← Overview

OmniSMF Configuration Reference

Operator-writable configuration is supplied through `config/runtime.exs`, which is driven largely by OS environment variables. Most values below have a built-in default and an environment variable that overrides it before the SMF starts. A few keys are set through application configuration only and have no environment variable (`chf_uri`, the `charging` block, `pgw_c_addr`, and the `pco` block); these are called out where they appear. The compiled application environment key is `:omnismf`.

```
config :omnismf,
  sbi_scheme: "http",                       # SBI_SCHEME
  sbi_addr:   "127.0.0.4",                  # SBI_ADDR
  sbi_port:   7777,                         # SBI_PORT
  nrf_uri:    "http://127.0.0.1:7777",      # NRF_URI
  udm_uri:    "http://127.0.0.12:7777",     # UDM_URI
  pcf_uri:    "http://127.0.0.13:7777",     # PCF_URI
  amf_uri:    "http://127.0.0.5:7777",      # AMF_URI
  upf_addr:   "10.179.1.24",                # UPF_ADDR
  upf_pfcp_port: 8805,                      # UPF_PFCP_PORT
  pfcp_addr:  "0.0.0.0",                    # PFCP_ADDR
  mcc: "999",                               # MCC
  mnc: "70",                                # MNC
  dns:  ["8.8.8.8", "8.8.4.4"],             # DNS
  dns6: ["2001:4860:4860::8888"],           # DNS6
  mtu:  1400,                               # MTU
  prometheus_metrics_port: 9568,            # PROMETHEUS_PORT
  heartbeat_interval: 10_000,               # HEARTBEAT_INTERVAL
  ue_ip_pool: [subnet_map: %{default: ["10.45.0.0/16"]}]  #
UE_IP_SUBNET_MAP / UE_IP_POOL
```

SBI, Peer and PLMN Parameters

Parameter	Type	Required	Default
`sbi_scheme`	string	No	`"http"`
`sbi_addr`	string	No	`"127.0.0.4"`
`sbi_port`	integer	No	`7777`
`nrf_uri`	string	No	`"http://127.0.0.1:7777"`
`udm_uri`	string	No	`"http://127.0.0.12:7777"`
`pcf_uri`	string	No	`"http://127.0.0.13:7777"`
`amf_uri`	string	No	`"http://127.0.0.5:7777"`

Parameter	Type	Required	Default	
`upf_addr`	string	No	`"10.179.1.24"`	
`upf_pfcp_port`	integer	No	`8805`	
`pfcp_addr`	string	No	`"0.0.0.0"`	
`mcc`	string	No	`"999"`	
`mnc`	string	No	`"70"`	
`heartbeat_interval`	integer (ms)	No	`10000`	

N26 Interworking

Parameter	Type	Required	Default	Env Var	Descript
`pgw_c_addr`	string	No	`"127.0.0.11"`	None (application config only)	The paire standalo PGW-C's S5/S8-C address, returned the EPS v during N2 interwork so the MME/SGW Create Session lands on PGW-C th fronts the same UP anchor a this SMF. via the `:omnismf` applicati environm there is r environm variable this key.

N40 Converged Charging (Nchf, TS 32.290 / TS 32.291)

The SMF can act as a converged-charging consumer toward the CHF over N40 (Nchf_ConvergedCharging). When enabled, it opens a Charging Data Request as each PDU session is established, updates it during the session from N4 URR usage reports, and closes it on release. The CHF is resolved via NRF discovery first, falling back to the configured `chf_uri` when discovery does not resolve one. Converged charging is disabled by default; while disabled the charging path is a no-op and no CHF calls are made.

The top-level `chf_uri` key and the `charging` block are set through the `:omnismf` application configuration only; neither has an environment variable.

```
config :omnismf, :charging,
  enabled: false,
  chf_uri: "http://127.0.0.20:7777"
```

Parameter	Type	Required	Default	Env V
`chf_uri`	string	No	`"http://127.0.0.20:7777"`	None (applica config o
`charging enabled`	boolean	No	`false`	None (applica config o
`charging chf_uri`	string	No	(falls back to top-level `chf_uri`)	None (applica config o

Parameter	Type	Required	Default	Env V

Session-AMBR toward the PCF

When creating the SM policy association, the subscribed Session-AMBR (read from the UDM DNN configuration `sessionAmbr` field) is sent to the PCF under **both** the spec field name `subsSessAmbr` (TS 29.512 `SmPolicyContextData`) and the legacy key `sessionAmbr`. Sending only `sessionAmbr` leaves `subsSessAmbr` unset, causing the PCF to fall back to its ~1000 Kbps default and cap every session. No operator configuration governs this; it is documented here so operators understand which field the PCF must honour.

UE-Facing PCO Defaults (flat keys)

These flat keys populate the Protocol Configuration Options returned to the UE in the PDU Session Establishment Accept. They are superseded by the structured `:pco` block below when that is present.

Parameter	Type	Required	Default	Env Var	D
`dns`	list of strings	No	`["8.8.8.8", "8.8.4.4"]`	`DNS`	I s a t C s t
`dns6`	list of strings	No	`["2001:4860:4860::8888"]`	`DNS6`	I s a t C s t
`mtu`	integer	No	`1400`	`MTU`	I M a t

UE IP Pool

Parameter	Type	Required	Default	Env V
`ue_ip_pool`	keyword (`subnet_map`)	No	`%{default: ["10.45.0.0/16"]}`	`UE_IP_SUB` / `UE_IP_PO`

The `UE_IP_SUBNET_MAP` JSON is keyed by exact DNN name, `^regex` pattern, or `"default"`; each value is a list of IPv4 and/or IPv6 CIDRs. Matching precedence is **exact DNN → regex → `default`**. Example:

```
{
  "internet":    ["10.45.0.0/16", "2001:db8:45::/64"],
  "ims":         ["10.47.0.0/24"],
  "^enterprise": ["10.99.0.0/16"],
  "default":     ["10.45.0.0/16"]
}
```

If neither `UE_IP_SUBNET_MAP` nor `UE_IP_POOL` is set, the default pool is `10.45.0.0/16`. See UE IP Address Allocation for the allocation and static-IP reservation behaviour.

P-CSCF and Protocol Configuration Options (`:pco`)

For VoNR/IMS the SMF returns the P-CSCF address (and the other PCO items: DNS, NBNS, link MTU) to the UE inside the PDU Session Establishment Accept ePCO. This block uses the **same layout and selection logic as the 4G PGW-**

C, so an operator configures both nodes identically. When present, `:pco` values take precedence over the flat `dns`/`dns6`/`mtu` keys above. This block is set in the `:omnismf` application configuration only and has no environment variable.

```
config :omnismf, :pco,
  p_cscf_ipv4_address_list: ["10.179.4.165"],
  p_cscf_ipv6_address_list: [],
  p_cscf_discovery_enabled: true,
  p_cscf_discovery_fqdn:
"pcscf.ims.mnc070.mcc999.3gppnetwork.org",
  p_cscf_discovery_dns_server: "10.179.2.10",
  p_cscf_discovery_timeout_ms: 5000,
  primary_dns_server_address: "8.8.8.8",
  secondary_dns_server_address: "8.8.4.4",
  primary_nbns_server_address: nil,
  secondary_nbns_server_address: nil,
  ipv4_link_mtu_size: 1400
```

Parameter	Type	Required	
`p_cscf_ipv4_address_list`	list of strings	No	`[]`
`p_cscf_ipv6_address_list`	list of strings	No	`[]`
`p_cscf_discovery_enabled`	boolean	No	`true`

Parameter	Type	Required	
`p_cscf_discovery_fqdn`	string	No	`pcscf.mnc{MNC}.`
`p_cscf_discovery_dns_server`	string	No	system resolver
`p_cscf_discovery_timeout_ms`	integer (ms)	No	`5000`
`primary_dns_server_address`	string	No	(flat `dns`)
`secondary_dns_server_address`	string	No	(flat `dns`)

Parameter	Type	Required	
`primary_nbns_server_address`	string | nil	No	`nil`
`secondary_nbns_server_address`	string | nil	No	`nil`
`ipv4_link_mtu_size`	integer	No	(flat `mtu`)

Legacy flat P-CSCF fallback keys

The flat keys `pcscf` and `pcscf6` are legacy fallbacks retained for parity with older PGW-C configurations. They are only consulted when the structured `:pco` P-CSCF address lists (`p_cscf_ipv4_address_list` / `p_cscf_ipv6_address_list`) are not set. The structured `:pco` form is preferred for new deployments. Each key accepts a single address string or a list of address strings. These keys are set through the `:omnismf` application configuration only and have no environment variable.

Parameter	Type	Required	Default	Env Var	Descri
`pcscf`	string or list of strings	No	`[]`	None (application config only)	Legacy static I fallback, used `p_cscf_ipv4_` is unset. Prefe structured `:pc`
`pcscf6`	string or list of strings	No	`[]`	None (application config only)	Legacy static I fallback, used `p_cscf_ipv6_` is unset. Prefe structured `:pc`

Metrics and Management Ports

Parameter	Type	Required	Default	Env Va
`prometheus_metrics_port`	integer	No	`9568`	`PROMETHEUS_P`
management API port (`:api_ex`)	integer	No	`8443`	`API_PORT`
Control Panel HTTPS port	integer	No	`7443`	`CONTROL_PANE`

The management API and Control Panel are served over TLS using the certificate at `priv/cert/omnitouch.crt` and key at `priv/cert/omnitouch.pem`. Only the listening ports are runtime-tunable via the environment variables above.

Management / OAM API

The management API (TLS, default port `8443`, env `API_PORT`) exposes the following endpoints for operations and diagnostics. All management endpoints are mounted under the `/api` prefix.

Method	Path	Purpose
GET	`/api/status/api`	API service status.
GET	`/api/status/nrf`	NRF registration status.
GET	`/api/status/nf`	NF (SMF) status summary.
GET	`/api/pdu_session`	List active PDU sessions.
POST	`/api/pdu_session`	Create a PDU session (operational testing).
GET	`/api/pdu_session/{id}`	Show a single PDU session.
DELETE	`/api/pdu_session/{id}`	Delete a single PDU session.
GET	`/api/upf`	UPF / PFCP association view.
POST	`/api/eps_handover`	Drive N26 EPS interworking (adopt / switch / lookup).
GET	`/api/ip_pool`	Overall IPv4 capacity plus a per-DNN pool summary.
GET	`/api/ip_pool/detail`	Per-DNN pools with each range's CIDR, totals, and allocated addresses.

Method	Path	Purpose
GET	`/api/statistics`	Session and operational statistics.
GET	`/api/oam/config`	Read runtime configuration.
PATCH/PUT	`/api/oam/config/{id}`	Update a runtime configuration value.
GET	`/api/oam/resources`	Resource utilisation snapshot.
GET	`/api/oam/diagnostics`	Diagnostics snapshot.
GET	`/api/oam/peers`	SBI peer (UDM/PCF/AMF/NRF) status.
GET	`/api/oam/pfcp_peers`	PFCP (UPF) peer status.
GET	`/api/oam/pfcp_session/{id}`	Inspect a PFCP session.
POST	`/api/oam/upf`	Manage the UPF association.
POST	`/api/oam/pfcp/reassociate`	Re-trigger PFCP association setup with the UPF.
POST	`/api/oam/cache/clear`	Clear internal caches.
POST	`/api/oam/log_level`	Change the runtime log level without a restart.

Method	Path	Purpose
POST	`/api/oam/nrf/reregister`	Force NRF re-registration.
DELETE	`/api/oam/session/{id}`	Drain a single session.
DELETE	`/api/oam/session/by_dnn/{id}`	Drain sessions by DNN.
DELETE	`/api/oam/session/by_supi/{id}`	Drain sessions by SUPI.
DELETE	`/api/oam/session/by_snssai/{id}`	Drain sessions by S-NSSAI.
DELETE	`/api/oam/session/by_upf/{id}`	Drain sessions by UPF.
POST	`/api/oam/session/modify`	Modify a session (operational testing).

Logging

The SMF emits structured JSON logs. The default log formatter is configured in `runtime.exs` and is not intended to be edited per-deployment:

```
config :logger, :default_formatter,
  format: {OmniLogger.JsonFormatter, :format},
  metadata: :all
```

Parameter	Type	Required	Default	Descri
`format`	formatter	No	`OmniLogger.JsonFormatter`	Emits e log line JSON o for ing by log pipelin
`metadata`	atom/list	No	`:all`	Include Logger metad (SUPI, sessior SM cor ref, DN proced in each line.

The runtime log level can be changed without a restart through the management API endpoint `POST /api/oam/log_level`. Filter logs by SUPI to trace a subscriber's full session lifecycle.

← Overview

OmniSMF Metrics

Metrics are exposed at `GET /metrics` on `prometheus_metrics_port` (default `9568`, env `PROMETHEUS_PORT`). All metric names below are prefixed as shown by the exporter.

PDU Session Metrics

Metric	Type	Labels	Descrip
`omni_smf_pdu_session_create_count`	counter	`result`	PDU sess create operatior
`omni_smf_pdu_session_modify_count`	counter	`result`	PDU sess modify operatior
`omni_smf_pdu_session_release_count`	counter	`result`	PDU sess release operatior
`omni_smf_pdu_session_creates_total`	counter	`result`, `dnn`	Total PDU session creates b result an DNN.
`omni_smf_pdu_session_releases_total`	counter	`result`	Total PDU session releases result.
`omni_smf_active_pdu_sessions_count`	gauge	`dnn`	Number active PD sessions DNN. Em on sessio establish and relea from the Context s (the sour

Metric	Type	Labels	Descrip
			truth for active sessions)
`omni_smf_session_duration_seconds`	distribution	none	PDU sess duration seconds, emitted c release a measured from sess establish (buckets: 5, 15, 30, 300, 900, 3600, 86 s).

Example (establishment success rate):

```
sum(rate(omni_smf_pdu_session_creates_total{result="success"}
[5m]))
  / sum(rate(omni_smf_pdu_session_creates_total[5m]))
```

Example (active sessions per DNN):

```
sum by (dnn) (omni_smf_active_pdu_sessions_count)
```

PFCP / UPF Metrics

Metric	Type	Labels	
`omni_smf_pfcp_sessions_total`	counter	`operation`	T s o (/
`omni_smf_pfcp_associations_total`	counter	`result`	T a s t (§
`omni_smf_pfcp_heartbeats_total`	counter	`result`	T h o t (§
`omni_smf_upf_health`	gauge	none	U a h 0
`omni_smf_n4_usage_reports_total`	counter	none	N r r t 2
`omni_smf_n4_usage_report_volume_bytes_total`	counter	none	T u

Metric	Type	Labels	
			v b a u

The two `omni_smf_n4_*` metrics are the SMF's only user-plane volume metrics: they populate from the URR usage reports the UPF returns over N4, so they only advance when the UPF has usage-reporting rules installed and is delivering reports.

Example (alert when the UPF association drops):

```
omni_smf_upf_health == 0
```

Example (user-plane volume throughput across all sessions):

```
sum(rate(omni_smf_n4_usage_report_volume_bytes_total[5m]))
```

Example (rate of usage reports received from the UPF):

```
sum(rate(omni_smf_n4_usage_reports_total[5m]))
```

Example (PFCP heartbeat failures toward the UPF):

```
sum(rate(omni_smf_pfcp_heartbeats_total{result="failure"}[5m]))
```

N40 Charging Metrics

Metric	Type	Labels	Description
`omni_smf_n40_charging_total`	counter	`operation`	Total N40 Nchf converged-charging operations toward the CHF by charging event (TS 32.290).

Example (rate of converged-charging operations by event):

```
sum by (operation) (rate(omni_smf_n40_charging_total[5m]))
```

NRF Metrics

Metric	Type	Labels	Description
`omni_smf_nrf_registration_status`	gauge	`nf_type`	NRF registration status (1 = registered, 0 = not).

Example:

```
omni_smf_nrf_registration_status == 0
```

BEAM VM Metrics

Metric	Type	Description
`beam_memory_total`	gauge	Total BEAM memory (bytes).
`beam_memory_processes`	gauge	Memory allocated to Erlang processes.
`beam_memory_processes_used`	gauge	Memory actually used by processes.
`beam_memory_system`	gauge	System memory.
`beam_memory_atom`	gauge	Total atom memory.
`beam_memory_atom_used`	gauge	Used atom memory.
`beam_memory_binary`	gauge	Binary memory.
`beam_memory_code`	gauge	Code memory.
`beam_memory_ets`	gauge	ETS table memory.
`beam_processes_count`	gauge	Number of Erlang processes.
`beam_ports_count`	gauge	Number of Erlang ports.
`beam_atom_count`	gauge	Number of atoms.
`beam_vm_uptime`	gauge	VM uptime (seconds).

The active-process count doubles as a session-scale signal, since each PDU session is a dedicated worker process. A sustained divergence between `beam_processes_count` and `omni_smf_active_pdu_sessions_count` can indicate orphaned session workers (see Troubleshooting).

← Overview

OmniSMF Operations Guide

OmniSMF is the Session Management Function (SMF) of the 5G Core. It owns the full lifecycle of PDU sessions: address allocation, policy association, user-plane programming and teardown. This guide covers the 3GPP role, the SBI and N4 interfaces it exposes, and the key procedures it drives, each with a sequence diagram.

3GPP Role and Specification References

Specification	Relevance
TS 23.501	System architecture: SMF role, PDU session concept, QoS model
TS 23.502	Procedures: PDU Session Establishment (§4.3.2), Modification (§4.3.3), Release (§4.3.4), Service Request (§4.2.3)
TS 29.502	Nsmf_PDUSession service API
TS 29.244	N4 interface: PFCP protocol between SMF and UPF
TS 29.503	Nudm_SubscriberDataManagement (sm-data) and Nudm_UEContextManagement (smf-registrations)
TS 29.512	Npcf_SMPolicyControl: SM policy association and notification toward PCF
TS 29.518	Namf_Communication: N1N2MessageTransfer toward AMF
TS 32.290 / TS 32.291	Nchf_ConvergedCharging (N40): converged charging toward the CHF
TS 24.501	5GS NAS (5GSM): PDU session establishment/modification, session type and 5GSM cause handling (§6.4.1.3)
TS 29.571	Common data types: `IpAddress`, S-NSSAI

Interfaces

Interface	Peer	Protocol	Purpose
N11	AMF	Nsmf_PDUSession (SBI, HTTP/2)	SM context create / retrieve update / release, N1N2MessageTransfer
N7	PCF	Npcf_SMPolicyControl (SBI)	SM policy association create + policy-notify callback
N10	UDM	Nudm_SDM + Nudm_UECM (SBI)	Session subscription data, S registration
N4	UPF	PFCP (UDP)	PFCP association + session establishment/modification/
N40	CHF	Nchf_ConvergedCharging (SBI)	Converged charging: open/update/close a Chargir Request over the PDU sessic lifecycle (CHF resolved via N discovery with a static fallba disabled by default)
N26	PGW-C	Internal interworking	Adopt / switch / lookup for 4 mobility
n/a	NRF	Nnrf_NFManagement (SBI)	NF registration + heartbeat outbound discovery)

SBI Endpoints

All SBI endpoints are served under the base URL `{SBI_SCHEME}://{SBI_ADDR}:{SBI_PORT}`.

Method	Path	Service	P
POST	`/nsmf-pdusession/v1/sm-contexts`	Nsmf_PDUSession	Create (PDU s establ
POST	`/nsmf-pdusession/v1/sm-contexts/{smContextRef}/retrieve`	Nsmf_PDUSession	Retrie Conte uses P GET)
POST	`/nsmf-pdusession/v1/sm-contexts/{smContextRef}/modify`	Nsmf_PDUSession	Updat Conte UP sta handc flow m releas
POST	`/nsmf-pdusession/v1/sm-contexts/{smContextRef}/release`	Nsmf_PDUSession	Releas Conte teardc
POST	`/nsmf-callback/sm-policy-notify/{smContextRef}`	Npcf callback	Receiv `SmPol` updat PCF (c QoS fl

Create SM Context

Mandatory request fields: `supi`, `sNssai`, `servingNetwork`, `dnn`, `smContextStatusUri`, `pduSessionId`, `anType`, `servingNfId`. Returns `201 Created` with `Location: {base}/nsmf-pdusession/v1/sm-contexts/{ref}`. Error mapping: `400 MANDATORY_IE_MISSING`, `404 DNN_DENIED`, `500 SYSTEM_FAILURE`, `503 NF_DISCOVERY_FAILURE` (UDM unreachable).

Retrieve SM Context

The AMF reads the current SM context by referencing it (TS 29.502 §5.2.2.6 uses `POST .../sm-contexts/{smContextRef}/retrieve`, not `GET`). The SMF returns `200 OK` with the current SM context view for a known reference, or `404 CONTEXT_NOT_FOUND` for an unknown one.

Update SM Context

The modify handler dispatches on the first recognized key in the body:

Body key	Scenario
`n2SmInfo` + `n2SmInfoType`	N2 SM information from gNB (`PDU_RES_SETUP_RSP` activates the tunnel; `PDU_RES_REL_RSP` deactivates it)
`upCnxState: "DEACTIVATED"`	AN release / UE idle entry (downlink FAR to BUFFER)
`upCnxState: "ACTIVATING"`	Service request; response carries N2 `PDU_RES_SETUP_REQ`
`hoState`	Handover state transition: `PREPARING`, `PREPARED`, `COMPLETED` (re-activates the tunnel), `CANCELLED`
`qosFlows`	Post-establishment QoS-flow add/modify (returns `204 No Content`; changes conveyed to the gNB via N2 SM info)
`release: true`	AMF-initiated release (returns `204 No Content`)
`servingNfId`	AMF instance change during mobility (returns `204 No Content`)

Release SM Context

The body may include `ueLocation` for final location recording. Returns `204 No Content`.

Key Procedures

PDU Session Establishment (TS 23.502 §4.3.2)

The N1N2MessageTransfer is sent asynchronously so the `201 Created` returns to the AMF first. The N1 SM message is a NAS PDU Session Establishment Accept and the N2 SM info is an NGAP `PDUSessionResourceSetupRequestTransfer`, carried as a `multipart/related` body (TS 29.518) with the binary NAS/NGAP parts referenced by `contentId`.

DNN Configuration Sourcing

A DNN's behaviour is defined in two places, and an operator must set both consistently for a DNN to come up correctly:

DNN attribute	Sourced from	How it is provisioned
Allowed S-NSSAI	AMF/UDM subscription	The AMF supplies `sNssai` on the Create SM Context; the DNN must exist under a matching S-NSSAI in the subscriber's UDM SM data
Session-AMBR	UDM `dnnConfiguration.sessionAmbr`	Provisioned in the HSS → UDM/UDR
Default QoS (5QI + ARP)	UDM `dnnConfiguration.5gQosProfile`	Provisioned in the HSS → UDM/UDR
PDU session type(s)	UDM `dnnConfiguration.pduSessionTypes`	`defaultSessionType` + `allowedSessionTypes`
SSC mode	UDM `dnnConfiguration.sscModes`	`defaultSscMode` + `allowedSscModes` (TS 23.501 §5.6.9.2)

DNN attribute	Sourced from	How it is provisioned
Static UE IP	UDM `dnnConfiguration.staticIpAddress`	Provisioned in the HSS → UDM/UDR
UE IP pool (dynamic)	**SMF** `ue_ip_pool` `subnet_map`	SMF configuration
DNS / MTU / P-CSCF (ePCO)	**SMF** `dns` / `dns6` / `mtu` / `:pco`	SMF configuration

The rule of thumb: **per-subscriber and per-DNN policy (S-NSSAI, AMBR, default QoS, session type, SSC mode, static IP) lives in the UDM subscription; the network resources handed to the UE (dynamic IP pool, DNS, MTU, P-CSCF) live in SMF configuration.** A DNN that is present in the SMF `subnet_map` but absent from the subscriber's UDM SM data is rejected with `404 DNN_DENIED`; a DNN present in the UDM but with no matching `subnet_map` entry and no `default` pool fails IP allocation with `:no_pool_for_dnn`.

UE IP Address Allocation

Every PDU session is assigned an IP address (IPv4, IPv6, or both) before the PFCP session is established with the UPF. The IP pool mirrors the 4G PGW-C allocation model. Sources are tried in priority order:

1. **N26 adopted address.** For a 4G-originated session moving to 5G over N26 (an `adoptedIpv4` on the create request), the UE IP the standalone PGW-C already allocated is reused verbatim; the address belongs to the

PGW-C's pool, so it is preserved across the handover, not re-allocated. For a dual-stack session the IPv6 portion is then allocated dynamically.

2. **Static IP (subscriber-pinned).** When the UDM SM subscription data contains a `staticIpAddress` for the requested DNN, that fixed address is honoured for every session on that DNN. This mirrors the 4G HSS/PGW-C static-IP behaviour and is ultimately provisioned in the HSS and surfaced through the UDM/UDR. For a dual-stack session the IPv6 portion is allocated dynamically.
3. **Dynamic pool.** Otherwise an address is allocated from the DNN's configured pool. Allocation picks a random free host address (excluding network/broadcast for IPv4), retries on collision, and is deduplicated across all active sessions.

The UE IP is returned to the pool on **any** worker exit (explicit release, crash, or supervisor shutdown), so a CPE stuck in an establish/release/retry loop cannot slowly leak pool addresses.

DNN-aware pools (`subnet_map`)

Pools are selected per-DNN via the `subnet_map`. Keys are exact DNN names, `^regex` patterns, or `:default`; values are lists of IPv4 and/or IPv6 CIDRs. Matching precedence is **exact DNN → regex → `:default`**. For an `IPV4V6` session the SMF allocates from both the IPv4 and IPv6 ranges of the matched pool. See UE IP Pool in the Configuration Reference.

Static IP field and reservation

The `staticIpAddress` field follows TS 29.503 (`DnnConfiguration`) and TS 29.571 (`IpAddress`): an array of objects, each optionally carrying `ipv4Addr` (a single object is also accepted). A static address is reserved in the pool so it is never handed out dynamically:

- A static address **inside** a configured range is counted against that pool and excluded from dynamic allocation.
- A static address **outside** every configured range is tracked for duplicate detection only and does not consume pool capacity (static IPs may live on their own routed subnet).

- If the static address is **already in use** by another live session, the new PDU session is rejected (`:static_ip_in_use`) rather than issuing a duplicate, matching the 4G PGW-C. This should only occur if the same static IP is misconfigured against two subscribers.

To provision a static IP, set `staticIpAddress` on the subscriber's DNN configuration (via the HSS → UDM/UDR); no SMF configuration change is required.

PDU session type reconciliation (TS 24.501 §6.4.1.3)

When a dual-stack (`IPV4V6`) session is requested but the matched pool only yields one address family, the SMF **reconciles the signalled session type down to the family it actually allocated** before it builds the N1 Establishment Accept and the N2 `PDUSessionResourceSetupRequestTransfer`:

- IPv4 allocated, no IPv6 → signal `IPV4` with 5GSM cause **#50 (PDU session type IPv4 only allowed)**.
- IPv6 allocated, no IPv4 → signal `IPV6` with 5GSM cause **#51 (PDU session type IPv6 only allowed)**.
- Both families present → signal `IPV4V6` unchanged.

This is required for interoperability: advertising `IPV4V6` while carrying only an IPv4 address makes the RAN reject the N2 resource setup. Operators serving dual-stack subscriptions from IPv4-only pools will therefore see those sessions come up as IPv4 with the corresponding NAS cause, rather than failing.

Monitoring

- `GET /api/ip_pool`: overall IPv4 capacity plus a per-DNN pool summary.
- `GET /api/ip_pool/detail`: per-DNN pools with each range's CIDR, total/allocated/available, and the full list of currently-allocated addresses (dynamic + static).

> **IPv6 note:** IPv6 addresses are allocated, reserved, released, and reported by the pool.

P-CSCF Discovery and Advertisement (VoNR / IMS)

For an IMS/VoNR PDU session the UE must learn a P-CSCF to register against. The SMF returns it in the **ePCO** of the PDU Session Establishment Accept (P-CSCF IPv4 container `0x000C`, IPv6 container `0x0001`), one container per address, identical to the 4G PGW-C. The P-CSCF is only returned when the DNN begins with `ims`. Selection order:

1. **DNS discovery + health check (preferred).** When `p_cscf_discovery_enabled`, the SMF resolves `_sip._tcp.<fqdn>` (SRV) to A/AAAA, then health-checks each candidate with a SIP `OPTIONS` (TCP then UDP). Only servers that answer are advertised, and the set is refreshed on a fixed 60-second cycle, so a P-CSCF that stops answering `OPTIONS` is dropped from the advertised set within roughly one minute, and a recovered one is re-added on the next cycle. The refresh runs independently of session establishment; new sessions always read the latest healthy set.
2. **Static fallback.** If discovery is disabled or returns nothing healthy, `p_cscf_ipv4_address_list` / `p_cscf_ipv6_address_list` are used.

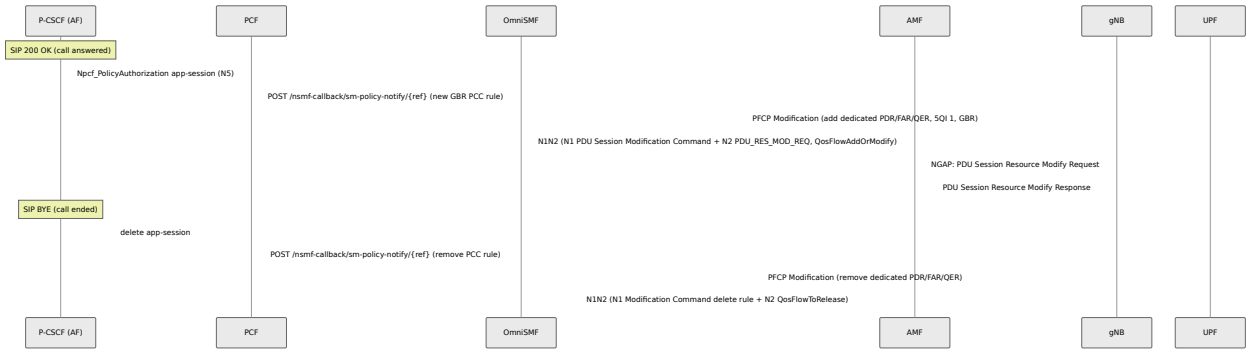
This mirrors the PGW-C exactly, so a mixed 4G/5G IMS deployment configures P-CSCF the same way on both nodes. See P-CSCF and Protocol Configuration Options.

Dedicated QoS Flow / GBR Bearer (VoNR, 5QI-1)

VoNR needs a dedicated GBR QoS flow (5QI 1) for the voice media, alongside the default non-GBR flow. Both a **static** (provisioned) and a **dynamic** (call-driven) path are supported.

Static: the GBR rule is provisioned in policy (the HSS PCRF charging-rule to UDR `sm-policy-data` to PCF PCC rule) and returned on the `sm-policies` decision. It is stashed and installed once the PFCP session exists, so the UPF marks the flow with its 5QI/GBR from the moment the session comes up.

Dynamic (call-driven): the flow is added when the call is answered and removed on BYE, driven by the PCF policy-notify callback:



The notification is delivered to `/nsmf-callback/sm-policy-notify/{smContextRef}` (the SMF reads `smPolicyDecision` from the body): a non-null PCC rule installs the flow, a null-valued rule removes it (TS 29.512, a null-valued PCC rule is a rule to remove). The AF app-session to SM-policy matching (by UE IP) is performed on the PCF.

PDU Session Modification: QoS Flow Update

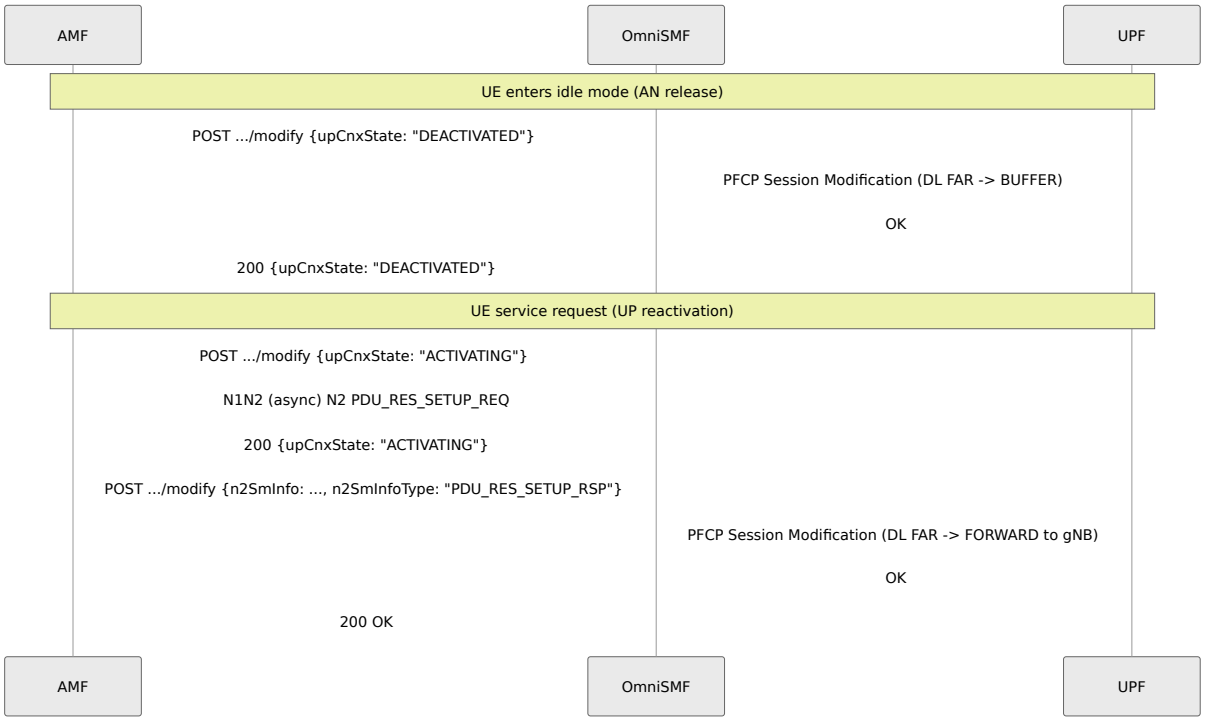
An AMF may also drive a QoS-flow modification directly through the modify endpoint with a `qosFlows` list, rather than via the PCF. Each entry either updates an existing flow (matched by `qfi`) or allocates a new QFI. The UPF is re-programmed with the changed QoS, and because `SmContextUpdatedData` defines no `qosFlows` JSON member, the response is `204 No Content`; the QoS change is conveyed to the gNB via N2 SM information.

PDU Session Release (TS 23.502 §4.3.4)

Teardown order is PCF policy delete → PFCP session delete → UDM deregistration → SM context status notification (`resourceStatus: RELEASED`) to

the AMF callback; the worker then releases the UE IP back to the pool and stops. The same teardown runs for an AMF-initiated `release: true` modify.

UE Idle / Service Request: UP Connection State (TS 23.502 §4.2.3)



On `ACTIVATING`, the SMF updates the PTI from the UE's latest establishment request and sends an N1N2MessageTransfer to the AMF to trigger the `PDUSessionResourceSetup` on the gNB; the `200` response carries `upCnxState: ACTIVATING`. The user plane is re-pointed at the gNB only once the gNB F-TEID arrives in the follow-up `PDU_RES_SETUP_RSP`.

Handover State Transitions

An AMF-driven handover progresses the session through `hoState` values on the modify endpoint:

- `PREPARING` / `PREPARED`: state is recorded; the user plane is not changed.
- `COMPLETED`: the tunnel is re-activated (PFCP modification, downlink FAR to the target gNB) and the handover state cleared.
- `CANCELLED`: the handover state is cleared with no user-plane change.

N4 PFCP Session Structure

Each PDU session installs the following PFCP IEs on the UPF (TS 29.244):

IE	Direction	Purpose
PDR (uplink)	Access → Core	Match GTP-U traffic from gNB on the UPF N3 F-TEID
PDR (downlink)	Core → Access	Match traffic from N6 by UE IP address
FAR (uplink)	Core	Forward to N6 (no outer header)
FAR (downlink)	Access	Initially BUFFER; updated to GTP-U FORWARD after `PDU_RES_SETUP_RSP`
QER	Both	Enforce session AMBR (uplink and downlink MBR); dedicated QER added per GBR flow
URR	Both	Time-based usage reporting (threshold derived from `heartbeat_interval`)

The single URR uses duration-based measurement with a time-threshold trigger. The threshold is derived from `heartbeat_interval` (six times its value, e.g. 60 s at the default 10 s heartbeat), so it is not independently tunable; raise `heartbeat_interval` to lengthen the reporting cadence. Usage reports the UPF sends back are recorded and surfaced as the `omni_smf_n4_usage_reports_total` and `omni_smf_n4_usage_report_volume_bytes_total` metrics (see Metrics), and, when N40 converged charging is enabled, forwarded to the CHF as interim Charging Data Requests.

The PFCP association with the UPF is established (with heartbeats) before any session request is sent. If the association is lost, it can be re-triggered through the management API (`POST /api/oam/pfcp/reassociate`).

N26 EPS Interworking (4G ↔ 5G)

The SMF and the standalone PGW-C share a UPF and coordinate over an internal N26 interworking path so a UE keeps its IP address across a handover:

- **Adopt (4G → 5G):** a 4G-originated EPS session is adopted into 5GS, reusing the PGW-C's already-allocated UE IP. Re-adopting an existing session returns the existing 5G session rather than creating a duplicate.
- **Switch:** an existing session's access side is switched to `:eps` (5G → 4G) or `:fivegs` (4G → 5G) by updating the access tunnel via a PFCP modification (S-GW S5/S8-U TEID/address for EPS, gNB N3 TEID/address for 5GS) while keeping the same UE IP and the same PFCP session on the UPF. The switch returns an EPS view (preserved UE IP, DNN, session AMBR, default EPS bearer id, and the PGW-U F-TEID) that the PGW-C uses to answer the SGW.
- **Lookup:** a UE's active PDU sessions can be read as EPS PDN-connection views by SUPI/IMSI.

The management API exposes `POST /api/eps_handover` to drive interworking. The paired PGW-C's S5/S8-C address is advertised via the `pgw_c_addr` configuration key (see Configuration Reference).

← Overview

OmniSMF Troubleshooting

PDU Session Establishment Fails with 404 DNN_DENIED

- **Symptom:** AMF receives `404` with cause `DNN_DENIED`.
- **Cause:** the UDM SM subscription data does not include the requested DNN.
- **Resolution:** verify the UDM subscriber data for the SUPI contains a `dnnConfigurations` entry matching the requested DNN (matching is case-insensitive). The SMF log shows `dnn_not_found`.

PDU Session Establishment Fails with 503 NF_DISCOVERY_FAILURE

- **Symptom:** AMF receives `503` with cause `NF_DISCOVERY_FAILURE`.
- **Cause:** the SMF could not reach the UDM at `udm_uri`.
- **Resolution:** verify connectivity from the SMF host to `udm_uri`, and that the UDM SBI port is reachable. The SMF log shows the underlying reason.

PFCP Session Establishment Rejected

- **Symptom:** the UPF returns a non-accepted cause in the PFCP Session Establishment Response.
- **Causes / resolution:**
  - `upf_addr` / `upf_pfcp_port` incorrect: verify the UPF is listening on the PFCP port.

- PFCP association not established: the SMF must complete PFCP Association Setup before sending session requests. Check startup logs for association messages; if needed, re-trigger via `POST /api/oam/pfcp/reassociate`.
- `pfcp_addr` not routable from the UPF: set it to an address the UPF can reach.

UE Receives No IP Address

- **Symptom:** session fails during IP assignment.
- **Causes / resolution:**
  - `:no_pool_for_dnn`: the requested DNN has no matching `subnet_map` entry and no `default`; add one.
  - `:ipv4_pool_exhausted` / `:ipv6_pool_exhausted`: the matched range is full; enlarge or add a range.
  - `:static_ip_in_use`: the same `staticIpAddress` is provisioned against two subscribers; correct the subscription data.
  - `:static_ip_invalid`: the provisioned `staticIpAddress.ipv4Addr` is not a valid IPv4 address; correct the subscription data.
- **Dual-stack served as single-stack:** a dual-stack request from an IPv4-only pool intentionally comes up as IPv4 with 5GSM cause #50 (see PDU session type reconciliation).

Session AMBR Capped at ~1 Mbps

- **Symptom:** every session's throughput is capped at roughly 1 Mbps regardless of the subscribed AMBR.
- **Cause:** the PCF received only a non-spec `sessionAmbr` key and left `subsSessAmbr` unset, so it fell back to its ~1000 Kbps default.
- **Resolution:** the SMF sends both `subsSessAmbr` (the TS 29.512 field name) and `sessionAmbr` on the SM policy association, and reads the subscribed AMBR from the UDM DNN configuration `sessionAmbr` field. Verify the UDM DNN configuration carries the correct `sessionAmbr`, and that the PCF honours `subsSessAmbr`. See Session-AMBR toward the PCF.

N1N2MessageTransfer to AMF Fails

- **Symptom:** the SM context and PFCP session are created but the UE never receives the Establishment Accept.
- **Cause:** the asynchronous N1N2MessageTransfer to the AMF failed; no automatic retry.
- **Resolution:** verify `amf_uri` and AMF reachability. To recover, release the SM context and retry establishment.

Dedicated VoNR Flow Not Created

- **Symptom:** a voice call establishes but no dedicated 5QI-1 GBR flow appears.
- **Causes / resolution:**
  - The PCF policy-notify callback did not arrive: confirm the PCF is configured with the notify URI `/nsmf-callback/sm-policy-notify/{smContextRef}` and that the AF (P-CSCF) app-session reached the PCF.
  - No QFI available: the log shows `No QFI available for PCC rule ...`; too many dedicated flows already exist on the session.
  - The PCC rule carried no 5QI / GBR: only rules with a resolvable `5qi` and GBR values become dedicated flows; verify the charging rule / QoS decision in policy.

High Session Count / Memory Growth

- **Symptom:** session worker count grows without matching releases.
- **Cause:** missed AMF/UE-initiated releases (e.g. after an AMF restart) leave orphaned session workers; there is no session timeout.
- **Resolution:** track the live active-session count with the `omni_smf_active_pdu_sessions_count` gauge (broken down by DNN), or read the `GET /api/statistics` and `GET /api/pdu_session` management endpoints (see Metrics). Sessions can be drained by DNN, SUPI, S-NSSAI, or

UPF via the `/api/oam/session/by_*` management endpoints. The UE IP is always returned to the pool when a worker exits, so draining orphaned workers reclaims their addresses.

Log Correlation

Logs are structured JSON with metadata (SUPI, PDU session id, SM context ref, DNN, procedure). Filter by SUPI to trace a subscriber's session lifecycle. Adjust the runtime log level via `POST /api/oam/log_level` without a restart.