- **UE attempts to register with network** – subscriber must be authenticated, equipment ID may be validated

- **MME entirely responsible with support from HSS/EIR**

- **Default bearer activation** – MME initiates, PGW responsible

- **PGW may get policy and charging rules from PCRF, may get subscriber’s available credit from OCS**

- **User plane is established**
S1-MME Interface

**eNodeB Emulation**
- Mainly relay function between UE and MME using S1-AP/SCTP stack

**UE Emulation**
- NAS signaling with security – encrypt requests, decrypt responses
- Inform MME of user and equipment identities
- Respond to authentication challenge
- Learn/retain current session and bearer identifiers

S13 Interface – EIR Emulation
- Diameter/SCTP
- Validate UE identity – configurable responses

S6a Interface – HSS Emulation
- Diameter/SCTP
- Provide authentication vectors
- Provide subscriber profile
- Learn UE location

S11 Interface – SGW/PGW Emulation
- GTP-Cv2/UDP
  - Simulate bearer activation – relay bearer’s attributes to MME with Create Session Response: PDN type, IP address(es) (V4, V6, or both), ID, QoS profile, PCO, Charging ID, APN restriction and AMBR, SGW user address, SGW control/user TEIDs, PGW address/TEID
  - Retain bearer information
  - Learn eNodeB TEID from Modify Bearer Request

**MME’s responsibilities are access control & session management – control plane only**
S11 Interface – MME Emulation

- **Control plane:** GTP-Cv2/UDP
- **Initiate default bearer activation with Create Session Request,** using pre-provisioned identities for subscribers and equipment
- **Learn/retain bearer attributes**

S1-U Interface – eNodeB Emulation

- **User plane:** GTP-U/UDP
- **Establish GTP tunnel with SGW**

S5 Interface – PGW Emulation

- **Control plane:** GTP-Cv2/UDP
- **User plane:** GTP-U/UDP
- **Simulate bearer activation – inform SGW of bearer’s attributes in Create Session Response:** PDN type, IP address(es) (V4, V6, or both), ID, QoS profile, and PCO, Charging ID, APN restriction and AMBR, PGW TEID
- **Retain bearer information**

*SGW’s primary focus is the user plane – packet routing and per-user/per-flow accounting*
S5 Interface – SGW Emulation
- Initiate default bearer activation using pre-provisioned identities for subscribers and equipment (including RAN capabilities)
- Learn/retain bearer attributes
- Establish GTP-U tunnel with PGW

Gx Interface – PCRF Emulation
- Provide initial policy and charging rules based on APN and PDN type

Gy Interface – OCS Emulation
- Maintain credit balance per subscriber/service and provide balance when requested
- Adjust balance per quota requests/usage reporting from PGW

SGi Interface
- Interface between core network and public PDN (in carrier’s network interface would not be exposed to PDN)
- Receive subscriber uplink traffic, generate response traffic, initiate downlink traffic

PGW’s primary focus is the user plane – bearer activation; packet routing, inspection, and screening; policy and rate enforcement; and service-level accounting
- UE attempts to access IMS service that requires a new data flow (e.g., streaming video)
- AF notifies PCRF of UE request
- PCRF pushes QoS policy decision to PGW, triggering PGW to initiate dedicated bearer activation
- PGW may query OCS for quota if service requires pre-paid credit
- Dedicated bearer request pushed downstream to eNodeB which establishes bearer and relays the bearer information back upstream to PGW
S1-MME Interface - eNodeB Emulation

- Establish requested bearer using ID assigned by MME, associate with referenced default bearer
- Correctly respond with a Bearer Setup Response, indicating whether requested QoS could be honored
- Relay UE’s SM Response

UE Emulation

- Formulate Session Management Response

S11 Interface – SGW/PGW Emulation

- If UE is idle, trigger Service Request process
- Generate Create Dedicated Bearer Request with identifiers, QoS, Traffic Flow Template, and Protocol Configuration Options (if configured)
- On successful response, learn bearer ID

MME assigns EPS Bearer Identity
S11 Interface – MME Emulation
- Establish bearer with requested QoS, associate with referenced default bearer
- Assign EPS Bearer Identity
- Correctly respond with a Create Bearer Response

S1-U Interface – eNodeB Emulation
- Respond to server-initiated traffic
- Measure data throughput

S5 Interface – PGW Emulation
- Generate Create Bearer Request with identifiers and pre-provisioned QoS, TFT, and PCO
- Learn EPS Bearer Identity
- Generate server-initiated traffic towards UE
- Respond to traffic from UE
- Measure data throughput

SGW relays request and response, routes downlink/uplink traffic
**S5 Interface – SGW Emulation**
- Establish bearer with requested QoS, associate with referenced default bearer
- Assign EPS Bearer Identity
- Correctly respond with a Create Bearer Response
- Generate UE-initiated traffic
- Measure data throughput

**Gx Interface – PCRF Emulation**
- Push QoS policy to PGW

**Gy Interface – OCS Emulation (conditional)**
- If subscriber is accessing a chargeable service, PGW may check for credit availability prior to activation

**SGi Interface – Application Server Emulation**
- Respond to traffic from UE
- Measure data throughput

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*PGW-initiated bearer activation triggered by PCRF, routes downlink/uplink traffic*
- An inter-MME mobility process without SGW relocation
- UE initiates procedure when it moves to a new tracking area
- MME obtains subscriber’s context from old MME, may request authentication
- MME initiates bearer modification
- MME notifies HSS of subscriber’s new location
- HSS notifies old MME that subscriber has relocated, old MME releases resources
S1-MME Interface

- Simulate UE TAU request with new location parameters
- Respond to authentication procedure if requested by MME (if MME determines that credentials are invalid)
- Receive TAU Accept

S1-U Interface

- Receive forwarded packets from old MME

S11 Interface – SGW/PGW Emulation

- Receive Modify Bearer Request
- Update subscriber’s location
- Respond with Modify Bearer Response

MME establishes subscriber session, obtains session information from previous MME, initiates bearer modification
**S11 Interface**
**MME Emulation**
(assumes both MMEs are emulated)
- Send Modify Bearer Request with subscriber’s new location and new MME
- Handle Modify Bearer Response

**S5 Interface – PGW Emulation**
- Receive Modify Bearer Request (sent if PGW requested User Location Information IE during attach)
- Update subscriber’s location and RAT type, which may cause a shift in QoS policy
- Respond with Modify Bearer Response

*SGW updates subscriber’s MME, may notify PGW of the subscriber’s new location if dynamic PCC is configured, routes downlink traffic to new MME*
SGW Emulation

- Notify PGW of subscriber’s new location and Radio Access Type with Modify Bearer Request
- Handle Modify Bearer Response

Gx Interface – PCRF Emulation

- Provide QoS profile for subscriber’s new RAT type
- PGW may not wait for the PCRF response – may continue and then initiate an Update Bearer Request if warranted

Gy Interface – OCS Emulation (conditional)

- If subscriber is accessing a chargeable service, PGW may check for rate/tariff differences for new location

PGW may react to subscriber’s new location by notifying PCRF and OCS; new RAN may not support existing QoS, may result in different rate for chargeable service
The UE, MME, and HSS can initiate the detach procedure, UE-initiated detach is shown.

UE requests a detach from the MME (NAS signaling) and eNodeB relays request, adding the cell location.

MME initiates Delete Session Request which is forwarded upstream, with each node deleting the subscriber’s bearers (SGW also releases UE context).

PGW may initiate session termination with the PCRF and, if subscriber was accessing a chargeable service, delivers final charging report to OCS.

AF may be notified by the PCRF that subscriber session has been terminated.

PGW acknowledges the SGW’s request with a Delete Session Response which is forwarded back to the MME.

MME may confirm the detach with the UE and then releases the S1 connection for the subscriber, triggering the eNodeB to release the subscriber’s bearers.

eNodeB releases the connection with the UE.
S1-MME Interface eNodeB Emulation
- **Initiate Detach Request with UE’s GUTI, Switch Off indication, and cell location towards MME**
- **Release S1-AP connection when requested**

S1-U Interface eNodeB Emulation
- **Delete subscriber’s bearers**

S11 Interface – SGW/PGW Emulation
- **Receive Delete Session Request**
- **Delete subscriber’s bearers and context, halt uplink/downlink user traffic**
- **Respond with Delete Session Response**

MME releases subscriber’s bearers, initiates Delete Session Request towards SGW
S11 Interface
MME Emulation
- Initiate Delete Session Request with UE’s TEID towards the SGW
- Receive Delete Session Response

S5 Interface – PGW Emulation
- Receive Delete Session Request
- Delete subscriber’s bearers, halt uplink/downlink user traffic
- Respond with Delete Session Response

SGW releases subscriber’s bearers and context, relays Delete Session Request towards PGW
**S5 Interface**

**SGW Emulation**
- Initiate Delete Session Request with UE’s TEID towards the PGW
- Receive Delete Session Response

**Gx Interface – PCRF Emulation**
- Receive session termination request
- Delete subscriber’s session
- Acknowledge session termination

**Gy Interface – OCS Emulation**
- Receive and acknowledge Credit Final Report

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**PGW releases subscriber’s bearers, notifies PCRF and OCS**