	Messages Sent	Bytes Received	Bytes Sent
1	ixro-qa-cpd6-04/Card01/Po...	0	1	1	0	23	23	2,884	3,688

MME-S6a Diameter

	Stat Name	Connection Open Attempt	Connection Open Successes	Connection Open Failures	MME S6a Messages Received	MME S6a Messages Sent	CER Messages Received	CER Messages Sent	CEA Messages Received
1	ixro-qa-cpd6-03/Card01/Po...	1	1	0	19	19	0	1	1

HSS-S6a/S6d Diameter

	Stat Name	Connection Open Attempt	Connection Open Successes	Connection Open Failures	HSS S6a/S6d Messages Received	HSS S6a/S6d Messages Sent	CER Messages Received	CER Messages Sent	CEA Messages Received
1	ixro-qa-cpd6-04/Card01/Po...	1	1	0	25	25	1	0	0

MME-S6a Application

	Stat Name	authenticationInfoRequest Sent	authenticationInfoAnswer Rcvd	authenticationInfoAnswer Delay	updateLocationRequest Sent	updateLocationAnswer Rcvd	updateLocationAnswer Delay	insertSubscriberDataRequest Rcvd
1	ixro-qa-cpd6-03/Card01/Po...	1	1	0	1	1	0	0

HSS-S6a/S6d Application

	Stat Name	authenticationInfoRequest Rcvd	authenticationInfoAnswer Sent	Auth Resync Attempts	Auth Resync Successful	Auth Resync Failed	updateLocationRequest Rcvd	updateLocationAnswer Sent
1	ixro-qa-cpd6-04/Card01/Po...	1	1	0	0	0	1	1

MME-S6a Diameter Errors

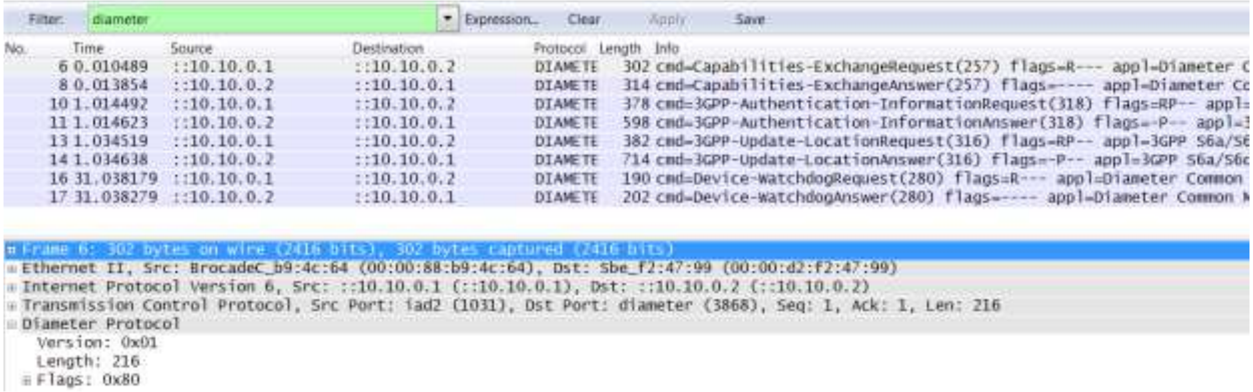
	Stat Name	DPR Message Retransmits	DPR Retries Exceeded	CER Message Retransmits	CER Retries Exceeded	Unsupported Messages Received	Malformed Messages Received	Reject Messages Sent	Error Messages Received
1	ixro-qa-cpd6-03/Card01/Po...	0	0	0	0	0	0	0	0

HSS-S6a/S6d Application Errors

	Stat Name	Transaction Failed	Transaction Reset	Unsupported Message Rcvd	Error Message Rcvd	Too Busy Errors Received	Unable to Deliver Rcvd	Redirect Indication Rcvd	Data Missing Errors Received
1	ixro-qa-cpd6-04/Card01/Po...	0	0	0	0	0	0	0	0

Figure 4. MME statistics: Diameter and Application

Analyze the capture:

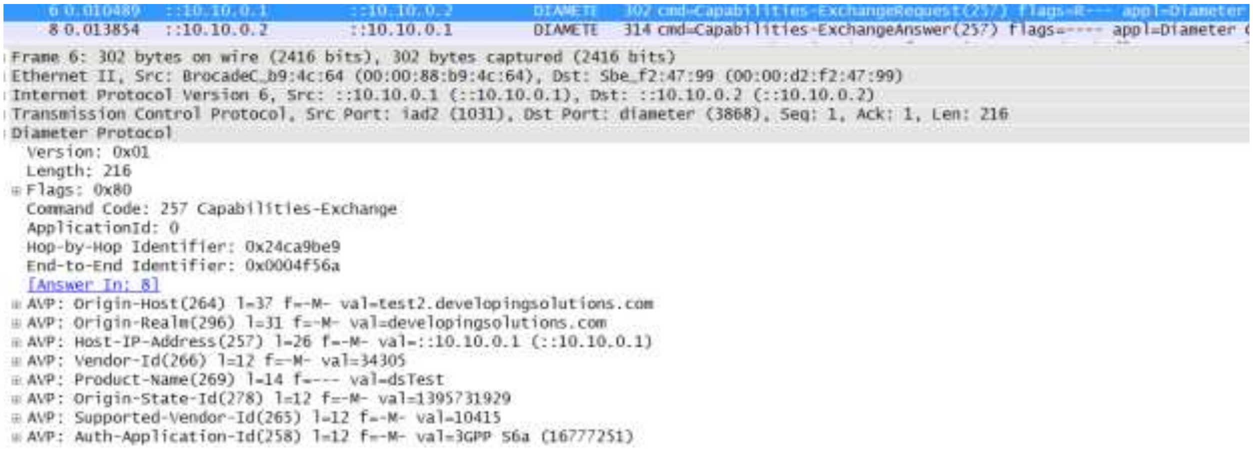


Filter: diameter

```
No.   Time       Source        Destination   Protocol Length Info
    6 0.010489   ::10.10.0.1   ::10.10.0.2   DIAMETE  302 cmd=Capabilities-ExchangeRequest(257) flags=R--- appl=Diameter C
    8 0.013854   ::10.10.0.2   ::10.10.0.1   DIAMETE  314 cmd=Capabilities-ExchangeAnswer(257) flags=---- appl=Diameter Co
   10 1.014492   ::10.10.0.1   ::10.10.0.2   DIAMETE  378 cmd=3GPP-Authentication-InformationRequest(318) flags=RP-- appl=
   11 1.014623   ::10.10.0.2   ::10.10.0.1   DIAMETE  598 cmd=3GPP-Authentication-InformationAnswer(318) flags=-P-- appl=3
   13 1.034519   ::10.10.0.1   ::10.10.0.2   DIAMETE  382 cmd=3GPP-Update-LocationRequest(316) flags=RP-- appl=3GPP S6a/S6
   14 1.034638   ::10.10.0.2   ::10.10.0.1   DIAMETE  714 cmd=3GPP-Update-LocationAnswer(316) flags=-P-- appl=3GPP S6a/S6c
   16 31.038179  ::10.10.0.1   ::10.10.0.2   DIAMETE  190 cmd=Device-WatchdogRequest(280) flags=R--- appl=Diameter Common
   17 31.038279  ::10.10.0.2   ::10.10.0.1   DIAMETE  202 cmd=Device-WatchdogAnswer(280) flags=---- appl=Diameter Common M
```

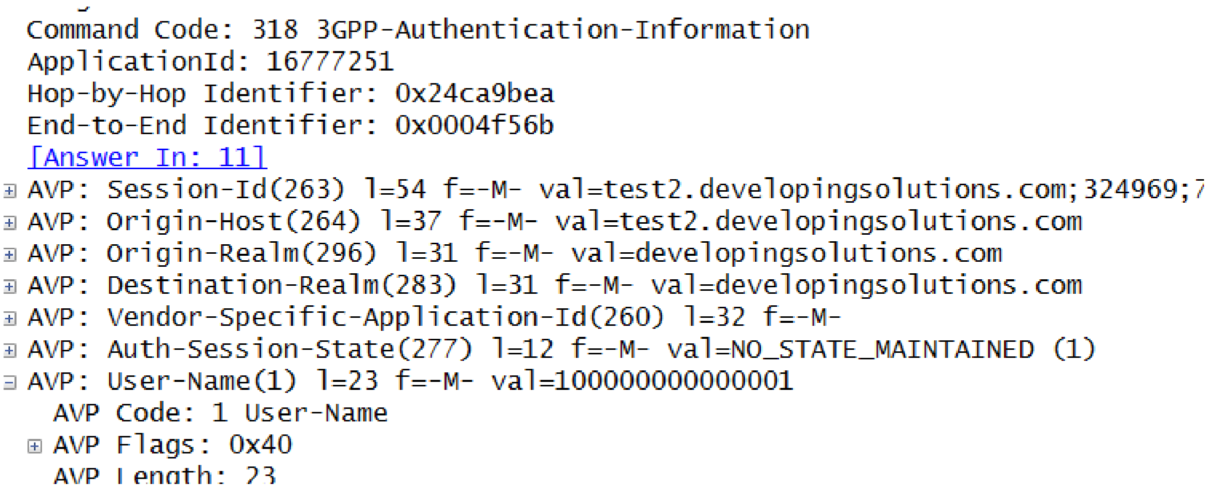
```
⊞ Frame 6: 302 bytes on wire (2416 bits), 302 bytes captured (2416 bits)
⊞ Ethernet II, Src: BrocadeC_b9:4c:64 (00:00:88:b9:4c:64), Dst: Sbe_f2:47:99 (00:00:d2:f2:47:99)
⊞ Internet Protocol Version 6, Src: ::10.10.0.1 (::10.10.0.1), Dst: ::10.10.0.2 (::10.10.0.2)
⊞ Transmission Control Protocol, Src Port: iad2 (1031), Dst Port: diameter (3868), Seq: 1, Ack: 1, Len: 216
⊟ Diameter Protocol
    Version: 0x01
    Length: 216
  ⊞ Flags: 0x80
```

a. CER/CEA exchange for establishing the Diameter connection



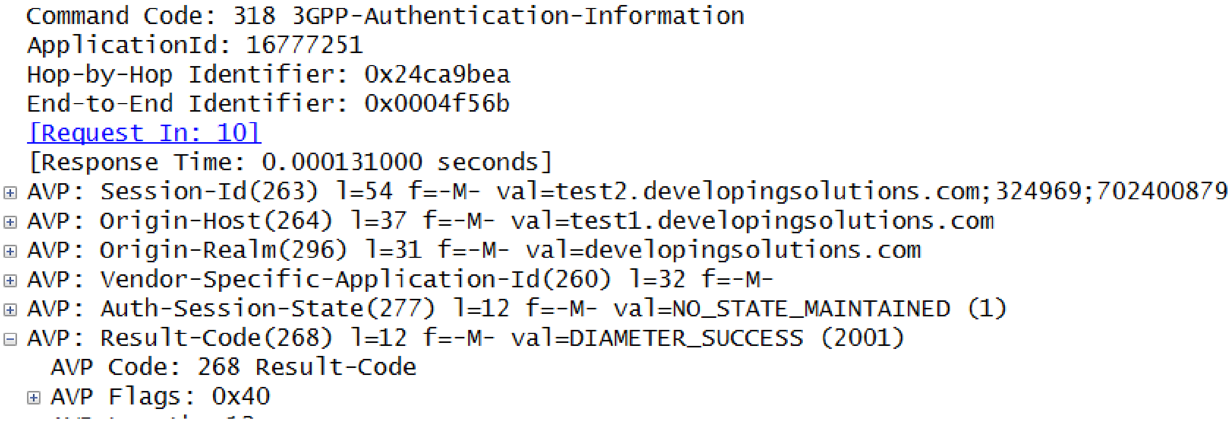
```
   6 0.010489   ::10.10.0.1        ::10.10.0.2        DIAMETE   302 cmd=Capabilities-ExchangeRequest(257) flags=R--- appl=Diameter
   8 0.013854   ::10.10.0.2        ::10.10.0.1        DIAMETE   314 cmd=Capabilities-ExchangeAnswer(257) flags=---- appl=Diameter (
Frame 6: 302 bytes on wire (2416 bits), 302 bytes captured (2416 bits)
Ethernet II, Src: BrocadeC_b9:4c:64 (00:00:88:b9:4c:64), Dst: Sbe_f2:47:99 (00:00:d2:f2:47:99)
Internet Protocol Version 6, Src: ::10.10.0.1 (::10.10.0.1), Dst: ::10.10.0.2 (::10.10.0.2)
Transmission Control Protocol, Src Port: iad2 (1031), Dst Port: diameter (3868), Seq: 1, Ack: 1, Len: 216
Diameter Protocol
  Version: 0x01
  Length: 216
⊞ Flags: 0x80
  Command Code: 257 Capabilities-Exchange
  ApplicationId: 0
  Hop-by-Hop Identifier: 0x24ca9be9
  End-to-End Identifier: 0x0004f56a
  [Answer In: 8]
⊞ AVP: Origin-Host(264) l=37 f=-M- val=test2.developingsolutions.com
⊞ AVP: Origin-Realm(296) l=31 f=-M- val=developingsolutions.com
⊞ AVP: Host-IP-Address(257) l=26 f=-M- val=::10.10.0.1 (::10.10.0.1)
⊞ AVP: Vendor-Id(266) l=12 f=-M- val=34305
⊞ AVP: Product-Name(269) l=14 f=--- val=dsTest
⊞ AVP: Origin-State-Id(278) l=12 f=-M- val=1395731929
⊞ AVP: Supported-Vendor-Id(265) l=12 f=-M- val=10415
⊞ AVP: Auth-Application-Id(258) l=12 f=-M- val=3GPP S6a (16777251)
```

b. Authentication Information Request for IMSI 10000000000001



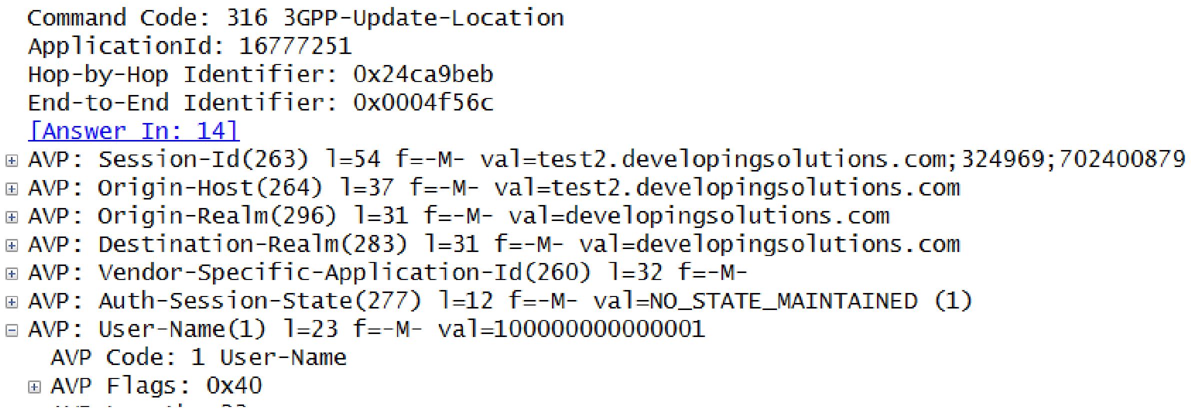
```
  Command Code: 318 3GPP-Authentication-Information
  ApplicationId: 16777251
  Hop-by-Hop Identifier: 0x24ca9bea
  End-to-End Identifier: 0x0004f56b
  [Answer In: 11]
⊞ AVP: Session-Id(263) l=54 f=-M- val=test2.developingsolutions.com;324969;7
⊞ AVP: Origin-Host(264) l=37 f=-M- val=test2.developingsolutions.com
⊞ AVP: Origin-Realm(296) l=31 f=-M- val=developingsolutions.com
⊞ AVP: Destination-Realm(283) l=31 f=-M- val=developingsolutions.com
⊞ AVP: Vendor-Specific-Application-Id(260) l=32 f=-M-
⊞ AVP: Auth-Session-State(277) l=12 f=-M- val=NO_STATE_MAINTAINED (1)
⊟ AVP: User-Name(1) l=23 f=-M- val=10000000000001
    AVP Code: 1 User-Name
  ⊞ AVP Flags: 0x40
    AVP Length: 23
```

c. Authentication Information Answer for IMSI 10000000000001



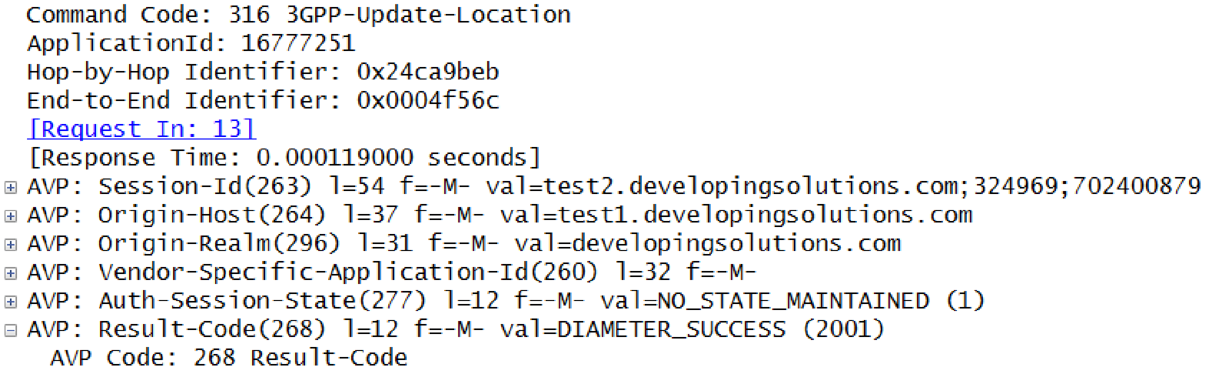
```
  Command Code: 318 3GPP-Authentication-Information
  ApplicationId: 16777251
  Hop-by-Hop Identifier: 0x24ca9bea
  End-to-End Identifier: 0x0004f56b
  [Request In: 10]
  [Response Time: 0.000131000 seconds]
⊞ AVP: Session-Id(263) l=54 f=-M- val=test2.developingsolutions.com;324969;702400879
⊞ AVP: Origin-Host(264) l=37 f=-M- val=test1.developingsolutions.com
⊞ AVP: Origin-Realm(296) l=31 f=-M- val=developingsolutions.com
⊞ AVP: Vendor-Specific-Application-Id(260) l=32 f=-M-
⊞ AVP: Auth-Session-State(277) l=12 f=-M- val=NO_STATE_MAINTAINED (1)
⊟ AVP: Result-Code(268) l=12 f=-M- val=DIAMETER_SUCCESS (2001)
    AVP Code: 268 Result-Code
  ⊞ AVP Flags: 0x40
```

d. Update Location Answer



```
  Command Code: 316 3GPP-Update-Location
  ApplicationId: 16777251
  Hop-by-Hop Identifier: 0x24ca9beb
  End-to-End Identifier: 0x0004f56c
  [Answer In: 14]
⊞ AVP: Session-Id(263) l=54 f=-M- val=test2.developingsolutions.com;324969;702400879
⊞ AVP: Origin-Host(264) l=37 f=-M- val=test2.developingsolutions.com
⊞ AVP: Origin-Realm(296) l=31 f=-M- val=developingsolutions.com
⊞ AVP: Destination-Realm(283) l=31 f=-M- val=developingsolutions.com
⊞ AVP: Vendor-Specific-Application-Id(260) l=32 f=-M-
⊞ AVP: Auth-Session-State(277) l=12 f=-M- val=NO_STATE_MAINTAINED (1)
⊟ AVP: User-Name(1) l=23 f=-M- val=100000000000001
    AVP Code: 1 User-Name
  ⊞ AVP Flags: 0x40
```

e. Update Location Answer



```
  Command Code: 316 3GPP-Update-Location
  ApplicationId: 16777251
  Hop-by-Hop Identifier: 0x24ca9beb
  End-to-End Identifier: 0x0004f56c
  [Request In: 13]
  [Response Time: 0.000119000 seconds]
⊞ AVP: Session-Id(263) l=54 f=-M- val=test2.developingsolutions.com;324969;702400879
⊞ AVP: Origin-Host(264) l=37 f=-M- val=test1.developingsolutions.com
⊞ AVP: Origin-Realm(296) l=31 f=-M- val=developingsolutions.com
⊞ AVP: Vendor-Specific-Application-Id(260) l=32 f=-M-
⊞ AVP: Auth-Session-State(277) l=12 f=-M- val=NO_STATE_MAINTAINED (1)
⊟ AVP: Result-Code(268) l=12 f=-M- val=DIAMETER_SUCCESS (2001)
    AVP Code: 268 Result-Code
```

Objective: AVP Modification

Usecases:

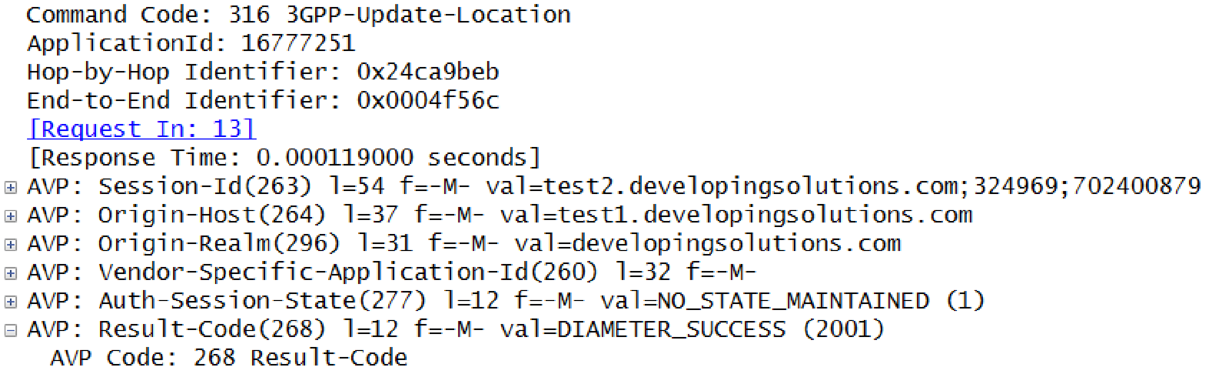
- Positive testing:
  - Adding custom AVPs (optional, proprietary, vendor-specific signaling information, AVPs not present in the current specification version, etc.)
  - Modifying the AVP to contain a specific value or changing the position of the AVP as desired within the message
  - Removing unwanted AVPs from a specific message
- Negative testing:
  - Returning error codes in Answer messages
  - Introducing corrupt or invalid AVPs
  - Removing mandatory AVPs
  - Configuring more instances than allowed for a certain AVP

SmartAVP^{TM} Features:

- AVP customization and substitution
- Create/modify/remove any AVP in any Diameter Application Message
- Configure an AVP from scratch
- Include vendor-specific or other optional AVPs in Diameter messages
- Insert multiple AVPs inside an AVP (nested AVPs)
- Define proprietary signaling or corrupt AVPs to facilitate negative testing
- Possibility of being compatible with any 3GPP spec version
- Simulate scenarios that are not as per specification to address some custom/specific scenarios (eq EUTRAN simulation with UTRAN parameters)
- Support for subscriber specific-data as AVPs data through the use of „transparent-data" option e.g. IMSI, IMEI, MSISDN, public/private identity, IP address of the subscriber (IPv4 or IPv6).
- Inter-operability with any customer equipment
- Negative testing

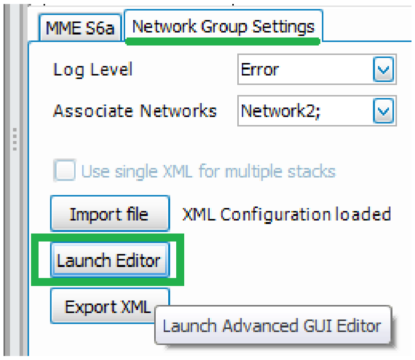
Step by Step instructions

1. Use IxLoad configuration created above.
2. Look into capture and identify a DIAMETER_SUCCESS result code for ULA message



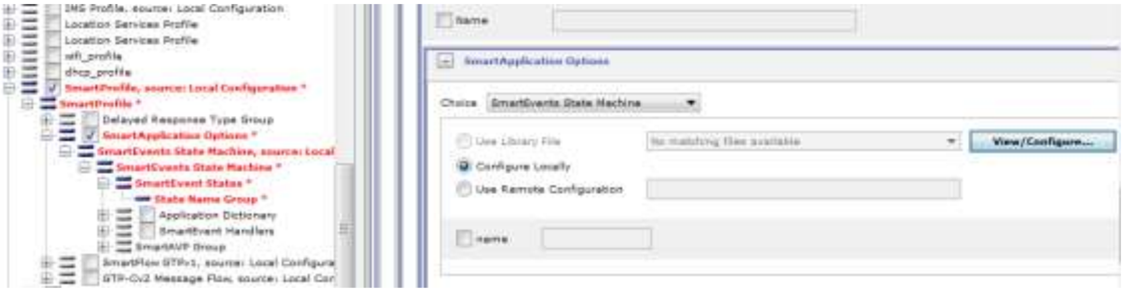
```
   Command Code: 316 3GPP-Update-Location
   ApplicationId: 16777251
   Hop-by-Hop Identifier: 0x24ca9beb
   End-to-End Identifier: 0x0004f56c
   [Request In: 13]
   [Response Time: 0.000119000 seconds]
 ⊞ AVP: Session-Id(263) l=54 f=-M- val=test2.developingsolutions.com;324969;702400879
 ⊞ AVP: Origin-Host(264) l=37 f=-M- val=test1.developingsolutions.com
 ⊞ AVP: Origin-Realm(296) l=31 f=-M- val=developingsolutions.com
 ⊞ AVP: Vendor-Specific-Application-Id(260) l=32 f=-M-
 ⊞ AVP: Auth-Session-State(277) l=12 f=-M- val=NO_STATE_MAINTAINED (1)
 ⊟ AVP: Result-Code(268) l=12 f=-M- val=DIAMETER_SUCCESS (2001)
     AVP Code: 268 Result-Code
```

3. Go to the S6a HSS simulation and launch the Advanced GUI editor



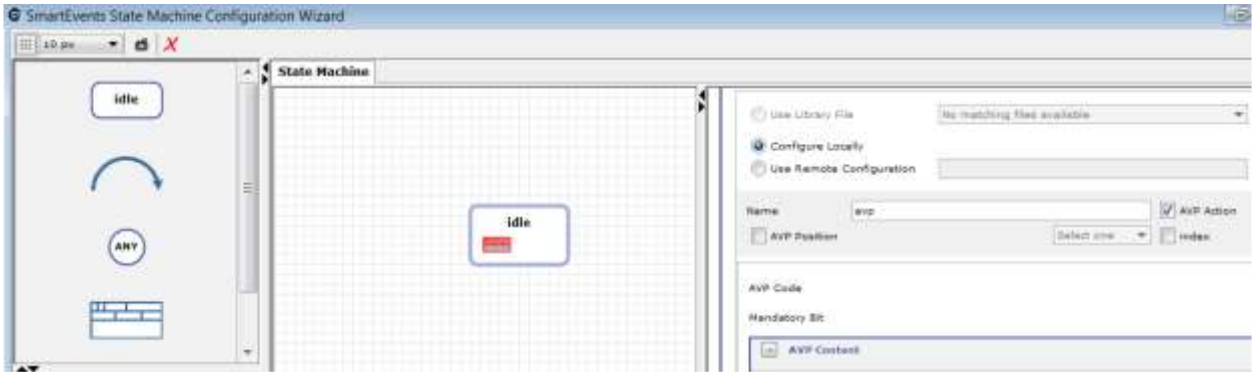
Log Level: Error
Associate Networks: Network2;
☐ Use single XML for multiple stacks
XML Configuration loaded

4. Under the configuration pane, scroll down to the Subscriber database
5. Enable Smart Events State machine


IMS Profile, source: Local Configuration
Location Services Profile
Location Services Profile
wifi_profile
dhcp_profile
SmartProfile, source: Local Configuration *
SmartProfile *
Delayed Response Type Group
SmartApplication Options *
SmartEvents State Machine, source: Local
SmartEvents State Machine *
SmartEvent States *
State Name Group *
Application Dictionary
SmartEvent Handlers
SmartAVP Group
SmartFlow GTPv1, source: Local Configura
GTP-Cv2 Message Flow, source: Local Con
Name
SmartApplication Options
View/Configure...
Name

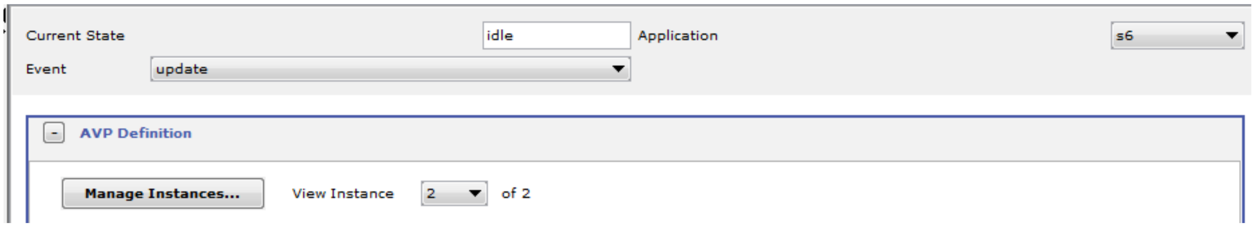
Choice: SmartEvents State Machine
○ Use Library File — No matching files available
● Configure Locally
○ Use Remote Configuration

6. Select “View/Configure” button on SmartEvents™ State Machine to open the editor and change the behavior
7. Add only one “Idle” state with one AVP configuration block inside it



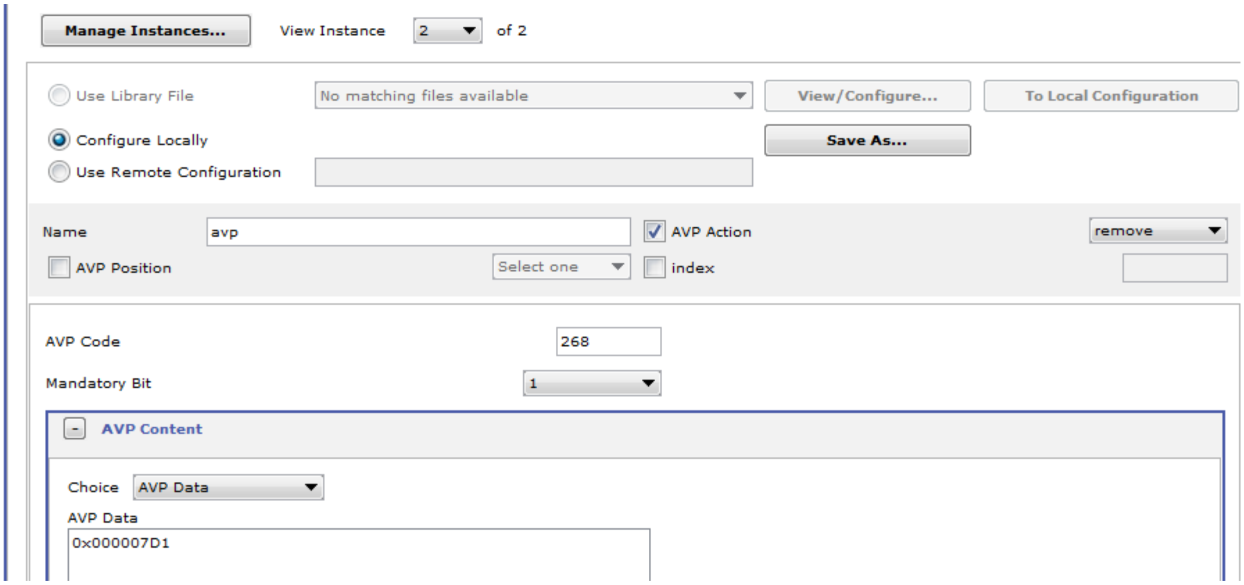
○ Use Library File — No matching files available
● Configure Locally
○ Use Remote Configuration
Name: avp ☑ AVP Action
☐ AVP Position — Select one ☐ index

8. Configure two SmartEvents™ instances that take effect on S6 interface on the Update event



Current State: idle
Application: s6
Event: update
View Instance: 2 of 2

9. Remove the current result code:



Manage Instances... View Instance 2 of 2

○ Use Library File — No matching files available — View/Configure... — To Local Configuration

● Configure Locally — Save As...

○ Use Remote Configuration

Name: avp — ☑ AVP Action: remove

☐ AVP Position — Select one — ☐ index

AVP Code: 268

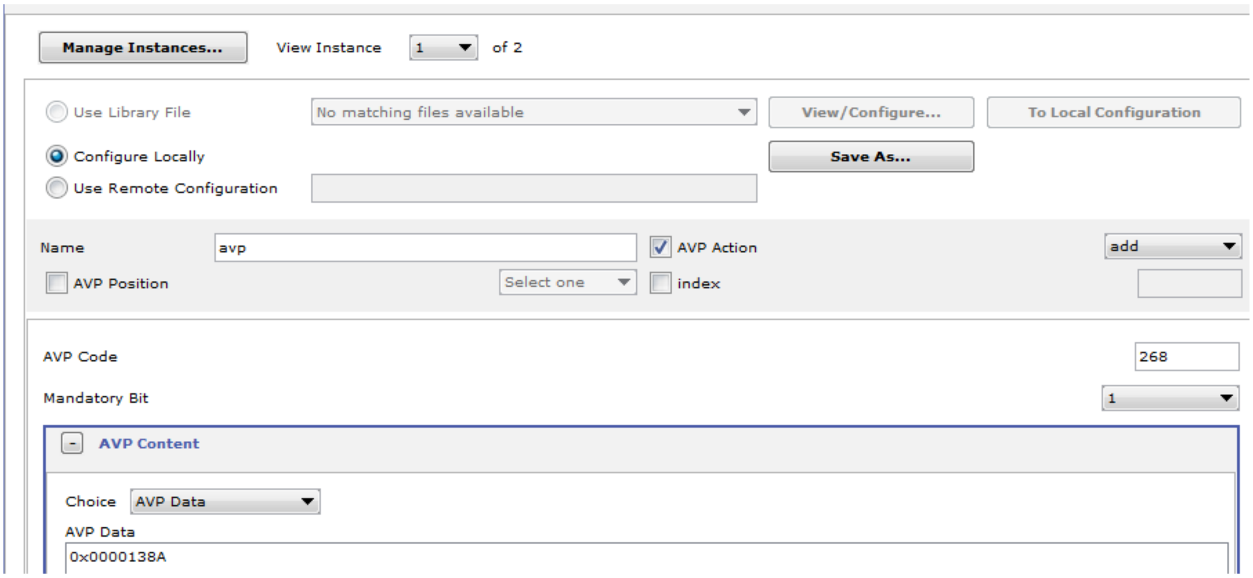
Mandatory Bit: 1

AVP Content

Choice: AVP Data

AVP Data: 0x000007D1

10. Add the new failure result code:



Manage Instances... View Instance 1 of 2

○ Use Library File — No matching files available — View/Configure... — To Local Configuration

● Configure Locally — Save As...

○ Use Remote Configuration

Name: avp — ☑ AVP Action: add

☐ AVP Position — Select one — ☐ index

AVP Code: 268

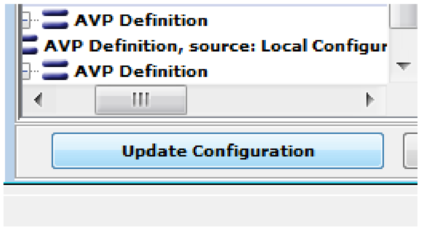
Mandatory Bit: 1

AVP Content

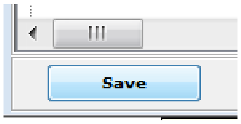
Choice: AVP Data

AVP Data: 0x0000138A

11. Update the Smart Events configuration



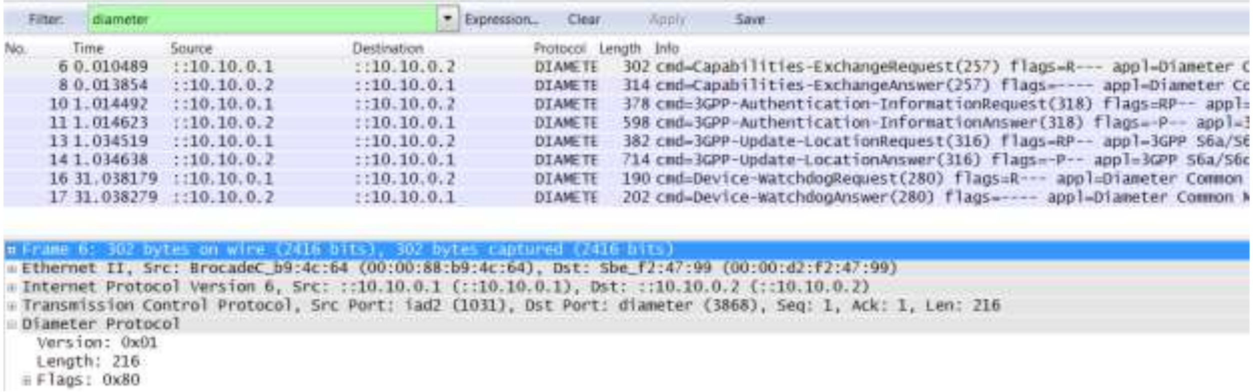
12. Save the Advanced configuration



Results Analysis

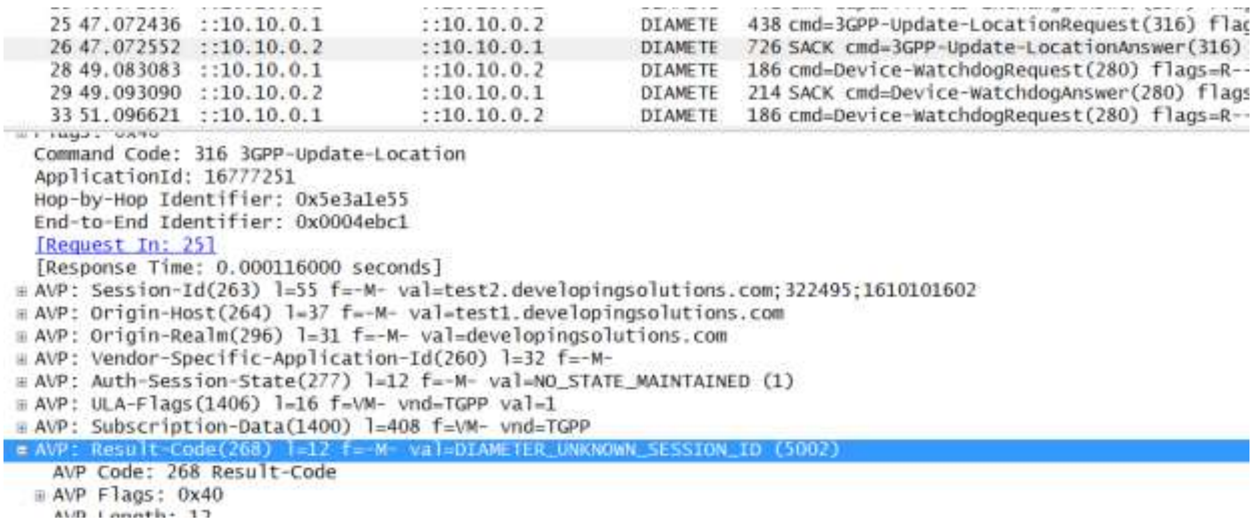
Run the test and check the following:

- ULA message should have a Result Code of 5002.
- The capture should be as per the desired message flow



```
No.   Time        Source        Destination    Protocol Length Info
    6 0.010489   ::10.10.0.1   ::10.10.0.2    DIAMETE   302 cmd=Capabilities-ExchangeRequest(257) flags=R--- appl=Diameter C
    8 0.013854   ::10.10.0.2   ::10.10.0.1    DIAMETE   314 cmd=Capabilities-ExchangeAnswer(257) flags=---- appl=Diameter Co
   10 1.014492   ::10.10.0.1   ::10.10.0.2    DIAMETE   378 cmd=3GPP-Authentication-InformationRequest(318) flags=RP-- appl=
   11 1.014623   ::10.10.0.2   ::10.10.0.1    DIAMETE   598 cmd=3GPP-Authentication-InformationAnswer(318) flags=-P-- appl=3
   13 1.034519   ::10.10.0.1   ::10.10.0.2    DIAMETE   382 cmd=3GPP-Update-LocationRequest(316) flags=RP-- appl=3GPP S6a/S6
   14 1.034638   ::10.10.0.2   ::10.10.0.1    DIAMETE   714 cmd=3GPP-Update-LocationAnswer(316) flags=-P-- appl=3GPP S6a/S6d
   16 31.038179  ::10.10.0.1   ::10.10.0.2    DIAMETE   190 cmd=Device-WatchdogRequest(280) flags=R--- appl=Diameter Common
   17 31.038279  ::10.10.0.2   ::10.10.0.1    DIAMETE   202 cmd=Device-WatchdogAnswer(280) flags=---- appl=Diameter Common M

⊞ Frame 6: 302 bytes on wire (2416 bits), 302 bytes captured (2416 bits)
⊞ Ethernet II, Src: BrocadeC_b9:4c:64 (00:00:88:b9:4c:64), Dst: Sbe_f2:47:99 (00:00:d2:f2:47:99)
⊞ Internet Protocol Version 6, Src: ::10.10.0.1 (::10.10.0.1), Dst: ::10.10.0.2 (::10.10.0.2)
⊞ Transmission Control Protocol, Src Port: iad2 (1031), Dst Port: diameter (3868), Seq: 1, Ack: 1, Len: 216
⊟ Diameter Protocol
    Version: 0x01
    Length: 216
  ⊞ Flags: 0x80
```



```
   25 47.072436  ::10.10.0.1      ::10.10.0.2      DIAMETE   438 cmd=3GPP-Update-LocationRequest(316) flag
   26 47.072552  ::10.10.0.2      ::10.10.0.1      DIAMETE   726 SACK cmd=3GPP-Update-LocationAnswer(316)
   28 49.083083  ::10.10.0.1      ::10.10.0.2      DIAMETE   186 cmd=Device-WatchdogRequest(280) flags=R--
   29 49.093090  ::10.10.0.2      ::10.10.0.1      DIAMETE   214 SACK cmd=Device-WatchdogAnswer(280) flags
   33 51.096621  ::10.10.0.1      ::10.10.0.2      DIAMETE   186 cmd=Device-WatchdogRequest(280) flags=R--
    Command Code: 316 3GPP-Update-Location
    ApplicationId: 16777251
    Hop-by-Hop Identifier: 0x5e3a1e55
    End-to-End Identifier: 0x0004ebc1
    [Request In: 25]
    [Response Time: 0.000116000 seconds]
  ⊞ AVP: Session-Id(263) l=55 f=-M- val=test2.developingsolutions.com;322495;1610101602
  ⊞ AVP: Origin-Host(264) l=37 f=-M- val=test1.developingsolutions.com
  ⊞ AVP: Origin-Realm(296) l=31 f=-M- val=developingsolutions.com
  ⊞ AVP: Vendor-Specific-Application-Id(260) l=32 f=-M-
  ⊞ AVP: Auth-Session-State(277) l=12 f=-M- val=NO_STATE_MAINTAINED (1)
  ⊞ AVP: ULA-Flags(1406) l=16 f=VM- vnd=TGPP val=1
  ⊞ AVP: Subscription-Data(1400) l=408 f=VM- vnd=TGPP
  ⊟ AVP: Result-Code(268) l=12 f=-M- val=DIAMETER_UNKNOWN_SESSION_ID (5002)
      AVP Code: 268 Result-Code
    ⊞ AVP Flags: 0x40
```

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