

OmniPGW

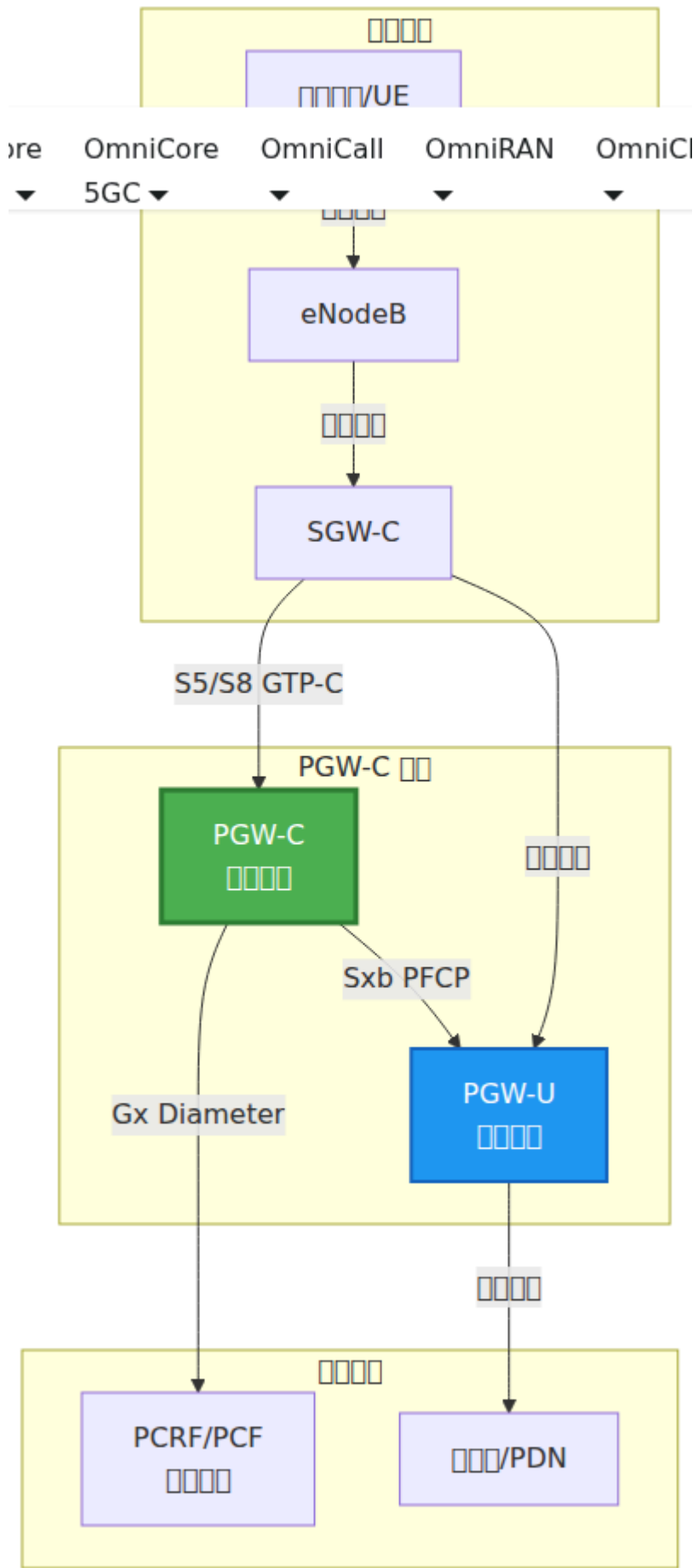
OmniPGW - (PGW-C)

OmniTouch

- 1.
 - 2.
 - 3.
 - 4.
 - 5.
 - 6.
 7. Web UI -
 - 8.
 - 9.
 - 10.
-

OmniPGW (PGW-C) 3GPP LTE (EPC) OmniTouch

- - UE
- **IP** - IP
- - PCRF
- - PGW-U

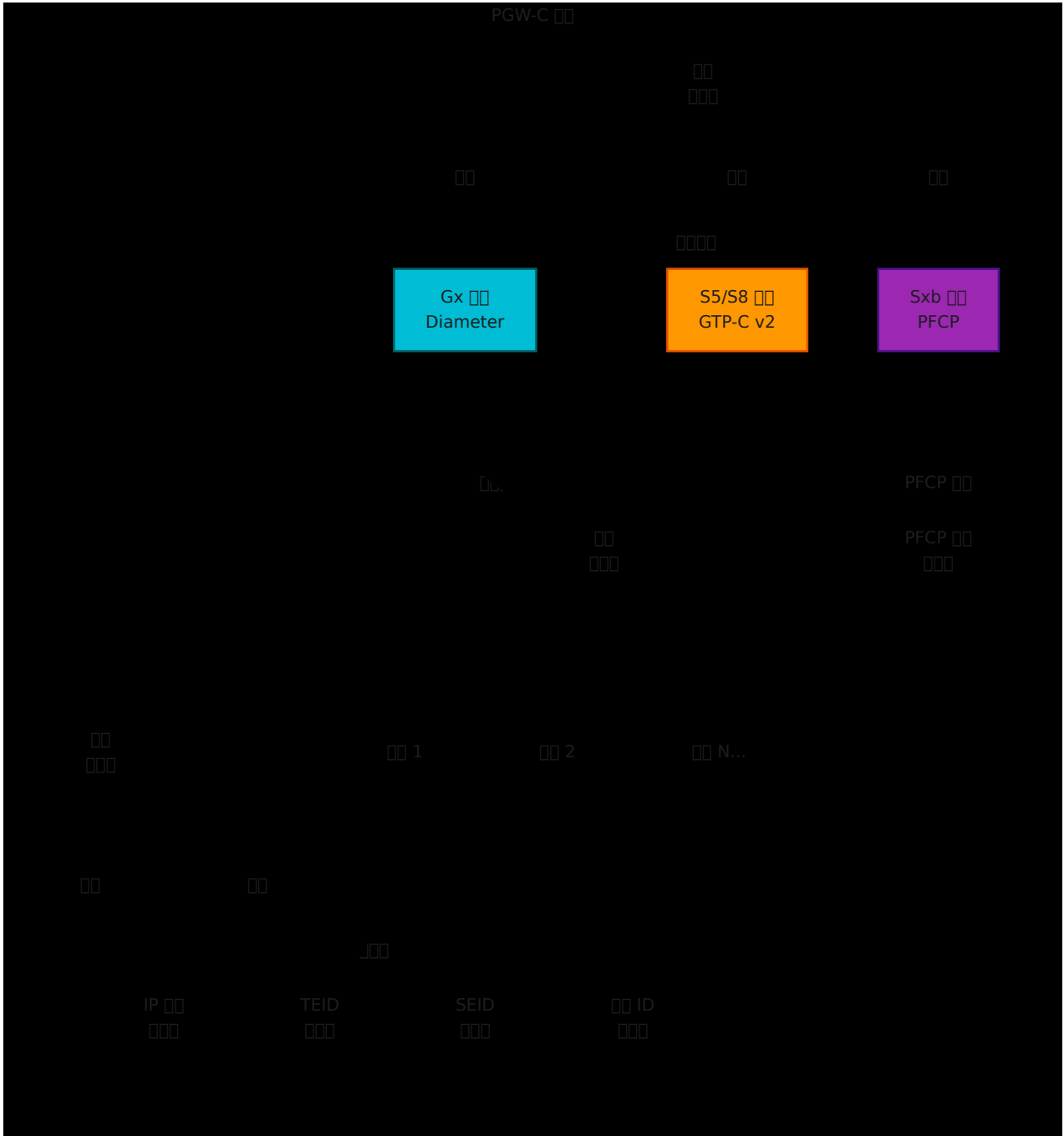


PGW-C

- **SGW-C** S5/S8 (GTP-C)
 - **UE IP**
 - **Gx (Diameter) PCRF**
 - **Sxb (PFCP) PGW-U**
 - **QoS QoS**
 -
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PGW-C □□ Elixir/OTP □□□□□□□□□□□□□□□□

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- **IPsec** - **IPsec**
- **IPsec** - **IPsec** PDN **IPsec** GenServer
- **IPsec** - **IPsec** (IPsecTEIDSEID)
- **PFCP** **IPsec** - **IPsec** PGW-U **IPsec** PFCP **IPsec**

IPsec

IPsec

PGW-C **IPsec** 3GPP **IPsec**

S5/S8 **IPsec** (**GTP-C v2**)

IPsec SGW-C **IPsec** PGW-C **IPsec**

IPsec **IPsec** UDP **IPsec** GTP-C **IPsec** 2

IPsec

- **IPsec**/**IPsec**
- **IPsec**/**IPsec**
- **IPsec**/**IPsec**
- **IPsec**/**IPsec**

IPsec **IPsec** **S5/S8** **IPsec**

Sxb **IPsec** (**PFCP**)

IPsec PGW-C **IPsec** PGW-U **IPsec**

IPsec **IPsec** UDP **IPsec** PFCP**IPsec**

IPsec

- **IPsec**/**IPsec**
- **IPsec**/**IPsec**

- 3GPP TS 23.002/3GPP
- 3GPP TS 23.002/3GPP
- 3GPP TS 23.002/3GPP

3GPP TS 23.002 PFCP/Sxb 3GPP

Gx (Diameter)

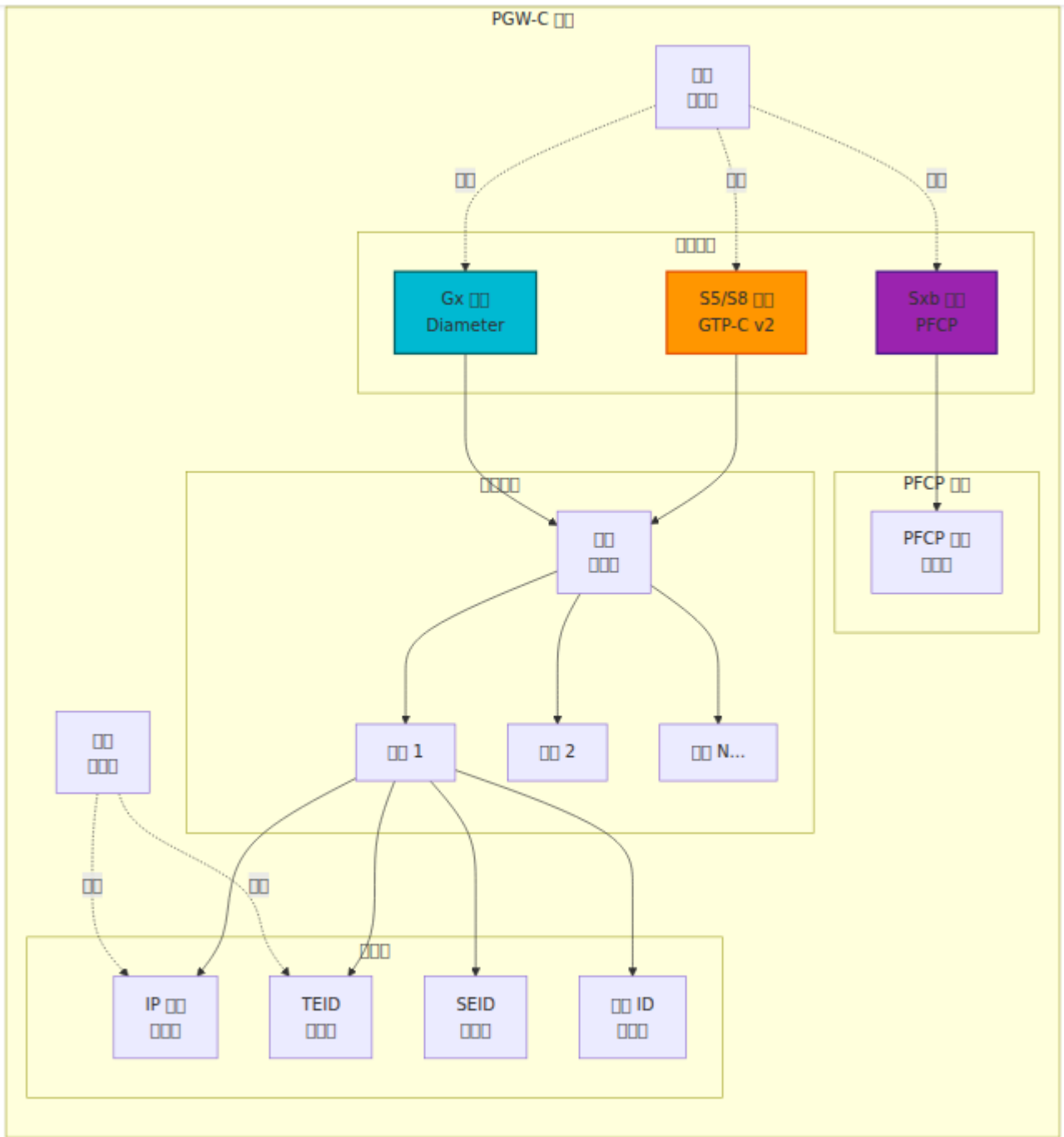
3GPP TS 23.002 (PCRF) 3GPP

3GPP Diameter (IETF RFC 6733)

3GPP

- 3GPP TS 23.002 (CCR-I/CCA-I)
- 3GPP TS 23.002 (CCR-T/CCA-T)

3GPP TS 23.002 Diameter Gx 3GPP



PDN

PDN UE

- UE IP -

- **APN** -
- - QoS
- **ID** -
- **TEID** ID - S5/S8
- **SEID** ID - Sxb

QoS

QoS

- - PDN
- - QoS
- **EBI** EPS ID -
- **QoS** - QCI/ARP/MBR/GBR

PFCP

PGW-C PGW-U

- **PDR** -
- **FAR** -
- **QER** QoS -
- **BAR** -

PFCP

IP

UE IP

- **APN** - APN
- - IP
- - UE IP
- - IP

UE IP

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- Elixir ~1.16
- Erlang/OTP 26+
- □ SGW-C □ PGW-U □ PCRF □□□□
- □□ LTE EPC □□

□□ OmniPGW

1. □ `config/runtime.exs` □□□□□□□□

2. □□□□□□□□

```
mix deps.get
mix compile
```

3. □□□□□□□□

```
mix run --no-halt
```

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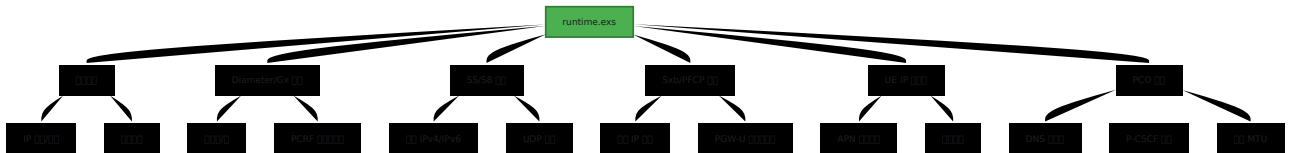
```
[info] □□ OmniPGW...
[info] □ 127.0.0.42:42069 □□□□□□□□
[info] □ 127.0.0.10 □□ S5/S8 □□
[info] □ 127.0.0.20 □□ Sxb □□
[info] □□ Gx □□
[info] □□ PFCP □□□□□□
[info] OmniPGW □□□□
```

□□□□□□ `http://127.0.0.42:42069/metrics` □□□□□□□□

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□□□□□□ `config/runtime.exs` □□□□□□□□□□□□□□

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□□	□□	□□
metrics	Prometheus □□□□□	□□□□
diameter	Gx □□□ PCRF	Diameter Gx □□
s5s8	GTP-C □□□ SGW-C	S5/S8 □□
sxb	PFCP □□□ PGW-U	PFCP □□
ue	UE IP □□□	IP □□□
pco	□□□□□□	PCO □□
CDR	□□□□□□□□	CDR □□

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Web UI - □□□□□□□□

OmniPGW □□□□□□ **Web UI** □□□

Web UI

http://<omnipgw-ip>:<web-port>/

Table

Category	URL	Description	Count
UE 00	/ue_search	0000000000	00
PGW 00	/pgw_sessions	0000000 PDN 00	2 0
00000	/session_history	0000000000	5 0
00000	/topology	0000000000	5 0
IP 0	/ip_pools	UE IP 0000000	2 0
PFCP 00	/pfcf_sessions	000 PGW-U 0 PFCP 00	2 0
UPF 00	/upf_status	00 PFCP 000000	2 0
UPF 00	/upf_selection	00 UPF 000000 P-CSCF 00	00
Diameter 000	/diameter	00 PCRF 000	1 0
P-CSCF 00	/pcscf_monitor	P-CSCF DNS 00000	5 0
Gy 000	/gy_simulator	00 Gy/Ro 00000	00
00	/cell_towers	00 OpenCellID 000	00
00	/logs	000000	00

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- □□ OmniPGW □□□□□□□□
- □□□□□□□□□□□□/□□□

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- □ IMSI□IP□MSISDN □ APN □□□□
- □□□□□□□□□□□□□□

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- □□□□ NOC/□□□□□□□□
- □□□□□□ IP □□□□□□

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1. `get /ue_search`
2. `POST /ue_search` (/ue_search)
3. `POST /imsi` IMSI/MSISDN `POST /ip` IP
4. `POST /ue_search`
 - a) `POST /ue_search` - `POST /ue_search`
 - b) `POST /ue_search` - `POST /ue_search` TAC/Cell ID
 - c) `POST /ue_search` - `POST /ue_search`
 - QCI/MBR/GBR
 - APN-AMBR
 - d) `POST /ue_search` - Gy ID
 - e) `POST /ue_search` - Gx PCC
 - f) `POST /ue_search` - `POST /ue_search`
5. `POST /ue_search` → `POST /diameter` Diameter PCRF
6. `POST /ue_search` → `POST /ue_search`

GET /ue_search

1. `GET /ue_search`
2. `POST /pgw_sessions` PGW
3. `POST /imsi` IMSI
4. `POST /ue_search`
 - `POST /ue_search` UE IP
 - QoS
 - `POST /ue_search`
5. `POST /ue_search` → `POST /ue_search` UE

POST /ue_search

1. `POST /ue_search` UPF → `POST /ue_search` PGW-U
2. `POST /ue_search` Diameter → `POST /ue_search` PCRF
3. `POST /ue_search` PGW → `POST /ue_search`

POST /ue_search

- `POST /ue_search` PGW
- `POST /ue_search`/
- `POST /ue_search`
- `POST /ue_search` APN

Web UI

Web UI

- UE
-
- PFCP/Diameter
-
- IMSI/MSISDN/IP
-
- QoS MBR/GBR/QCI
-
-
- IP
-

Prometheus

-
-
-
-
-

Web UI Prometheus

Web UI OmniPGW Prometheus

-

- `teid_registry_count` - S5/S8
- `seid_registry_count` - PCFP
- `session_id_registry_count` - Gx
- `address_registry_count` - UE IP
- `charging_id_registry_count` - ID

-

- `s5s8_inbound_messages_total` - GTP-C
- `sxb_inbound_messages_total` - PCFP
- `gx_inbound_messages_total` - Diameter
-

-

- `s5s8_inbound_errors_total` - S5/S8
- `sxb_inbound_errors_total` - PCFP
- `gx_inbound_errors_total` - Diameter

HTTP

```
curl http://127.0.0.42:42069/metrics
```


OmniPGW

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│   │   └── pco-configuration.md       DNS/P-CSCF/MTU 目次
│   ├── 目次
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│   │   ├── diameter-gy.md             Gy/Ro/OCS 目次
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Mermaid

Mermaid のインストール

- インストール
- 実行
- 設定
- トラブルシューティング

インストール

実行

- 実行
- 設定
- トラブルシューティング

設定

トラブルシューティング

- 実行
- 設定
- トラブルシューティング

インストール

実行

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2. configuration.md - □□
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4. session-management.md - □□□□

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1. OPERATIONS.md - □□□□□□□□
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3. pco-configuration.md - □□□□
4. monitoring.md - □□□□

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- □□□□ 14
- □□□□ ~10,900+
- □□□□ ~265 KB
- **Mermaid** □□□ 75+
- □□□□□ 150+

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- □ □□/□□□□□□
- □ OTP/Elixir □□
- □ □□□□
- □ □□ GenServer □□□

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- □ PFCP□□□□□□□□□□
- □ GTP-C v2□GPRS □□□□□
- □ Diameter□RFC 6733□

3GPP □□

- □ Sxb□PGW-C ↔ PGW-U□
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 - □ QoS □□
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3GPP □□

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TS 32.251	□□□□□□□
TS 23.401	EPC □□

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- □□□□ [config/runtime.exs](#)
-

OmniPGW □□□□

runtime.exs □□□□□□□□

□ Omnitouch □□□□□□□□

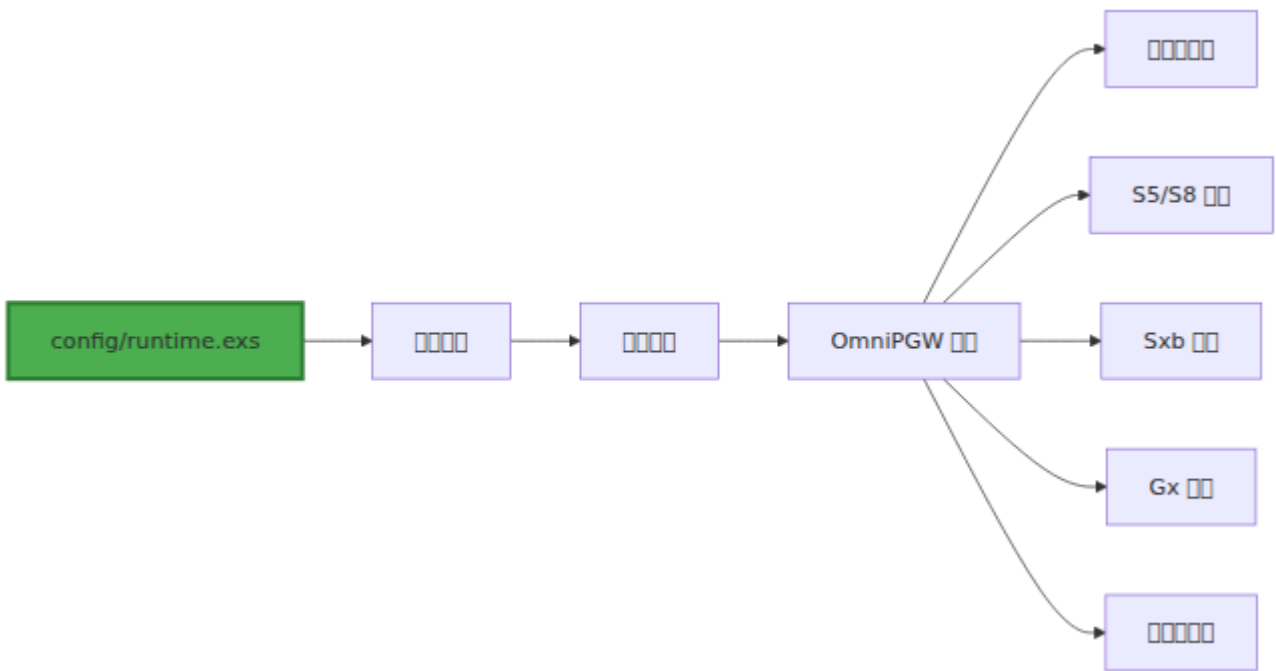
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1. □□
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 3. □□□□
 4. Diameter/Gx □□
 5. S5/S8 □□
 6. Gn/Gp □□ (GGSN)
 7. Sxb/PFCP □□
 - UPF □□□□
 - □□ UPF □□□□□□□□
 - □□ DNS □□□□
 - □□□□□□
 8. UE IP □□□□
 9. PCO □□
 10. Web UI □□
 11. □□□□
 12. □□□□
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OmniPGW □□ □□□□□□□□□□ `config/runtime.exs` □□□□□□□□ □□□□□□ □□□□□□□□□□□□□□□□□□
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```
pgw_c/  
├─ config/  
│   ├── config.exs      # □□□□□□□□ runtime.exs□  
│   ├── dev.exs        # □□□□□□□□  
│   ├── prod.exs       # □□□□□□□□  
│   └─ runtime.exs     # ← □□□□□□□□
```

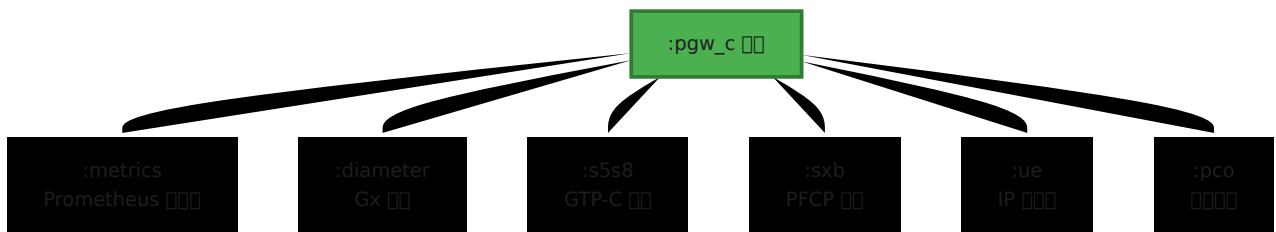
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```
# config/runtime.exs
import Config

config :logger, level: :info

config :pgw_c,
  metrics: %{...},
  diameter: %{...},
  s5s8: %{...},
  sxb: %{...},
  ue: %{...},
  pco: %{...}
```

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□□ Prometheus □□□□□□□□ OmniPGW□

配置

```
config :pgw_c,  
  metrics: %{  
    # 是否启用  
    enabled: true,  
  
    # HTTP 服务的 IP 地址  
    ip_address: "0.0.0.0",  
  
    # 端口  
    port: 9090,  
  
    # 注册表轮询周期  
    registry_poll_period_ms: 10_000  
  }
```

配置

配置项	类型	值	说明
<code>enabled</code>	布尔	<code>true</code>	是否启用
<code>ip_address</code>	字符串 IP	<code>"0.0.0.0"</code>	监听地址 0.0.0.0 = 所有 IP
<code>port</code>	整数	<code>9090</code>	HTTP 服务端口 <code>/metrics</code>
<code>registry_poll_period_ms</code>	整数	<code>10_000</code>	注册表轮询周期

配置

配置 - 监听 IP

```
metrics: %{
  enabled: true,
  ip_address: "10.0.0.20", # 10.0.0.20
  port: 9090,
  registry_poll_period_ms: 5_000 # 5 000ms
}
```

10 - 10.0.0.20

```
metrics: %{
  enabled: true,
  ip_address: "127.0.0.1",
  port: 42069, # 42069
  registry_poll_period_ms: 10_000
}
```

10.0.0.1

```
metrics: %{
  enabled: false
}
```

10.0.0.1

```
# 10.0.0.1
curl http://<ip_address>:<port>/metrics

# 10
curl http://10.0.0.20:9090/metrics
```

10 10.0.0.20 10.0.0.1

Diameter/Gx 配置

配置

配置 Diameter 服务器 Gx 服务器 PCRF 服务器

配置

```
config :pgw_c,  
  diameter: %{  
    # Diameter 服务器 IP 地址  
    listen_ip: "0.0.0.0",  
  
    # OmniPGW 的 Diameter 服务器 Origin-Host  
    host: "omnipgw.epc.mnc001.mcc001.3gppnetwork.org",  
  
    # OmniPGW 的 Diameter 服务器 Origin-Realm  
    realm: "epc.mnc001.mcc001.3gppnetwork.org",  
  
    # PCRF 服务器  
    peer_list: [  
      %{  
        # PCRF Diameter 服务器  
        host: "pcrf.epc.mnc001.mcc001.3gppnetwork.org",  
  
        # PCRF 服务器  
        realm: "epc.mnc001.mcc001.3gppnetwork.org",  
  
        # PCRF IP 地址  
        ip: "10.0.0.30",  
  
        # 是否 PCRF 服务器  
        initiate_connection: true  
      }  
    ]  
  }  
}
```

□□

□□	□□	□□	□□
listen_ip	□□□□IP□	□	Diameter □□□□
host	□□□□FQDN□	□	OmniPGW □ Origin-Host□□□□ FQDN□
realm	□□□□□□	□	OmniPGW □ Origin-Realm
peer_list	□□	□	PCRF □□□□□

□□□□□□

□□	□□	□□	□□
host	□□□□FQDN□	□	PCRF Diameter □□
realm	□□□□□□	□	PCRF □
ip	□□□□IP□	□	PCRF IP □□
initiate_connection	□□	□	OmniPGW □□□□□ PCRF

FQDN □□

Diameter □□□□ FQDN□

```
# □□
host: "omnipgw.epc.mnc001.mcc001.3gppnetwork.org"

# □□
host: "omnipgw"           # □□ FQDN
host: "10.0.0.20"        # □□□□□ IP
```

3GPP □□□

```
<hostname>.epc.mnc<MNC>.mcc<MCC>.3gppnetwork.org
```

```
□□□
```

- omnigw.epc.mnc001.mcc001.3gppnetwork.org (MCC=001, MNC=001)
- pgw-c.epc.mnc260.mcc310.3gppnetwork.org (MCC=310, MNC=260 - □□ T-Mobile)

```
□□
```

```
□□ PCRF□
```

```
diameter: %{  
  listen_ip: "0.0.0.0",  
  host: "omnigw.epc.mnc001.mcc001.3gppnetwork.org",  
  realm: "epc.mnc001.mcc001.3gppnetwork.org",  
  peer_list: [  
    %{  
      host: "pcrf.epc.mnc001.mcc001.3gppnetwork.org",  
      realm: "epc.mnc001.mcc001.3gppnetwork.org",  
      ip: "10.0.0.30",  
      initiate_connection: true  
    }  
  ]  
}
```

```
□□ PCRF□□□□□
```

```
diameter: %{
  listen_ip: "0.0.0.0",
  host: "omnipgw.epc.mnc001.mcc001.3gppnetwork.org",
  realm: "epc.mnc001.mcc001.3gppnetwork.org",
  peer_list: [
    %{
      host: "pcrf-primary.epc.mnc001.mcc001.3gppnetwork.org",
      realm: "epc.mnc001.mcc001.3gppnetwork.org",
      ip: "10.0.1.30",
      initiate_connection: true
    },
    %{
      host: "pcrf-backup.epc.mnc001.mcc001.3gppnetwork.org",
      realm: "epc.mnc001.mcc001.3gppnetwork.org",
      ip: "10.0.2.30",
      initiate_connection: true
    }
  ]
}
```

PCRF 配置

```
diameter: %{
  listen_ip: "0.0.0.0",
  host: "omnipgw.epc.mnc001.mcc001.3gppnetwork.org",
  realm: "epc.mnc001.mcc001.3gppnetwork.org",
  peer_list: [
    %{
      host: "pcrf.epc.mnc001.mcc001.3gppnetwork.org",
      realm: "epc.mnc001.mcc001.3gppnetwork.org",
      ip: "10.0.0.30",
      initiate_connection: false # PCRF 配置
    }
  ]
}
```

配置 Diameter Gx 接口

S5/S8

GTP-C SGW-C

```
config :pgw_c,  
  s5s8: %{\br/>    # S5/S8 IPv4  
    local_ipv4_address: "10.0.0.20",  
  
    # IPv6  
    local_ipv6_address: nil,  
  
    # GTP-C 2123  
    local_port: 2123,  
  
    # GTP-C 500ms  
    # GTP-C  
    request_timeout_ms: 500,  
  
    # GTP-C 3  
    # = request_timeout_ms * request_attempts  
    request_attempts: 3  
  }  
}
```

□□

□□	□□	□□	□□
<code>local_ipv4_address</code>	□□□□IPv4□	□□	S5/S8 □□□ IPv4 □□
<code>local_ipv6_address</code>	□□□□IPv6□	<code>nil</code>	S5/S8 □□□ IPv6 □□□□□□
<code>local_port</code>	□□	<code>2123</code>	GTP-C □ UDP □□□□□□□ 2123□
<code>request_timeout_ms</code>	□□	<code>500</code>	□□□□□□□□□□□□
<code>request_attempts</code>	□□	<code>3</code>	□□□□□□□□□□

□□□□

- □□□ GTP-C □□ 2
- □□□ UDP
- □□□□□ 2123
- □□□ □ SGW-C □□

□□

□ **IPv4**□□□□□

```
s5s8: %{\n  local_ipv4_address: "10.0.0.20"\n}
```

IPv4 + IPv6 □□□

```
s5s8: %{\n  local_ipv4_address: "10.0.0.20",\n  local_ipv6_address: "2001:db8::20"\n}
```

□□□□□□□□□□

```
s5s8: %{
  local_ipv4_address: "10.0.0.20",
  local_port: 2124 # □□□□
}
```

□□□□□□

```
s5s8: %{
  local_ipv4_address: "10.0.0.20",
  request_timeout_ms: 1500, # □□□□ 1.5 □
  request_attempts: 3 # □□□□□ 4.5 □
}
```

□□□□□

S5/S8 □□□□□□□□□□□□□ GTP-C □□/□□□□□□□□□□□□□□□□□□□□□□

□□□□□□□□□

$$\square\square\square\square\square\square = \text{request_timeout_ms} \times \text{request_attempts}$$
$$\square\square\square 500\text{ms} \times 3 = 1.5 \text{ s}$$

□□□□□

□□□□	□□□□	□□□□□□
□□□ (<50ms)	200-300ms	600-900ms
□□ (50-150ms)	500ms□□□□□	1.5s
□□□ (>150ms)	1000-2000ms	3-6s
□□/□□□□	2000-3000ms	6-9s

Wireshark

- Wireshark “NetworkMinion” Wireshark
- Wireshark NetworkMinion
- Wireshark NetworkMinion

NetworkMinion

- NetworkMinion "NetworkMinion"
- NetworkMinion PCRF Diameter NetworkMinion 5012
- NetworkMinion Charging-Rule-Remove NetworkMinion

IP

IP

- IP/NetworkMinion
- NetworkMinion SGW-C
- NetworkMinion VRRP/HSRP

iptables

```
# NetworkMinion SGW-C NetworkMinion GTP-C
iptables -A INPUT -p udp --dport 2123 -s <sgw_c_network> -j ACCEPT
```

Gn/Gp (GGSN)

NetworkMinion

NetworkMinion GTP-C v1 NetworkMinion SGSN NetworkMinion GGSN NetworkMinion 2G/3G

□□□

```
config :pgw_c,  
  gn: %{\br/>    # Gn □□□□ IPv4 □□  
    local_ipv4_address: "10.0.0.20",  
  
    # □□□□ IPv6 □□□□□□ 2G/3G □□□□ IPv4□  
    local_ipv6_address: nil,  
  
    # GTP-C □□□□ S5/S8 □□□  
    local_port: 2123  
  },  
  
  # □ PC0 □□□□ DNS □□□□□□ S5/S8 □□□  
  dns: %{\br/>    primary_ipv4: {8, 8, 8, 8},  
    secondary_ipv4: {8, 8, 4, 4}  
  }  
}
```

□□

□□	□□	□□	□□
<code>local_ipv4_address</code>	□□□ □IPv4□	□□	Gn □□□ IPv4 □□□GGSN □□□
<code>local_ipv6_address</code>	□□□ □IPv6□	<code>nil</code>	Gn □□□ IPv6 □□□□□□□□□□
<code>local_port</code>	□□	<code>2123</code>	UDP □□□□ GTP-C v1□□ S5/S8 □ □□

DNS

IP	Port	IP	Port
primary_ipv4	53	{8, 8, 8, 8}	PCO DNS
secondary_ipv4	53	{8, 8, 4, 4}	PCO DNS

Ports

- GTP-C 1 (3GPP TS 29.060)
- UDP
- 2123 GTP-C v2
- SGSN

S5/S8

OmniPGW PGW 4G GGSN 2G/3G

- UDP 2123
- GTP
- IP 4G 2G/3G
- IP UPF/PFCP

Gn/Gp

Sxb/PFCP

Ports

PFCP PGW-U

配置

```
config :pgw_c,  
  sxb: %{  
    # PFCP 地址 IP  
    local_ip_address: "10.0.0.20",  
  
    # PFCP 端口  
    local_port: 8805  
  }
```

表

配置项	值	注释	说明
local_ip_address	10.0.0.20	IP	PFCP 地址
local_port	8805	端口	PFCP UDP 端口

配置

- 配置 **UPF** 地址和端口，格式为 `upf_selection` 地址 + 端口
- 配置 UPF 名称
 - 格式为 `"UPF-<ip>:<port>"`
 - 配置 PFCP 地址和 UPF 名称
 - 5 个 UPF
- UPF 名称格式为 `upf_selection` 地址 + **UPF** 名称
- 配置 UPF 名称和 DNS 名称 UPF

表

配置

```
sxb: %{  
  local_ip_address: "10.0.0.20"  
}
```

```
# [][] upf_selection [][] UPF [][]  
# - [][] [][] [][] "UPF-10.0.0.21:8805"  
# - [][] PFCP [][] [][] UPF [][]  
# - 5 [][] [][]
```

[][] **PFCP** [][]

```
sxb: %{  
  local_ip_address: "10.0.0.20",  
  local_port: 8806 # [][] PFCP [][]  
}
```

[] **UPF** [][] [][] [][]

```

sxb: %{
  local_ip_address: "10.0.0.20"
},
upf_selection: %{
  rules: [
    %{
      name: "IMS ",
      priority: 10,
      match_field: :apn,
      match_regex: ~r/^ims$/,
      upf_pool: [
        %{remote_ip_address: "10.0.1.21", remote_port: 8805,
weight: 100},
        %{remote_ip_address: "10.0.1.22", remote_port: 8805,
weight: 100}
      ]
    }
  ],
  fallback_pool: [
    %{remote_ip_address: "10.0.2.21", remote_port: 8805, weight:
100}
  ]
}
# 3 UPF 10.0.1.21 10.0.1.22 10.0.2.21 000000

```

DNS

```

sxb: %{
  local_ip_address: "10.0.0.20"
},
upf_selection: %{
  dns_enabled: true,
  dns_query_priority: [:ecgi, :tai],
  dns_suffix: "epc.3gppnetwork.org",
  fallback_pool: [
    %{remote_ip_address: "10.0.2.21", remote_port: 8805, weight:
100}
  ]
}
# DNS UPF

```

UPF 部署

UPF 部署时，UPF 部署 `upf_selection` 部署

部署

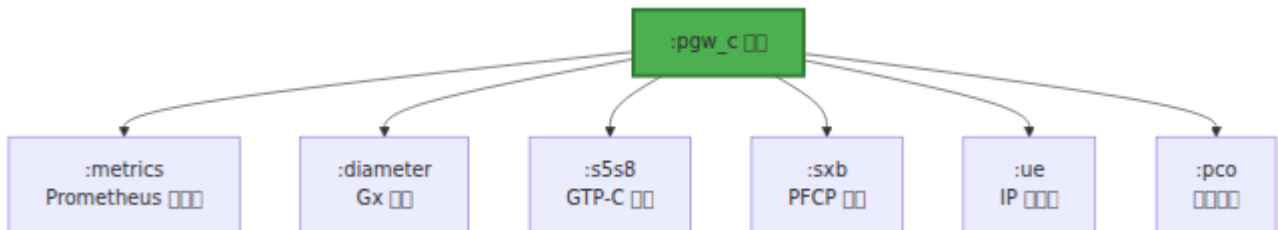
UPF 部署 `upf_selection` 部署

1. 部署 - 部署
2. **DNS** 部署 - 部署 UPF 部署
3. 部署 - 部署 DNS 部署

部署

1. 部署 - 部署
2. 部署 **DNS** 部署 - 部署 UPF 部署
3. 部署 - 部署 DNS 部署

UPF 部署



部署

部署

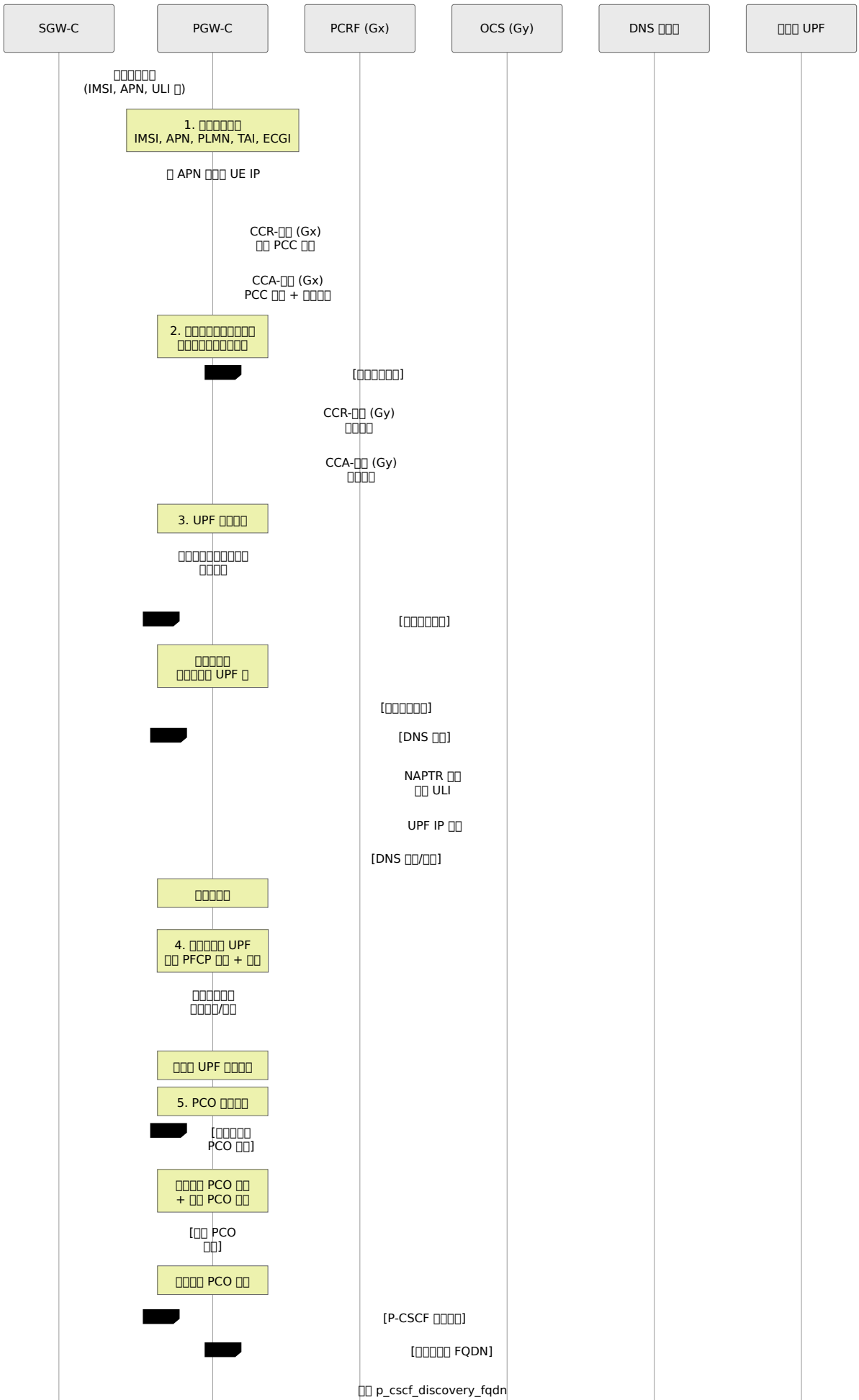
項目	説明	正規表現
:imsi	IMSI	^313380.*
:apn	APN / DNN	^internet\. ^ims\.
:serving_network_plmn_id	PLMN ID	^313380\$
:sgw_ip_address	SGW IP	^10\.100\..*
:uli_tai_plmn_id	TAI PLMN ID	^313.*
:uli_ecgi_plmn_id	E-UTRAN PLMN ID	^313.*

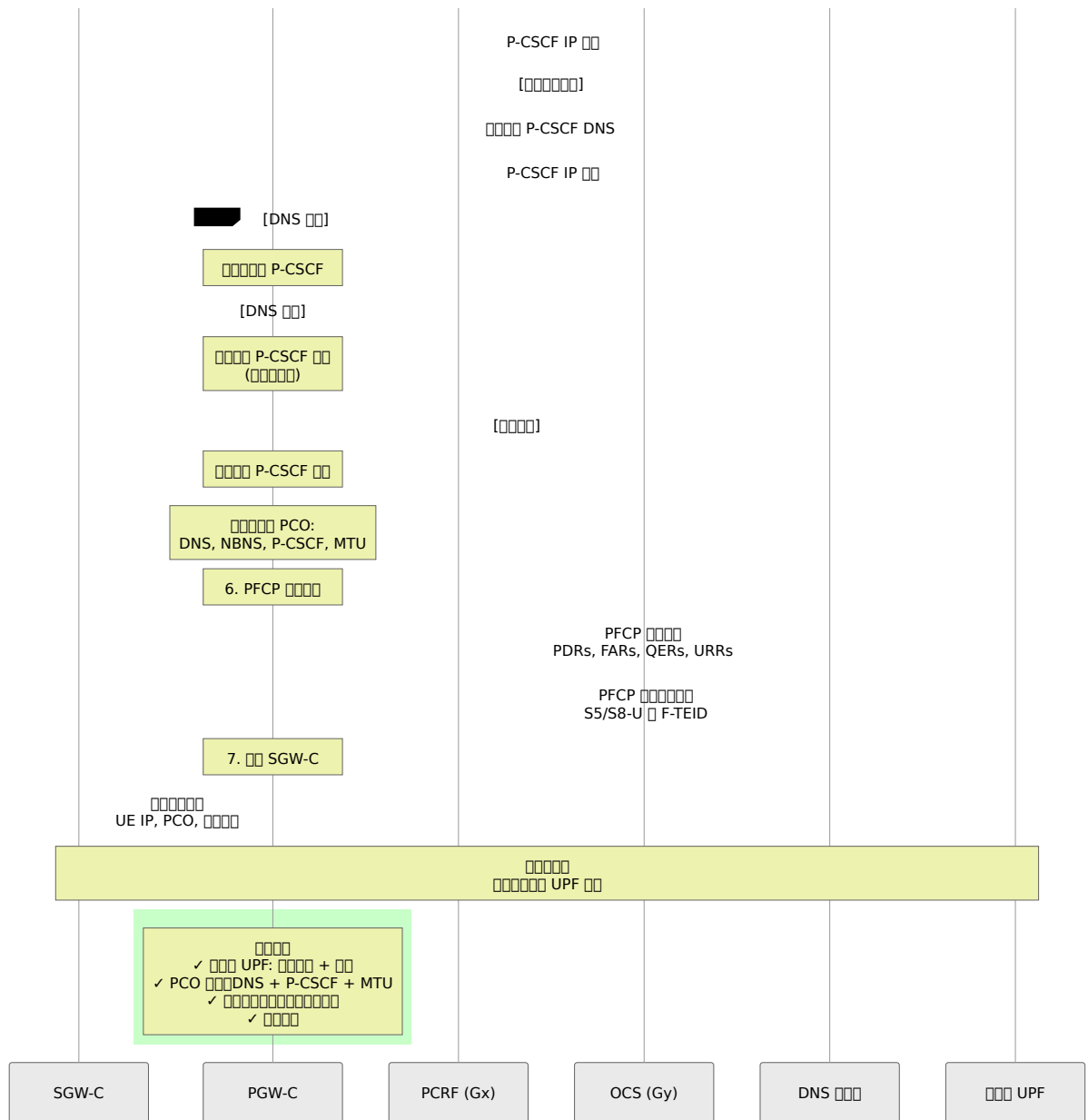
設定

項目	説明	値	単位
UPF	UPF		UPF
APN	APN	IMS/	
IMSI	IMSI		
DNS	MEC/DNS		DNS
		UPF	

□□□□□□□□

□□□□□□□□□□□□□□□□□□ UPF □□□ PCO □□□





□□□□□□

1. UPF □□□□□□

- □□□□□□□□□□ → DNS □□ → □□□□
- □□□□□□□□□□□□
- □□/□□□□□□□□□□□□
- □□ PFCP □□ □□□□ UPF □□□□□□□□

2. PCO □□□□□□

- □□ PCO □□ → P-CSCF DNS □□ → □□ PCO □❓❓❓
- □□□□□□□□□□□□□□□□□□□□□□□□□□□□

- 网络 PCO 网络 网络 PCO 网络

3. P-CSCF 网络

- 网络 FQDN → 网络 DNS 网络 → 网络 PCO → 网络 PCO
- 网络 P-CSCF 网络 网络

4. 网络

- PCRF 网络 + 网络=1网络
- OCS 网络
- PGW-C 网络 CCR-网络
- 网络 Diameter Gx 网络 网络 Diameter Gy 网络 网络

网络

网络 UPF 网络

```

config :pgw_c,
  # PFCP [] - [] UPF [] upf_selection []
  sxb: %{
    local_ip_address: "127.0.0.20"
  },

  # UPF [] - [] UPF []
  upf_selection: %{
    # [] DNS []
    dns_enabled: false,
    dns_query_priority: [:ecgi, :tai, :rai, :sai, :cgi],
    dns_suffix: "epc.3gppnetwork.org",
    dns_timeout_ms: 5000,

    # []
    rules: [
      # [] 1[]IMS [] - []
      %{
        name: "IMS []",
        priority: 20,
        match_field: :apn,
        match_regex: "^ims",
        upf_pool: [
          weight: 80,
          %{remote_ip_address: "10.100.2.21", remote_port: 8805,
          weight: 20}
          %{remote_ip_address: "10.100.2.22", remote_port: 8805,
          weight: 20}
        ]
      },

      # [] 2[] APN
      %{
        name: "[]",
        priority: 15,
        match_field: :apn,
        match_regex: "^(enterprise|corporate)\.apn",
        upf_pool: [
          weight: 100,
          %{remote_ip_address: "10.100.3.21", remote_port: 8805,
          weight: 100}
        ]
      },

      # [] 3[] - []

```

```

    %{
      name: "互联网",
      priority: 5,
      match_field: :apn,
      match_regex: "^internet",
      upf_pool: [
        %{remote_ip_address: "10.100.1.21", remote_port: 8805,
weight: 33},
        %{remote_ip_address: "10.100.1.22", remote_port: 8805,
weight: 33},
        %{remote_ip_address: "10.100.1.23", remote_port: 8805,
weight: 34}
      ]
    }
  ],

  # 本地 - 本地 DNS 服务器
  fallback_pool: [
    %{remote_ip_address: "127.0.0.21", remote_port: 8805,
weight: 100}
  ]
}

```

互联网

本地

- 本地 DNS 服务器 `upf_selection` 本地 UPF 服务器
- 本地 DNS 服务器 UPF 服务器
- 本地 DNS 服务器 `upf_pool` 本地 UPF 服务器
- 本地 DNS 服务器 `fallback_pool` 本地
- 本地 **DNS** 本地 DNS 服务器
- 本地 DNS 服务器 UPF 服务器
- 本地 DNS 服务器 UPF 本地 5 本地

本地

- 本地 `sxb.peer_list` 本地
- 本地 `selection_list`

- 每个 UPF 都有一个 `upf_selection` 属性

UPF 属性

1. 每个 UPF 属性

- `upf_selection` = PCF 属性 + 最多 3 个属性
- 每个 UPF 属性
- 每个 UPF 属性 `upf_selection` 属性

2. 每个/每个 `weight: 0` 属性 UPF

- 每个 **UPF** 属性 `> 0` 属性
- 每个 **UPF** 属性 `== 0` 属性 UPF 属性
- 每个 UPF 属性 `weight: 1`

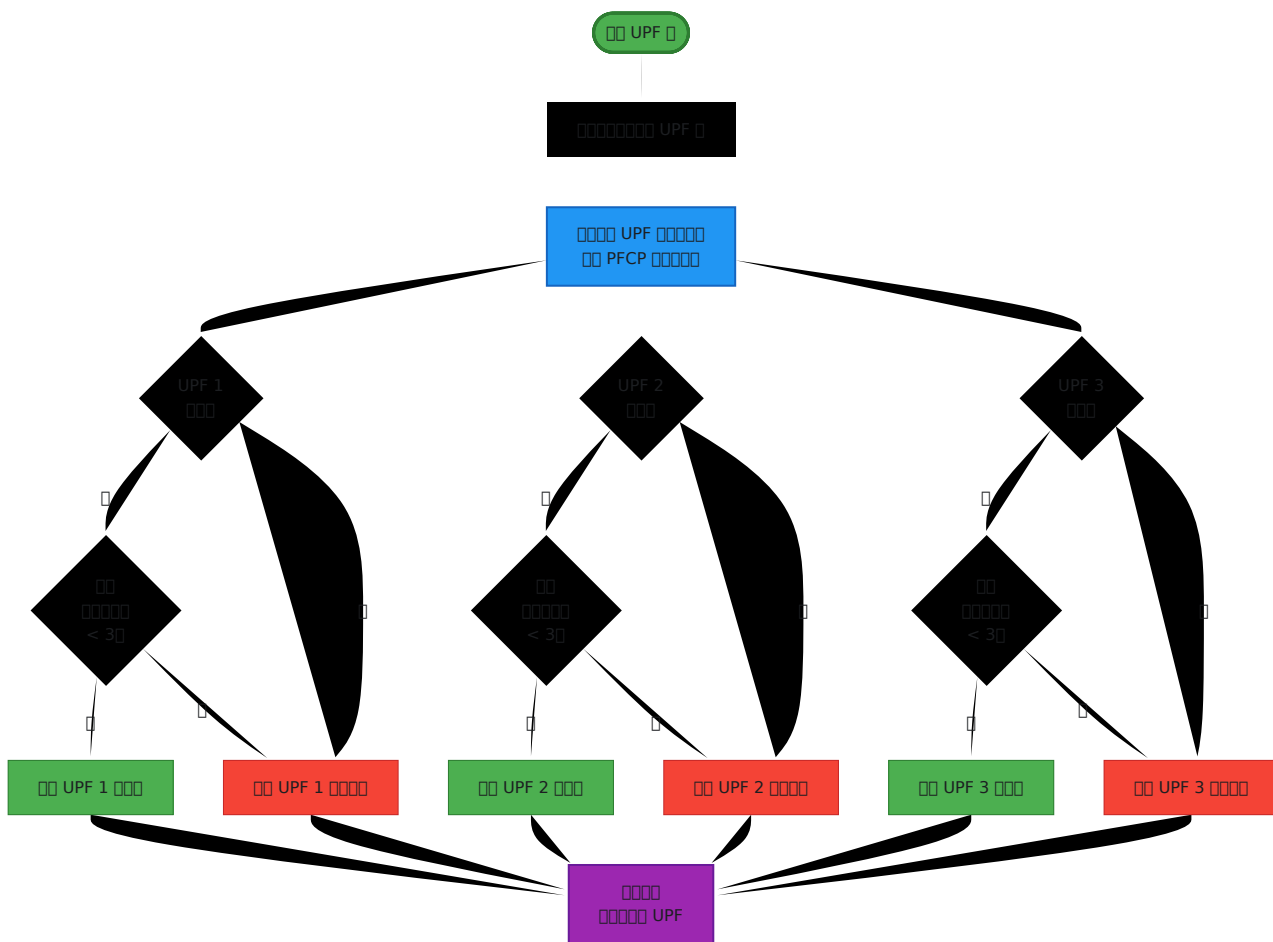
3. 每个/每个/每个/每个/每个/每个 UPF

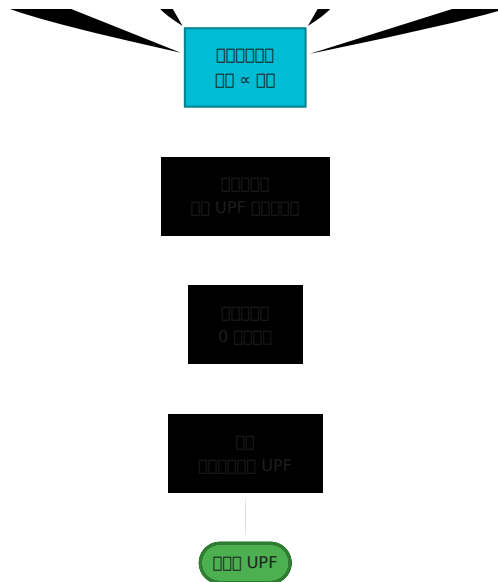
- 每个/每个/每个/每个/每个/每个 70% 属性 .21 20% 属性 .22 10% 属性 .23
- 每个/每个/每个 UPF 属性
- 属性 = 属性

4. 每个/每个/每个 UPF 属性

- 每个/每个/每个 `"UPF-<ip>:<port>"`
- 每个/每个/每个 PCF 属性 5 属性
- 每个/每个 UPF 属性

□□□□□□□□/□□





0000000000

00 [

UPF-A: 00 50, 00 ✓

UPF-B: 00 30, 00 ✓

UPF-C: 00 20, 00 ✓

]

0000050 + 30 + 20 = 100

000000

UPF-A: 0-49 (50%)

UPF-B: 50-79 (30%)

UPF-C: 80-99 (20%)

0000063 → 00 UPF-B

0000015 → 00 UPF-A

0000091 → 00 UPF-C

00/0000000000

□□□□[
UPF-A: □□ 100, □□ ✓ (□□)
UPF-B: □□ 0, □□ ✓ (□□)
]

□□ 1□UPF-A □□
→ □□□□□□[UPF-A: 100]
→ □□□□□ UPF-A

□□ 2□UPF-A □□
→ □□□□□□□ UPF
→ □□□□□[UPF-B: 1]
→ □□□□□□□□□□ UPF-B
→ □□□“□□□□□ UPF □□□□□□□□□ UPF”

□□ 3□□□□□□□□
→ □□□□□ UPF
→ □□□□□□□[UPF-A: 100, UPF-B: 0]
→ □□□□□□□□□□□□□□□□□□
→ □□□“□□□□□□□□ UPF□□□□□□□□□□□□□□□□□□”

□□□□□□□□

```

# 25%
upf_pool: [
  %{remote_ip_address: "10.0.1.1", remote_port: 8805, weight: 1},
  %{remote_ip_address: "10.0.1.2", remote_port: 8805, weight: 1},
  %{remote_ip_address: "10.0.1.3", remote_port: 8805, weight: 1},
  %{remote_ip_address: "10.0.1.4", remote_port: 8805, weight: 1}
]

# 90% / 10%
upf_pool: [
  %{remote_ip_address: "10.0.1.21", remote_port: 8805, weight:
90},
  %{remote_ip_address: "10.0.1.22", remote_port: 8805, weight: 10}
]

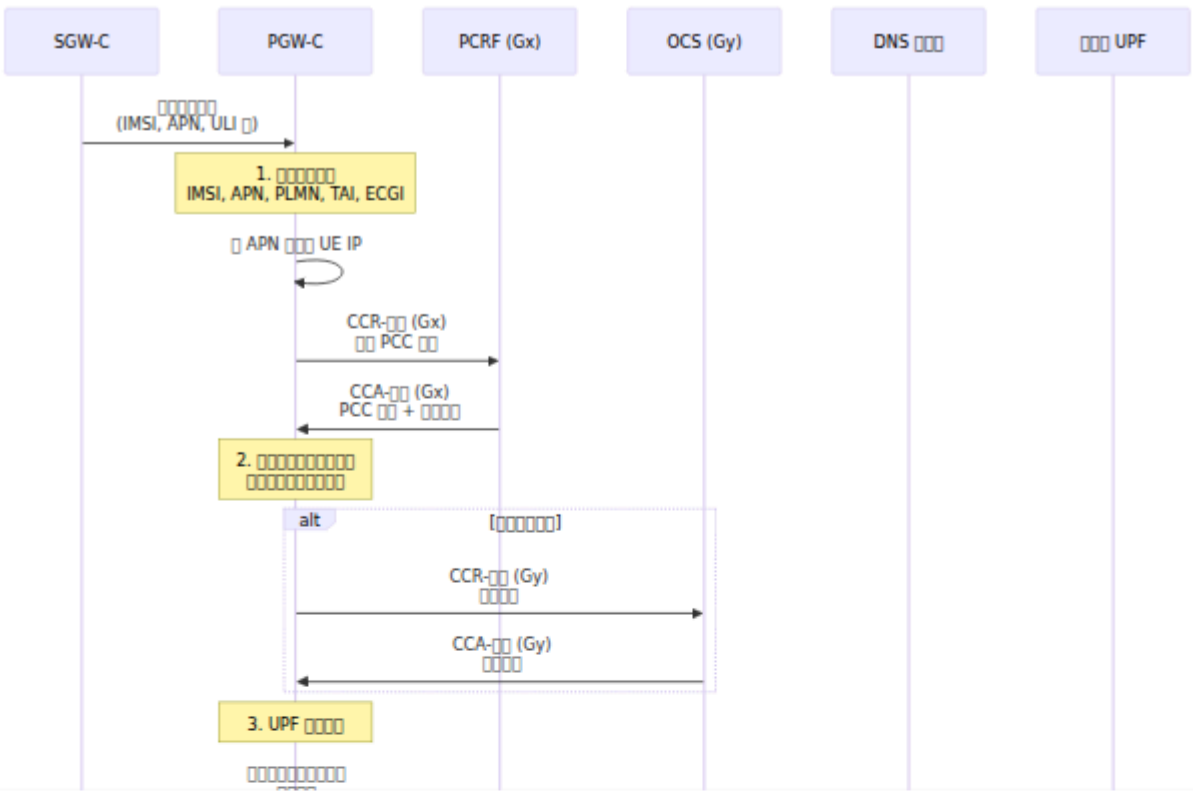
# 100% 0%
upf_pool: [
  %{remote_ip_address: "10.0.1.21", remote_port: 8805, weight:
100}, #
  %{remote_ip_address: "10.0.1.22", remote_port: 8805, weight: 0}
#
]

#
upf_pool: [
  %{remote_ip_address: "10.0.1.1", remote_port: 8805, weight:
100}, #
  %{remote_ip_address: "10.0.1.2", remote_port: 8805, weight: 0},
# 1
  %{remote_ip_address: "10.0.1.3", remote_port: 8805, weight: 0}
# 2
]
# 100% 50/50%

# A/B 50% / 50%
upf_pool: [
  %{remote_ip_address: "10.0.1.100", remote_port: 8805, weight:
50}, #
  %{remote_ip_address: "10.0.1.200", remote_port: 8805, weight:
50} #
]

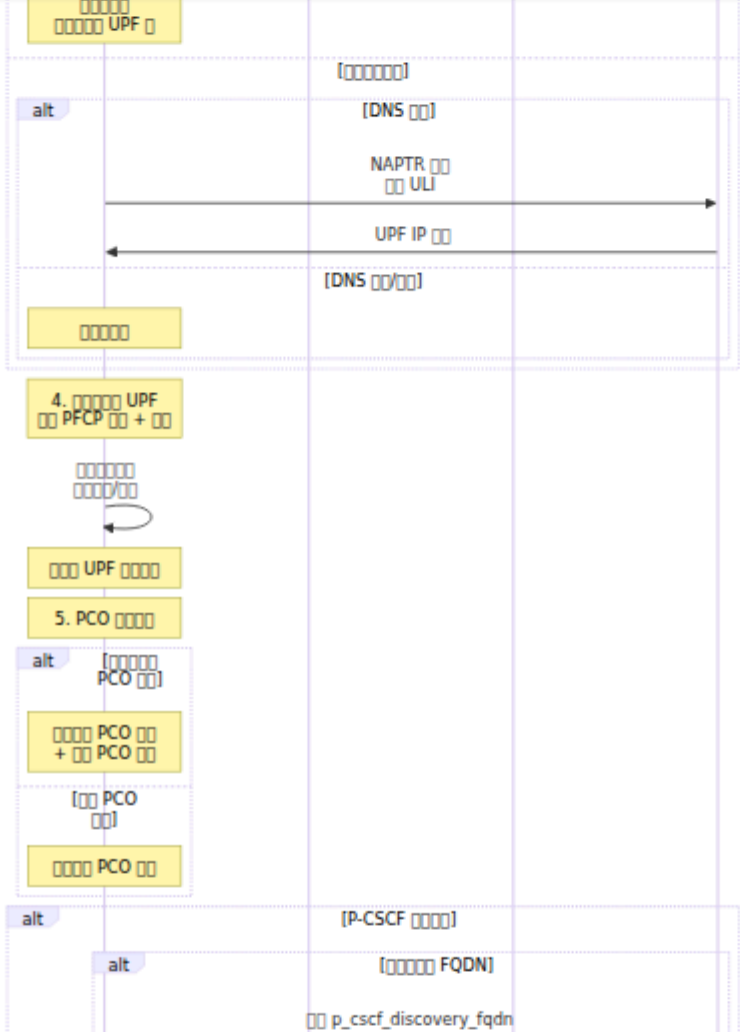
```

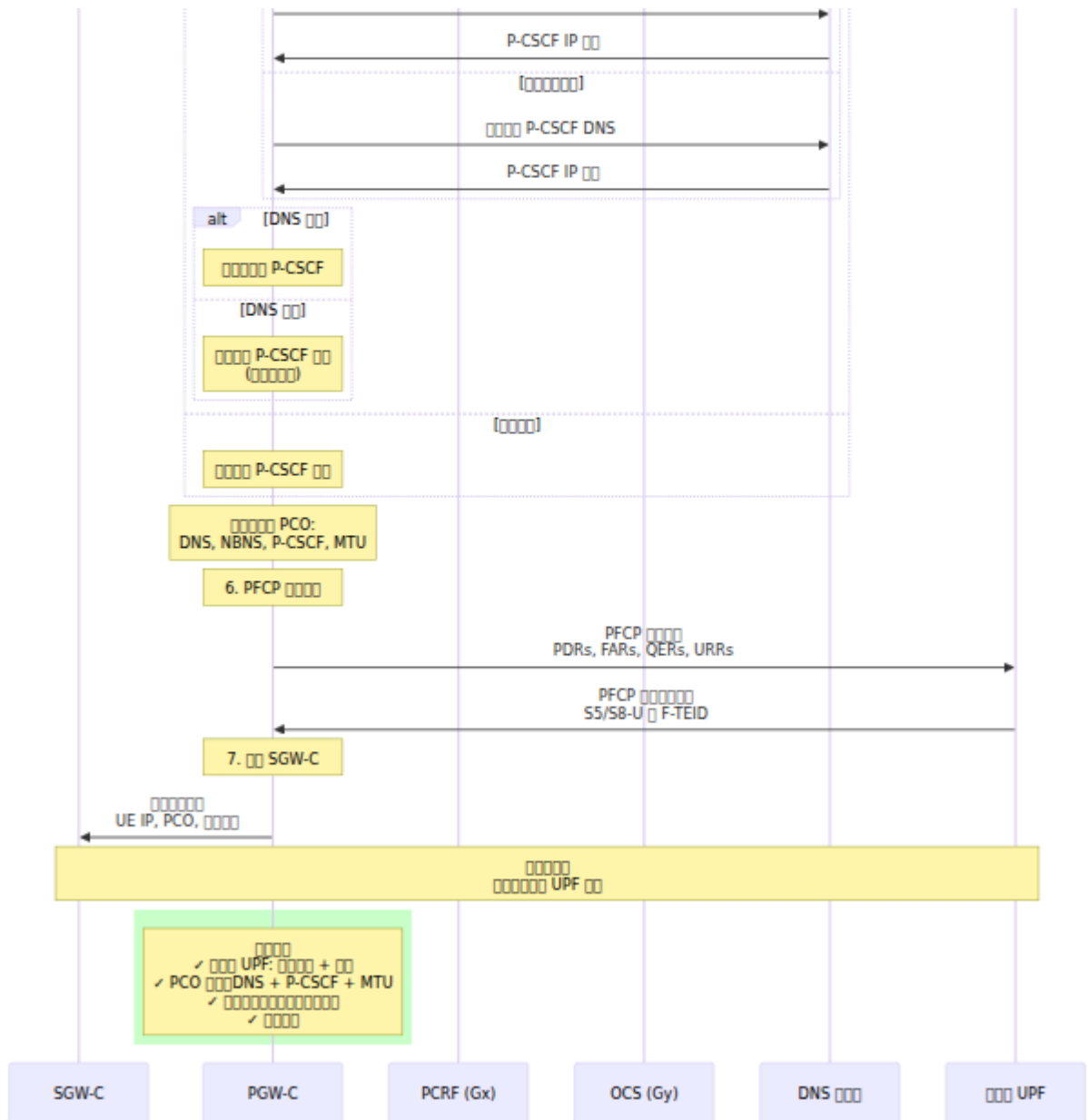

PCO □□□□□□



ore OmniCore OmniCall OmniRAN OmniCharge Platform A

5GC





PCO

1. **PCO**
2. **P-CSCF DNS**
3. **PCO** /

IMS DNS

```

IMS 配置“IMS 配置”配置
├─ DNS 配置
├─ P-CSCF配置 DNS 配置 p_cscf_discovery_fqdn
│   └─ DNS 配置
└─ MTU配置

```

```

配置“配置”配置
├─ DNS 配置 192.168.1.10 192.168.1.11
├─ P-CSCF配置
└─ MTU配置 1500

```

```

配置
├─ DNS 配置
├─ P-CSCF配置 DNS配置
└─ MTU配置

```

配置 PCO 配置

- primary_dns_server_address - DNS 配置 IP
- secondary_dns_server_address - DNS 配置 IP
- primary_nbns_server_address - WINS 配置 IP
- secondary_nbns_server_address - WINS 配置 IP
- p_cscf_ipv4_address_list - P-CSCF 配置 IP 配置 IMS - PCO 配置 P-CSCF 配置
- ipv4_link_mtu_size - MTU 配置

配置 P-CSCF 配置

PCO 通过 UPF 连接到 P-CSCF

- `p_cscf_discovery_fqdn` - DNS 中 P-CSCF 的 FQDN
"pcscf.mnc380.mcc313.3gppnetwork.org"

过程如下

- PGW-C 通过 DNS 获取 FQDN
- DNS 返回 P-CSCF IP
- 通过 P-CSCF 连接到 PCO 的 UE
- DNS 返回 PCO 的 `p_cscf_ipv4_address_list` PCO
- 通过 P-CSCF 连接到 PCO

过程如下

- IMS APN** - IMS 连接到 P-CSCF
- P-CSCF
- DNS 中 UE 连接到 P-CSCF
- DNS 返回 P-CSCF

过程如下 **P-CSCF** 与 **IMS**

```

rules: [
  %{
    name: "IMS []",
    priority: 20,
    match_field: :apn,
    match_regex: "^ims",
    upf_pool: [
      %{remote_ip_address: "10.100.2.21", remote_port: 8805,
weight: 80},
      %{remote_ip_address: "10.100.2.22", remote_port: 8805,
weight: 20}
    ],
    # P-CSCF [] DNS [] P-CSCF []
    # DNS [] FQDN [] P-CSCF IP
    p_cscf_discovery_fqdn: "pcscf.mnc380.mcc313.3gppnetwork.org",
    # IMS [] P-CSCF [] DNS []
    pco: %{
      p_cscf_ipv4_address_list: ["10.101.2.100", "10.101.2.101"]
      # DNS[]NBNS[]MTU [] pco []
    }
  }
]

```

[][][] **DNS** [][]

```

rules: [
  %{
    name: "PCO",
    priority: 15,
    match_field: :apn,
    match_regex: "^(enterprise|corporate)\.apn",
    upf_pool: [
      %{remote_ip_address: "10.100.3.21", remote_port: 8805,
weight: 100}
    ],
    # PCO DNS MTU
    pco: %{
      primary_dns_server_address: "192.168.1.10",
      secondary_dns_server_address: "192.168.1.11",
      ipv4_link_mtu_size: 1500
      # P-CSCF/NBNS PCO
    }
  }
]

```

PCO

```

rules: [
  %{
    name: "IoT APN - IoT",
    priority: 10,
    match_field: :apn,
    match_regex: "^iot\\.m2m",
    upf_pool: [
      %{remote_ip_address: "10.100.5.21", remote_port: 8805,
weight: 100}
    ],
    # IoT PCO
    pco: %{
      primary_dns_server_address: "8.8.8.8",
      secondary_dns_server_address: "8.8.4.4",
      primary_nbns_server_address: "10.0.0.100",
      secondary_nbns_server_address: "10.0.0.101",
      p_cscf_ipv4_address_list: [], # IoT P-CSCF
      ipv4_link_mtu_size: 1280 # MTU
    }
  }
]

```

IoT

- **IMS/VoLTE** P-CSCF
- **APN** DNS
- **IoT/M2M** DNS MTU
- DNS
-

DNS **UPF**

ULI UPF DNS NAPTR DNS `upf_selection`

PFCP UPF PFCP

```

upf_selection: %{
  # Enable DNS
  dns_enabled: true,

  # Query priority
  dns_query_priority: [:ecgi, :tai, :rai, :sai, :cgi],

  # 3GPP NAPTR DNS
  dns_suffix: "epc.3gppnetwork.org",

  # DNS timeout
  dns_timeout_ms: 5000,

  # ...
}

```

DNS

1. Enable DNS
2. Enable UE DNS NAPTR
 - ECGI `eci-<hex>.ecgi.epc.mnc<MNC>.mcc<MCC>.epc.3gppnetwork.org`
 - TAI `tac-lb<hex>.tac-hb<hex>.tac.epc.mnc<MNC>.mcc<MCC>.epc.3gppnetwork.org`
 - RAI/SAI/CGI 3GPP TS 23.003
- 3.
4. DNS
- 5.

DNS

```

; NAPTR PLMN 313-380 TAC 100
tac-lb64.tac-hb00.tac.epc.mnc380.mcc313.epc.3gppnetwork.org IN
NAPTR 10 50 "a" "x-3gpp-upf:x-sxb" "" upf-edge-1.example.com.

; UPF A
upf-edge-1.example.com IN A 10.100.1.21

```


- 0000000000
- 0000000000

0000

00/00000000 weight: 0 000

1. 000000 UPF
2. 000 000000 > 000 000000 == 00
3. 0000000000 UPF000000 UPF
4. 00000000000000000000 UPF000000 10
5. 00000000 UPF0000000000

000000000000 > 000

1. 00000000 UPF
2. 0000 UPF 0000000000
3. 00000000 UPF0000000000

000000

```
[debug] 0000 UPF 002/3 00 UPF01 000
[info] 0000 UPF 00000000 UPF01 00 UPF0000 0 00 10
[warning] 00000000 UPF000 3 00000000000000
```

00 **UPF** 00

000000

```

# 检查 UPF 是否健康
iex> PGW_C.PFCP_Node.is_peer_healthy?({10, 100, 1, 21})
true

# 获取 UPF 健康状态
iex> PGW_C.PFCP_Node.get_peer_health({10, 100, 1, 21})
%{
  associated: true,
  missed_heartbeats: 0,
  healthy: true,
  registered: true
}

```

Web UI

- 访问 `/upf_selection`
- 检查 UPF 是否健康
- 检查 UPF 是否健康
- 检查 UPF 是否健康
- 检查 UPF 是否健康

配置

1. `upf_selection` 配置 UPF 是否健康

```

upf_selection: %{
  rules: [
    %{
      name: "internet",
      priority: 10,
      match_field: :apn,
      match_regex: "^internet",
      upf_pool: [
        %{remote_ip_address: "10.100.1.21", remote_port: 8805,
weight: 100}
      ]
    }
  ],
  fallback_pool: [
    %{remote_ip_address: "10.100.2.21", remote_port: 8805,
weight: 100}
  ]
}
# UPF
# - 5
# -
# -

```

2. **UPF** `weight: 0` `weight: 0`

```

upf_pool: [
  %{remote_ip_address: "10.1.1.1", remote_port: 8805, weight:
100}, #
  %{remote_ip_address: "10.1.1.2", remote_port: 8805, weight:
0} #
]

```

3. **Web UI** `UPF`

4. `3`

UPF

`PGW-C` `DNS` `UPF` `upf_selection`

□□□□

□□□□□□□□□□□□ DNS□□□□□□ UPF □□□□□□□□

1. □□ **PFCP** □□□□□□ UPF □□□□□□□□
2. □□ **PFCP** □□□□□□ UPF □□ PFCP □□
3. □□□□□□□□□□□□ UPF □□□□□□□□□□□□
4. □□□□□□□□□□□□□□□□10 □□□□
5. □□□□□□□□□□ UPF □□□□□□

□□ **UPF** □□□□□

□□□□□ UPF □□□□□□□□□□□□□□

```
%{
  name: "Dynamic-UPF-<IP>",                                     # □□□"Dynamic-UPF-10-100-
  1-21"
  remote_ip_address: <discovered_ip>,                           # □□ DNS □□□□ IP
  remote_port: 8805,                                             # □□ PFCP □□□□□□□□
  initiate_pfcg_association_setup: true,                       # PGW-C □□□□
  heartbeat_period_ms: 10_000                                   # 10 □□□□□
}
```

| □□□□□ UPF □□□□□□□□□□□ **upf_selection** □□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□□

□□□□ **DNS** □□□□ **UPF**

```
# DNS □□□□□□ upf-edge-2.example.com -> 10.200.5.99
# □ UPF □□□□□□ upf_selection □□□□

# □□□□□□□□
# 1. □□□□□□□□ UPF 10.200.5.99
# 2. □□□□"UPF {10, 200, 5, 99} □□□□□□□□□□□□□□..."
# 3. □ 10.200.5.99:8805 □□ PFCP □□□□□□□□
# 4. □□ UPF □□□□□□□□□□□□□□□□□□
# 5. □□ UPF □□□□□□□□□□□□□□□□□□□□□□
```

□□

□ □□□□□□□□□ DNS □ UPF □□□□□□□□□□□□

□ **

PGW-C CDR (CDR) 說明

PGW-C 說明

OmniPGW 及 Omnitouch 說明

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說明

PGW-C CDR 說明 PGW-C CDR 說明

SGW-C CDR 說明 EPC 說明

說明

- CSV 說明 - 說明
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- 3GPP - 3GPP TS 32.251 PS TS 32.298 CDR
- 3GPP - 3GPP TS 32.251 PS TS 32.298 CDR

CDR

Field	Description
CDR	CDR
CDR	CDR
CDR	CDR
CDR	CDR
CDR	CDR
CDR	CDR

CDR

CDR

```
<epoch_timestamp>
```

CDR

```
1726598022
```

CDR Unix

CDR

CDR

- PGW-C: `/var/log/pgw_c/cdrs/`

`cdr_directory` `config/runtime.exs`

CDR

```
# CDR  
# HH:MM:SS (unix_timestamp)  
# HH:MM:SS (unix_timestamp)  
# <gateway_name>  
#  
epoch,imsi,event,charging_id,msisdn,ue_imei,timezone_raw,plmn,tac,eci
```

- CDR Unix
 - Unix
 - PGW-C `pgw_name`
 - CSV
-

CDR 表

表名

列名	データ型	長さ	説明
0	epoch	整数	UNIX 時刻
1	imsi	文字列	IMSI
2	event	文字列	CDR イベント名 "default_bearer_start"
3	charging_id	整数	充電 ID
4	msisdn	文字列	MSISDN ISDN 番号
5	ue_imei	文字列	UE IMEI
6	timezone_raw	文字列	UE 時刻領域
7	plmn	文字列	PLMN
8	tac	文字列	TAC
9	eci	文字列	E-UTRAN セル ID
10	sgw_ip	文字列	SGW-C S5/S8 インターフェイス IP
11	ue_ip	文字列	UE IP アドレス IPv4 IPv6
12	pgw_ip	文字列	PGW-C S5/S8 インターフェイス IP
13	apn	文字列	APN
14	qci	整数	QoS プロファイル ID

OID	Object Name	Value	Description
15	octets_in	INTEGER	Number of octets received
16	octets_out	INTEGER	Number of octets transmitted

CDR Objects

Objects

CDR Objects

Object Name	Value	Value	Description
default_bearer_start	INTEGER	INTEGER	Start of default bearer
default_bearer_update	INTEGER	INTEGER	Update of default bearer
default_bearer_end	INTEGER	INTEGER	End of default bearer

Objects

- `default` - Default PDN objects
- `dedicated` - Dedicated PDN objects

Objects

```

default_bearer_start      - INTEGER
default_bearer_update    - INTEGER
default_bearer_end       - INTEGER
dedicated_bearer_start   - INTEGER
dedicated_bearer_update  - INTEGER
dedicated_bearer_end     - INTEGER

```

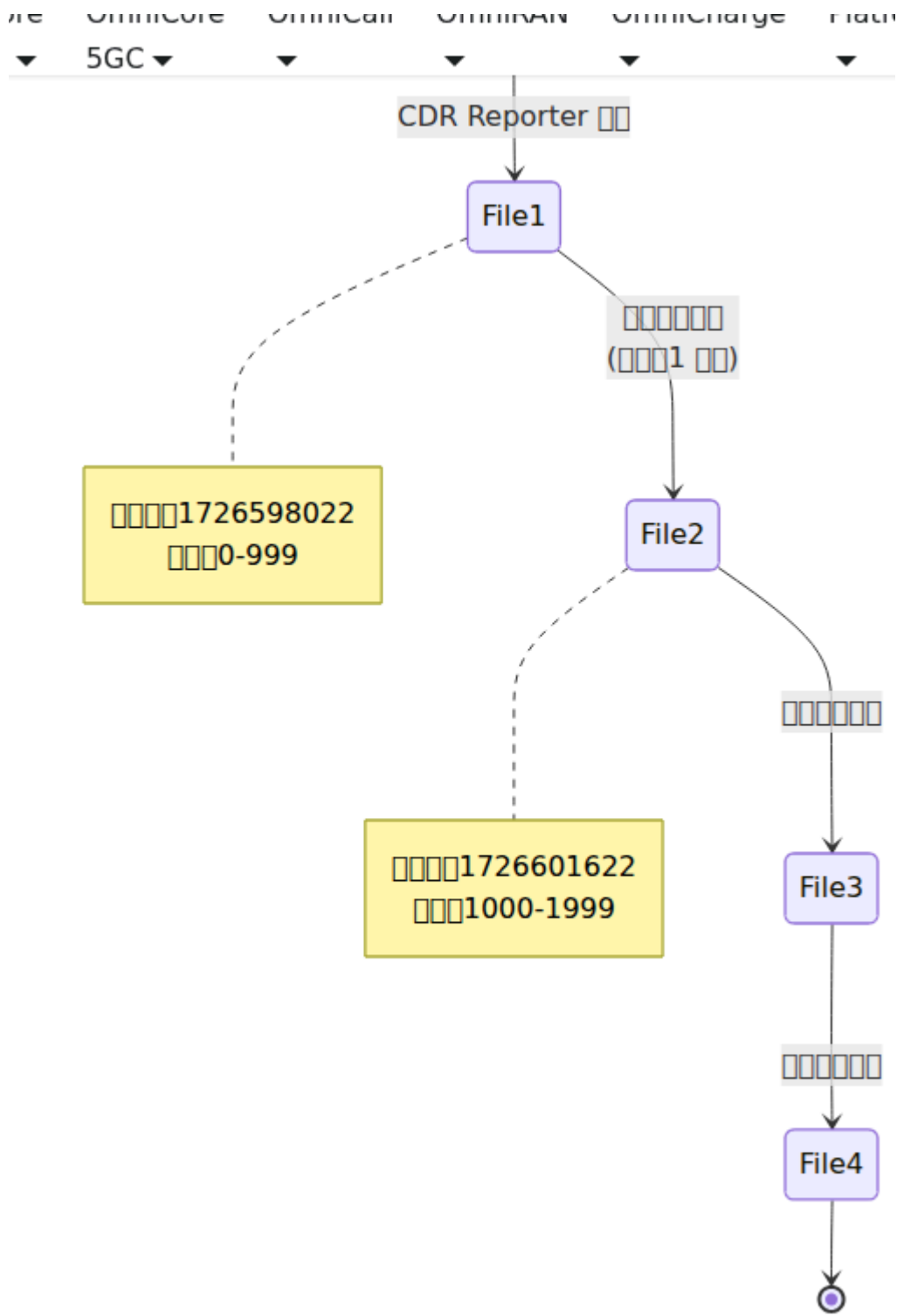
□□□□

□□ **CDR** □□

```
# □□ CDR □□  
# □□□□□□18:53:42 (1726598022)  
# □□□□□□19:53:42 (1726601622)  
# □□□□sgw-c-prod-01  
# epoch,imsi,event,charging_id,msisdn,ue_imei,timezone_raw,plmn,tac,e  
1726598022,310260123456789,default_bearer_start,12345,15551234567,123  
1726598322,310260123456789,default_bearer_update,12345,15551234567,12  
1726598622,310260123456789,default_bearer_update,12345,15551234567,12  
1726598922,310260123456789,default_bearer_end,12345,15551234567,12345
```

□□□□

CDR □□□□□□□□□□□□□□□□



000000

1. 0000 CDR 00
2. 0000000000000000
3. 00000000
4. 000 CDR 000000

□□

□□□□

PGW-C CDR □□□ `config/runtime.exs` □□□□

□□	□ □	□□	□□□	□□□
<code>pgw_name</code>	□ □ □	PGW □□□□ □□□□ □ CDR □□□	"omni- pgw01"	◆◆◆□□□□□□□ ID
<code>cdr_file_duration</code>	□ □	□□□□ □□□□ □□	3600000	3600000□1 □□□
<code>cdr_directory</code>	□ □ □	CDR □□□□ □□	"/tmp/pgw_c"	<code>/var/log/pgw_c/cdrs</code>
<code>usage_report_interval</code>	□ □	URR □□□□ □□□□ - PGW- U □□ □□□□ □□□	60000	60000□1 □□□

□□□□

□□□□ (**config/runtime.exs**):

```

config :pgw_c,
  # CDR
  pgw_name: "omni-pgw01",
  cdr_file_duration: 3_600_000,           # 1
  cdr_directory: "/var/log/pgw_c/cdrs",

  # URR PGW-U
  usage_report_interval: 60_000          # 60

```

PGW-C:

```

config :pgw_c,
  pgw_name: "pgw-c-prod-01",
  cdr_file_duration: 3_600_000,           # 1
  cdr_directory: "/var/log/pgw_c/cdrs",
  usage_report_interval: 60_000          # 1

```

PGW-C:

```

config :pgw_c,
  pgw_name: "pgw-c-dev",
  cdr_file_duration: 300_000,             # 5
  cdr_directory: "/tmp/pgw_c_cdrs",
  usage_report_interval: 30_000          # 30

```

PGW-C:

```

config :pgw_c,
  pgw_name: "pgw-c-prod-heavy",
  cdr_file_duration: 1_800_000,          # 30
  cdr_directory: "/mnt/fast-storage/cdrs",
  usage_report_interval: 300_000         # 5

```

URR

PGW-C **PFCP URNs** PGW-U URN PGW-U CDR

URR

1. `usage_report_interval` PFCP
2. PGW-C URR
3. PGW-U
4. `bearer_update` CDR
5. `bearer_end` CDR

`usage_report_interval: 60_000`

- PGW-U 60
- 60 CDR
-

URR

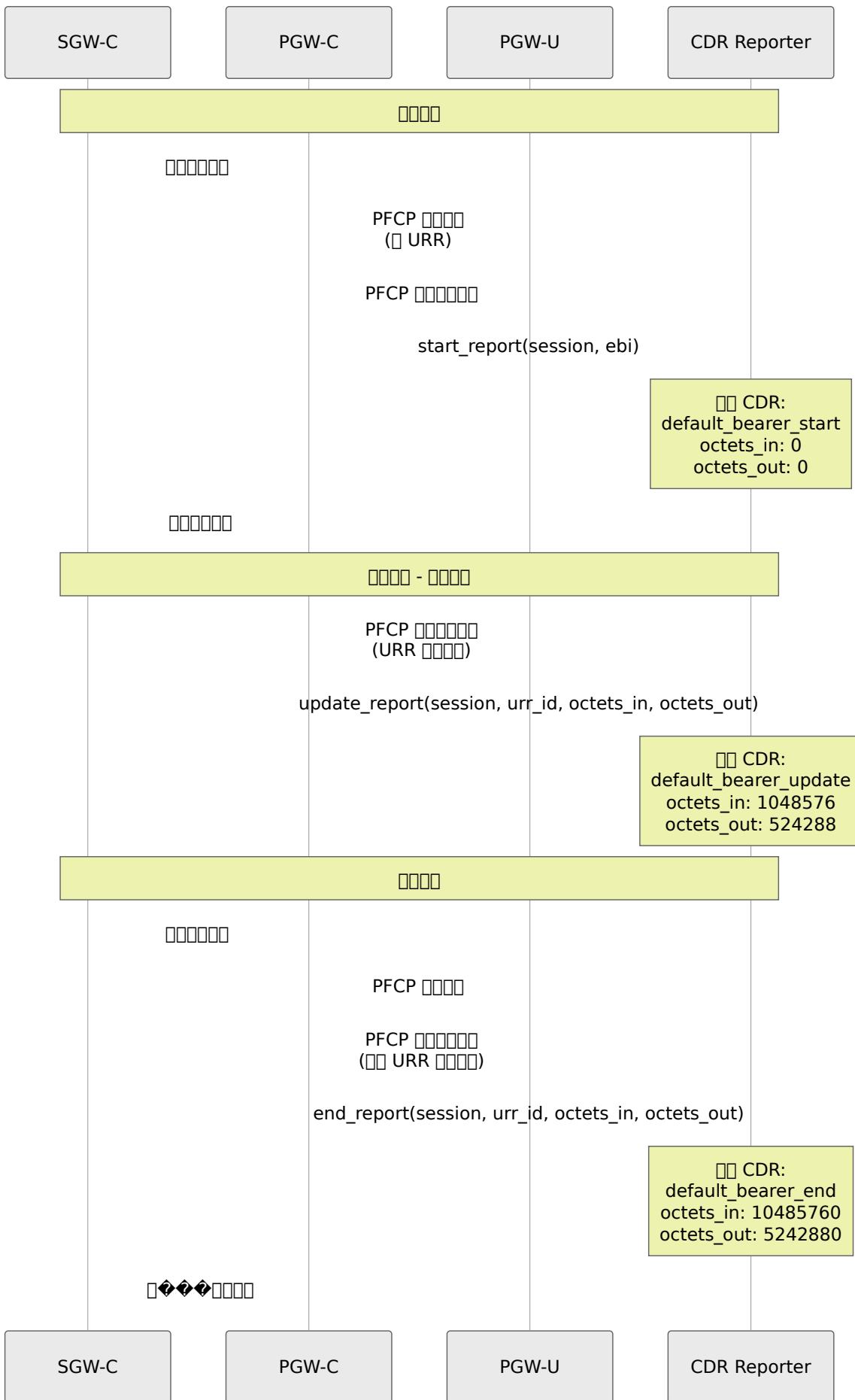
```
# lib/core/session/types.ex
defmodule PGW_C.Session.Types.URR do
  typedstruct do
    field :urr_id, non_neg_integer()
    field :measurement_method, :duration | nil
    field :reporting_triggers, :time_threshold | nil
    field :time_threshold, non_neg_integer() | nil #
  end
end
```

PFCP URR PFCP `lib/core/session/impl/procedures.ex:468`
URR

CDR

CDR

PGW-C CDR



CDR 0000

1. 0000

- 000 0000000000
- 000 000000000000
- **octets_in** 0
- **octets_out** 0

2. 0000

- 000 0 PGW-U 00 PFCP 00000000URR 00000
- 000 0000000000
- **octets_in** 0000000000000000
- **octets_out** 0000000000000000
- 000 URR 0000000000 `usage_report_interval` 000

3. 0000

- 000 0 PGW-U 00 PFCP 000000000000000000
- 000 0000000000000000
- **octets_in** 00000000
- **octets_out** 00000000

00000000

1. epoch00000

000 Unix 0000000000

000 CDR 00000000

000

2. imsi

15

MCCMNC + MSIN

310260123456789



MCC MNC MSIN

(310) (260) (123456789)

UE

3. event CDR

<bearer_type>_bearer_<event>

- default_bearer_start
- default_bearer_update
- default_bearer_end
- dedicated_bearer_start
- dedicated_bearer_update
- dedicated_bearer_end

- EBI EPS ID LBI ID default
- EBI LBI dedicated

EBI LBI

4. charging_id

32

12345

PGW-C

- SGW PGW
- Gy/Gz
-

5. msisdn

E.164

ISDN

+

15551234567



CC

(1) (5551234567)

UE MME HSS

6. ue_imei

IMEI 15

TAC 8 + SNR 6 + Spare 1

IMEI

IMEI

123456789012345



TAC

SNR S

UE MME

7. timezone_raw UE

timezone

UE

CSV

timezone

UE

, ()

8. plmn

MCC: 505, MNC: 57

↓

"50557"

↓

"055570"

↓

0x055570 = 349552

349552 → MCC: 505, MNC: 57

MME UE

9. tac

16

UE

0 - 65535

1234

UE MME

-
-
- TAI

10. eci E-UTRAN

28

E-UTRAN UE

eNodeB ID 20 + ID 8

0 - 268,435,455

5678

MME UE

-
-
-

11. sgw_ip SGW IP

IPv4 IPv6

SGW-C S5/S8 IP F-TEID

IPv4 IPv6

```
10.0.0.15      (IPv4)
2001:db8::15  (IPv6)
```

S5/S8

12. ue_ip UE IP

IPv4|IPv6

UE IP PDN

<ipv4>|<ipv6>

```
172.16.1.100|      ( IPv4)
|2001:db8::1      ( IPv6)
172.16.1.100|2001:db8::1 ( )
```

PGW-C PDN PAA

- IPv4 IPv4
 - IPv6 IPv6
 - PDN
-

13. pgw_ip PGW IP

IPv4 IPv6

PGW-C S5/S8 IP F-TEID

IPv4 IPv6

```
10.0.0.20      (IPv4)
2001:db8::20   (IPv6)
```

PGW-C

14. apn

100

PDN

DNS

```
internet
ims
mms
enterprise.corporate
```

MME

- -
 - IP
-

15. qci QoS

8

QoS

1 - 9 128-254

QCI

QCI					
1	GBR	2	100 ms	10 ⁻²	
2	GBR	4	150 ms	10 ⁻³	
3	GBR	3	50 ms	10 ⁻³	
4	GBR	5	300 ms	10 ⁻⁶	
5	Non-GBR	1	100 ms	10 ⁻⁶	IMS
6	Non-GBR	6	300 ms	10 ⁻⁶	
7	Non-GBR	7	100 ms	10 ⁻³	
8	Non-GBR	8	300 ms	10 ⁻⁶	
9	Non-GBR	9	300 ms	10 ⁻⁶	

9 →

PGW-C QoS

16. octets_in

64

UE

1048576 → 1 MB

PGW-U PFCP URR

- update
- end
- start 0
- URR `usage_report_interval`

17. octets_out

64

UE →

524288 → 512 KB

PGW-U PFCP URR

- `update` 0000000
 - `end` 00000000
 - `start` 000000 0
 - `URR` 0000000000 `usage_report_interval` 000
-

00

00 1 0000000000000000

0000

1. 0000
2. 5 000000000000 10 MB 000 5 MB
3. 0000

CDR 000

```
# 00 CDR 000
# 0000000010:00:00 (1726570800)
# 0000000011:00:00 (1726574400)
# 000000pgw-c-01
# epoch,imsi,event,charging_id,msisdn,ue_imei,timezone_raw,plmn,tac,e
1726570800,310260111111111,default_bearer_start,10001,1555111111,111
1726571100,310260111111111,default_bearer_update,10001,1555111111,11
1726571400,310260111111111,default_bearer_end,10001,1555111111,11111
```

00 2 0000000000000000

0000

1. 00000000IPv4 + IPv6
2. 000000
3. 0000

CDR 000

```
1726570800,310260222222222,default_bearer_start,10002,15552222222,222
1726571100,310260222222222,default_bearer_update,10002,15552222222,22
1726571400,310260222222222,default_bearer_update,10002,15552222222,22
1726571700,310260222222222,default_bearer_update,10002,15552222222,22
1726572000,310260222222222,default_bearer_end,10002,15552222222,22222
```

00 30000000000000

0000

1. 00000000QCI 9
2. 000000000000QCI 6
3. 0000000000
4. 000000
5. 000000

CDR 000

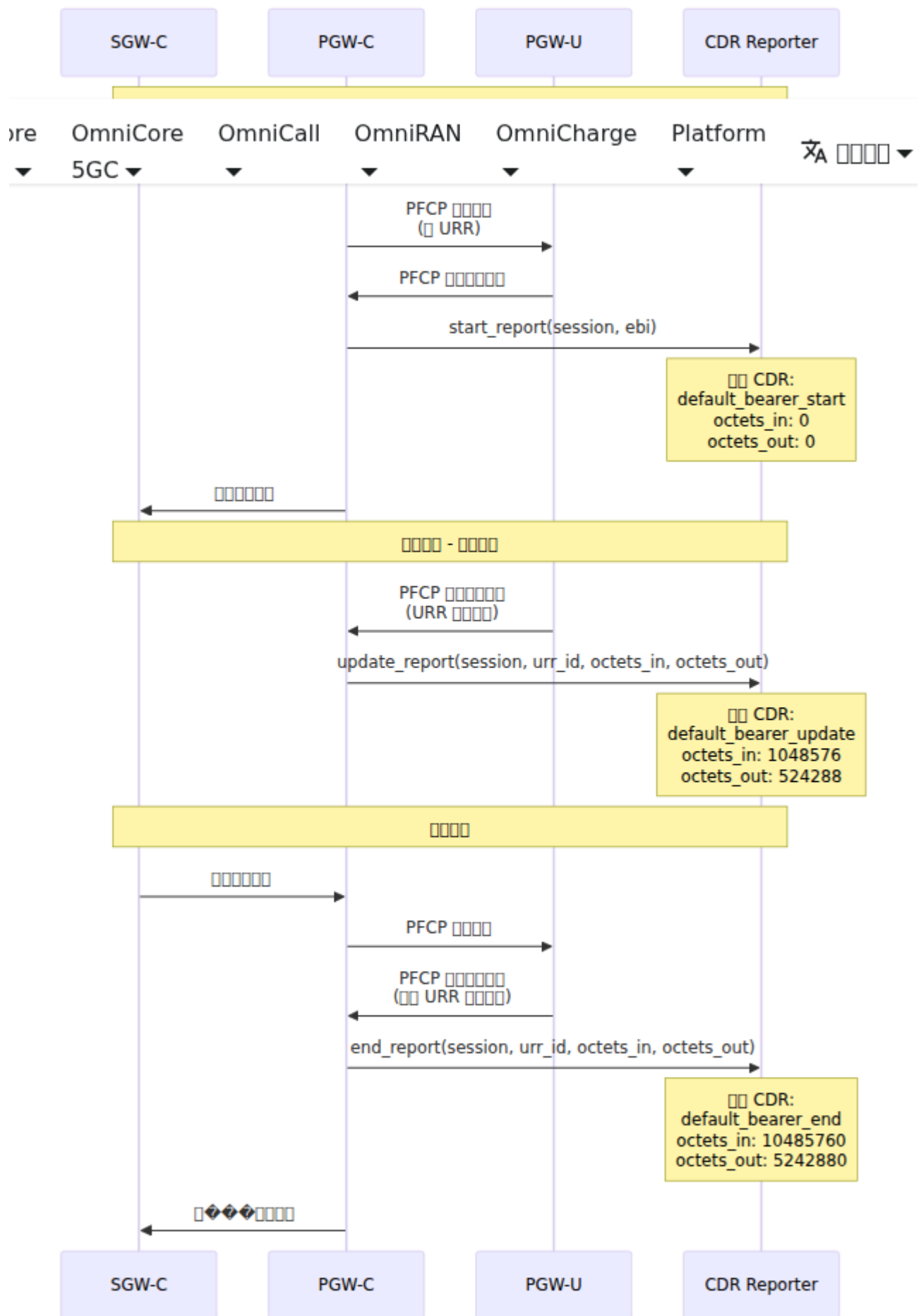
```
1726570800,310260333333333,default_bearer_start,10003,15553333333,333
1726571100,310260333333333,dedicated_bearer_start,10004,15553333333,3
1726571400,310260333333333,default_bearer_update,10003,15553333333,33
1726571400,310260333333333,dedicated_bearer_update,10004,15553333333,
1726571700,310260333333333,dedicated_bearer_end,10004,15553333333,333
1726572000,310260333333333,default_bearer_end,10003,15553333333,33333
```

000

- 00000100030000000000 10 MB000 4 MB
- 00000100040000000000 200 MB000 2 MB
- 000 QCI 009 0 60000000 QoS 00

□□

CDR □□□□



CDR 处理

1. 实时监控

```
# 实时监控 CDR 文件 PGW-C
inotifywait -m /var/log/pgw_c/cdrs/ -e close_write | while read
path action file; do
    # 实时监控 CDR
    process_cdr "$path$file"
done
```

2. 日志

```
# 实时监控 CDR 日志
tail -F /var/log/pgw_c/cdrs/* | process_cdr_stream
```

CDR 类型

- **CDR** - 实时监控 CDR 文件
- **PFCP** CDR - 实时监控 URRs 在 PGW-U 上的 CDR
- **CDR** - CDR 实时监控
- **CDR** - CDR 实时监控 URR
- **Gx** CDR - CDR 实时监控 QCI
- **Gy** CDR - 实时监控

3GPP 标准

- TS 32.251 - 实时监控 PS
- TS 29.274 - 3GPP 实时监控 EPS GTP-C
- TS 29.244 - CP 实时监控 PFCP - **URR**
- TS 32.298 - CDR

CDR □□ - PGW-C □□□□□□□□

□ Omnitouch □□□□□□

□□□□ 1.0 □□□□ 2025-12-28

Diameter Gx

(PCRF) 1

1

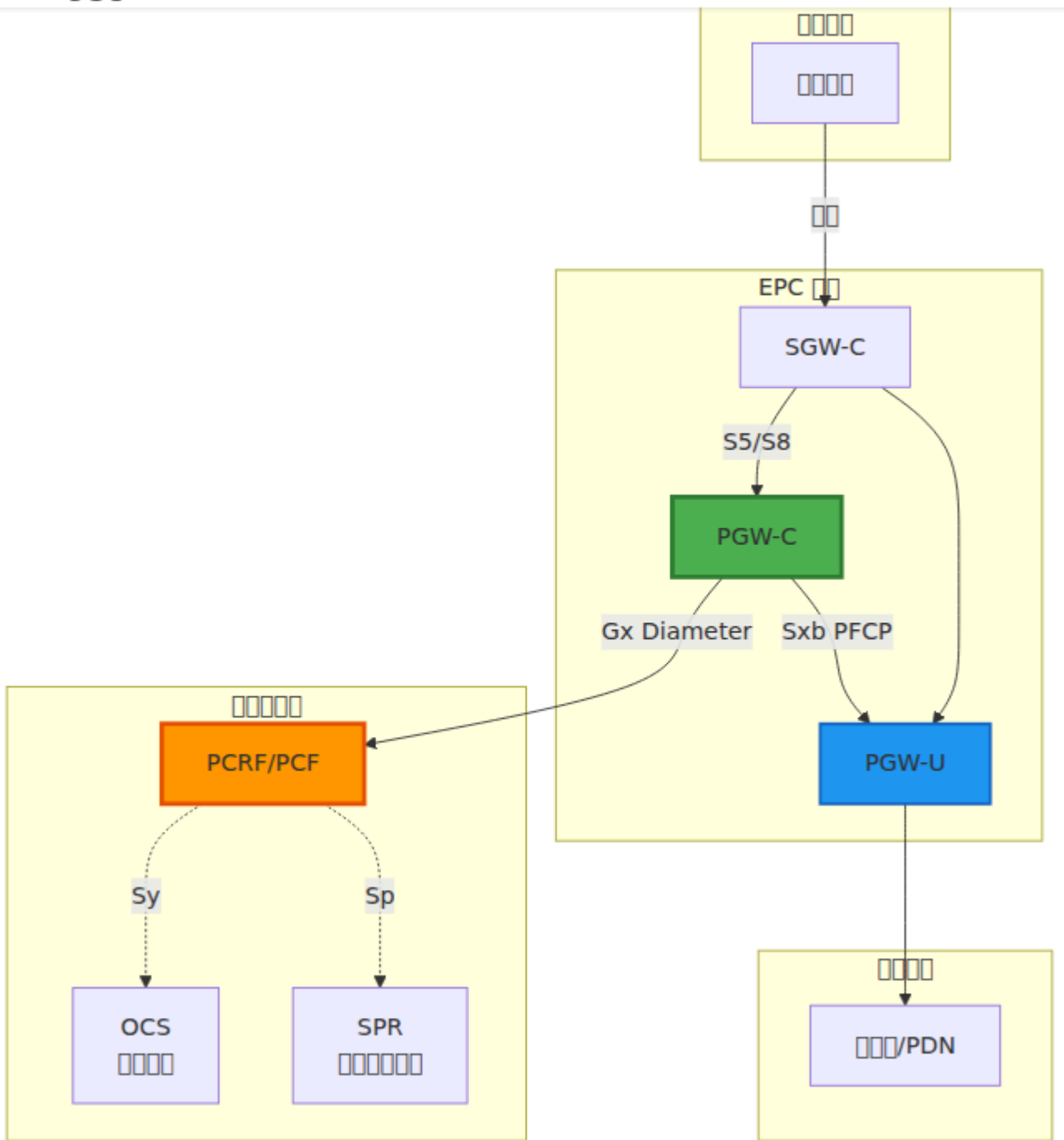
1. 1
2. Gx 1
3. Diameter 1
4. 1
5. 1
6. 1
7. 1
8. 1
9. 1

1

Gx 1 PGW-C 1 PCRF 1 PCF 1 5G 1

- 1 - 1 QoS 1
- 1 - 1
- 1 - 1
- 1 - 1

Network Gx



□□□□

□□	□□
□□□□	PCRF □□ PCC □□□□□□□□□□
QoS □□	□□□□□□□□ QoS □□
□□□□	□□□/□□□□□□□□□□
□□□□	□□□□□□/□□□□
□□□□	□□□□□□□□□□

Gx □□□□

3GPP □□

- □□□ 3GPP TS 29.212
- **Diameter** □□ **ID** 16777238 (Gx)
- □□□ Diameter □□□□ (RFC 6733)

□□□□

□□ UE PDN □□□□□□□□□□ **Gx** □□□□ **Session-ID** □□□□□□□□

- □ UE □□□□□ (CCR-Initial)
- □□□□□□□□□□ (CCR-Update) - □□
- □ UE □□□□□ (CCR-Termination)

Session ID

Session-ID: <Origin-Host>;<high32>;<low32>[;<optional>]

Example: omni-pgw_c.epc.mnc999.mcc999.3gppnetwork.org;1234567890;98765

Fields

- **Origin-Host**: PGW-C IP Address
- **high32**: High 32 bits of the Session ID
- **low32**: Low 32 bits of the Session ID

Diameter

Fields

Diameter fields are defined in RFC 6733

```

Diameter Header (20 bytes)
├─ Version (1 byte) = 1
├─ Message Length (3 bytes)
├─ Flags (1 byte)
│   ├─ R: Request (1) / Answer (0)
│   ├─ P: Proxiable
│   ├─ E: Error
│   └─ T: Potentially retransmitted
├─ Command Code (3 bytes)
├─ Application ID (4 bytes) = 16777238 (Gx)
├─ Hop-by-Hop ID (4 bytes)
└─ End-to-End ID (4 bytes)

```

```

AVPs (00-00)
├─ AVP Header
│   ├─ AVP Code
│   ├─ Flags (V, M, P)
│   └─ AVP Length
└─ Vendor ID (optional)
    └─ AVP Data

```

00 Diameter 00

AVP000-0000

- Diameter 00000000
- 0000000000
- 00000000 AVP0

000

- 00/000
- CCR000000000/ CCA000000000

00000

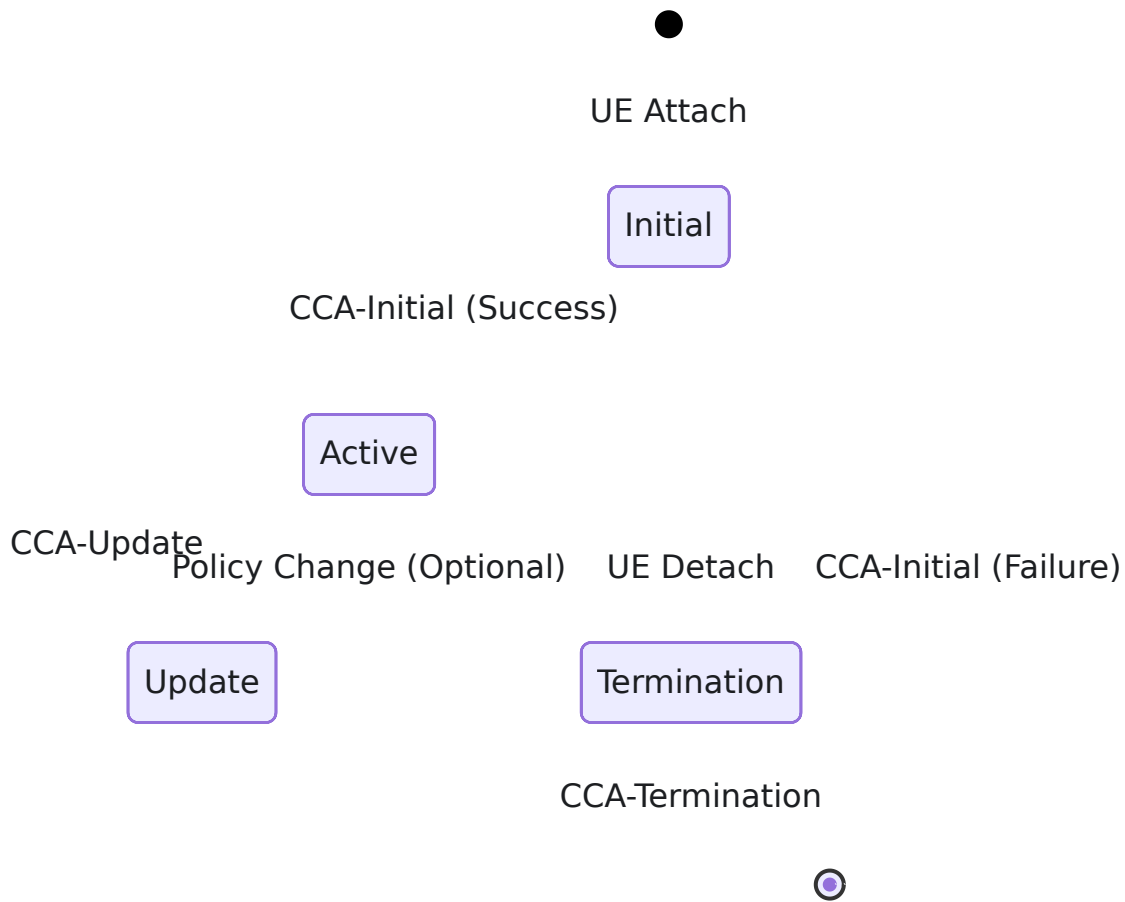
- 2001 - DIAMETER_SUCCESS
- 3xxx - 0000
- 4xxx - 0000

- 5xxx - □□□□

□□□□□□

PGW-C □□ **Diameter** □□□□□□□□ RFC 4006 □□□□ Gx□

□□□□



CCR-Initial□□□□□□□□ - □□□□

□□□□ UE □□□□ PDN □□

□□□□

- □□□□□□□□□□□□
- □ PCRF □□ UE □□□□□□

- QoS

PGW-C AVP

AVP	AVP		
Session-Id	263	UTF8String	Gx
Auth-Application-Id	258	Unsigned32	16777238 (Gx)
Origin-Host	264	DiamIdent	PGW-C Diameter
Origin-Realm	296	DiamIdent	PGW-C Diameter
Destination-Realm	283	DiamIdent	PCRF
CC-Request-Type	416	Enumerated	1 = INITIAL_REQUEST
CC-Request-Number	415	Unsigned32	0
Subscription-Id	443	Grouped	UE IMSI/MSISDN
Called-Station-Id	30	UTF8String	APN
Framed-IP-Address	8	OctetString	UE IPv4
IP-CAN-Type	1027	Enumerated	5 = 3GPP-EPS
RAT-Type	1032	Enumerated	1004 = EUTRAN
QoS-Information	1016	Grouped	QoS (AMBR)
Network-Request-Support	1024	Enumerated	
Supported-Features	628	Grouped	Gx

CCR-I

```
CCR (Command Code: 272, Request)
├─ Session-Id: "pgw_c.example.com;123;456"
├─ Auth-Application-Id: 16777238
├─ Origin-Host: "omni-pgw_c.epc.mnc999.mcc999.3gppnetwork.org"
├─ Origin-Realm: "epc.mnc999.mcc999.3gppnetwork.org"
├─ Destination-Realm: "epc.mnc999.mcc999.3gppnetwork.org"
├─ CC-Request-Type: INITIAL_REQUEST (1)
├─ CC-Request-Number: 0
├─ Subscription-Id (Grouped)
│   └─ Subscription-Id-Type: END_USER_IMSI (1)
│       └─ Subscription-Id-Data: "310260123456789"
├─ Called-Station-Id: "internet"
├─ Framed-IP-Address: 100.64.1.42
├─ IP-CAN-Type: 3GPP-EPS (5)
├─ RAT-Type: EUTRAN (1004)
├─ QoS-Information (Grouped)
│   └─ APN-Aggregate-Max-Bitrate-UL: 100000000 (100 Mbps)
│       └─ APN-Aggregate-Max-Bitrate-DL: 50000000 (50 Mbps)
├─ Network-Request-Support: 1
└─ Supported-Features: [...]
```

CCA-Initial -

PCRF CCR-I

-
- PCC
- QoS

PGW-C AVP

AVP 名称	AVP 代码	描述
Result-Code	268	成功 (2001) 消息
Experimental-Result	297	实验性结果
QoS-Information	1016	QoS 信息
Charging-Rule-Install	1001	安装 PCC 规则
Charging-Rule-Definition	1003	规则定义
Default-EPS-Bearer-QoS	1049	默认 EPS 承载 QoS

消息内容

```

CCA (Command Code: 272, Answer)
├─ Session-Id: "pgw_c.example.com;123;456"
├─ Result-Code: DIAMETER_SUCCESS (2001)
├─ Origin-Host: "pcrf.example.com"
├─ Origin-Realm: "example.com"
├─ Auth-Application-Id: 16777238
├─ CC-Request-Type: INITIAL_REQUEST (1)
├─ CC-Request-Number: 0
├─ QoS-Information (Grouped)
│   ├─ APN-Aggregate-Max-Bitrate-UL: 50000000 (50 Mbps - reduced)
│   └─ APN-Aggregate-Max-Bitrate-DL: 100000000 (100 Mbps -
increased)
├─ Charging-Rule-Install (Grouped)
│   ├─ Charging-Rule-Name: "default_internet_rule"
│   └─ Charging-Rule-Name: "video_streaming_rule"
└─ Charging-Rule-Definition (Grouped)
    ├─ Charging-Rule-Name: "default_internet_rule"
    ├─ QoS-Information: {...}
    └─ Precedence: 1000

```

CCR-Termination 消息 - 消息

消息 UE 消息 PDN 消息

□□□

- □□ PCRF □□□□
- □□□□/□□□□

□ **CCR-I** □□□□□□

- `CC-Request-Type: TERMINATION_REQUEST (3)`
- □□□□□□□□
- □□□ AVP □□

□□ **CCR-T**□

```
CCR (Command Code: 272, Request)
├─ Session-Id: "pgw_c.example.com;123;456"
├─ Auth-Application-Id: 16777238
├─ Origin-Host: "omni-pgw_c.epc.mnc999.mcc999.3gppnetwork.org"
├─ Origin-Realm: "epc.mnc999.mcc999.3gppnetwork.org"
├─ Destination-Realm: "epc.mnc999.mcc999.3gppnetwork.org"
├─ CC-Request-Type: TERMINATION_REQUEST (3)
├─ CC-Request-Number: 1
└─ Termination-Cause: DIAMETER_LOGOUT (1)
```

CCA-Termination

□□□□ PCRF □ CCR-T □□□

□□□

- □□□□□□
- □□□□□□□□

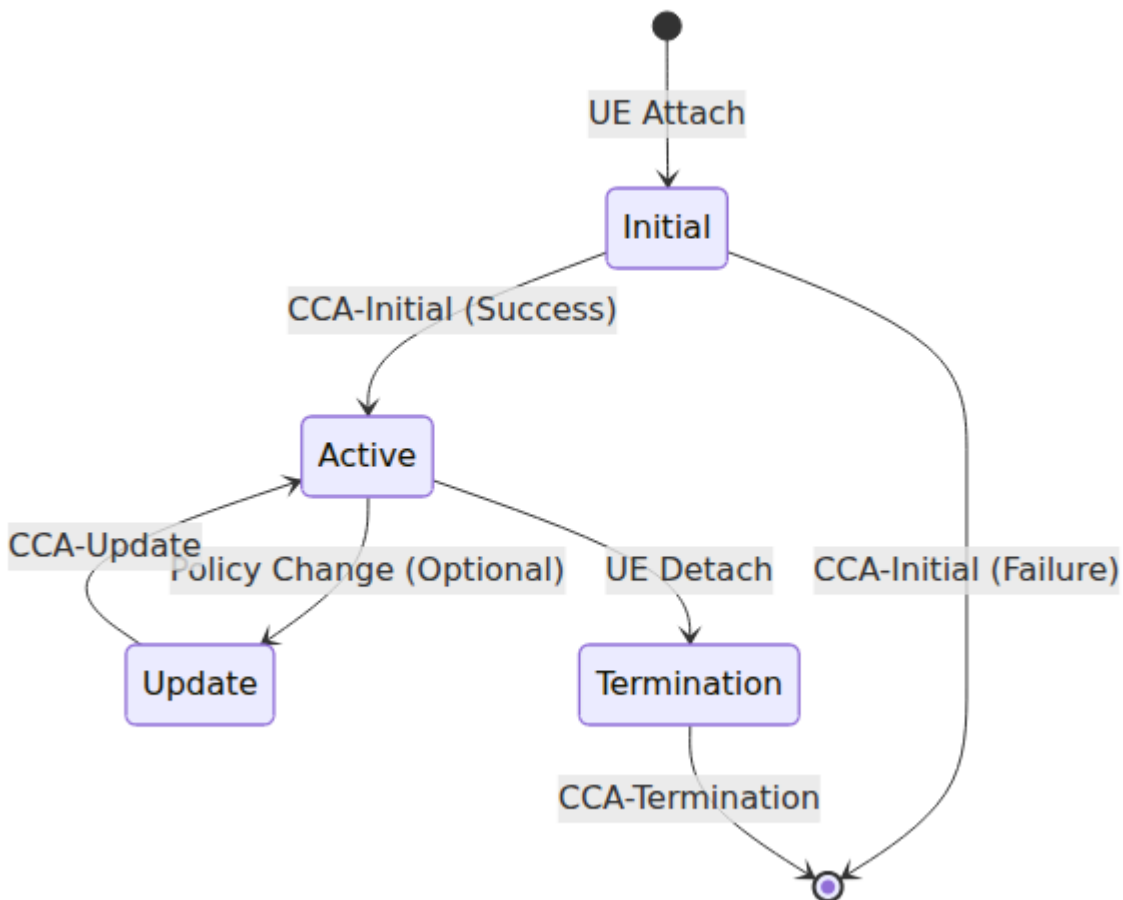
□□ **CCA-T**□

CCA (Command Code: 272, Answer)
├─ Session-Id: "pgw_c.example.com;123;456"
├─ Result-Code: DIAMETER_SUCCESS (2001)
├─ Origin-Host: "pcrf.example.com"
├─ Origin-Realm: "example.com"
├─ Auth-Application-Id: 16777238
├─ CC-Request-Type: TERMINATION_REQUEST (3)
└─ CC-Request-Number: 1

□□□□□□□□

PCC □□□□

PCC□□□□□□□□□□ □□□□□□□□□□□□



□□□□

1. □□□□

- □□□□□□□□
- □□□ "video_streaming_rule"

2. □□□□

- □□□□ = □□□□□□
- □□□0-65535
- □□□□□□□□□□

3. □□□□TFT - □□□□□□□□

- □□□□□□□□□□□□□□
- □□□
 - IP 5 □□□□□□□□/□□ IP□□/□□□□
 - "permit out ip from any to 8.8.8.8 80"

4. QoS □□□

- **QCI**□**QoS** □□□□□□ 1-9□□□□□□□□128-254□□□□□□□□
 - QCI 1□□□□□□□
 - QCI 5□IMS □□
 - QCI 9□□□□□□□□
- **ARP**□□□□□□□□□□□□□□ □□□□
- **MBR/GBR**□ □□/□□□□□□

5. □□□□□□

- □□□□□ □□□□□□□□□□ OCS □□ - □ **Diameter Gy** □□□□
- □□□□□□ □□□□□□□□□□□□□□
- □□/□□□□□□ OCS□□□□ **Diameter Gy** □□□□□□□□□□ CDR□□□□□ - □ □□ **CDR** □□□□

6. □□□□□□

- □□□□ □□□□□□

- 配置 配置

配置配置

PCRF 配置配置配置配置

1. 配置配置配置配置

Charging-Rule-Install (Grouped)

└─ Charging-Rule-Name: "gold_subscriber_internet"

└─ Charging-Rule-Name: "video_qos_boost"

2. 配置配置配置配置

Charging-Rule-Definition (Grouped)

└─ Charging-Rule-Name: "dynamic_rule_123"

└─ Precedence: 100

└─ Flow-Information (Grouped)

| └─ Flow-Description: "permit out ip from any to 192.0.2.0/24"

| └─ Flow-Direction: DOWNLINK

└─ QoS-Information (Grouped)

| └─ QoS-Class-Identifier: 5

| └─ Max-Requested-Bandwidth-UL: 10000000

| └─ Max-Requested-Bandwidth-DL: 50000000

└─ Rating-Group: 1000

QoS 配置 AVP

APN-AMBR配置配置配置配置

配置配置 APN 配置配置 GBR 配置

QoS-Information (Grouped)

└─ APN-Aggregate-Max-Bitrate-UL: 100000000 # 100 Mbps

└─ APN-Aggregate-Max-Bitrate-DL: 200000000 # 200 Mbps

PGW-C 配置

- AMBR
 - PGW-U QER
-

Gx

`config/runtime.exe`

```

config :pgw_c,
  diameter: %{
    # Diameter IP
    listen_ip: "0.0.0.0",

    # PGW-C Diameter (Origin-Host)
    host: "omni-pgw_c.epc.mnc999.mcc999.3gppnetwork.org",

    # PGW-C Diameter (Origin-Realm)
    realm: "epc.mnc999.mcc999.3gppnetwork.org",

    # PCRF
    peer_list: [
      %{
        # PCRF Diameter
        host: "pcrf.epc.mnc999.mcc999.3gppnetwork.org",

        # PCRF PGW-C
        realm: "epc.mnc999.mcc999.3gppnetwork.org",

        # PCRF IP
        ip: "10.0.0.30",

        # PGW-C PCRF
        # true = PGW-C PCRF
        # false = PCRF
        initiate_connection: true
      }
    ]
  }
}

```

PCRF

```

config :pgw_c,
  diameter: %{
    listen_ip: "0.0.0.0",
    host: "omni-pgw_c.epc.mnc999.mcc999.3gppnetwork.org",
    realm: "epc.mnc999.mcc999.3gppnetwork.org",
    peer_list: [
      %{
        host: "pcrf-primary.example.com",
        realm: "epc.mnc999.mcc999.3gppnetwork.org",
        ip: "10.0.1.30",
        initiate_connection: true
      },
      %{
        host: "pcrf-backup.example.com",
        realm: "epc.mnc999.mcc999.3gppnetwork.org",
        ip: "10.0.2.30",
        initiate_connection: true
      }
    ]
  }
}

```

□□□□□

- Diameter □□□□□□□□□□
- □□□□□□□□□□
- □□□□□□□□□□□□□□

□□□□□□

Diameter □□□□□ **FQDN**□□□□□□□□□□

```

# □□ - FQDN □□
host: "pgw_c.epc.mnc999.mcc999.3gppnetwork.org"

# □□□ - □□□□□□ Diameter □□
host: "pgw_c"
host: "10.0.0.20" # □□□ IP □□

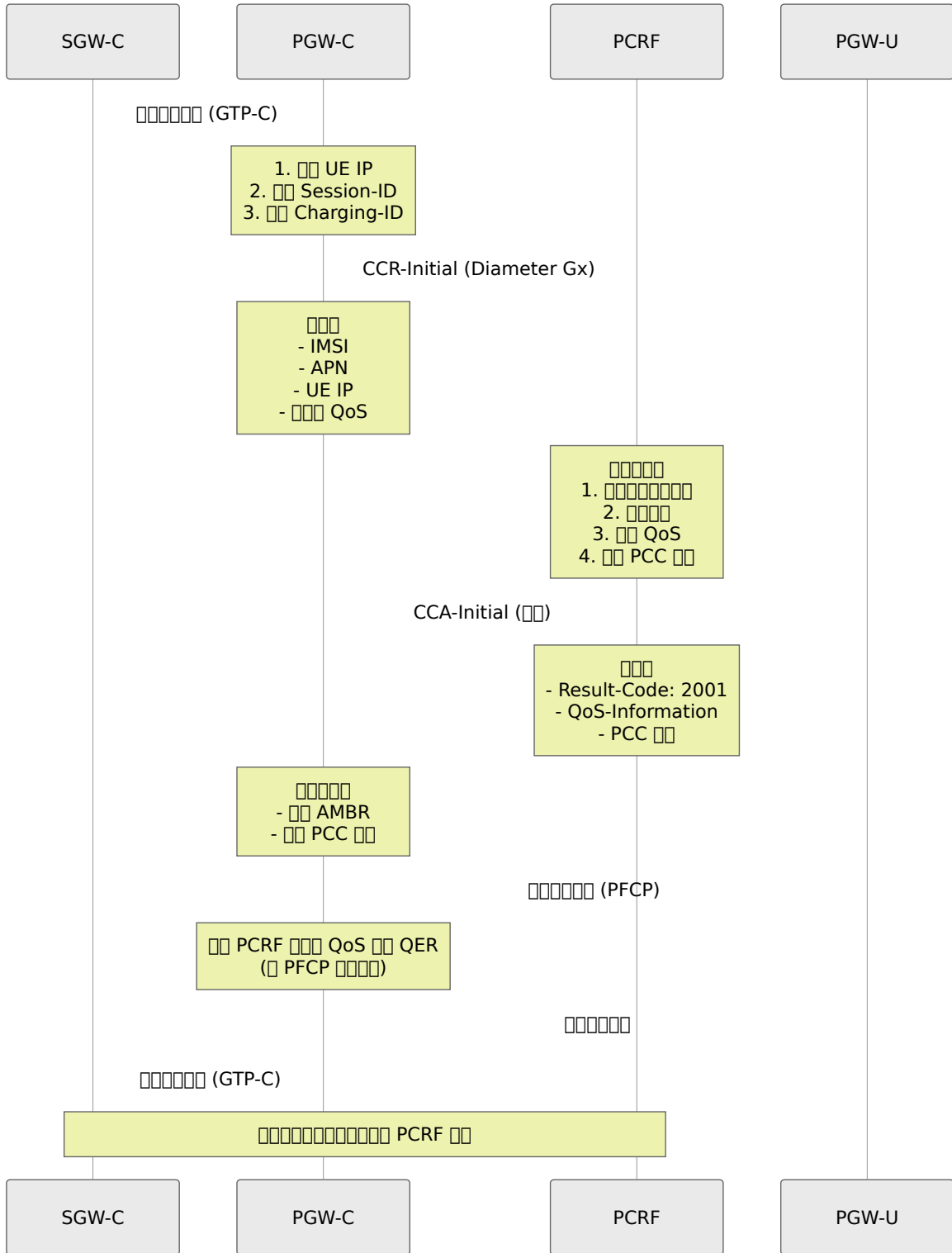
```

□□□□□

- □□□□□□□□
 - □□□ 3GPP PLMN □□□□□ `epc.mncXXX.mccYYY.3gppnetwork.org`
-

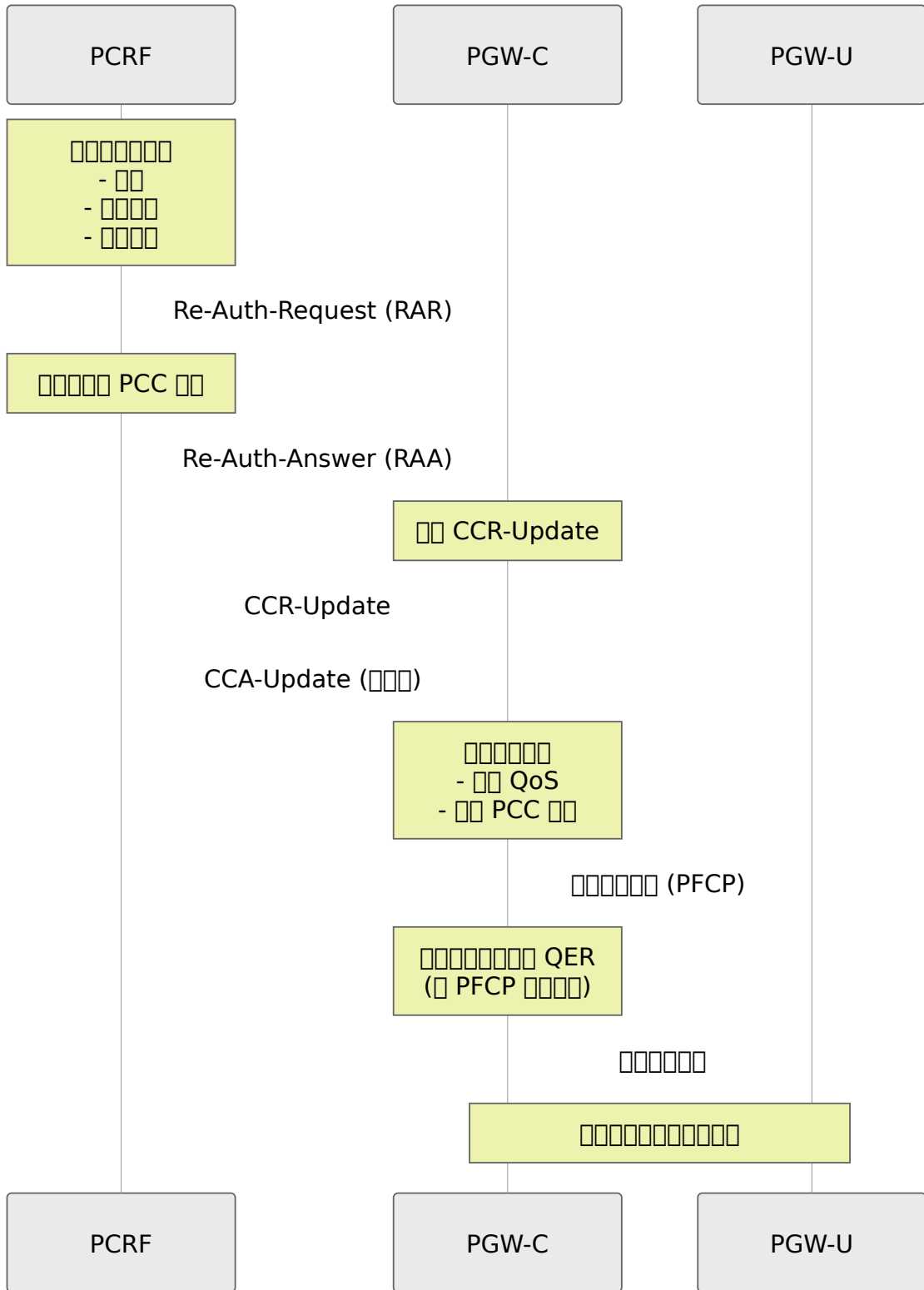
□□□

□□□□□□□

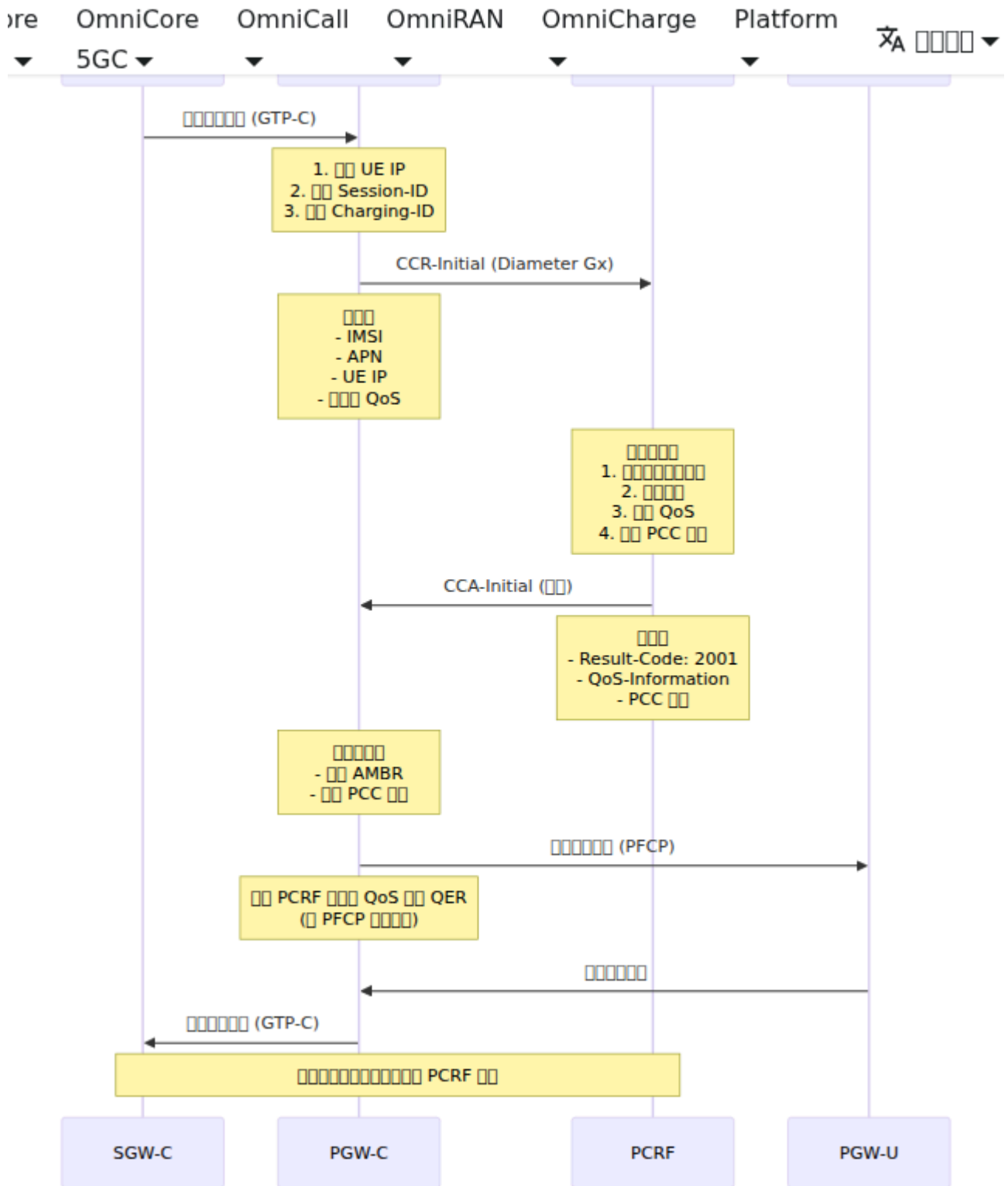


□□ PCRF □ QoS □□□□ QER□QoS □□□□□□ PFCP □□ PGW-U□□ QER □□□□□□
 □ PFCP □□□

□□□□□□□□□□



□□□□



□□□□

□□□□

PGW-C □ CCA □□□□□□ Diameter □□□□□

□□□□□

□□	□□	□□
2001	DIAMETER_SUCCESS	□□□□□□

□□□□ (5xxx)□

□□	□□	PGW-C □□
5002	DIAMETER_UNKNOWN_SESSION_ID	□□□□□□□□
5030	DIAMETER_USER_UNKNOWN	□□□□□□□□
5140	DIAMETER_ERROR_INITIAL_PARAMETERS	□□□□□□□□
5003	DIAMETER_AUTHORIZATION_REJECTED	□□□□□□□□

□□□□ (4xxx)□

□□	□□	PGW-C □□
4001	DIAMETER_AUTHENTICATION_REJECTED	□□□□□□
4010	DIAMETER_TOO_BUSY	□□□□
4012	DIAMETER_UNABLE_TO_COMPLY	□□□□□□□□

실패 원인

실패 원인

Experimental-Result (Grouped)

└ Vendor-Id: 10415 (3GPP)

└ Experimental-Result-Code: <vendor-specific code>

실패 원인 3GPP

코드	오류 메시지	설명
5065	IP_CAN_SESSION_NOT_AVAILABLE	PCRF 실패
5143	INVALID_SERVICE_INFORMATION	실패

실패 원인

CCR-I 실패

실패 원인 PCRF 실패 CCR-Initial

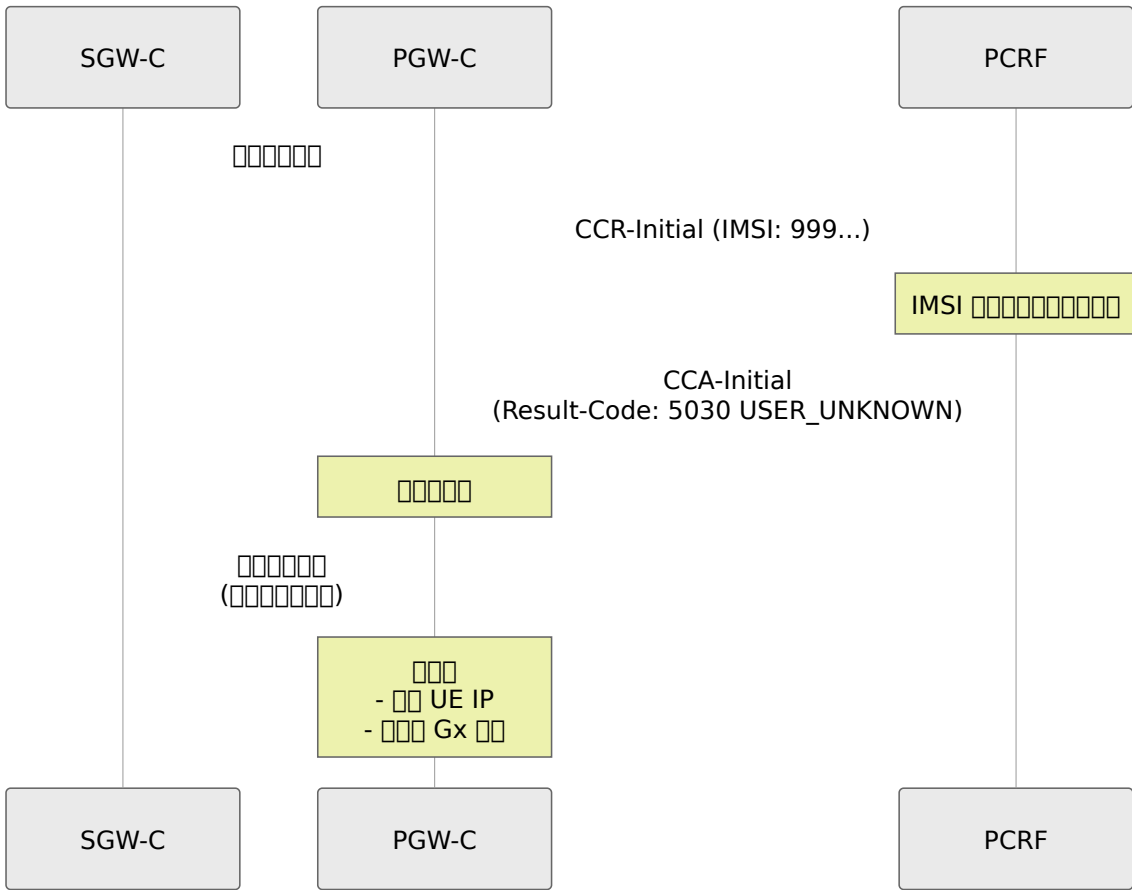
1. PGW-C 실패
2. 실패 원인 CCA
 - "Session-ID CCR-Initial ..."
 - SGW-C 실패
 - 실패
3. SGW-C 실패

실패 원인 SGW-C 실패

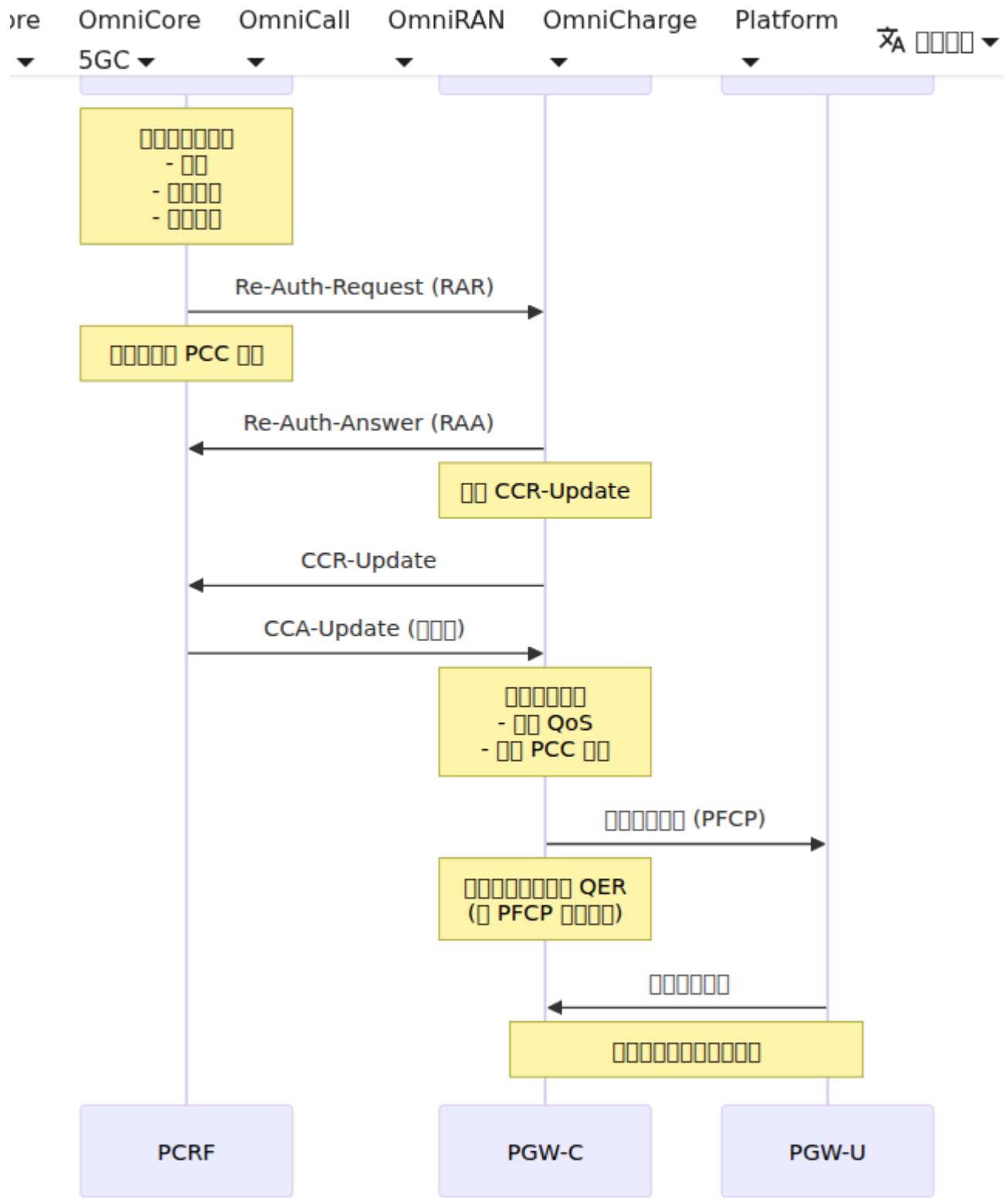
실패 원인 CCR-Initial 실패 PGW-C 실패 SGW-C 실패
:remote_peer_not_responding

실패 원인

실패 원인 1 PCRF 실패



2 PCRF



□□□□

□□□□

1. Diameter □□□□□□

□□□

- □□□“Diameter □□□□□□”
- □□□ CCR-Initial

□□□□□

- PCRF □□□□
- □□□ PCRF IP □□□
- □□□□□ Diameter □□□3868□
- Diameter □□□□□/□□□□□□□

□□□□□

```
# □□□□□□  
ping <pcrf_ip>  
  
# □□ Diameter □□□TCP 3868□  
telnet <pcrf_ip> 3868  
  
# □□ Diameter □□□□  
# □□□□□□□□ FQDN□□□□ IP
```

□□□□□

```

config :pgw_c,
  diameter: %{
    # FQDN IP
    host: "pgw_c.epc.mnc999.mcc999.3gppnetwork.org",
    realm: "epc.mnc999.mcc999.3gppnetwork.org",
    peer_list: [
      %{
        host: "pcrf.epc.mnc999.mcc999.3gppnetwork.org",
        ip: "10.0.0.30"
      }
    ]
  }
}

```

2. CCR-Initial

-
- “CCR-Initial”

- PCRF
-
- PCRF Session-ID

1. PCRF
2. PCRF
3. ping <pcrf_ip>
- 4.

3. PCRF

- CCA-Initial Result-Code != 2001
-

□□□□□□

□□□□	□□□□	□□□□
5030	IMSI □□□□□□□□	□ HSS/SPR □□□□□
5003	□□□□□	□□□□□□
4010	PCRF □□□□	□□□□□ PCRF □□

□□□□□

```
# PGW-C □□□□□  
[error] Diameter Gx □□□□□□□ 5030 (DIAMETER_USER_UNKNOWN)  
[error] IMSI 3102609999999999 □ PCRF □□
```

4. QoS □□□

□□□

- □□□□□□ QoS □□
- □□□□□□□□□□

□□□□□

1. □□ **CCA-Initial**□

- □□ **QoS-Information** AVP □□□□
- □□ **APN-Aggregate-Max-Bitrate-UL/DL** □

2. □□ **PFCP** □□□□□

- □□ QER □□□□□□□ MBR □□□
- □□ PGW-U □□□□□ QER □□

3. □□ **PCRF** □□□

- □□ PCRF □□

- `QoS`

5. Diameter `PCRF`

`PCRF`

- Diameter `PCRF`
- `"PCRF"`

`PCRF`

- `PCRF`

`PCRF`

`PCRF`

```
# PCRF
config :pgw_c,
  diameter: %{
    realm: "epc.mnc999.mcc999.3gppnetwork.org", # PGW-C PCRF
    peer_list: [
      %{
        realm: "epc.mnc999.mcc999.3gppnetwork.org" # PCRF PCRF
      }
    ]
  }
}
```

`CCR-Initial`

```
Origin-Realm: "epc.mnc999.mcc999.3gppnetwork.org"
Destination-Realm: "epc.mnc999.mcc999.3gppnetwork.org"
```

`Gx`

`Gx`

```

# Gx 消息
rate(gx_inbound_messages_total{message_type="gx_CCA"}[5m])
rate(gx_outbound_messages_total{message_type="gx_CCR"}[5m])

# Gx 错误
rate(gx_inbound_errors_total[5m])

# Gx 成功率
sum(rate(gx_outbound_responses_total{result_code_class="2xxx"}
[5m])) /
sum(rate(gx_outbound_responses_total[5m])) * 100

# 按 PCRF 实例 Gx 消息
rate(gx_outbound_responses_total{result_code_class!="2xxx"}[5m])
by (diameter_host)

# Gx 会话数
session_id_registry_count

# Gx 处理时长分布
histogram_quantile(0.95,
rate(gx_inbound_handling_duration_bucket[5m]))

```

监控项名称

gx_outbound_responses_total   按 PCRF 实例 Diameter 消息成功率

- **message_type** 消息类型 gx_RAA gx_CCA
- **result_code_class** 结果码类 2xxx 3xxx 4xxx 5xxx
- **diameter_host** PCRF 实例

告警规则

- **2001** DIAMETER_SUCCESS - 成功
- **3001** DIAMETER_COMMAND_UNSUPPORTED - 不支持
- **5012** DIAMETER_UNABLE_TO_COMPLY - 无法遵守
- **5030** DIAMETER_USER_UNKNOWN - 用户未知

配置

```

# Gx ErrorRateHigh
- alert: GxErrorRateHigh
  expr: rate(gx_inbound_errors_total[5m]) > 0.1
  for: 5m
  annotations:
    summary: "Gx ErrorRateHigh"

# Gx ResponseFailureRate
- alert: GxResponseFailureRate
  expr: |

sum(rate(gx_outbound_responses_total{result_code_class!="2xx"}
[5m])) /
  sum(rate(gx_outbound_responses_total[5m])) > 0.1
  for: 5m
  annotations:
    summary: "Gx ResponseFailureRate"
    description: "10% Gx ResponseFailureRate"

# PCRF Failures
- alert: GxPCRFFailures
  expr:
rate(gx_outbound_responses_total{result_code_class=~"4xxx|5xxx"}
[5m]) by (diameter_host) > 0.05
  for: 3m
  annotations:
    summary: "PCRF {{ $labels.diameter_host }} Failures"
    description: "PCRF Failures"

# SessionRejection
- alert: GxSessionRejection
  expr: rate(gx_inbound_errors_total{result_code="5030"}[5m]) >
0.01
  for: 5m
  annotations:
    summary: "PCRF USER_UNKNOWN"

```

PCRF

PCRF Diameter

```
# config/runtime.exs
config :logger, level: :debug
```

```
# iex>
iex> Logger.configure(level: :debug)
```

Output:

- [debug] CCR-Initial Session-ID: ...
- [debug] CCA-Initial Result-Code 2001
- [error] Diameter ...

Web UI - Diameter

OmniPGW Web UI Diameter

Diameter

URL: <http://<omnipgw-ip>:<web-port>/diameter>

PCRF Diameter Gx PCRF

1. PCRF

- PCRF - PCRF
- PCRF - PCRF
- 1 PCRF

2. PCRF

- Origin-Host - Diameter (Origin-Host)
- IP - PCRF IP
- 3868 - Diameter 3868
- /
- TCP SCTP
- PGW PCRF
- Diameter
- PCRF
- ID - Diameter Gx = 16777238

3. PCRF

- PCRF
- CER/CEA
- PCRF
- PCRF

PCRF

1. 00000000 Diameter 00
2. 0000 PCRF 00000“0000”
3. 0000000000000000
4. 0000 ID 00 Gx0167772380

00000000000000**Gx** 0000

1. 0000000000“PCRF 00”00
2. 00 Diameter 00
3. 0000000000
 - 00000
 - 00000000
 - 00 PCRF 00000000
 - 00 TCP 3868 00000000
 - 000000000000
 - 0000000000000000
 - PCRF 00000000

00 **Diameter** 0000

1. 0000 PCRF 0000
2. 00 Diameter 00
3. 00000000000000
4. 0000000000“000000”
5. 000000000000
 - 0000000000
 - 00 ID 00 Gx
 - 00000000 PCRF 0000

0000000000

- 0000 PCRF 00
1. Diameter 000000“0000”
 2. 0000 PCRF 0“0000”
 3. 000000000000
 4. 000000000000“0000”

00 **Diameter** 000000

- 配置“名称”
- ID 为 Gx16777238
- PCRF 配置

配置

```
Web UI 配置
配置“名称”
配置
initiate_connection: true
```

- OmniPGW 配置
- PCRF 配置
- 配置

配置

- 配置 - 1 配置
- 配置 - 配置/配置
- 配置 **Diameter** 配置 - 配置 Diameter CLI 配置
- 配置 - 配置
- 配置 - 配置 Diameter 配置
- 配置 - 配置 Diameter 配置

配置

配置 Web UI 配置 Prometheus 配置

- Gx 配置
- CCR/CCA 配置
- 配置

Web UI = “配置” 配置 = “配置”

□□□□

□□□□□

- □□□□ - Diameter □□□PCRF □□□□□
- **PFCP** □□ - □□ PCC □□□ QER □□ QoS □□
- □□□□ - □□□□□□□□□□□□
- **QoS** □□□□□ - □□□ QoS □□□□□□□

□□□□

- **Diameter Gy** □□ - □□ PCC □□□□□□□□□□
- □□ **CDR** □□ - □□□□□□□□□□□□
- **PCO** □□ - IMS □□□□□ P-CSCF □□

□□

- □□□□ - Gx □□□□□□□□□□□□□□□□
- **S5/S8** □□ - □□□□□□□□□□

□□□□□□

IMS Gy/Ro

OCS

- 1.
 2. 3GPP
 3. Gy/Ro
 - 4.
 - 5.
 - 6.
 - 7.
 - 8.
 - 9.
 - 10.
 11. Gx
 - 12.
-

Gy IMS Ro PGW-C** OCS**

- -
- -
- -
- -
- -

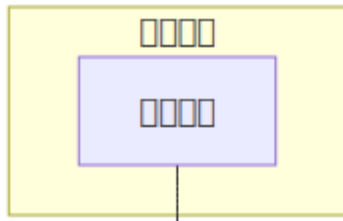
□□□□□□□

□□	□□□□□Gy/Ro□	□□□□□Gz/Rf□
□□	□□□□□□□	□□□□□
□□	□□□□□	□□□□□
□□□□	□□□□□□□□□	□□□□□□□□
□□	OCS□□□□□□□□	CGF/CDF□□□□□□□□
□□	□□□□□	□□□□□□□□□
□□□	□□□□□□□	□□□□□□□
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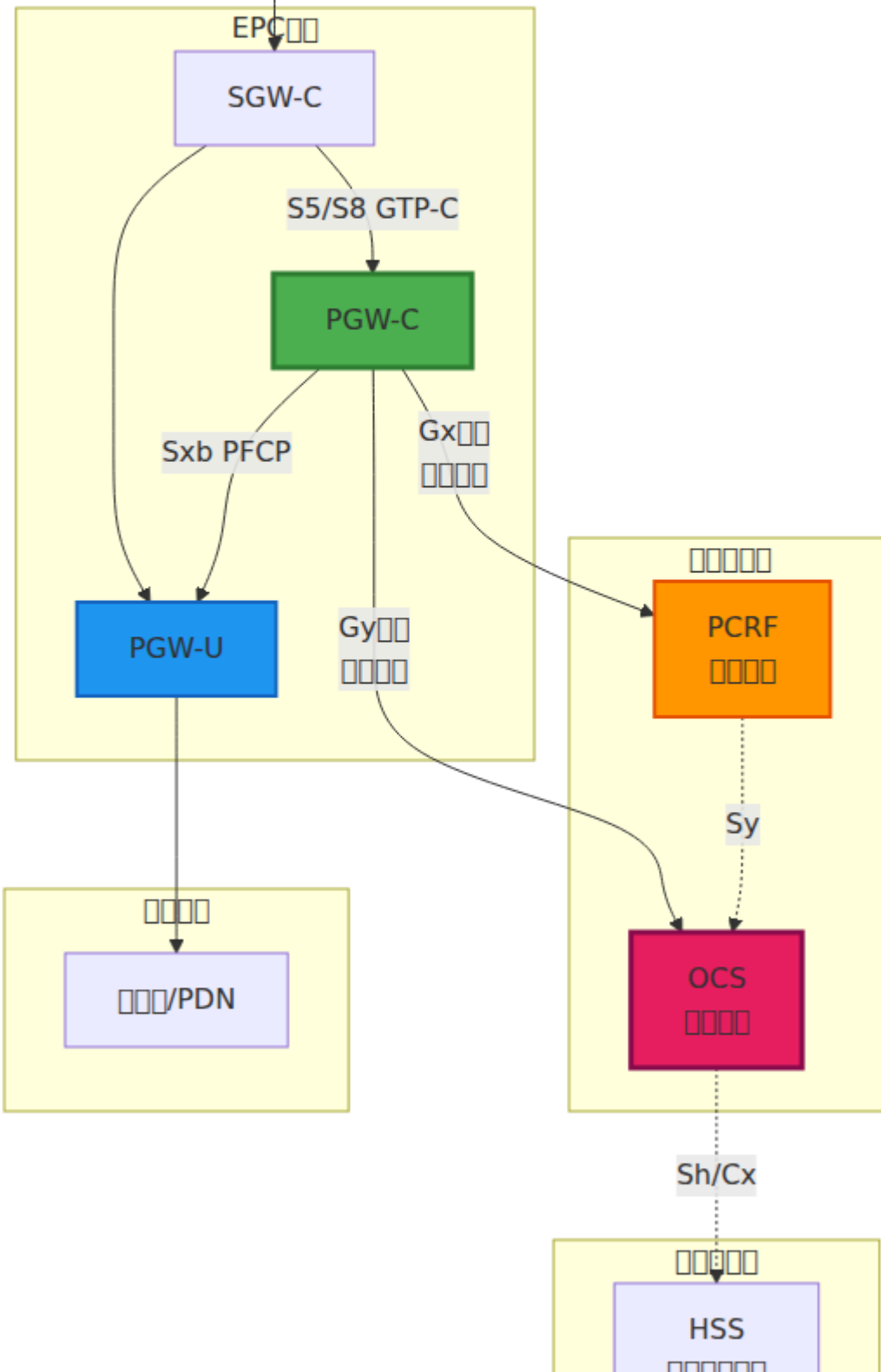
□□□ □□CDR□□ □□□□□□□□□□□□□□□

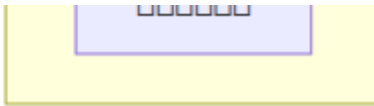
□□□ □□□□ □□□□□PDN□□□□□□□□□□□□□□

□□□□□Gy



Core OmniCore OmniCall OmniRAN OmniCharge Platform
 ▼ 5GC ▼ ▼ ▼ ▼ ▼

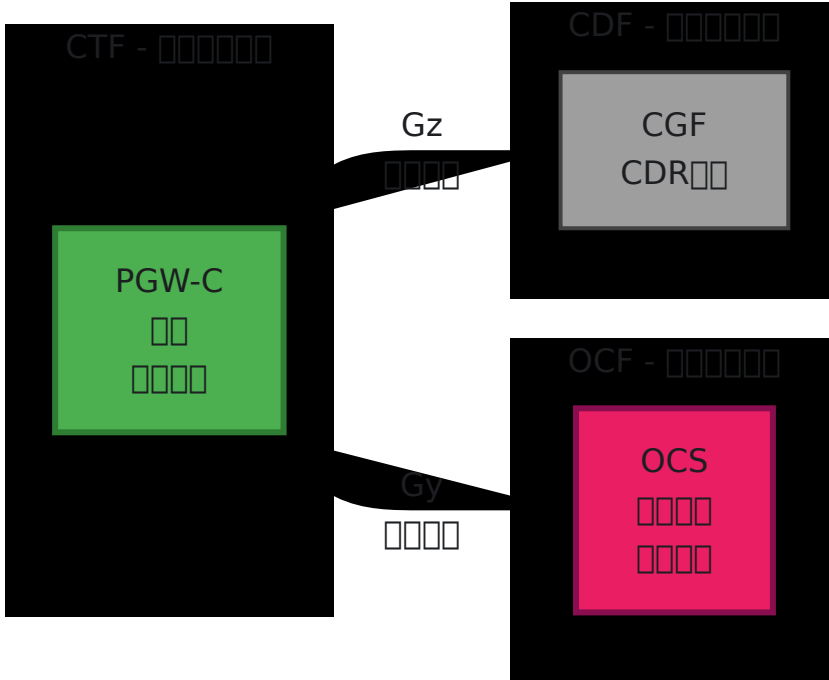




0000

00	00
0000	0000000000OCS000
0000	000000000000000000
000000	000000
0000	00000000000000
0000	000000000000
0000	00000000000000

3GPP



CTF

PGW-C CTF

1. -
2. -
3. -
4. -
5. -

OCF

OCS OCF

1. -
2. - MB
3. -

4. 4G - 4G LTE
5. 4G - 4G LTE

Gy/Ro

3GPP

- 3GPP TS 32.299
- 3GPP TS 32.251 PS
- ID** 4 Gy/Ro -
- RFC 4006

UE PDN **Session-ID** **Gy/Ro**

- CCR-Initial
- CCR-Update
- CCR-Termination

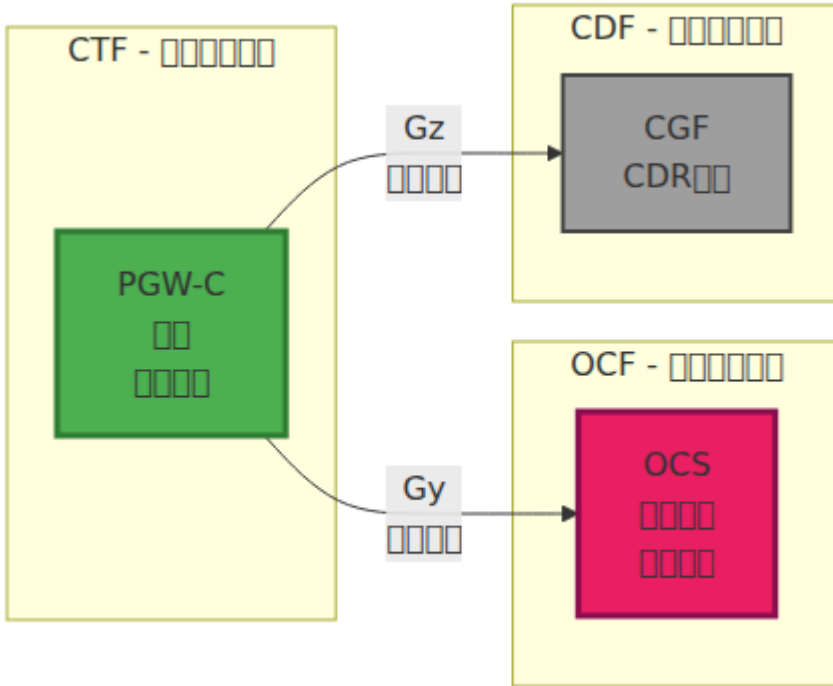
ID

```
Session-ID: <Origin-Host>;<high32>;<low32>[;<optional>]  
: omni-  
pgw_c.epc.mnc999.mcc999.3gppnetwork.org;9876543210;12345;gy
```


- Origin-Host:** PGW-C
- high32:** 32
- low32:** 32
- optional:** "gy" Gx

□□□□□□

□□□□



CCR-Initial□□□□□□□ - □□□

□□□ UE□□PDN□□□□□□□□□□□□□□

□□□

- □□OCS□□□□□□□□
- □□□□□□□□□□
- □□Gy/Ro□□

PGW-C□□□□□□**AVP**□

AVP	AVP		
Session-Id	263	UTF8String	Gy
Auth-Application-Id	258	Unsigned32	4
Origin-Host	264	DiamIdent	PGW-C
Origin-Realm	296	DiamIdent	PGW-C
Destination-Realm	283	DiamIdent	OCS
CC-Request-Type	416	Enumerated	1 = INITIAL_REQUEST
CC-Request-Number	415	Unsigned32	0
Subscription-Id	443	Grouped	UE IMS/MSISDN
Service-Context-Id	461	UTF8String	
Multiple-Services-Credit-Control	456	Grouped	
Requested-Service-Unit	437	Grouped	
Used-Service-Unit	446	Grouped	0
Service-Identifier	439	Unsigned32	
Rating-Group	432	Unsigned32	

CCR-I

```
CCR (0000: 272, 00)
├─ Session-Id: "pgw_c.example.com;123;456;gy"
├─ Auth-Application-Id: 4
├─ Origin-Host: "omni-pgw_c.epc.mnc999.mcc999.3gppnetwork.org"
├─ Origin-Realm: "epc.mnc999.mcc999.3gppnetwork.org"
├─ Destination-Realm: "epc.mnc999.mcc999.3gppnetwork.org"
├─ CC-Request-Type: INITIAL_REQUEST (1)
├─ CC-Request-Number: 0
├─ Subscription-Id (Grouped)
│   └─ Subscription-Id-Type: END_USER_IMSI (1)
│       └─ Subscription-Id-Data: "310260123456789"
├─ Subscription-Id (Grouped)
│   └─ Subscription-Id-Type: END_USER_E164 (0)
│       └─ Subscription-Id-Data: "15551234567"
├─ Service-Context-Id: "32251@3gpp.org"
├─ Multiple-Services-Credit-Control (Grouped)
│   └─ Service-Identifier: 1
│       └─ Rating-Group: 100
│           └─ Requested-Service-Unit (Grouped)
│               └─ CC-Total-Octets: 10000000 (0010 MB)
└─ Used-Service-Unit (Grouped)
    └─ CC-Total-Octets: 0 (0000)
```

CCA-Initial00000000 - 0000

0000 OCS00CCR-I

0000

- 0000000000
- 0000000000
- 0000000000

PGW-C0000000AVP0

AVP名	AVP番号	内容
Result-Code	268	2001 (成功)
Multiple-Services-Credit-Control	456	サービスクレジット制御
Granted-Service-Unit	431	サービス単位の割当
Validity-Time	448	有効期間
Result-Code	268	成功
Final-Unit-Indication	430	最終サービス単位の指示
Volume-Quota-Threshold	-	体積クォータ閾値

例

```

CCA (AVP番号: 272, 内容)
├─ Session-Id: "pgw_c.example.com;123;456;gy"
├─ Result-Code: DIAMETER_SUCCESS (2001)
├─ Origin-Host: "ocs.example.com"
├─ Origin-Realm: "example.com"
├─ Auth-Application-Id: 4
├─ CC-Request-Type: INITIAL_REQUEST (1)
├─ CC-Request-Number: 0
├─ Multiple-Services-Credit-Control (Grouped)
│   ├─ Result-Code: DIAMETER_SUCCESS (2001)
│   ├─ Service-Identifier: 1
│   ├─ Rating-Group: 100
│   └─ Granted-Service-Unit (Grouped)
│       └─ CC-Total-Octets: 10000000 (約10 MB)
├─ Validity-Time: 3600 (1時間)
└─ Volume-Quota-Threshold: 8000000 (約8 MBの80%)

```

CCR-Update (サービス更新) - 例

例

- 80%
-
-
-

-
-
-

CCR-I

- CC-Request-Type: UPDATE_REQUEST (2)
- CC-Request-Number
- Used-Service-Unit
- Requested-Service-Unit

CCR-U

```

CCR ( : 272, )
├─ Session-Id: "pgw_c.example.com;123;456;gy"
├─ Auth-Application-Id: 4
├─ Origin-Host: "omni-pgw_c.epc.mnc999.mcc999.3gppnetwork.org"
├─ Origin-Realm: "epc.mnc999.mcc999.3gppnetwork.org"
├─ Destination-Realm: "epc.mnc999.mcc999.3gppnetwork.org"
├─ CC-Request-Type: UPDATE_REQUEST (2)
├─ CC-Request-Number: 1
└─ Multiple-Services-Credit-Control (Grouped)
    ├─ Service-Identifier: 1
    ├─ Rating-Group: 100
    ├─ Used-Service-Unit (Grouped)
    │   └─ CC-Total-Octets: 8000000 (8 MB)
    └─ Requested-Service-Unit (Grouped)
        └─ CC-Total-Octets: 10000000 (10 MB)
  
```

CCA-Update

OCS CCR-U

-
-
-

1.

```
CCA (00)
└─ Multiple-Services-Credit-Control
    └─ Result-Code: DIAMETER_SUCCESS (2001)
        └─ Granted-Service-Unit
            └─ CC-Total-Octets: 10000000 (10 MB)
                └─ Validity-Time: 3600
```

2.

```
CCA (00)
└─ Multiple-Services-Credit-Control
    └─ Result-Code: DIAMETER_SUCCESS (2001)
        └─ Granted-Service-Unit
            └─ CC-Total-Octets: 1000000 (1 MB)
                └─ Final-Unit-Indication
                    └─ Final-Unit-Action: TERMINATE (0)
```

3.

CCA (00)

└─ Result-Code: DIAMETER_CREDIT_LIMIT_REACHED (4012)

└─ Multiple-Services-Credit-Control

└─ Result-Code: DIAMETER_CREDIT_LIMIT_REACHED (4012)

└─ Final-Unit-Indication

└─ Final-Unit-Action: TERMINATE (0)

CCR-Termination 00000000 - 0000

0000

- UE 00
- PDN 0000
- 0000000000

0000

- 00000000
- 00Gy/Ro 00
- 0000

000000

- CC-Request-Type: TERMINATION_REQUEST (3)
- Used-Service-Unit 00000000
- Requested-Service-Unit 00000000
- Termination-Cause

00 CCR-T 0000

```
CCR (0000: 272, 00)
├─ Session-Id: "pgw_c.example.com;123;456;gy"
├─ Auth-Application-Id: 4
├─ Origin-Host: "omni-pgw_c.epc.mnc999.mcc999.3gppnetwork.org"
├─ Origin-Realm: "epc.mnc999.mcc999.3gppnetwork.org"
├─ Destination-Realm: "epc.mnc999.mcc999.3gppnetwork.org"
├─ CC-Request-Type: TERMINATION_REQUEST (3)
├─ CC-Request-Number: 5
├─ Termination-Cause: DIAMETER_LOGOUT (1)
└─ Multiple-Services-Credit-Control (Grouped)
    ├─ Service-Identifier: 1
    ├─ Rating-Group: 100
    └─ Used-Service-Unit (Grouped)
        └─ CC-Total-Octets: 18500000 (00018.5 MB)
```

CCA-Termination00000000 - 0000

0000 OCS00CCR-T

0000

- 00000000
- 0000
- 00000000

00CCA-T0

```
CCA (0000: 272, 00)
├─ Session-Id: "pgw_c.example.com;123;456;gy"
├─ Result-Code: DIAMETER_SUCCESS (2001)
├─ Origin-Host: "ocs.example.com"
├─ Origin-Realm: "example.com"
├─ Auth-Application-Id: 4
├─ CC-Request-Type: TERMINATION_REQUEST (3)
└─ CC-Request-Number: 5
```

□□□□□□

□□□□□□

OCS□□□□□□□□□□□□

□□□□	AVP	□□	□□
□□	CC-Time	□	□□□□□□□□□□ □
□□	CC-Total-Octets	□□□□□□+□ □□	□□□□
□□□□ □□	CC-Input-Octets, CC-Output-Octets	□□□□□□	□□□□□
□□□□	CC-Service-Specific-Units	□□□□□	□□□□□□API□□
□□	-	□□□□	□□□□□□□

□□□□□□

□□ PGW-C□□□□□□□□□□□□

□□□□ OCS□□**Volume-Quota-Threshold**□**Time-Quota-Threshold**□PGW-C□□
PGW-U□PFCP□□□□□□□□□□□□PFCP□□□□

□□□□□

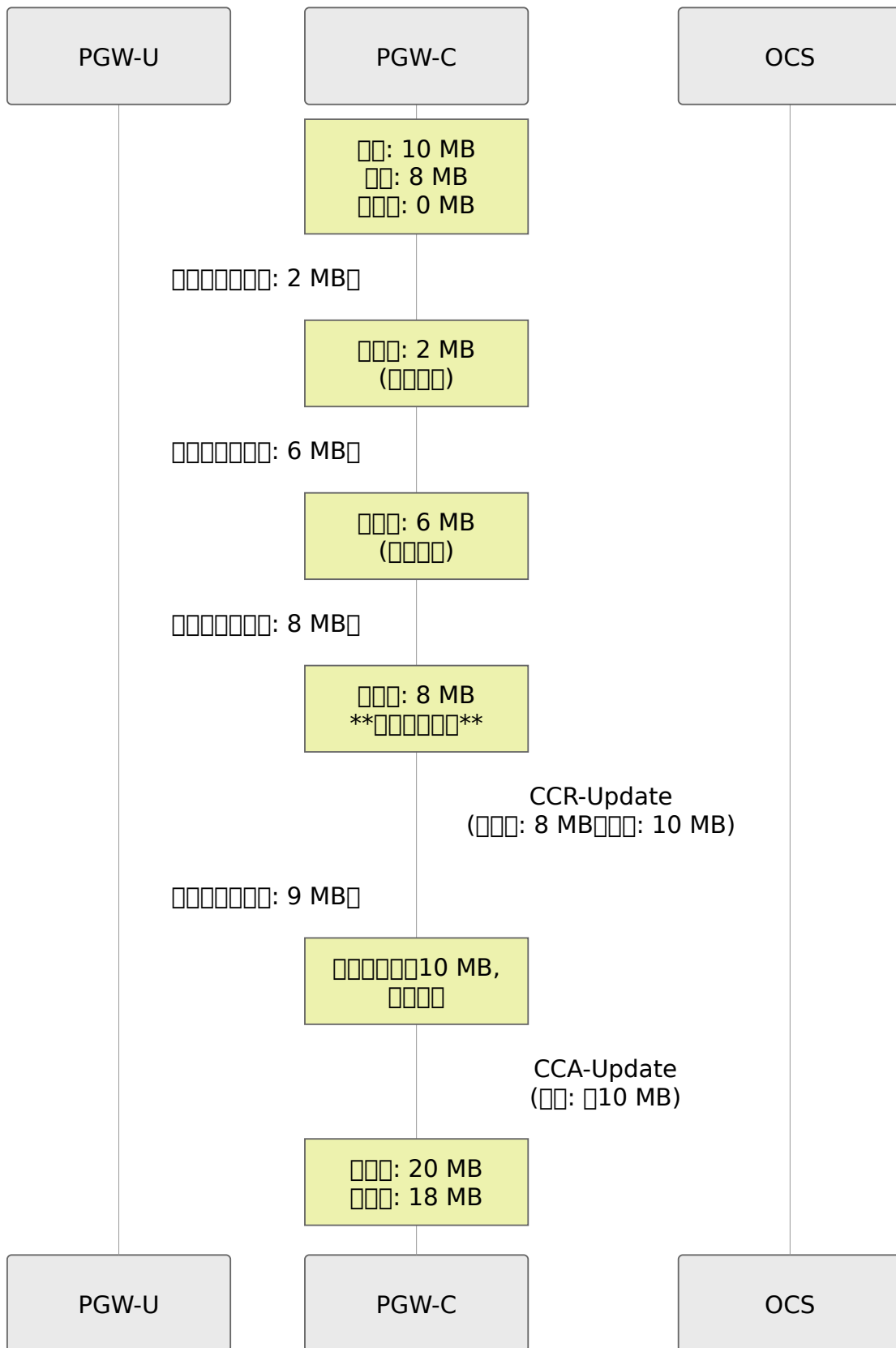
1. OCS 10 MB 80% 8 MB
2. PGW-C PGW-U PFCP
3. 8 MB
 - PGW-C CCR-Update
 -
4. OCS
5. CCR-Update
 - PGW-C

Granted-Service-Unit: 10000000 10 MB
 Volume-Quota-Threshold: 8000000 8 MB

8 MB → CCR-Update
 2 MB OCS

PGW-C

PGW-C PGW-U PFCP



□□□□□□

□□□□□□□□□□□□

OCS CCA Final-Unit-Indication AVP

Final-Unit-Action		PGW-C
TERMINATE	0	
REDIRECT	1	
RESTRICT_ACCESS	2	

CCA ()

```
└─ Multiple-Services-Credit-Control
   └─ Result-Code: DIAMETER_SUCCESS (2001)
   └─ Granted-Service-Unit
      └─ CC-Total-Octets: 1000000 (1 MB)
      └─ Final-Unit-Indication
         └─ Final-Unit-Action: REDIRECT (1)
            └─ Redirect-Server (Grouped)
               └─ Redirect-Address-Type: URL (2)
                  └─ Redirect-Server-Address:
                     "http://topup.example.com"
```

PGW-C

- TERMINATE:** CCR-T
- REDIRECT:** PFCP HTTP URL
- RESTRICT_ACCESS:** PFCP IP

3GPP TS 23.203, TS 29.212, TS 32.251

□□□□PCR□□Gx□□□□**PCC**□□□□□□□□PCC□□□□□□□□Gx□□□

□□□□□□

□□□□□□

PGW-C□□CCR-I□PCRF

PCRF□□PCC□□

PCC□□□□
□□□□
□□□

□PCC□□□□
□□□

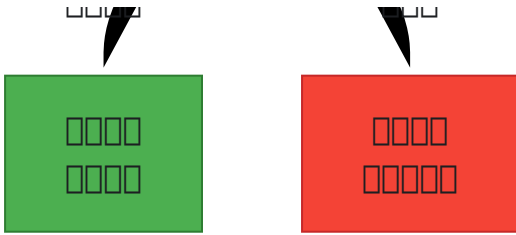
□□□□□□□□

PGW-C□□CCR-I
□OCS

□□□□
□□□

OCS
□□□

□□□□ □□□□



□□□□□□**PCC**□□

PCRF□□□**Gx**□□**CCA-I**□□

```

CCA (Gx□□)
├─ Charging-Rule-Definition (Grouped)
│  └─ Charging-Rule-Name: "prepaid_data_rule"
│  └─ Rating-Group: 100
│  └─ Online: 1 (□□□□□□)
│  └─ Offline: 0 (□□□□□□)
│  └─ Metering-Method: VOLUME (1)
│  └─ Precedence: 100
│  └─ Flow-Information: [...]
│  └─ QoS-Information: [...]

```

PCC□□□□□□□□**AVP**□

AVP	AVP		
Rating-Group	432	Unsigned32	OCSE
Online	1009	0=, 1=	Gy
Offline	1008	0=, 1=	Gz
Metering-Method	1007	0=, 1=, 2=	
Reporting-Level	1011	0=, 1=	

		Rating-Group	
1	0		
0	1		
1	1		
0	0	-	

PDN

```

□□□□□□□□
├─ Rating-Group: 100□□□□□□
└─ Online: 1

```

```

□□□□1□□□□□□
├─ Rating-Group: 200□□□□□□
└─ Online: 1

```

```

□□□□2□IMS□□□□
├─ Rating-Group: 300□□□□□
└─ Online: 1

```

PGW-C Gy□□□

- □□**CCR-I**□□□□□MSCC□□□□□□□□□□□□□□□□□□□

```

CCR-Initial
├─ Session-Id: "...
└─ Multiple-Services-Credit-Control
    ├─ [Rating-Group: 100] → □□□□
    ├─ [Rating-Group: 200] → □□□□
    └─ [Rating-Group: 300] → □□

```

OCS□□□

```

CCA-Initial
├─ Multiple-Services-Credit-Control
    ├─ [Rating-Group: 100] → □□: 10 MB
    ├─ [Rating-Group: 200] → □□: 5 MB□□□□□□□□
    └─ [Rating-Group: 300] → □□: 60□

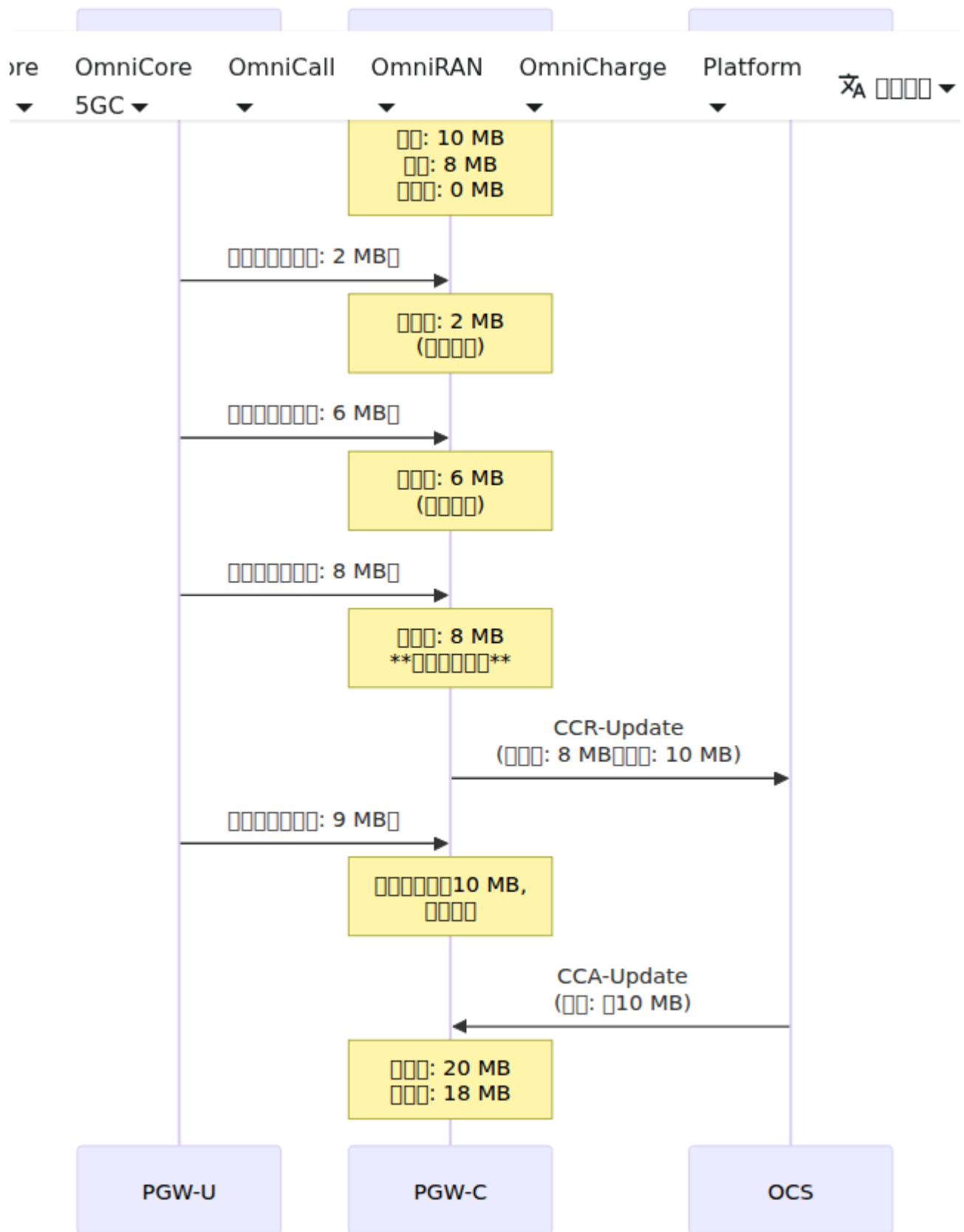
```

□□□□□□□□

PGW-C□□□□□□□□□□□□□□

```
# [][]
state.charging_quotas = %{
  100 => %{granted: 10_000_000, used: 0, threshold: 8_000_000},
  200 => %{granted: 5_000_000, used: 0, threshold: 4_000_000},
  300 => %{granted: 60_000, used: 0, threshold: 48_000} # []
}
```

[][][][][][][]



□□□□□□□□

MSCC□□□□□□□□AVP

□□□ □□□□□/□□□□□□□□□□

◆◆□□

```
Multiple-Services-Credit-Control (Grouped, AVP 456)
├─ Service-Identifier (Unsigned32, AVP 439)
├─ Rating-Group (Unsigned32, AVP 432)
├─ Requested-Service-Unit (Grouped, AVP 437)
│   ├─ CC-Time (Unsigned32, AVP 420)
│   ├─ CC-Total-Octets (Unsigned64, AVP 421)
│   ├─ CC-Input-Octets (Unsigned64, AVP 412)
│   └─ CC-Output-Octets (Unsigned64, AVP 414)
├─ Used-Service-Unit (Grouped, AVP 446)
│   └─ [□Requested-Service-Unit□□□□□]
├─ Granted-Service-Unit (Grouped, AVP 431)
│   └─ [□Requested-Service-Unit□□□□□]
├─ Validity-Time (Unsigned32, AVP 448)
├─ Result-Code (Unsigned32, AVP 268)
└─ Final-Unit-Indication (Grouped, AVP 430)
    └─ Final-Unit-Action (Enumerated, AVP 449)
```

Table with 3 columns

Item	Category	Price
Item 1	Category A	Price 1
Item 2	1=Category 2=Category 3=Category	100=Price 200=Price
Item 3	Category	Price
Item 4	Category	Price
Item 5	Category RG	OCS Price

Text

```
Service-Identifier: 1000000000
├─ Rating-Group: 1000000000 - $0.01/MB
└─ Rating-Group: 2000000000 - $0.05/MB

Service-Identifier: 2000000000
└─ Rating-Group: 3000000000 - $0.10/MB
```

Text

Gy

config/runtime.exs

```

config :pgw_c,
  gy: %{
    # 
    enabled: true,

    # OCS
    timeout_ms: 5000,

    # PCRF
    default_requested_quota: 10_000_000, # 10 MB

    # 
    # (0.8 = 80% CCR-Update)
    quota_threshold_percentage: 0.8,

    # OCS
    # : :block, :allow
    timeout_action: :block,

    # OCS
    # : :terminate, :redirect
    no_credit_action: :terminate,

    # URL no_credit_action: :redirect
    topup_redirect_url: "http://topup.example.com"
  },
  diameter: %{
    listen_ip: "0.0.0.0",
    host: "omni-pgw_c.epc.mnc999.mcc999.3gppnetwork.org",
    realm: "epc.mnc999.mcc999.3gppnetwork.org",

    # OCS
    peer_list: [
      # PCRF Gx
      %{
        host: "pcrf.epc.mnc999.mcc999.3gppnetwork.org",
        realm: "epc.mnc999.mcc999.3gppnetwork.org",
        ip: "10.0.0.30",
        initiate_connection: true
      },
      # OCS Gy
      %{
        host: "ocs.epc.mnc999.mcc999.3gppnetwork.org",

```

```
    realm: "epc.mnc999.mcc999.3gppnetwork.org",
    ip: "10.0.0.40",
    initiate_connection: true
  }
]
}
```

□□□□□□

enabled

- `true` □□□□□□□□□□ CCR □□□□ OCS
- `false` □□□□□□□□□□ Gy □□

timeout_ms

- □□ OCS □ CCA □□□□□
- □□□ 3000-5000 ms

default_requested_quota

- □□ PCRF □□□□□□□□□□□
- □□□□ 1-100 MB

quota_threshold_percentage

- □□□□□□□□□□ CCR-Update
- □□□ 0.75-0.85 □ 75%-85% □
- □□ = □□□□□□□□□□□□
- □□ = □□□□□□□□□□

timeout_action

- `:block` - □□ OCS □□□□□□□□□□□□□□□□
- `:allow` - □□ OCS □□□□□□□□□□□□□□□□

no_credit_action

- `:terminate` - □□□□□□□□□□

- `:redirect` - 00000000

00000000

000000000000

```
config :pgw_c,  
  gy: %{\br/>    enabled: true,  
    timeout_action: :block,  
    no_credit_action: :terminate,  
    quota_threshold_percentage: 0.8  
  }
```

00/000

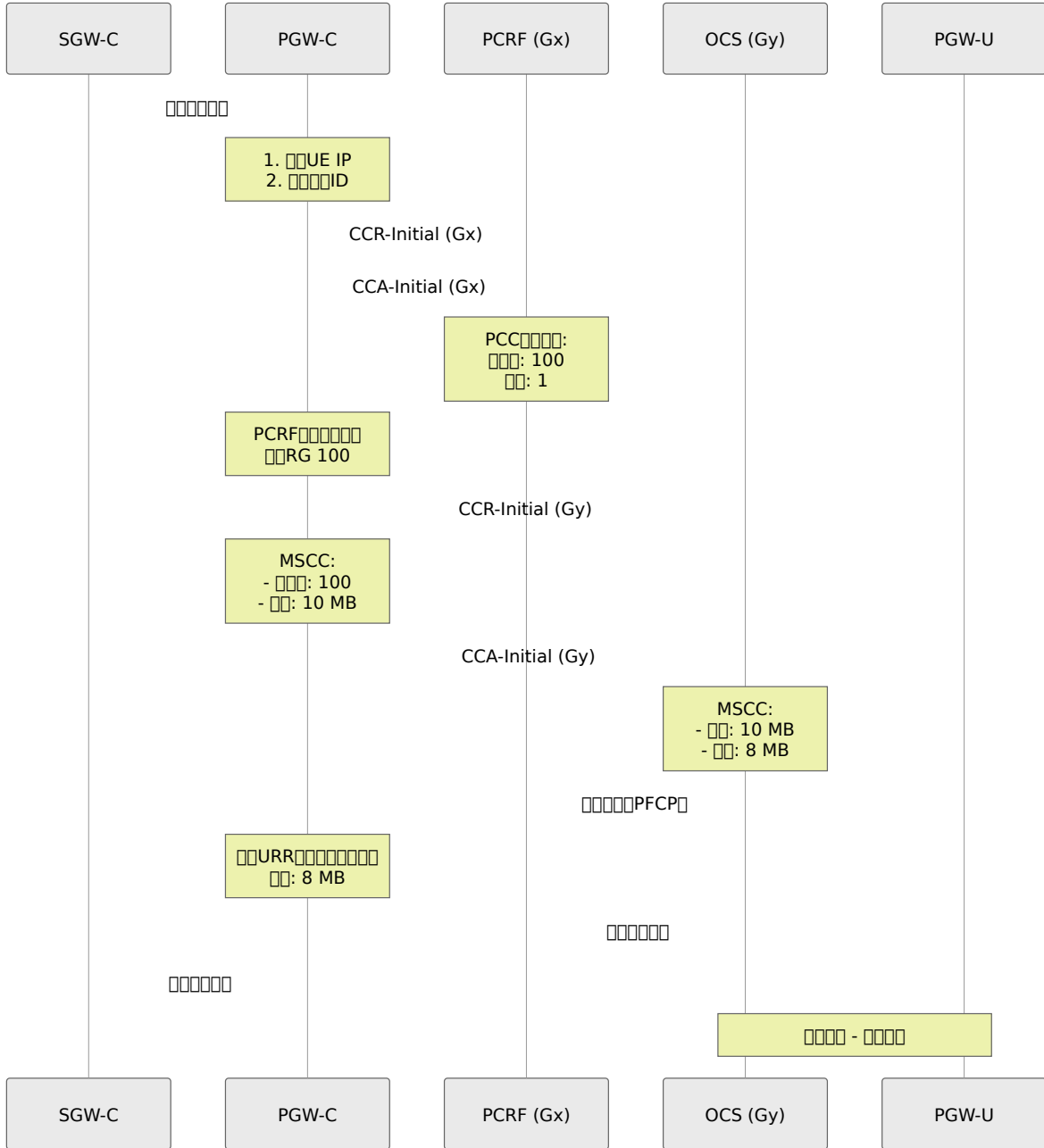
```
config :pgw_c,  
  gy: %{\br/>    enabled: false # 0000  
  }
```

0000000000000000

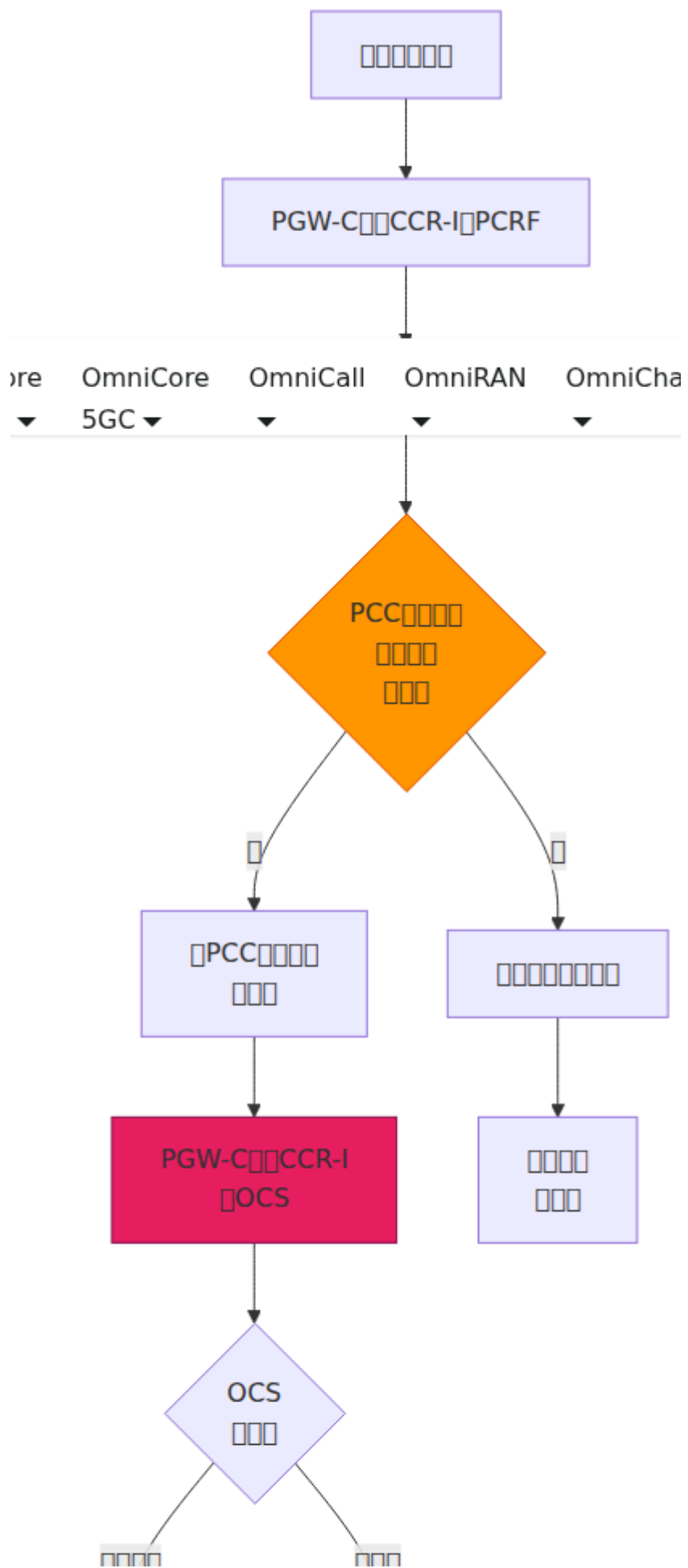
```
config :pgw_c,  
  gy: %{\br/>    enabled: true, # PCRFB000000  
    timeout_action: :allow, # OCS000000000  
    no_credit_action: :terminate  
  }
```

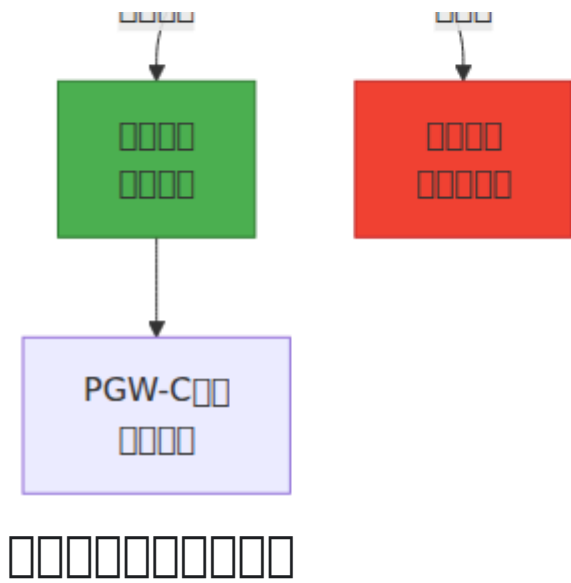
□□□□

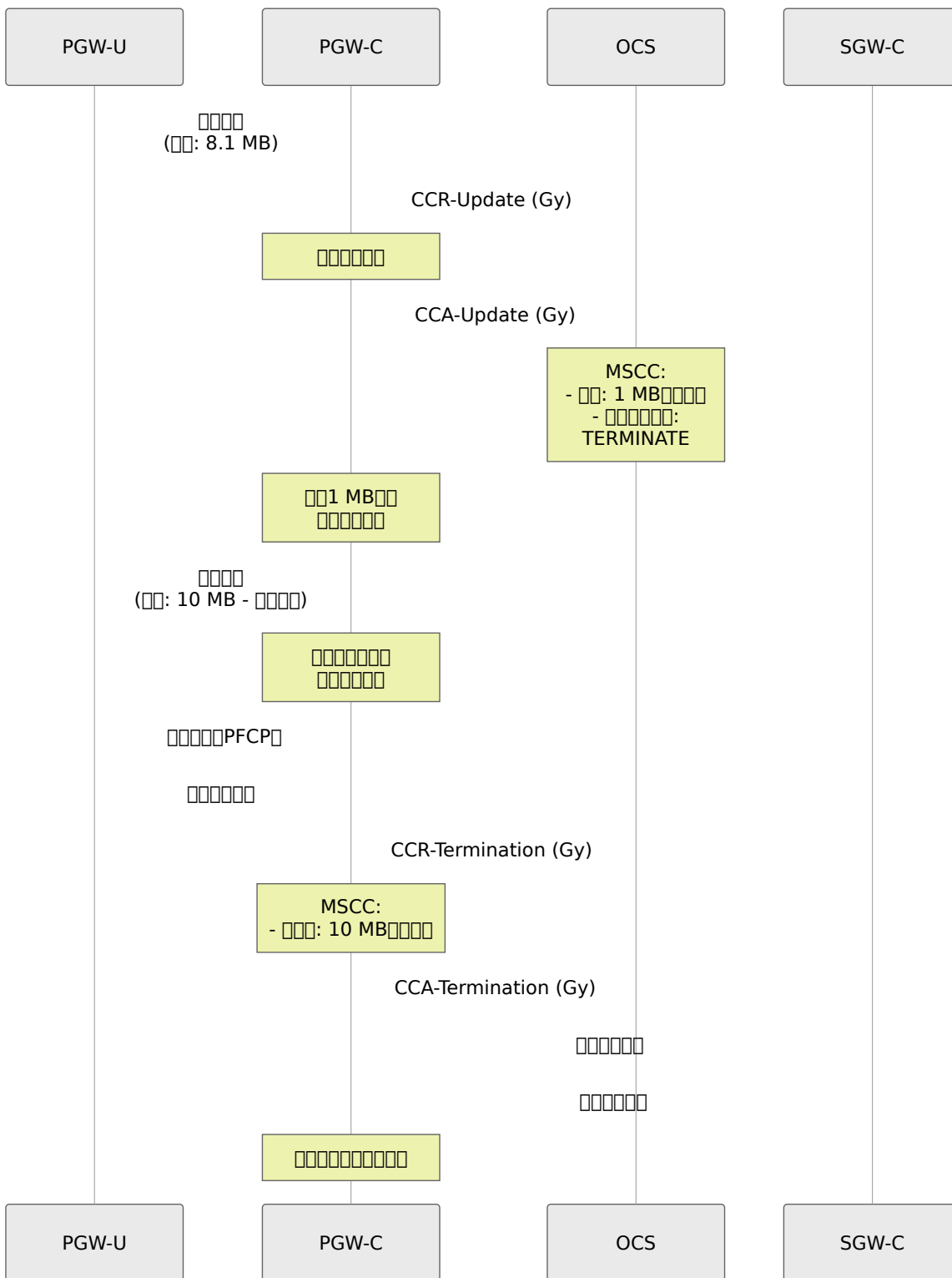
□□□□□□□□



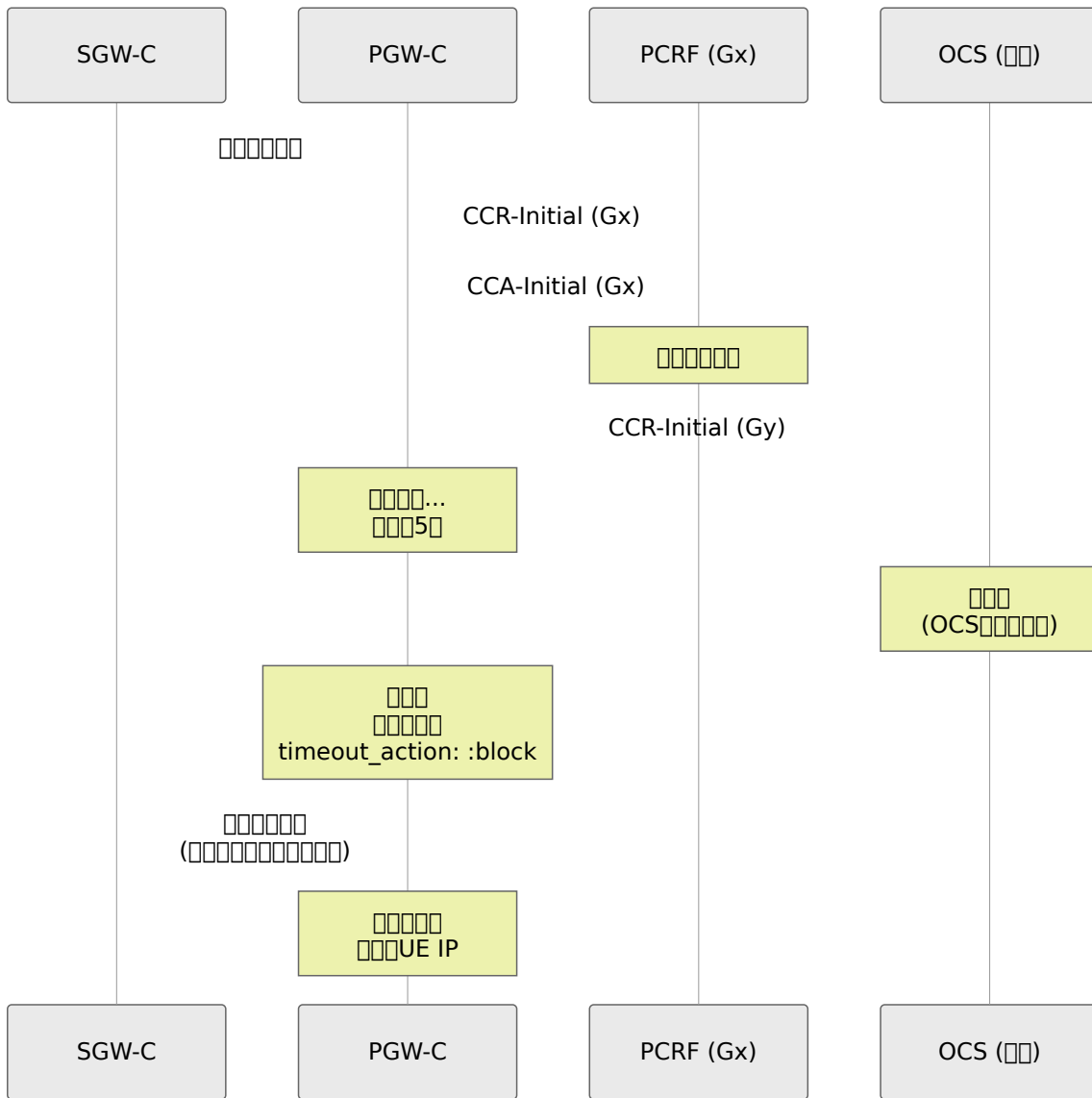
□□□□□□ **CCR-Update** □







OCS



IP

IP

IP

Code	Message	Severity
2001	DIAMETER_SUCCESS	Information

4xxx

Code	Message	PGW-C
4010	DIAMETER_TOO_BUSY	Information
4011	DIAMETER_UNABLE_TO_COMPLY	Information
4012	DIAMETER_CREDIT_LIMIT_REACHED	Information

5xxx

Code	Message	PGW-C
5003	DIAMETER_AUTHORIZATION_REJECTED	Information
5031	DIAMETER_USER_UNKNOWN	Information

Result-Code

Result-Code

1. -
2. **MSCC** -

CCA-Initial

└─ Result-Code: DIAMETER_SUCCESS (2001) ← OK

└─ Multiple-Services-Credit-Control

└─ [Rating-Group: 100]

└─ Result-Code: DIAMETER_SUCCESS (2001) ← RG 100 OK

└─ [Rating-Group: 200]

└─ Result-Code: DIAMETER_CREDIT_LIMIT_REACHED (4012) ←

RG 200

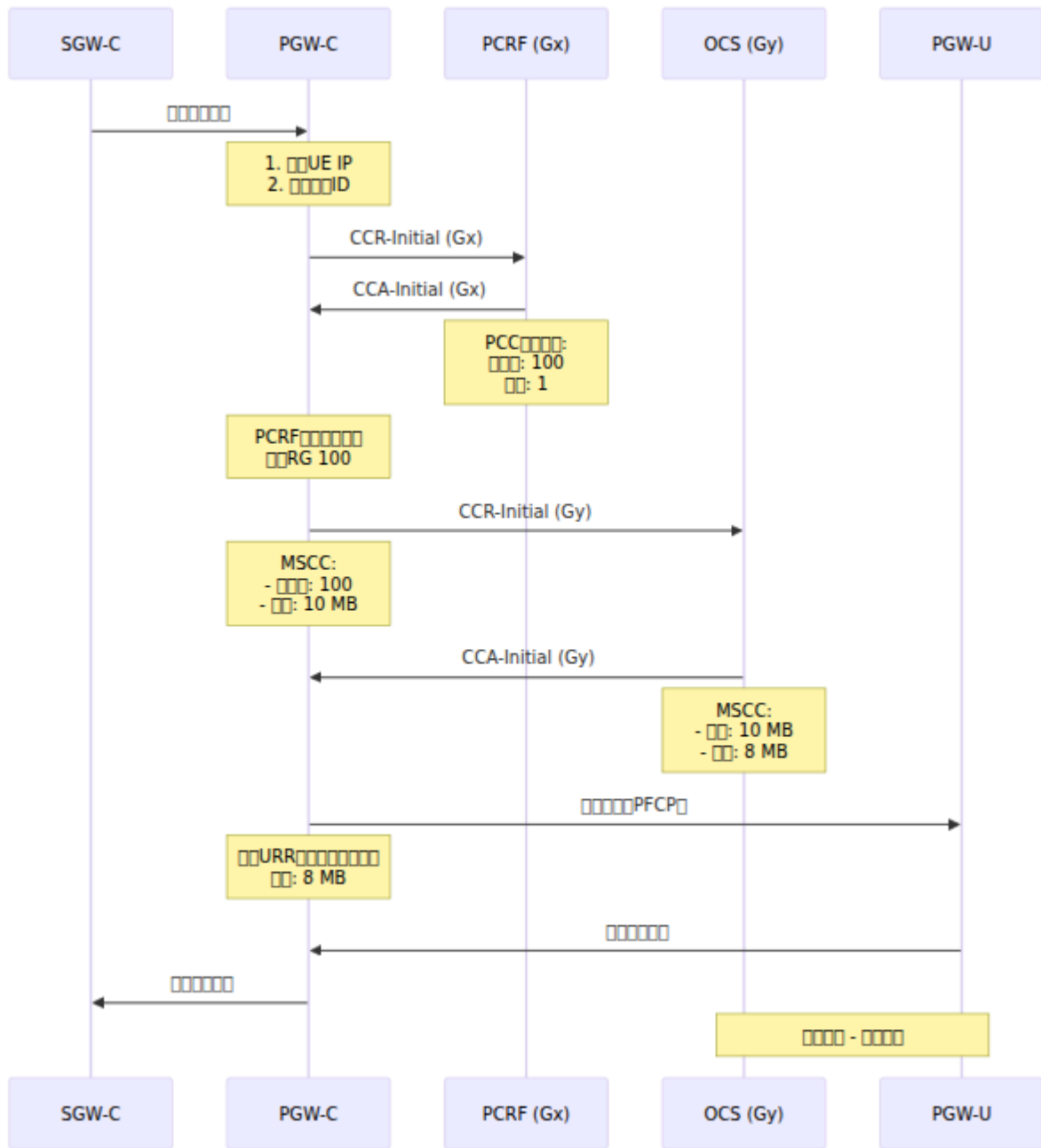
PGW-C

- 100
- 200

Gx

Gx PCRF  Gy 

Gx-Gy



1. 1. 1. 1.

1. 1. 1. 1.

PGW-C□□□□□□□□

↓

□□CCR-I□PCRFGx□

↓

□□CCA-I□PCC□□

↓

□□PCC□□□

- □□□□□□□□

- □□=1□

↓

□□□□

□□CCR-I□OCS□Gy□□□□□

↓

□□CCA-I□□□

↓

□□□□□□□□

□□□□□□□□

□□□□

□□□□□□□□

2. □□□□□□PCRFGxRAR□

PCRFGx□□□RAR□□□□□□□□

↓

□□PCC□□□□□=1□□□□=200

↓

PGW-C□□CCR-U□OCS□Gy□

- □□□□200□□MSCC

↓

OCS□□□□□□□□

↓

□□□□□□□□□□

□□□□

□□□□

1. CCR-Initial□OCS□□

□□□

- □□□□□□“OCS□□”
- □□□“CCR-Initial□Gy□□□”

□□□□□

- OCS□□□
- □□□□OCS IP□□□
- □□□□□□□□□□3868□
- OCS□□

□□□□□

```
# □□□□□□  
ping <ocs_ip>  
  
# □□□□□□□□TCP 3868□  
telnet <ocs_ip> 3868  
  
# □□□□  
# □□□peer_list□□□□□OCS□□□□
```

2. □□□□OCS□□

□□□

- CCA-I□Result-Code != 2001
- □□□□□□□□□

□□□□□□□□

Code	Category	Item
4012	Category 1	Item 1
5003	Category 2	Item 2
5031	Category 3	Item 3 (OCS)

Section 1

- Item 1 (OCS)
- Item 2 (OCS)
- Item 3 (CCR-I, IMSI/MSISDN)

3. Section 3

Section 4

- Item 1
- Item 2 (CCR-Update)

Section 5

- Item 1 (PGW-U, URR)
- Item 2
- Item 3 (PFCP)

Section 6

- Item 1 (PFCP, URR)

URR

```

├─ URR-ID: 1
├─ Measurement-Method: VOLUME
├─ Volume-Threshold: 8000000 8 MB
└─ Reporting-Triggers: VOLUME_THRESHOLD

```

- Item 2 (PGW-U)

3. `quota_threshold_percentage`

4. `quota_threshold`

`quota`

- OCS `quota_threshold` “`quota_threshold`”
- `quota`

`quota`

- CCR-I `quota_threshold` OCS `quota_threshold`
- PCR-F `quota_threshold`

`quota`

1. `PCR-F` `PCC` `quota_threshold`
 2. `OCS` `quota_threshold`
 3. `PCC` `OCS` `quota_threshold`
-

□□

□□□□

```
# Gy□□□□  
rate(gy_inbound_messages_total{message_type="cca"}[5m])  
rate(gy_outbound_messages_total{message_type="ccr"}[5m])  
  
# Gy□□□□  
rate(gy_inbound_errors_total[5m])  
  
# □□□□□□  
rate(gy_quota_exhausted_total[5m])  
  
# OCS□□□  
rate(gy_timeout_total[5m])  
  
# Gy□□□□□□□□  
histogram_quantile(0.95,  
rate(gy_inbound_handling_duration_bucket[5m]))
```



```
# GyErrorRateHigh
- alert: GyErrorRateHigh
  expr: rate(gy_inbound_errors_total[5m]) > 0.1
  for: 5m
  annotations:
    summary: "GyErrorRateHigh"

# OcsTimeout
- alert: OcsTimeout
  expr: rate(gy_timeout_total[5m]) > 0.05
  for: 2m
  annotations:
    summary: "OcsTimeout"

# GyQuotaExhaustionSpike
- alert: CreditExhaustionSpike
  expr: rate(gy_quota_exhausted_total[5m]) > 10
  for: 5m
  annotations:
    summary: "CreditExhaustionSpike"
```

Web UI - GyErrorRateHigh

OmniPGW GyErrorRateHigh/RoamingOcsTimeout

URL `http://<omnipgw-ip>:<web-port>/gy_simulator`

0000 00000000000000000000

0000

1. 0000

- **IMSI** - 0000000000“310170123456789”
- **MSISDN** - 0000000000“14155551234”
- 0000 - 0000000000000000
- 00**ID** - 00000000
- 0000 - 00000

2. CCR-I

- 00CCR-Initial0000000000
- 0000000000000000
- 00OCS0000000000

3. 00

- 0000 - 00000000Gy
- **OCS** - 00OCS000000
- 0000 - 0000000000

- IMSI - MSISDN
- IMSI - IMSI

IMS

1. IMSI/MSISDN
2. IMSI/MSISDN 1000000000 1 MB
3. IMSI/MSISDN
4. IMSI/MSISDN "CCR-I"
5. IMSI/MSISDN

IMS

- IMSI/MSISDN OCS
 - IMSI/MSISDN
 - IMSI/MSISDN
 - IMSI/MSISDN
-

IMS

IMS

- **Gx** - PCRF IMSI/MSISDN PCC
- **CDR** - IMSI/MSISDN
- **IMS** - IMSI/MSISDN

IMS

- **IMS** - PDN IMSI/MSISDN
- **PFCP** - IMSI/MSISDN URR PGW-U
- **S5/S8** - GTP-C IMSI/MSISDN

□□

- □□□□ - Gy□□□□□□□□□□OCS□□□□
 - **UE IP**□□ - □□□□□□IP□□□□
-

□□□□□□

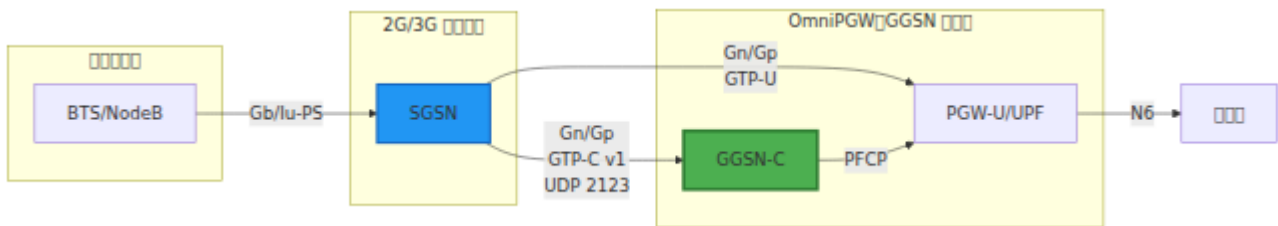
Gn/Gp

SGSN GTP-C 2G/3G

OmniPGW Omnitouch

Gn/Gp OmniPGW 2G/3G GGSN GPRS GTP-C v1
GGSN SGSN PDP

- Gn PLMN SGSN
- Gp PLMN SGSN



PGW S5/S8

	GGSN (Gn/Gp)	PGW (S5/S8)
	GTP-C v1	GTP-C v2
3GPP	TS 29.060	TS 29.274
	PDP	PDN +
	NSAPI (0-15)	EBI (5-15)
		Gx (PCRF)
QoS	R99 QoS	EPS QoS (QCI)
	2123	2123

GTP-C 1

- GTP-C v1 (3GPP TS 29.060)
- UDP
- 2123 S5/S8 GTP-C v2
-

TEID

PDP TEID

- GGSN TEID OmniPGW
- GGSN TEID UPF

- **SGSN** 的 **TEID** 与 SGSN 的 IP 地址
- **SGSN** 的 **TEID** 与 SGSN 的 IP 地址

转换

SGSN → GGSN: 本地 TEID = GGSN 的 TEID

GGSN → SGSN: 本地 TEID = SGSN 的 TEID

CUPS 网络架构

OmniPGW 的 2G/3G 的 CUPS 网络

- 本地 **GSN** 的 OmniPGW 的 IP 地址 `gn.local_ipv4_address`
- 本地 **GSN** 的 UPF 的 IP 地址 PFCP 的 IP 地址

本地 GGSN-C 的 PGW-U/UPF 的 IP 地址 CUPS 网络

NSAPI 网络架构

NSAPI 的 PDP 网络

- 本地 5-15-0-4 的 IP
- 本地 PDP 的 IP
- 本地 LTE/EPC 的 EBI

□□

□□□□

```
# config/runtime.exs
config :pgw_c,
  # gn gn/gp
  gn: %{
    # Gn IPv4
    local_ipv4_address: "10.0.0.20",

    # IPv6
    local_ipv6_address: nil,

    # GTP-C v1 S5/S8
    local_port: 2123
  },

  # PCO DNS PGW
  dns: %{
    primary_ipv4: {8, 8, 8, 8},
    secondary_ipv4: {8, 8, 4, 4}
  }
}
```

Gn □□□□

□□	□□	□ □	□□	□□
local_ipv4_address	□□ □	□	-	□□ Gn □□□□ IPv4 □□□□□□ SGSN □ □□ GGSN □□□
local_ipv6_address	□□ □	□	nil	□□□ IPv6 □□□□□□ 2G/3G □□□□□ IPv4□
local_port	□□	□	2123	GTP-C □ UDP □□□□□ 3GPP TS 29.060 □□□□□□□ S5/S8 □□□

DNS

Parameter	Required	Optional	Default	Description
primary_ipv4	Yes	No	{8, 8, 8, 8}	PCO DNS IPv4 address
secondary_ipv4	Yes	No	{8, 8, 4, 4}	PCO DNS IPv4 address
primary_ipv6	Yes	No	nil	DNS IPv6 address
secondary_ipv6	Yes	No	nil	DNS IPv6 address

Example

Example

```
# SGSN GTP-C
iptables -A INPUT -p udp --dport 2123 -s <sgsn_network>/24 -j ACCEPT

# SGSN GTP-C
iptables -A OUTPUT -p udp --dport 2123 -d <sgsn_network>/24 -j ACCEPT
```

Example

PDP

Example PDP

SGSN → GGSN

PDP

Information Elements

IE	Length	Description
IMSI	13	Subscriber Identity Module (SIM) number
NSAPI	5-15	Network Service Access Point Identifier
TEID I	4	Tunnel Endpoint Identifier (TEID) for the I-S-GSN
TEID S	4	Tunnel Endpoint Identifier (TEID) for the S-GSN
PDN	4	PDN IP address
APN	11	Access Point Name (APN)
GSN I	4	GSN ID for the I-S-GSN
GSN S	4	GSN ID for the S-GSN
QoS	4	Quality of Service (QoS) parameters
MSISDN	13	Mobile Subscriber ISDN Number
APN	11	Access Point Name (APN)
...

...

□□ PDP □□□□□

├─ IMSI: 310260123456789

├─ NSAPI: 5

├─ TEID □□ I: 0x12345678

├─ TEID □□: 0x87654321

├─ □□□□□□: IPv4□□□□

├─ APN: internet

├─ GSN □□□□□□: 10.1.1.100

├─ GSN □□□□□□: 10.1.1.100

├─ QoS □□□□: [R99 QoS □□]

└─ PCO: [DNS □□□]

□□ **PDP** □□□□□

□□□ GGSN → SGSN

□□□□□ PDP □□□□□□□□□□□

□□□□□□□

IE 名称	长度	说明
名称	长度	名称
名称	长度	名称
名称	长度	名称
TEID 名称 I	长度	名称
TEID 名称	长度	名称
NSAPI	长度	名称 NSAPI
名称 ID	长度	名称 ID
名称	长度	名称 UE IP 名称
名称 名称	IP	名称 名称
名称 名称	IP	名称 名称
QoS 名称	长度	名称 QoS 名称
名称	长度	DNS 名称

名称

```

PDP Context
├── APN: (128)
├── TEID I: 0xAABBCCDD
├── TEID S: 0xDDCCBBAA
├── NSAPI: 5
├── APN ID: 0x11223344
├── IP Address
│   └── IPv4: 100.64.1.42
├── GSN I: 10.0.0.20
├── GSN S: 10.0.0.20
├── QoS: [QoS]
└── PCO
    ├── DNS: 8.8.8.8
    └── DNS: 8.8.4.4

```

PDP Context

SGSN → GGSN

SGSN PDP Context SGSN QoS

Context

- SGSN Context
- QoS
- SGSN

Context

IE	Value
NSAPI	PDP Context
TEID I	SGSN TEID
GSN I	SGSN
QoS	QoS

UE **PDP** Context

UE → GGSN → SGSN

UE PDP Context

UE Context

IE	Content
TEID	UE TEID
TEID	GGSN TEID
GSN	GGSN
QoS	QoS

UE **PDP** Context

UE → SGSN → GGSN

UE PDP Context

UE Context

IE	Content
NSAPI	UE PDP Context
QoS	QoS

UE **PDP** Context

UE → GGSN → SGSN

UE PDP Context

UE Context

IE 00	00
00	00000000

0000

0000 / 00

00000

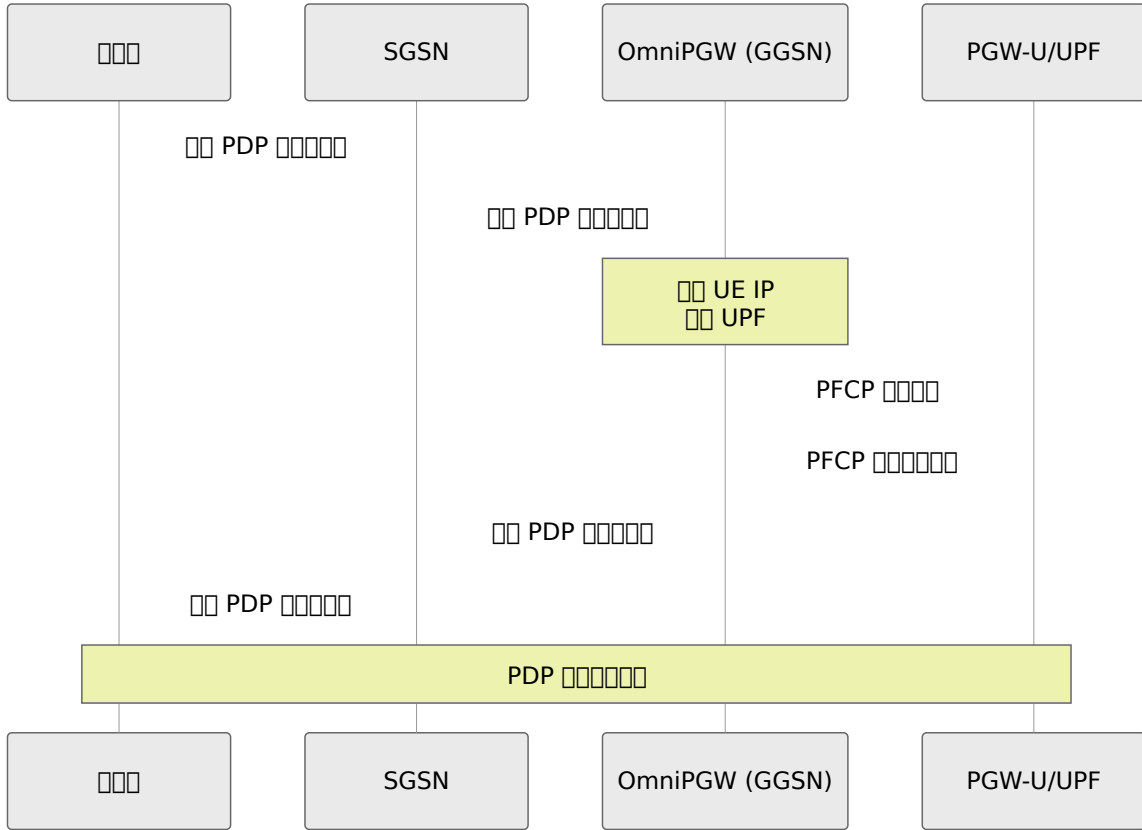
0000000000000000

0000000

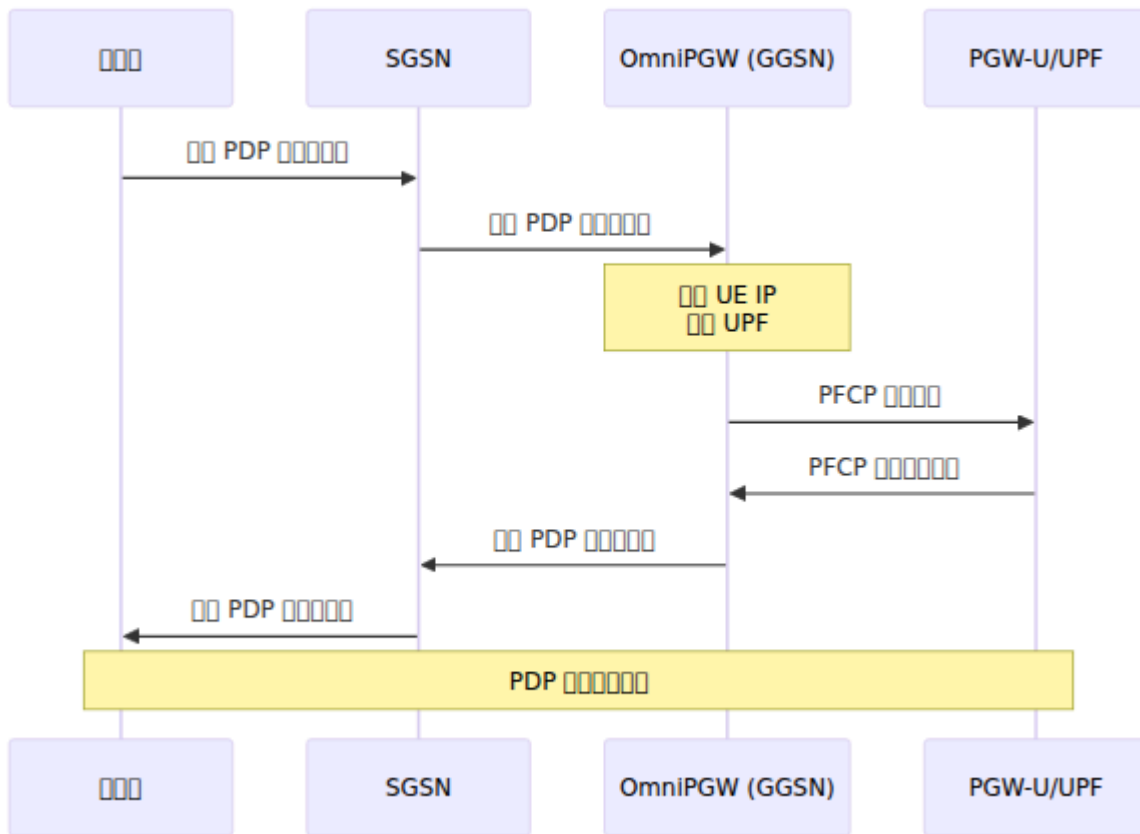
IE 00	00
00	0000000000000000

□□□

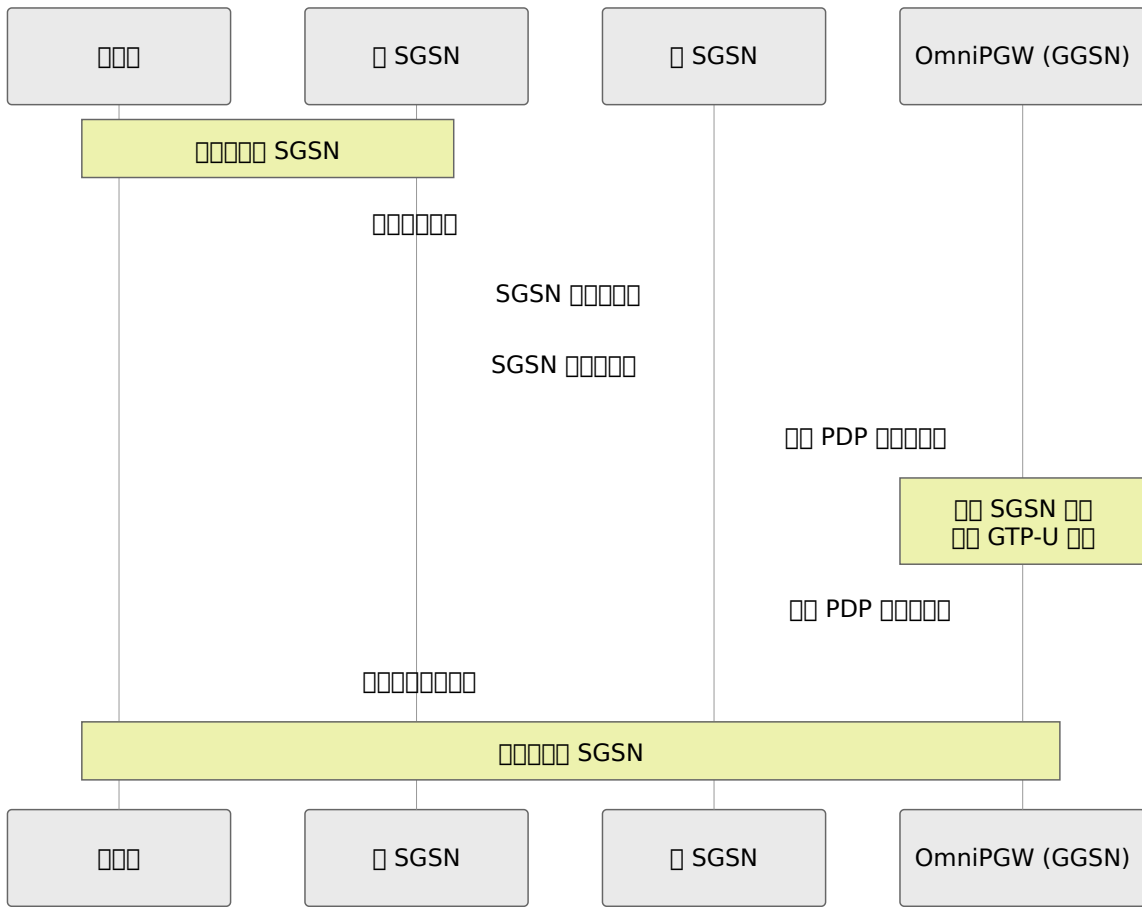
PDP □□□□□



PDP 信令流程



SGSN



OmniPGW

OmniPGW is a GGSN that acts as a PGW for all UEs.

UE IP

The PGW stores the UE IP address in the AddressRegistry table.

UPF/PFCP

The PGW stores PFCP rules in the UPF.

- The PGW stores PDR/FAR/QER rules in the UPF.
- The PGW stores upf_selection rules in the UPF.

- 3GPP TS 23.203 PFCP 3.2.1

3GPP TS 23.203 Gy

3GPP TS 23.203 Diameter Gy 3.2.1

- 3GPP TS 23.203
- PGW 3GPP TS 23.203 Gy 3.2.1
- 3GPP TS 23.203 Diameter Gy 3.2.1

CDR 3.2.1

3GPP TS 23.203 PGW 3.2.1 CDR 3.2.1 3.2.1 CDR 3.2.1

3GPP TS 23.203

3GPP

3GPP	3GPP	3GPP
128	3GPP TS 23.203	3GPP TS 23.203

□□□□

□□	□□	□□□□
192	□◆◆□	□□□ PDP □□□
193	□□□□□□□	GTP □□□□□□
194	IMSI □□	□□□□□
195	MS □ GPRS □□	MS □□□
196	MS □□□ GPRS	MS □□□□
197	MS □□	MS □□□□
198	□□□□□□	GTP □□□□□
199	□□□□□	□□□□
200	□□□□□□	□□□□□
201	□□ IE □□	IE □□□□
202	□□ IE □□	□□□□□ IE
203	□□ IE □□	□□ IE □□
204	□□□□	□□□□
205	□□□□	□□□□□
206	P-TMSI □□□□□	□□□□
207	GPRS □□□□	□□□□
208	□□□□□□	□□□□□□

項目	単位	説明
209	メッセージ数	メッセージ数

項目

Gn メトリック

```
# メトリック
gn_inbound_messages_total{message_type="create_pdp_context_request"}
gn_inbound_messages_total{message_type="update_pdp_context_request"}
gn_inbound_messages_total{message_type="delete_pdp_context_request"}

gn_outbound_messages_total{message_type="create_pdp_context_response"}
gn_outbound_messages_total{message_type="update_pdp_context_response"}
gn_outbound_messages_total{message_type="delete_pdp_context_response"}

# 遅延バケット
gn_outbound_transaction_duration_bucket
```

メトリック

PDP メトリック

```
rate(gn_inbound_messages_total{message_type="create_pdp_context_request"}
[5m])
```

メトリック

```
sum(rate(gn_outbound_messages_total{message_type="create_pdp_context_response"}
[5m]))
/
sum(rate(gn_inbound_messages_total{message_type="create_pdp_context_request"}
[5m]))
```

📄 PDP 📄📄

```
gn_inbound_messages_total{message_type="create_pdp_context_request"}  
-  
gn_inbound_messages_total{message_type="delete_pdp_context_request"}
```

📄📄📄

📄📄📄 PDP 📄📄📄📄

📄📄

- SGSN 📄📄 PDP 📄📄📄
- 📄📄📄📄
- SGSN 📄📄

📄📄📄📄

1. 📄📄📄📄
2. OmniPGW 📄📄📄 IP 📄📄
3. 📄📄📄 UDP 2123
4. UPF/PFCP 📄📄📄

📄📄

```

# 00 OmniPGW 000000
netstat -ulnp | grep 2123

# 00000000
tcpdump -i any -n port 2123

# 0000
grep "local_ipv4_address" config/runtime.exs

# 00 PFCP 00
curl http://pgw:9090/metrics | grep pfc

```

0000 PDP 0000000000

000

- 00 PDP 000000000000
- PDP 000000

000❓❓

```

00 199000000000
  → IP 000
  → 000 curl http://pgw:9090/metrics | grep address_registry_count
  → 0 ue.subnet_map 000 IP 0

00 2020000 IE 0000
  → SGSN 000000 IE
  → 00 SGSN 00
  → 0 tcpdump 000000

00 204000000000
  → UPF/PFCP 00
  → 00 PFCP 00000
  → 00 OmniPGW 00

```

000000 PDP 000000

000

- PDP Context
- Context

Context

- PDP Context TEID
- NSAPI
- Context

Context

```
# Context
curl http://pgw:9090/metrics | grep session_count

# Context
journalctl -u omnipgw | grep "PDP Context"
```

Context

Context

1. S5/S8 Context

- Gn S5/S8 UDP 2123
- OmniPGW Context GTP
- IP Context 2G/3G 4G

2. SGSN Context

- Context SGSN Context GGSN IP
- Gn Context VLAN
- Context Gp

3. IP Context

- IP Context PGW GGSN

- 2G/3G APN

1. session_count

- session_count
- 2G/3G
- 2G/3G

2. UDP

- S5/S8
- 4-8 MB

GSN OmniPGW

1. APN

- APN GSN
- PCO DNS

2. IP

- IP
- APN

3. QoS

- R99 QoS
 - 2G/3G QCI
-

□□□□

□□□□

- □□□□ - □□□□□□□□
- □□□□ - □□□□□□□□
- **UE IP** □□ - IP □□□□
- **PCO** □□ - □□□□□□

□□□□

- **S5/S8** □□ - 4G/LTE □□□□
- **PFCP** □□ - □□□□□□
- **Diameter Gy** □□ - □□□□

□□

- □□□□ - □□□□□□
- □□□□ - □□□□
- □□ **CDR** □□ - CDR □□

□□□□

- **3GPP TS 29.060** - GPRS □□□□□GTP□□□□ Gn □ Gp □□
- **3GPP TS 23.060** - □□□□□□□□□GPRS□□□□□□□□
- **3GPP TS 24.008** - □□□□□□□□ 3 □□□□□□□□□□□□□□

□□□□□□

OmniPGW Gn/Gp □□ - □ *Omnitouch* □□□□□□□□

OmniPGW 部署架构图

Prometheus 部署图

OmniTouch 部署图

部署

1. 部署
 2. 部署
 3. 部署
 4. Prometheus 部署
 5. Grafana 部署
 6. 部署
 7. 部署
 8. 部署
-

部署

OmniPGW 部署架构图

1. 部署架构图

- 部署
- PFCP 部署
- Diameter 部署
- 部署

2. Prometheus 部署架构图

- 部署
- 部署

- `prometheus`
- `node_exporter`

OmniPGW **Prometheus** `node_exporter` `prometheus` `grafana`

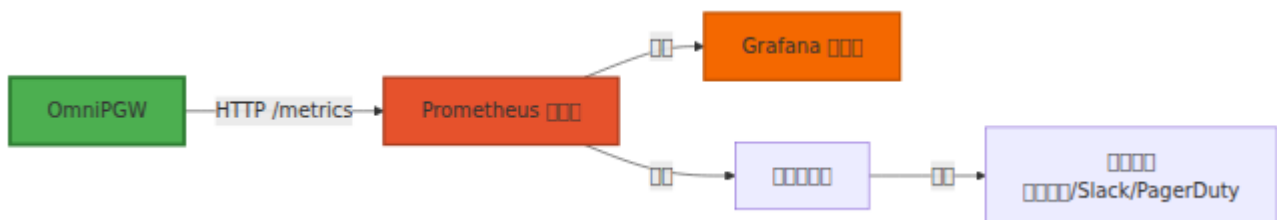
- `node_exporter` - `node_exporter`
- `PFCP` `node_exporter` - `node_exporter`
- `Diameter Gx` - `node_exporter`

Prometheus `node_exporter`

OmniPGW `node_exporter` **Prometheus** `node_exporter` `prometheus` `grafana`

- `node_exporter` - `node_exporter`
- `node_exporter` - `node_exporter`
- `node_exporter` - `node_exporter`
- `node_exporter` - `node_exporter`
- `node_exporter` - `node_exporter`

`node_exporter`



`node_exporter`

`node_exporter`

`node_exporter` `node_exporter`

```
config :pgw_c,  
  metrics: %{  
    enabled: true,  
    ip_address: "0.0.0.0", # 0.0.0.0  
    port: 9090, # HTTP 9090  
    registry_poll_period_ms: 5_000 # 5000  
  }  
}
```

0000

HTTP 000

```
http://<omnipgw_ip>:<port>/metrics
```

000

```
curl http://10.0.0.20:9090/metrics
```

0000

000 **Prometheus** 0000 000

```
# HELP teid_registry_count 000000 TEID 00  
# TYPE teid_registry_count gauge  
teid_registry_count 150  
  
# HELP address_registry_count 0000000000  
# TYPE address_registry_count gauge  
address_registry_count 150  
  
# HELP s5s8_inbound_messages_total 0 S5/S8 0000000000  
# TYPE s5s8_inbound_messages_total counter  
s5s8_inbound_messages_total{message_type="create_session_request"}  
1523  
s5s8_inbound_messages_total{message_type="delete_session_request"}  
1487
```

□□□□

OmniPGW □□□□□□□□

□□□□

□□□□□□

□□□□	□□	□□
teid_registry_count	Gauge	□□ S5/S8 □□□TEID □□□
seid_registry_count	Gauge	□□ PFCP □□□SEID □□□
session_id_registry_count	Gauge	□□ Gx □□□Diameter □□ ID □□□
session_registry_count	Gauge	□□□□□IMSI□EBI □□
address_registry_count	Gauge	□□□ UE IP □□
charging_id_registry_count	Gauge	□□□□ ID□□□□ □□ CDR □□ □□□ CDR □□□□□
sxb_sequence_number_registry_count	Gauge	□□□□ PFCP □□□□□□□□
s5s8_sequence_number_registry_count	Gauge	□□□□ S5/S8 □□□□□□□□
sxb_peer_registry_count	Gauge	□□□ PFCP □□□□□□

□□□

```

# Counter
teid_registry_count

# Rate
rate(teid_registry_count[5m])

# Max Over Time
max_over_time(teid_registry_count[1h])

```

Counter

S5/S8 (GTP-C) Counter

Counter	Type	Labels	Description
s5s8_inbound_messages_total	Counter	message_type	S5/S8 Inbound Messages
s5s8_outbound_messages_total	Counter	message_type	S5/S8 Outbound Messages
s5s8_inbound_errors_total	Counter	message_type	S5/S8 Inbound Errors

Labels

- create_session_request
- create_session_response
- delete_session_request
- delete_session_response
- create_bearer_request
- delete_bearer_request

Sxb (PCF) Counter

计数器	类型	消息类型	方向
sxb_inbound_messages_total	Counter	message_type	下行 PFCP 消息
sxb_outbound_messages_total	Counter	message_type	上行 PFCP 消息
sxb_inbound_errors_total	Counter	message_type	PFCP 下行消息错误
sxb_outbound_errors_total	Counter	message_type	PFCP 上行消息错误

消息类型

- association_setup_request
- association_setup_response
- heartbeat_request
- heartbeat_response
- session_establishment_request
- session_establishment_response
- session_modification_request
- session_deletion_request

Gx (Diameter) 消息

名称	类型	索引	单位
gx_inbound_messages_total	Counter	message_type	消息 Diameter 消息
gx_outbound_messages_total	Counter	message_type	消息 Diameter 消息
gx_inbound_errors_total	Counter	message_type	Diameter 消息
gx_outbound_errors_total	Counter	message_type	Diameter 消息
gx_outbound_responses_total	Counter	message_type, result_code_class, diameter_host	消息 Diameter 消息 消息 消息

消息类型

- gx_CCA (Credit-Control-Answer)
- gx_CCR (Credit-Control-Request)
- gx_RAA (Re-Auth-Answer)
- gx_RAR (Re-Auth-Request)

消息类型结果代码类 gx_outbound_responses_total

- 2xxx - 消息类型 2001 DIAMETER_SUCCESS
- 3xxx - 消息类型 3001 DIAMETER_COMMAND_UNSUPPORTED
- 4xxx - 消息类型 4001 DIAMETER_AUTHENTICATION_REJECTED
- 5xxx - 消息类型 5012 DIAMETER_UNABLE_TO_COMPLY

消息主机

```

# Gx
sum(rate(gx_outbound_responses_total{result_code_class="2xxx"}[5m]))
sum(rate(gx_outbound_responses_total[5m])) * 100

# PCRF
rate(gx_outbound_responses_total{result_code_class!="2xxx"}[5m]) by (

# Re-Auth-Answer
gx_outbound_responses_total{message_type="gx_RAA",result_code_class='

# PCRF
rate(gx_outbound_responses_total{result_code_class=~"4xxx|5xxx",diame
[5m]) > 0.1

```

Table

Field	Type	Index	Cardinality
rescues_total	Counter	module, function	1

Table

Table

項目名	種類	単位	
s5s8_inbound_handling_duration	Histogram	request_message_type	S [[[
sxb_inbound_handling_duration	Histogram	request_message_type	F [[[
gx_inbound_handling_duration	Histogram	request_message_type	[[[[[

項目名

項目名	種類	単位	
s5s8_outbound_transaction_duration	Histogram	request_message_type	
sxb_outbound_transaction_duration	Histogram	request_message_type	
gx_outbound_transaction_duration	Histogram	request_message_type	

項目名

- 0.0001, 0.0005, 0.001, 0.005, 0.01, 0.05, 0.1, 0.5, 1.0, 5.0
- 100µs, 500µs, 1ms, 5ms, 10ms, 50ms, 100ms, 500ms, 1s, 5s

000

```
# 95th 000 S5/S8 00
histogram_quantile(0.95,
  rate(s5s8_inbound_handling_duration_bucket[5m])
)

# 00 PFCP 00
rate(sxb_inbound_handling_duration_sum[5m]) /
rate(sxb_inbound_handling_duration_count[5m])
```

UPF 0000

UPF 00000

0000	00	00	00
upf_peers_total	Gauge	-	000 UPF 00000
upf_peers_healthy	Gauge	-	000 UPF 0000000000 + 00000
upf_peers_unhealthy	Gauge	-	0000 UPF 00000
upf_peers_associated	Gauge	-	0000 PFCP 000 UPF 00 000
upf_peers_unassociated	Gauge	-	00 PFCP 000 UPF 0000 0
upf_peer_healthy	Gauge	peer_ip	00 UPF 00000001=0000 0=00000
upf_peer_missed_heartbeats	Gauge	peer_ip	00 UPF 0000000000

□□□

```
# □□ UPF □□□  
upf_peers_healthy / upf_peers_total  
  
# □□□□ UPF □□□□  
upf_peers_unhealthy > 0  
  
# □□□□ UPF □□  
upf_peer_healthy{peer_ip="10.98.0.20"}  
  
# □□□□□□□ UPF  
upf_peer_missed_heartbeats > 2
```

□□□□□

```

# [] UPF []
- alert: UPF_Peer_Down
  expr: upf_peer_healthy == 0
  for: 1m
  labels:
    severity: critical
  annotations:
    summary: "UPF {{ $labels.peer_ip }} []"
    description: "UPF [] PFCP []"

# [] UPF []
- alert: UPF_Pool_Degraded
  expr: (upf_peers_healthy / upf_peers_total) < 0.5
  for: 2m
  labels:
    severity: critical
  annotations:
    summary: "UPF []"
    description: "[] {{ $value | humanizePercentage }} [] UPF []"

# []
- alert: UPF_Heartbeat_Issues
  expr: upf_peer_missed_heartbeats > 2
  for: 30s
  labels:
    severity: warning
  annotations:
    summary: "UPF {{ $labels.peer_ip }} []"
    description: "{{ $value }} []"

```

P-CSCF []

P-CSCF []

メトリック	タイプ	ラベル	説明
<code>pcscf_fqdns_total</code>	Gauge	-	登録された P-CSCF FQDN の数
<code>pcscf_fqdns_resolved</code>	Gauge	-	DNS が解決された P-CSCF FQDN の数
<code>pcscf_fqdns_failed</code>	Gauge	-	解決失敗した P-CSCF FQDN の数
<code>pcscf_servers_total</code>	Gauge	-	P-CSCF サーバの総数
<code>pcscf_servers_healthy</code>	Gauge	<code>fqdn</code>	FQDN ごとに P-CSCF サーバの健康状態
<code>pcscf_servers_unhealthy</code>	Gauge	<code>fqdn</code>	FQDN ごとに P-CSCF サーバの不健康状態

この P-CSCF メトリックは IMS サービスに

関連しています。

メトリック

メトリック	タイプ	ラベル
<code>license_status</code>	Gauge	<code>1 = 有効 0 = 無効</code>

例

```
# 有効
license_status == 1

# 無効
license_status == 0
```

メトリック

```
- alert: PGW_C_License_Invalid
  expr: license_status == 0
  for: 1m
  labels:
    severity: critical
  annotations:
    summary: "PGW-C [redacted]"
    description: "[redacted] - [redacted]"
```

[redacted]

[redacted] GTP-C [redacted] "[redacted]" (73)[redacted]
[redacted]

Wireshark [redacted] "[redacted]" [redacted]

[redacted]

- [redacted] omnipgwc
- [redacted] URL [redacted] config/runtime.exs [redacted] :license_client [redacted]
- [redacted] license_status == 0 [redacted] GTP-C [redacted] 73 [redacted]
- [redacted]
- Diameter [redacted] GTP-C [redacted] PFCP [redacted]
- [redacted] - [redacted]

□□□□

Erlang VM □□□

□□□□	□□	□□
<code>vm_memory_total</code>	Gauge	□ VM □□□□□□
<code>vm_memory_processes</code>	Gauge	□□□□□□□□
<code>vm_memory_system</code>	Gauge	□□□□□□□□
<code>vm_system_process_count</code>	Gauge	□ Erlang □□
<code>vm_system_port_count</code>	Gauge	□□□□□□

Prometheus □□

□□□□

□ OmniPGW □□□ Prometheus `prometheus.yml` □

```
# prometheus.yml
global:
  scrape_interval: 15s
  evaluation_interval: 15s

scrape_configs:
  - job_name: 'omnipgw'
    static_configs:
      - targets: ['10.0.0.20:9090']
        labels:
          instance: 'omnipgw-01'
          environment: 'production'
          site: 'datacenter-1'
```

OmniPGW

```
scrape_configs:
  - job_name: 'omnipegw'
    static_configs:
      - targets:
          - '10.0.0.20:9090'
          - '10.0.0.21:9090'
          - '10.0.0.22:9090'
        labels:
          environment: 'production'
```

Kubernetes

```
scrape_configs:
  - job_name: 'omnipegw'
    kubernetes_sd_configs:
      - role: pod
    relabel_configs:
      - source_labels: [__meta_kubernetes_pod_label_app]
        action: keep
        regex: omnipegw
      - source_labels: [__meta_kubernetes_pod_ip]
        target_label: __address__
        replacement: '${1}:9090'
```

```
# Prometheus
curl http://prometheus:9090/api/v1/targets

# 
curl 'http://prometheus:9090/api/v1/query?
query=teid_registry_count'
```

Grafana 安装

安装步骤

1. 安装 Prometheus 服务

```
docker → docker-compose → Prometheus → Prometheus  
URL: http://prometheus:9090
```

2. 配置 Grafana

配置 Prometheus 数据源 JSON 格式

配置项

配置 1

```
# 名称  
teid_registry_count  
  
# 仪表盘Gauge  
# 阈值  
#   0 < 5000  
#   5000-8000  
#   8000 <
```

配置 2

```
# 名称  
rate(s5s8_inbound_messages_total{message_type="create_session_request"  
[5m])  
  
# 仪表盘  
# 单位/秒
```

3 IP

```
# /24 254 IP
(address_registry_count / 254) * 100

# Gauge
# 0-100
#
# < 70%
# 70-85%
# > 85%
```

4 95th

```
#
histogram_quantile(0.95,

rate(s5s8_inbound_handling_duration_bucket{request_message_type="crea
[5m])
)

#
#
```

5

```
#
rate(s5s8_inbound_errors_total[5m])

#
# /
# > 0.1
```

6 Gx

```
# Gx 2xx
sum(rate(gx_outbound_responses_total{result_code_class="2xxx"}
[5m])) /
sum(rate(gx_outbound_responses_total[5m])) * 100
```

```
# Gauge
# 0-100
#
# > 95%
# 90-95%
# < 90%
```

00 - 000000000000

```
# 00000000000000000000
sum(rate(gx_outbound_responses_total[5m])) by (result_code_class)

# 000000000000
# 000{{ result_code_class }}
```

00 - 0 **PCRF** 000000

```
# 0000 PCRF 000000
sum(rate(gx_outbound_responses_total[5m])) by (diameter_host,
result_code_class)

# 000000000000
# 000{{ diameter_host }} - {{ result_code_class }}
```

00 **7UPF** 0000

```
# 健康なピアの割合
(upf_peers_healthy / upf_peers_total) * 100

# 健康なピアGauge
# 健康なピア0-100%
# 健康なピア
#   健康なピア100%
#   健康なピア50-99%
#   健康なピア< 50%
```

健康なピア - 健康なピア **UPF** 健康なピア

```
# 健康なピア UPF 健康なピア
upf_peer_healthy

# 健康なピア
# 健康なピア
#   1 = "UP"健康なピア
#   0 = "DOWN"健康なピア
```

□□□□□□□□

```
{
  "dashboard": {
    "title": "OmniPGW - □□□□",
    "panels": [
      {
        "title": "□□□□",
        "targets": [
          {
            "expr": "teid_registry_count",
            "legendFormat": "□□□□"
          }
        ],
        "type": "graph"
      },
      {
        "title": "□□□□□□",
        "targets": [
          {
            "expr":
"rate(s5s8_inbound_messages_total{message_type=\"create_session_reque
[5m])",
            "legendFormat": "□□/□"
          }
        ],
        "type": "graph"
      },
      {
        "title": "IP □□□□",
        "targets": [
          {
            "expr": "(address_registry_count / 254) * 100",
            "legendFormat": "□□□□ %"
          }
        ],
        "type": "gauge"
      },
      {
        "title": "□□□□□□p95□",
        "targets": [
          {
            "expr": "histogram_quantile(0.95,
```

```
rate(s5s8_inbound_handling_duration_bucket[5m]))",
    "legendFormat": "S5/S8 p95"
  },
  {
    "expr": "histogram_quantile(0.95,
rate(sxb_inbound_handling_duration_bucket[5m]))",
    "legendFormat": "PFCP p95"
  }
],
"type": "graph"
}
]
}
```

□□

□□□□

□□ omnipgw_alerts.yml □

```

groups:
- name: omnipgw
  interval: 30s
  rules:
    # []
    - alert: OmniPGW_HighSessionCount
      expr: teid_registry_count > 8000
      for: 5m
      labels:
        severity: warning
      annotations:
        summary: "OmniPGW []"
        description: "{{ $value }} []8000"

    - alert: OmniPGW_SessionCountCritical
      expr: teid_registry_count > 9500
      for: 2m
      labels:
        severity: critical
      annotations:
        summary: "OmniPGW []"
        description: "{{ $value }} []"

    # IP []
    - alert: OmniPGW_IPPoolUtilizationHigh
      expr: (address_registry_count / 254) * 100 > 80
      for: 10m
      labels:
        severity: warning
      annotations:
        summary: "OmniPGW IP []"
        description: "IP [] {{ $value }}% []"

    - alert: OmniPGW_IPPoolExhausted
      expr: address_registry_count >= 254
      for: 1m
      labels:
        severity: critical
      annotations:
        summary: "OmniPGW IP []"
        description: "[] IP"

    # []

```

```

- alert: OmniPGW_HighErrorRate
  expr: rate(s5s8_inbound_errors_total[5m]) > 0.1
  for: 5m
  labels:
    severity: warning
  annotations:
    summary: "OmniPGW S5/S8"
    description: "{{ $value }} S5/S8"

- alert: OmniPGW_GxErrorRate
  expr: rate(gx_inbound_errors_total[5m]) > 0.05
  for: 5m
  labels:
    severity: warning
  annotations:
    summary: "OmniPGW Gx"
    description: "{{ $value }} Diameter"

# Gx
- alert: OmniPGW_GxResponseFailureRate
  expr: |

sum(rate(gx_outbound_responses_total{result_code_class!="2xxx"}
[5m])) /
  sum(rate(gx_outbound_responses_total[5m])) > 0.1
  for: 5m
  labels:
    severity: warning
  annotations:
    summary: "OmniPGW Gx"
    description: "{{ $value | humanizePercentage }} Gx
    2xxx"

- alert: OmniPGW_GxPCRFFailures
  expr:
rate(gx_outbound_responses_total{result_code_class=~"4xxx|5xxx"}
[5m]) by (diameter_host) > 0.05
  for: 3m
  labels:
    severity: warning
  annotations:
    summary: "PCRF {{ $labels.diameter_host }}"
    description: "{{ $value }} PCRF {{
$labels.diameter_host }}"

```

```

# UPF [] [] [] []
- alert: OmniPGW_UPF_PeerDown
  expr: upf_peer_healthy == 0
  for: 1m
  labels:
    severity: critical
  annotations:
    summary: "UPF [] [] {{ $labels.peer_ip }} [] []"
    description: "UPF [] [] PFCP [] []"

- alert: OmniPGW_UPF_PoolDegraded
  expr: (upf_peers_healthy / upf_peers_total) < 0.5
  for: 2m
  labels:
    severity: critical
  annotations:
    summary: "UPF [] []"
    description: "{{ $value | humanizePercentage }} % UPF [] []
[] [] < 50% []"

- alert: OmniPGW_UPF_HeartbeatFailures
  expr: upf_peer_missed_heartbeats > 2
  for: 30s
  labels:
    severity: warning
  annotations:
    summary: "UPF {{ $labels.peer_ip }} [] [] [] []"
    description: "{{ $value }} [] [] [] [] [] []"

- alert: OmniPGW_UPF_AllDown
  expr: upf_peers_healthy == 0 and upf_peers_total > 0
  for: 30s
  labels:
    severity: critical
  annotations:
    summary: "[] [] UPF [] [] [] [] [] []"
    description: "[] [] [] [] UPF [] [] [] [] [] []"

# [] [] [] []
- alert: OmniPGW_HighLatency
  expr: |
    histogram_quantile(0.95,
      rate(s5s8_inbound_handling_duration_bucket[5m])

```

```

    ) > 100000
  for: 5m
  labels:
    severity: warning
  annotations:
    summary: "OmniPGW 高CPU使用"
    description: "p95 CPU 使用率 {{ $value }}µs (> 100ms)"

# 高メモリ使用
- alert: OmniPGW_HighMemoryUsage
  expr: vm_memory_total > 2000000000
  for: 10m
  labels:
    severity: warning
  annotations:
    summary: "OmniPGW 高メモリ使用"
    description: "VM メモリ使用量 {{ $value | humanize }}B 超過"

- alert: OmniPGW_HighProcessCount
  expr: vm_system_process_count > 100000
  for: 10m
  labels:
    severity: warning
  annotations:
    summary: "OmniPGW 高プロセス数"
    description: "{{ $value }} Erlang プロセス数超過"

```

□□□□□□□□

```
# alertmanager.yml
global:
  resolve_timeout: 5m

route:
  receiver: 'ops-team'
  group_by: ['alertname', 'instance']
  group_wait: 10s
  group_interval: 10s
  repeat_interval: 12h

routes:
  - match:
      severity: critical
    receiver: 'pagerduty'

  - match:
      severity: warning
    receiver: 'slack'

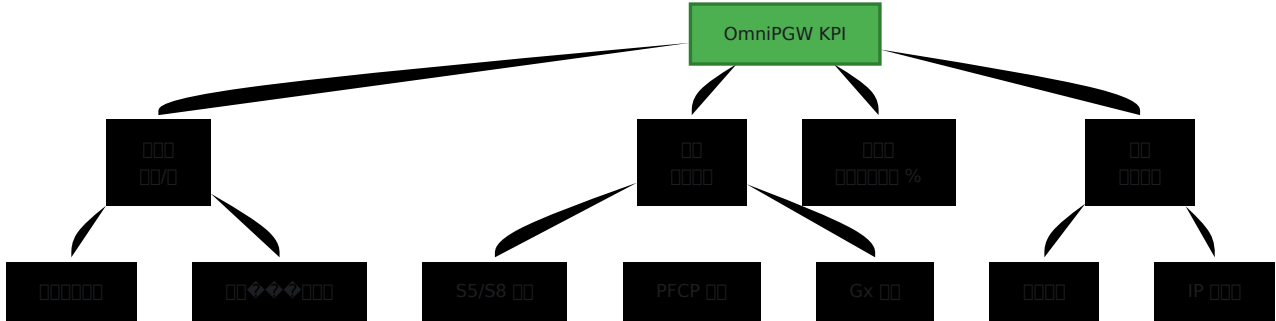
receivers:
  - name: 'ops-team'
    email_configs:
      - to: 'ops@example.com'

  - name: 'slack'
    slack_configs:
      - api_url:
          'https://hooks.slack.com/services/YOUR/SLACK/WEBHOOK'
        channel: '#omnipgw-alerts'
        title: 'OmniPGW □□□{{ .GroupLabels.alertname }}'
        text: '{{ range .Alerts }}{{ .Annotations.description }}{{
end }}'

  - name: 'pagerduty'
    pagerduty_configs:
      - service_key: 'YOUR_PAGERDUTY_KEY'
```

□□□□

□□□□□□ (KPI)



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□□□□□□

```
rate(s5s8_inbound_messages_total{message_type="create_session_request"
[5m] )
```

□□□□□□

```
rate(s5s8_inbound_messages_total{message_type="delete_session_request"
[5m] )
```

□□□□□

```
rate(s5s8_inbound_messages_total{message_type="create_session_request"
[5m] ) -
rate(s5s8_inbound_messages_total{message_type="delete_session_request"
[5m] )
```

□□□□

□□□□□□□□□□□□

```
# p50
histogram_quantile(0.50,
  rate(s5s8_inbound_handling_duration_bucket[5m])
)

# p95
histogram_quantile(0.95,
  rate(s5s8_inbound_handling_duration_bucket[5m])
)

# p99
histogram_quantile(0.99,
  rate(s5s8_inbound_handling_duration_bucket[5m])
)
```

□□□□□□□□□□

```
histogram_quantile(0.95,
  rate(s5s8_inbound_handling_duration_bucket[5m])
) by (request_message_type)
```

□□□□

□□□□□□**24**□□□□

```
teid_registry_count -
teid_registry_count offset 24h
```

□□□□□

```
# □□□□□□ 10,000 □□
10000 - teid_registry_count
```

□□□□□□□□

```
# 1
(10000 - teid_registry_count) /
(rate(teid_registry_count[1h]) * 86400)
```

□□□□□□

□□□□

□□□□□□□□

□□□

```
rate(s5s8_inbound_errors_total[5m]) by (message_type)
```

□□□

- □□□□□□
- □□ PCRF □□□Gx □□□
- □□ IP □□□

□□□□□□□□

□□□

```
histogram_quantile(0.95,
rate(s5s8_inbound_handling_duration_bucket{request_message_type="crea
[5m])
)
```

□□□

- □□ Gx □□□PCRF □□□□□
- □□ PFCP □□□PGW-U □□□□□

- 0000000000

000**PCRF** 0000

000

```
# 00 Gx 000000
sum(rate(gx_outbound_responses_total{result_code_class!="2xxx"}
[5m])) /
sum(rate(gx_outbound_responses_total[5m])) * 100

# 0 PCRF 0000
sum(rate(gx_outbound_responses_total[5m])) by (diameter_host,
result_code_class)

# 0000000000
rate(gx_outbound_responses_total{result_code_class="5xxx"}[5m]) by
(diameter_host)
```

000

- 00 PCRF 00000000
- 00 PCRF 000000005xxx 000000000000
- 00 Diameter 00000
- 00 PCRF 0000000000
- 00 50120DIAMETER_UNABLE_TO_COMPLY0000 Re-Auth-Request 00

0000000000

000

```
# 00000
rate(vm_memory_total[1h])

# 000000
rate(vm_memory_processes[1h])

# 000000
rate(vm_system_process_count[1h])
```

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- □□□□□□
- □□□□□□
- □□□□□□□□□□

□□□□

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```
max_over_time(teid_registry_count[24h])
```

□□□□□□□□

```
teid_registry_count /  
avg_over_time(teid_registry_count[7d])
```

□□□□□



```
abs(  
  teid_registry_count -  
  avg_over_time(teid_registry_count[1h])  
) > 100
```

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□□□□□

1. □□□□□ 15-30 □□□□□□□□□□□□
2. □□□ 15 □□□□□□□□□□
3. □□□ □□□□□□□□□□□□□□□□□□□□□□□□□□□□

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1. □□□□ - NOC □□□ KPI
2. □□□□ - □□□□□□□□
3. □□□□□□ - □□□□□□

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1. □□□□□□ - □□□□□□□□□□□□
 2. □□ - □□ → □□□□□□□□□□
 3. □□□ - □□□□□□□□□□□□□□
-

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-  - Prometheus □□□□□□□□□□□□
-  - □□□□□□□□

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- **PFCP** □□ - PFCP □□□□□UPF □□□□
- **Diameter Gx** □□ - Gx □□□□□PCRF □□□□
- **Diameter Gy** □□ - Gy □□□□□□□□□□OCS □□
- **S5/S8** □□ - GTP-C □□□□□SGW-C □□

□□□□

- **P-CSCF** □□ - P-CSCF □□□□□IMS □□
 -  - □□□□□□□□□□□□
 - **UE IP** □□ - IP □□□□□□
-

###

OmniPGW □□□□ - □ *Omni*touch □□□□□□

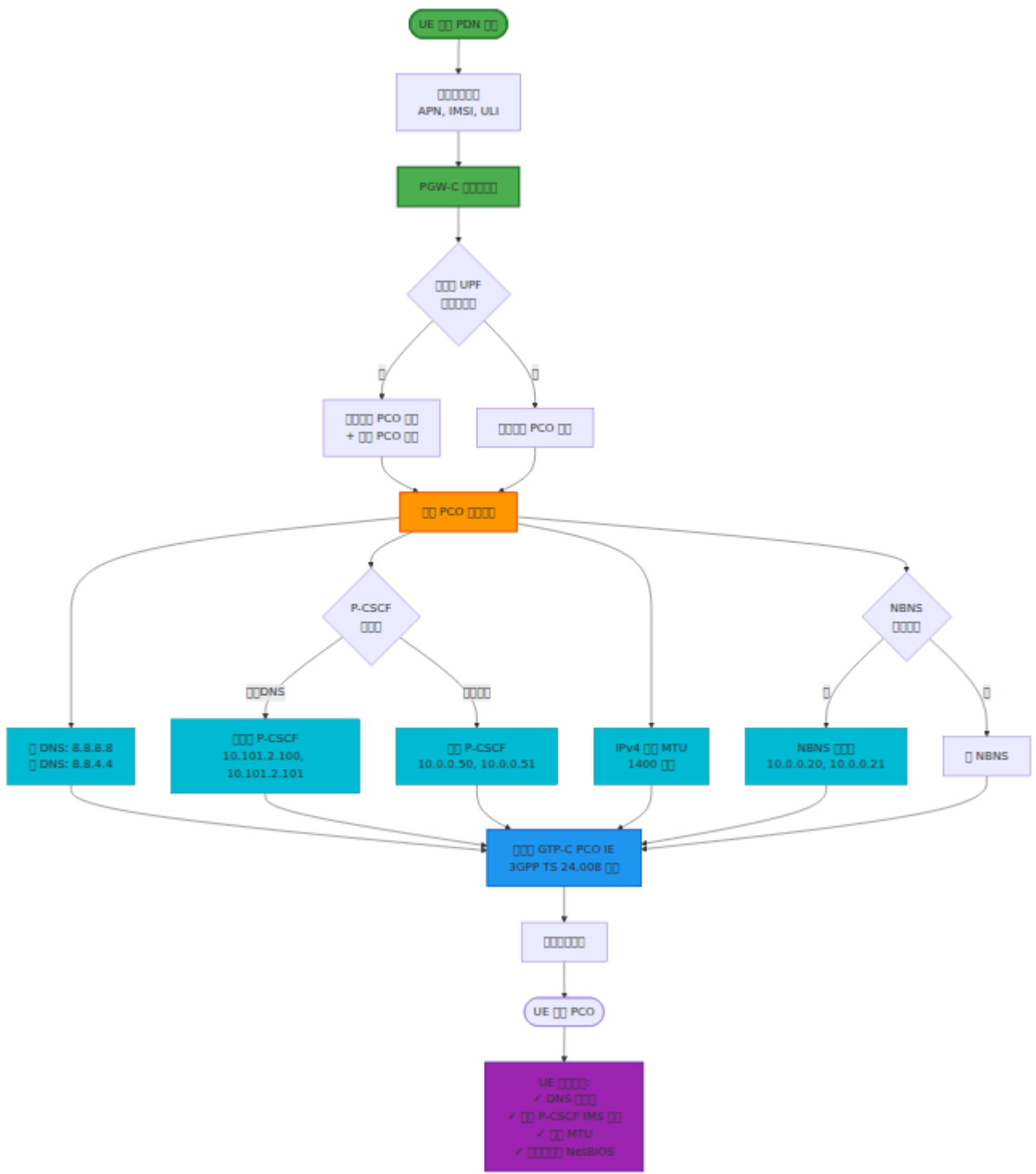
□□□□□□ (PCO)

□□□ **UE** □□□□□

OmniPGW □ *Omnitouch* □□□□□□

□□

PCO (□□□□□□) □□ PDN □□□□□□□□□□ UE (□□□□) □□□□□□□□□□□□ UE □□□□□□□□□□ DNS□
IMS□□□□□□□□□□



PCO [] [] [] []

IE 名称	IE ID	描述	备注
DNS 选项 IPv4 选项	0x000D	DNS 选项	
DNS 选项 IPv4 选项	0x000D	DNS 选项	
P-CSCF IPv4 选项	0x000C	IMS 选项 P-CSCF	IMS (IMS)
IPv4 选项 MTU	0x0010	MTU 选项	
NBNS 选项 IPv4 选项	0x0011	NetBIOS 选项	

□□

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```
# config/runtime.exs
config :pgw_c,
  pco: %{
    # DNS □□□ (□□)
    primary_dns_server_address: "8.8.8.8",
    secondary_dns_server_address: "8.8.4.4",

    # NBNS □□□ (□□□□□□ Windows □□)
    primary_nbns_server_address: nil,
    secondary_nbns_server_address: nil,

    # IMS/VoLTE □ P-CSCF □□ (□□)
    p_cscf_ipv4_address_list: [],

    # P-CSCF □□□□ (□□)
    p_cscf_discovery_enabled: false,
    p_cscf_discovery_dns_server: nil,
    p_cscf_discovery_timeout_ms: 5000,

    # IPv4 MTU □□ (□□)
    ipv4_link_mtu_size: 1400
  }
```

PCO □□

DNS □□□□□

□ **DNS** □□ **DNS**□

```
pco: %{\n  primary_dns_server_address: "8.8.8.8",\n  secondary_dns_server_address: "8.8.4.4"\n}
```

DNS

	DNS	DNS
Google	8.8.8.8	8.8.4.4
Cloudflare	1.1.1.1	1.0.0.1
Quad9	9.9.9.9	149.112.112.112
OpenDNS	208.67.222.222	208.67.220.220

DNS

```
pco: %{\n  primary_dns_server_address: "10.0.0.10",\n  secondary_dns_server_address: "10.0.0.11"\n}
```

P-CSCF (IMS)

IMS/VoLTE

```
pco: %{\n  p_cscf_ipv4_address_list: [\n    "10.0.0.50", # P-CSCF\n    "10.0.0.51" # P-CSCF\n  ]\n}
```

P-CSCF ()

- IMS ــــــــــــــــ
- VoLTE/VoWiFi/RCS ــــــــ
- UE ــــــــــــــــ SIP

P-CSCF ــــــــ

ــــــــ DNS ــــــــ P-CSCF ــــــــ

OmniPGW ــــــــ DNS ــــــــ P-CSCF ــــــــ 3GPP TS 23.003 ــــــــ TS 24.229 ــــــــ
 ــــــــPGW-C ــــــــ DNS ــــــــ P-CSCF ــــــــ

```
pco: %{
  # ــــــــ P-CSCF ــــــــ
  p_cscf_discovery_enabled: true,

  # P-CSCF ــــــــ DNS ــــــــ (ــــــــ)
  p_cscf_discovery_dns_server: {10, 179, 2, 177},

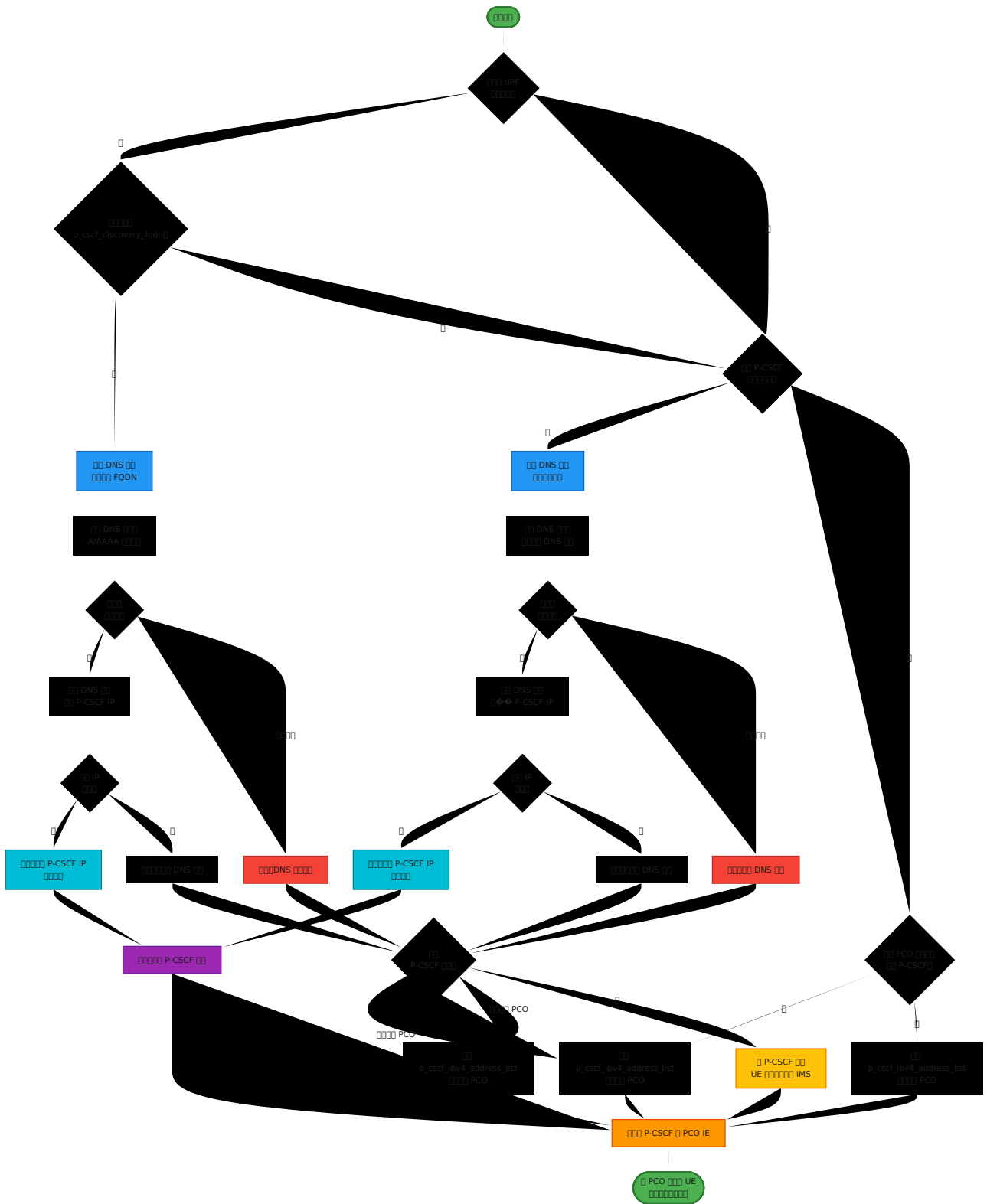
  # DNS ــــــــ (ــــــــ)
  p_cscf_discovery_timeout_ms: 5000,

  # ــــــــ P-CSCF ــــــــ (ــــــــ DNS ــــــــ)
  p_cscf_ipv4_address_list: ["10.0.0.50"]
}
```

ــــــــ

1. ــــــــ `p_cscf_discovery_enabled: true` ــــــــPGW-C ــــــــ DNS ــــــــ P-CSCF ــــــــ
2. DNS ــــــــ `p_cscf_discovery_dns_server`
3. ــــــــ DNS ــــــــ P-CSCF ــــــــ PCO ــــــــ UE
4. ــــــــ DNS ــــــــ `p_cscf_ipv4_address_list`
5. ــــــــ P-CSCF ــــــــ

P-CSCF 配置



配置

- 配置 **FQDN** (配置) - `p_cscf_discovery_fqdn` UPF 配置
- 配置 **DNS** (配置) - `p_cscf_discovery_enabled: true` 配置 PCO 配置

- 3. **PCO** `p_cscf_ipv4_address_list` PCO
- 4. **PCO** () - `p_cscf_ipv4_address_list` PCO

P-CSCF

- DNS /
-
-
-

P-CSCF

<code>p_cscf_discovery_enabled</code>		<code>false</code>	DNS P-CSCF
<code>p_cscf_discovery_dns_server</code>	(IP)	<code>nil</code>	DNS IP 4 ({10, 179, 2, 177})
<code>p_cscf_discovery_timeout_ms</code>		<code>5000</code>	DNS

- **IMS** - P-CSCF DNS
- - DNS P-CSCF
- - DNS P-CSCF
- - P-CSCF

DNS IMS

```

pco: %{
  primary_dns_server_address: "10.0.0.10",
  secondary_dns_server_address: "10.0.0.11",

  # P-CSCF
  p_cscf_discovery_enabled: true,
  p_cscf_discovery_dns_server: {10, 179, 2, 177}, # IMS DNS
  p_cscf_discovery_timeout_ms: 3000,

  # P-CSCF (DNS)
  p_cscf_ipv4_address_list: [
    "10.0.0.50", #
    "10.0.0.51" #
  ],

  ipv4_link_mtu_size: 1400
}

```

P-CSCF

P-CSCF UPF APN DNS P-CSCF

```

# upf_selection
rules: [
  %{
    name: "IMS",
    priority: 20,
    match_field: :apn,
    match_regex: "^ims",
    upf_pool: [...],

    # P-CSCF
    p_cscf_discovery_fqdn: "pcscf.mnc380.mcc313.3gppnetwork.org"
  }
]

```

P-CSCF UPF

P-CSCF P-CSCF

NBNS 配置 (NetBIOS)

Windows 配置

```
pco: %{\n  primary_nbns_server_address: "10.0.0.20",\n  secondary_nbns_server_address: "10.0.0.21"\n}
```

配置

- Windows 配置
- 配置
- NetBIOS 配置

MTU 配置

配置

```
pco: %{\n  ipv4_link_mtu_size: 1400 # \n}
```

MTU 配置

MTU	配置
1500	配置
1400	配置 GTP 配置
1420	配置
1280	IPv6 配置 MTU
1360	VPN/配置

□□□ □□ LTE □□ **1400** □□□ GTP-U □□□

□□□□

Internet APN

```
pco: %{  
  primary_dns_server_address: "8.8.8.8",  
  secondary_dns_server_address: "8.8.4.4",  
  ipv4_link_mtu_size: 1400  
}
```

IMS APN

```
pco: %{  
  primary_dns_server_address: "10.0.0.10",  
  secondary_dns_server_address: "10.0.0.11",  
  p_cscf_ipv4_address_list: [  
    "10.0.0.50",  
    "10.0.0.51"  
  ],  
  ipv4_link_mtu_size: 1400  
}
```

□□ **P-CSCF** □□ □□□ IMS □□□□□□ P-CSCF □□□□

␣␣ APN

```
pco: %{  
  primary_dns_server_address: "10.100.0.10",  
  secondary_dns_server_address: "10.100.0.11",  
  primary_nbns_server_address: "10.100.0.20",  
  secondary_nbns_server_address: "10.100.0.21",  
  ipv4_link_mtu_size: 1400  
}
```

PCO ␣ GTP-C ␣␣␣␣␣␣

␣␣␣␣␣␣

OmniPGW ␣ ␣␣␣␣␣␣ ␣␣␣␣␣␣ PCO␣

```
␣␣␣␣␣␣  
├─ ␣␣: ␣␣␣␣␣␣  
├─ UE IP ␣␣: 100.64.1.42  
├─ PCO (␣␣␣␣␣␣)  
│   ├─ DNS ␣␣␣ IPv4 ␣␣: 8.8.8.8  
│   ├─ DNS ␣␣␣ IPv4 ␣␣: 8.8.4.4  
│   ├─ P-CSCF IPv4 ␣␣: 10.0.0.50  
│   ├─ P-CSCF IPv4 ␣␣: 10.0.0.51  
│   └─ IPv4 ␣␣ MTU: 1400
```

UE ␣␣

UE ␣␣ PCO ␣␣

1. ␣␣␣␣␣␣␣␣␣␣ DNS ␣␣␣
2. ␣ P-CSCF ␣␣ IMS ␣␣
3. ␣␣␣ MTU ␣␣␣␣␣␣

UE

UE DNS

UE

- UE IP
- DNS

PCO

1. PCO DNS
2. UE IP DNS
3. DNS

PCO

```
# DNS
ping 8.8.8.8

# UE DNS
nslookup google.com 8.8.8.8

# PCO
grep "primary_dns_server_address" config/runtime.exs
```

IMS

IMS

- VoLTE
- UE IMS

IMS

1. P-CSCF
2. P-CSCF IP
3. P-CSCF

□□□□

```
# □□ P-CSCF □□  
pco: %{\br/>  p_cscf_ipv4_address_list: ["10.0.0.50"] # □□□□  
}
```

□□□**MTU** □□

□□□

- □□□□□□□□□□□□□□□□
- □□□□□□□
- □□□□

□□□□

- MTU □□□□□□□□
- MTU □□□□□□□□

□□□□

```
# □□□GTP □□□□ 1400  
pco: %{\br/>  ipv4_link_mtu_size: 1400  
}  
  
# □□□□□□□□□□□□□□□□  
pco: %{\br/>  ipv4_link_mtu_size: 1360  
}
```

□□□□

DNS □□

1. □□□□ DNS □□□

- □□□Google (8.8.8.8)□Cloudflare (1.1.1.1)
- □□□□□□ DNS

2. □□□□□ DNS

- □□□□
- □□□□□

3. □□ DNS □□□

- □□ DNSSEC □□□□
- □□ DNS □□□□□□□□

IMS □□

1. □□□□ P-CSCF

- □□ 2 □□□□□□
- □□□□□□□□□□

2. □□□□□

- P-CSCF □□□□ UE IP □□□
- □□ SIP □□□

MTU □□

1. □□□□

- GTP-U: 36 □□ (IPv4)
- IPsec: □□ (50-100 □□)

2. LTE MTU

- MTU 1400
- MTU

3. MTU

- MTU
- MTU

MTU

MTU

- runtime.exs UPF PCO
- UE IP - IP APN
- P-CSCF - P-CSCF

MTU

- PDN
- S5/S8 - GTP-C PCO
- PFCP -

IMS VoLTE

- Diameter Gx - IMS
- PCO

MTU

OmniPGW PCO - Omnitouch

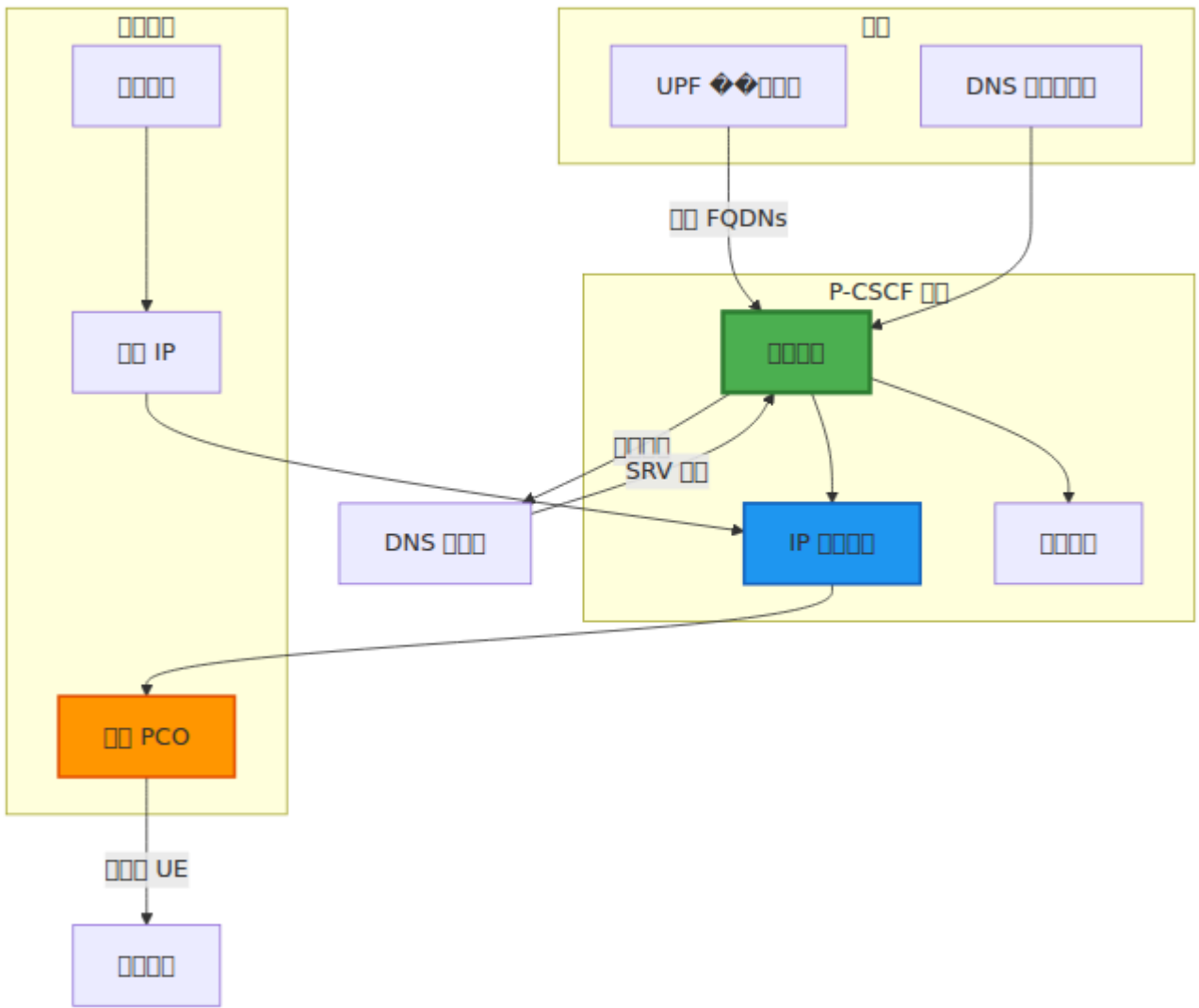
P-CSCF

P-CSCF

OmniPGW Omnitouch

P-CSCF DNS SRV IMS P-CSCF SIP OPTIONS

- **P-CSCF**
- DNS 60
- **SIP OPTIONS** ping P-CSCF
 - TCP SIP OPTIONS
 - UDP TCP UDP
 - :up :down
- Web UI IP
-
- **Prometheus** Prometheus



□□

1. □□□□
2. □□
3. □□□□
4. Web UI □□
5. □□□□□□□□
6. □□□□
7. DNS □□
8. □□□□
9. □□□□

□□□□

□□□□

```
# config/runtime.exs

# □□ PCO □□□□□ P-CSCF □□□ DNS □□□□
config :pgw_c,
  pco: %{
    p_cscf_discovery_dns_server: "10.179.2.177",
    p_cscf_discovery_enabled: true,
    p_cscf_discovery_timeout_ms: 5000
  },

  upf_selection: %{
    rules: [
      # IMS □□ - □□ P-CSCF □□
      %{
        name: "IMS □□",
        priority: 20,
        match_field: :apn,
        match_regex: "^ims",
        upf_pool: [
          weight: 80}
          %{remote_ip_address: "10.100.2.21", remote_port: 8805,
        ],
        # P-CSCF □□ FQDN□□□□□ UPF □□□□□□□□□□□□□□
        p_cscf_discovery_fqdn:
        "pcscf.mnc380.mcc313.3gppnetwork.org",
        # □□□□□□□□ PCO □□□□□
        pco: %{
          p_cscf_ipv4_address_list: ["10.101.2.100",
          "10.101.2.101"]
        }
      }
    ]
  }
}
```

□□□ □□□□ □□□□□□ UPF □□□□□□□□□□ PCO □□ □□□□□ P-CSCF □□□□□

□□□□

1. □□ OmniPGW
 2. □□□ **Web UI** → **P-CSCF** □□ (https://localhost:8086/pcscf_monitor)
 3. □□□□□□□□□□ IP
-

□□

□□ **P-CSCF** □□□□

□ PCO □□□□□□ P-CSCF □□□ DNS □□□□

```
pco: %{\n  # □□ P-CSCF □□□ DNS □□□□□□□□ UE □ DNS □□□\n  p_cscf_discovery_dns_server: "10.179.2.177",\n\n  # □□ P-CSCF DNS □□□□\n  p_cscf_discovery_enabled: true,\n\n  # DNS SRV □□□□□□□□□□\n  p_cscf_discovery_timeout_ms: 5000,\n\n  # □□ P-CSCF □□□□□□□□□□\n  p_cscf_ipv4_address_list: ["10.101.2.146"]\n}
```

□□□ **P-CSCF FQDNs**

□□ UPF □□□□□□□□□□□□ P-CSCF □□ FQDN□

```

upf_selection: %{
  rules: [
    # IMS 000 - IMS 0000 P-CSCF
    %{
      name: "IMS 000",
      match_field: :apn,
      match_regex: "^ims",
      upf_pool: [...],
      p_cscf_discovery_fqdn:
"pcscf.ims.mnc380.mcc313.3gppnetwork.org",
      pco: %{
        p_cscf_ipv4_address_list: ["10.101.2.100"] # 000
      }
    },

    # 000 - 0000000 P-CSCF
    %{
      name: "0000000",
      match_field: :apn,
      match_regex: "^enterprise",
      upf_pool: [...],
      p_cscf_discovery_fqdn: "pcscf.enterprise.example.com",
      pco: %{
        p_cscf_ipv4_address_list: ["192.168.1.50"] # 000
      }
    },

    # 0000 - 0 P-CSCF 0000000000000000
    %{
      name: "0000000",
      match_field: :apn,
      match_regex: "^internet",
      upf_pool: [...]
      # 0 p_cscf_discovery_fqdn - 00000 PCO 000
    }
  ]
}

```

□□□□

□□□□

1. □□□□

- P-CSCF □□ GenServer □□□
- □□□□□□ UPF □□□□□□□□□□□□ P-CSCF FQDNs

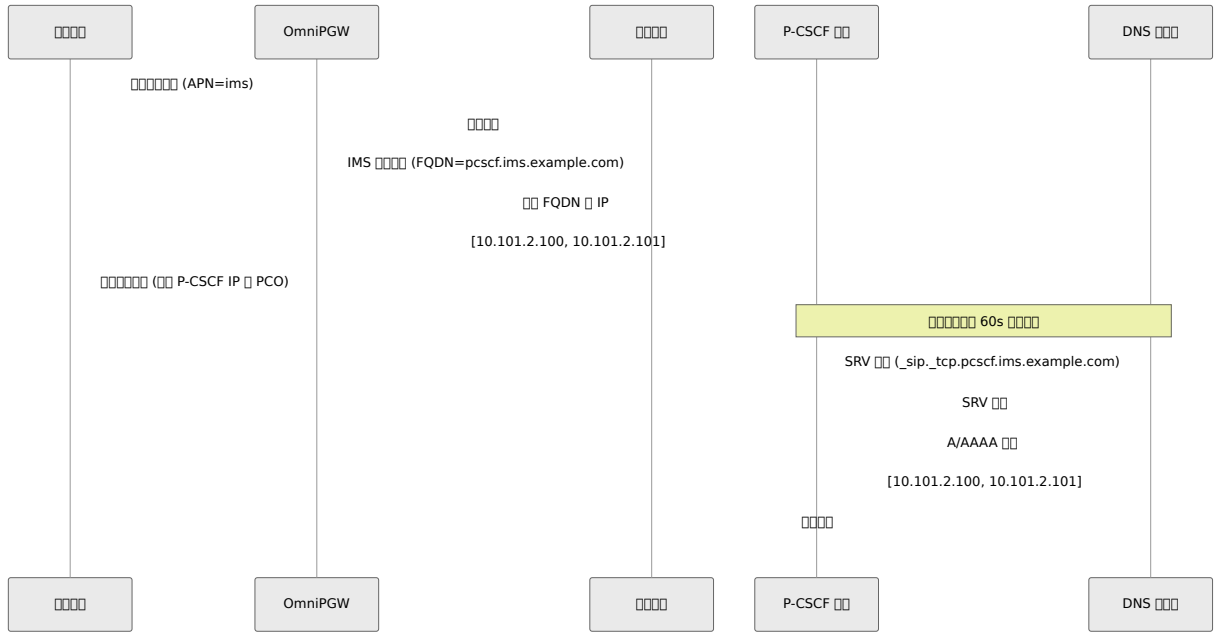
2. FQDN □□

- □□□□□ FQDN □□□□□□□□□□
- □□□□□□ FQDN □□□□ DNS SRV □□
- **SIP OPTIONS** □□□□□□□□□□□□□□□□□□
 - □□□□ TCP□SIP/2.0/TCP □ 5060 □□□
 - □□ TCP □□□□□□□□ UDP□SIP/2.0/UDP □ 5060 □□□
 - □□□□□□□□□ □:up□□□□□□□ □:down□□□□/□□□
- □□□IP□□□□□□□□□□□□□□□□□□□□□□

3. □□□□□□ 60 □□

- □□□□□□□□ FQDNs
- DNS □□□□□□□□□□□□□□
- □□□□□□□□□□□□
 - □□ TCP □□ SIP OPTIONS□□□□□5 □□
 - □□ TCP □□□□□□□□ UDP□□□□□5 □□
 - □□□□□□□□□□□□
- □□□□□□□□□□ DNS □□□□□□□□

□□□□□□



DNS □□□□

□□□□ **DNS SRV** □□ □□□□ P-CSCF □□□□

1. **SRV** □□□□ `_sip._tcp.{fqdn}` □ SRV □□
2. □□□□□□□□□□□□□□□□
3. □□□□□□ SRV □□□□□□□□□□
4. □□□□□□□□□□□□□□□□ IP □□□□A/AAAA □□□□
5. □□□□□□□□ IP □□□□□□□□

P-CSCF □□□□□□□□

□□□□□□□□□□ **FQDN** □□□□ **PCO** □□□□**FQDN** □□□□

```

%{
  name: "IMS  ",
  p_cscf_discovery_fqdn: "pcscf.mnc380.mcc313.3gppnetwork.org", #
←  ""
  pco: %{
    p_cscf_ipv4_address_list: ["10.101.2.100", "10.101.2.101"] #
←  ""
  }
}

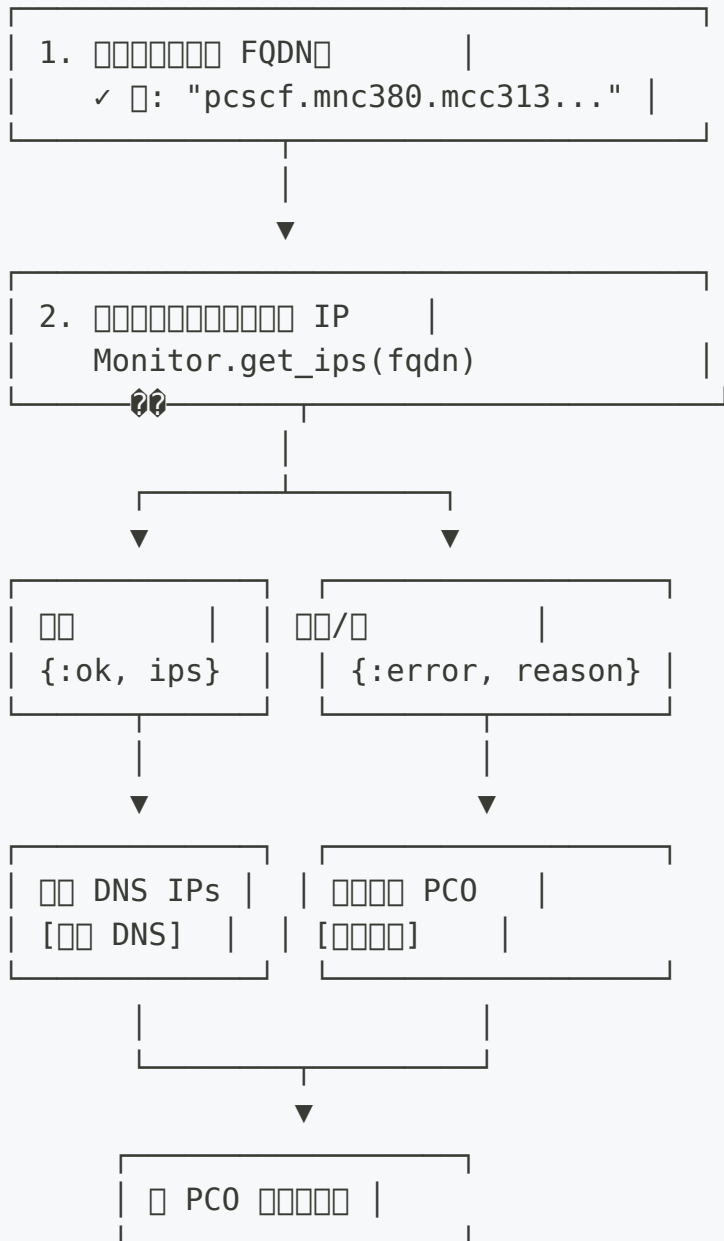
```

Table

Field	P-CSCF	IP	Value
FQDN pco.p_cscf_discovery_fqdn	DNS pco.p_cscf_discovery_fqdn	DNS IP	"FQDN pcscf.example.com P-CSCF"
FQDN pco.p_cscf_ipv4_address_list	PCO pco.p_cscf_ipv4_address_list	IP	"FQDN P-CSCF IPs..., "
FQDN pco.p_cscf_ipv4_address_list	PCO pco.p_cscf_ipv4_address_list	IP	
	PCO pco.p_cscf_ipv4_address_list	IP	
FQDN	PCO pco.p_cscf_ipv4_address_list	IP	

Table

IMS 配置



配置

1. DNS 配置

```
UE:
  p_cscf_discovery_fqdn: "pcscf.ims.example.com"
  pco.p_cscf_ipv4_address_list: ["10.101.2.100"]
```

```
DNS UE: [10.101.2.150, 10.101.2.151]
UE UE: [10.101.2.150, 10.101.2.151] ← DNS
UE: DNS PCO UE
```

2 DNS

```
UE:
  p_cscf_discovery_fqdn: "pcscf.ims.example.com"
  pco.p_cscf_ipv4_address_list: ["10.101.2.100"]
```

```
DNS UE: ERROR :no_naptr_records
UE UE: [10.101.2.100] ← PCO
UE: DNS
```

3 FQDN

```
UE:
  # p_cscf_discovery_fqdn
  pco.p_cscf_ipv4_address_list: ["192.168.1.50"]
```

```
UE UE: [192.168.1.50] ← PCO
UE: DNS
```

1. DNS
2. DNS
- 3.
- 4.

FQDN PCO

```
# ✓ PC: PC000000
%{
  p_cscf_discovery_fqdn: "pcscf.ims.example.com", # PC
  pco: %{
    p_cscf_ipv4_address_list: ["10.101.2.100"] # PC
  }
}

# △ PC: PC0000000000 PC00
%{
  p_cscf_discovery_fqdn: "pcscf.ims.example.com"
  # PC0000000000
}

# ✓ PC: PC0000 DNS PC
%{
  pco: %{
    p_cscf_ipv4_address_list: ["192.168.1.50"]
  }
}
```

Web UI

P-CSCF

PC000000 https://localhost:8086/pcscf_monitor

- **IPsec**
 - **IPsec** **IPsec** **FQDNs**
 - **IPsec** **FQDN** **IPsec** **FQDN**
 - **IPsec** **5** **IPsec**

- **IPsec**
 - **IPsec** **FQDNs** **IPsec** **FQDN** **IPsec**
 - **IPsec** **DNS** **IPsec** **FQDNs**
 - **DNS** **IPsec** **FQDNs**
 - **IPsec** **P-CSCF** **IPsec** **FQDNs** **IPsec**
 - **IPsec** **SIP OPTIONS** **IPsec** **SIP OPTIONS** **IPsec**
 - **IPsec** **SIP OPTIONS** **IPsec** **SIP OPTIONS** **IPsec**
 - **DNS** **IPsec** **DNS** **IPsec** **IPsec**
 - **IPsec** **SIP OPTIONS** **IPsec** **60s** **5s** **IPsec**

IPsec **DNS** **IPsec** **P-CSCF** **IPsec** **SIP OPTIONS**

UPF **IPsec**

UPF **IPsec** (`/upf_selection`) **IPsec** **P-CSCF** **IPsec**

```

IMS (20)
  APN: ^ims
  UPF-IMS-Primary (10.100.2.21:8805)

P-CSCF
  FQDN: pcscf.mnc380.mcc313.3gppnetwork.org
  : ✓ (2 IP)
  IPs: 10.101.2.100, 10.101.2.101

PCO
  DNS: 10.103.2.195
  P-CSCF: 10.101.2.100, 10.101.2.101

```

□□□□□□□□

Prometheus

P-CSCF Prometheus 42069

Gauge

```

# FQDN
pcscf_fqdns_total          # FQDN
pcscf_fqdns_resolved      # FQDNs DNS
pcscf_fqdns_failed        # FQDNs DNS

#
pcscf_servers_total       # DNS SRV P-CSCF
pcscf_servers_healthy    # SIP OPTIONS
pcscf_servers_unhealthy  # SIP OPTIONS

# FQDN
pcscf_servers_healthy{fqdn="..."} # FQDN
pcscf_servers_unhealthy{fqdn="..."} # FQDN

```

□□□□□□□□

- **healthy**: 成功した SIP OPTIONS ping (TCP 及 UDP)
- **unhealthy**: 失敗した SIP OPTIONS (5s 以内)

概要

DNS 監視

```
# 成功した FQDNs
pcscf_fqdns_resolved

# DNS 成功率
(pcscf_fqdns_resolved / pcscf_fqdns_total) * 100

# 総サーバー数
pcscf_servers_total
```

SIP OPTIONS 監視

```
# 成功した FQDNs
pcscf_servers_healthy

# 失敗した FQDNs
pcscf_servers_unhealthy

# SIP OPTIONS 成功率
(pcscf_servers_healthy / pcscf_servers_total) * 100

# 特定の FQDN 監視
pcscf_servers_healthy{fqdn="pcscf.mnc380.mcc313.3gppnetwork.org"}

# 監視対象サーバーが存在しない場合
pcscf_servers_healthy == 0 AND pcscf_servers_total > 0
```

Prometheus 監視

```

# [] P-CSCF []
- alert: AllPCSCFServersDown
  expr: pcscf_servers_healthy == 0 AND pcscf_servers_total > 0
  for: 5m
  labels:
    severity: critical
  annotations:
    summary: "[] P-CSCF []"
    description: "{{ $value }} [] (0) - [] SIP OPTIONS []"

# [] 50% []
- alert: MajorityPCSCFServersDown
  expr: (pcscf_servers_healthy / pcscf_servers_total) < 0.5
  for: 5m
  labels:
    severity: warning
  annotations:
    summary: "[] P-CSCF []"
    description: "[] {{ $value }}% [] SIP OPTIONS"

# [] DNS []
- alert: PCSCFDNSResolutionFailed
  expr: pcscf_fqdns_failed > 0
  for: 5m
  labels:
    severity: warning
  annotations:
    summary: "P-CSCF DNS []"
    description: "{{ $value }} [] FQDN []"

```

[][][]

[][][][][]

```
[info] P-CSCF [] []
[info] [] 2 [] [] P-CSCF FQDNs [] []: ["pcscf.ims.example.com",
"pcscf.enterprise.example.com"]
[info] P-CSCF []: [] FQDN pcscf.ims.example.com
[debug] P-CSCF []: [] pcscf.ims.example.com [] 2 [] IP
[warning] P-CSCF []: [] pcscf.enterprise.example.com: :nxdomain
[debug] [] FQDN pcscf.ims.example.com [] P-CSCF []: [{10, 101,
2, 100}, {10, 101, 2, 101}]
```

□□□□

□□□□ □□□□ □□□□□□□□

□ 1 □□DNS □□□□□□

```
p_cscf_discovery_fqdn: "pcscf.ims.example.com"
```

- □□□□ DNS □□□□□□ IP
- □□□□□□□□ IP
- □□□□□□□□□□□□□□

□ 2 □□□□□□□□□□ PCO□□□□

```
pco: %{
  p_cscf_ipv4_address_list: ["10.101.2.100", "10.101.2.101"]
}
```

- □□ DNS □□□□□□□□ IP□□□□
- □□□□□□□□□□
- □□□□□□□□□□□□□□

3. PCO 配置

```
# PCO 配置
pco: %{
  p_cscf_ipv4_address_list: ["10.101.2.146"]
}
```

- DNS 配置
- P-CSCF 配置
- 其他配置

配置

配置 "IMS 配置" 配置

1. DNS 配置 "pcscf.ims.example.com"
 - └ IP → [10.101.2.100, 10.101.2.101] ✓
 - └ 配置 → 配置
2. PCO 配置
 - └ IP → [10.101.2.100, 10.101.2.101] ✓
 - └ 配置 → 配置
3. PCO 配置
 - └ IP [10.101.2.146] ✓ (配置)

DNS 配置

DNS 配置

DNS 配置 SRV 及 A/AAAA 记录 P-CSCF 配置

```

; P-CSCF SRV _sip._tcp
_sip._tcp.pcscf.mnc380.mcc313.3gppnetwork.org. IN SRV 10 50 5060
pcscf1.example.com.
_sip._tcp.pcscf.mnc380.mcc313.3gppnetwork.org. IN SRV 20 50 5060
pcscf2.example.com.

; A
pcscf1.example.com. IN A 10.101.2.100
pcscf2.example.com. IN A 10.101.2.101

```

OmniPGW FQDN `_sip._tcp.` `p_cscf_discovery_fqdn:`
`"pcscf.mnc380.mcc313.3gppnetwork.org"`
`_sip._tcp.pcscf.mnc380.mcc313.3gppnetwork.org`

SRV

SRV

```

_service._proto.domain. IN SRV priority weight port target.

```

- 10 20
- =
- SIP TCP 5060 UDP 5060
- IP

DNS

```
# SRV _sip._tcp
dig SRV _sip._tcp.pcscf.mnc380.mcc313.3gppnetwork.org
@10.179.2.177

#
# _sip._tcp.pcscf.mnc380.mcc313.3gppnetwork.org. 300 IN SRV 10 50
5060 pcscf1.example.com.

# P-CSCF IP
dig A pcscf1.example.com @10.179.2.177

#
# pcscf1.example.com. 300 IN A 10.101.2.100
```


FQDN “”

- Web UI X
- :nxdomain :timeout :no_naptr_records

1. DNS
2. FQDN DNS
3. NAPTR
4. DNS

```
# 1. DNS ping
ping 10.179.2.177

# 2. NAPTR
dig NAPTR pcscf.mnc380.mcc313.3gppnetwork.org @10.179.2.177

# 3. OmniPGW
grep "P-CSCF" /var/log/pgw_c.log

# 4.
grep "p_cscf_discovery_dns_server" config/runtime.exs

# 5. Web UI
# FQDN "0" IP
```

IP

- Web UI "0 IP"
- ✓ X

1. NAPTR FQDN
2. IMS/SIP
3. A/AAAA

```
# NAPTR
dig NAPTR pcscf.example.com @10.179.2.177

# "SIP" "IMS":
# : "SIP+D2U", "x-3gpp-ims:sip"
# : "HTTP", "FTP"

# A/AAAA
dig pcscf1.example.com A @10.179.2.177
```

如何配置 P-CSCF

如何

- UE 如何配置 P-CSCF 地址
- 如何配置 P-CSCF IP

如何

1. DNS 如何配置
2. 如何配置
3. FQDN 如何

如何

```
# 1. 如何 P-CSCF 地址
# 如何 FQDN 如何

# 2. 如何
grep "如何 FQDN 如何 P-CSCF 如何" /var/log/pgw_c.log

# 3. 如何 UPF 如何
# 如何 FQDN 如何

# 4. 如何
# 如何 APN 如何
```

如何配置 DNS 如何

如何

- 如何
- 如何 `pcscf_discovery_query_duration_seconds`

如何

1. DNS 如何
2. 如何 DNS 如何
3. 如何

□□□□

```
# □□□□□□
pco: %{
  p_cscf_discovery_timeout_ms: 2000 # □ 5000ms □□
}

# □□□□□□□□ DNS □□□
pco: %{
  p_cscf_discovery_dns_server: "10.0.0.10" # □□ DNS
}
```

□□□□

1. DNS □□□□□

□□□□ DNS □◀▶

```
pco: %{
  # □□□ P-CSCF □□□ DNS□□ UE DNS □□□
  p_cscf_discovery_dns_server: "10.179.2.177",

  # UE DNS □□□□□□□□□□□□□□
  primary_dns_server_address: "8.8.8.8",
  secondary_dns_server_address: "8.8.4.4"
}
```

□□□□

- □□□□□□ UE DNS □□□ IMS DNS
- □□□□□□□□□□□□
- □□□□□□□□

2. 配置 P-CSCF 地址

```
%{
  p_cscf_discovery_fqdn: "pcscf.ims.example.com", # 配置
  pco: %{
    p_cscf_ipv4_address_list: ["10.101.2.100"] # 配置
  }
}
```

配置

- 配置 DNS 地址
- 配置
- 配置 SLA 配置

3. 配置 P-CSCF 地址 FQDN

```
rules: [
  # IMS
  %{
    name: "IMS",
    match_regex: "^ims",
    p_cscf_discovery_fqdn:
"pcscf.ims.mnc380.mcc313.3gppnetwork.org"
  },

  # 配置
  %{
    name: "配置",
    match_regex: "^enterprise",
    p_cscf_discovery_fqdn: "pcscf.enterprise.example.com"
  }
]
```

配置

- 配置 P-CSCF 地址
- 配置

- `severity: warning`

4. `HighPCSCFQueryLatency` DNS Alert

```
# HighPCSCFQueryLatency alert
alert: HighPCSCFQueryLatency
expr: histogram_quantile(0.95,
pcscf_discovery_query_duration_seconds_bucket) > 2
for: 5m
labels:
  severity: warning
annotations:
  summary: "P-CSCF DNS latency (p95 > 2s)"
```

5. `pcscf_monitor_fqdns_failed` Alert

- **Web UI** `Alerts` P-CSCF Alerts
- `Alerts` `pcscf_monitor_fqdns_failed` Alert
- `Alerts` DNS Alert
- `Alerts` DNS Alert

6. `pcscf_monitor_fqdns_failed` Alert

```
# pcscf_monitor_fqdns_failed alert
pco: %{
  p_cscf_discovery_timeout_ms: 5000 # 5
}

# pcscf_monitor_fqdns_failed alert
pco: %{
  p_cscf_discovery_timeout_ms: 2000 # 2
}
```

7. `pcscf_monitor_fqdns_failed` Alert

`pcscf_monitor_fqdns_failed` Alert

```
# P-CSCF DNS
pcscf.mnc380.mcc313.3gppnetwork.org. IN NAPTR 10 50 "s" "SIP+D2U"
"" _sip._udp.pcscf1.example.com.
```

```
# P-CSCF DNS
pcscf.mnc380.mcc313.3gppnetwork.org. IN NAPTR 20 50 "s" "SIP+D2U"
"" _sip._udp.pcscf2.example.com.
```

□□□□

- **PCO** □□ - □□□□□□□□ DNS □ P-CSCF □□
- □□□□ - □□□□ OmniPGW □□□□
- □□ - □□□□□□□□□□
- □□□□ - □□□□□□□□ PCO □□
- **PFCP** □□ - □□□□□□□□

□□□□□

OmniPGW P-CSCF □□ - □ *Omni*touch □□□□□□

PFCP/Sxb

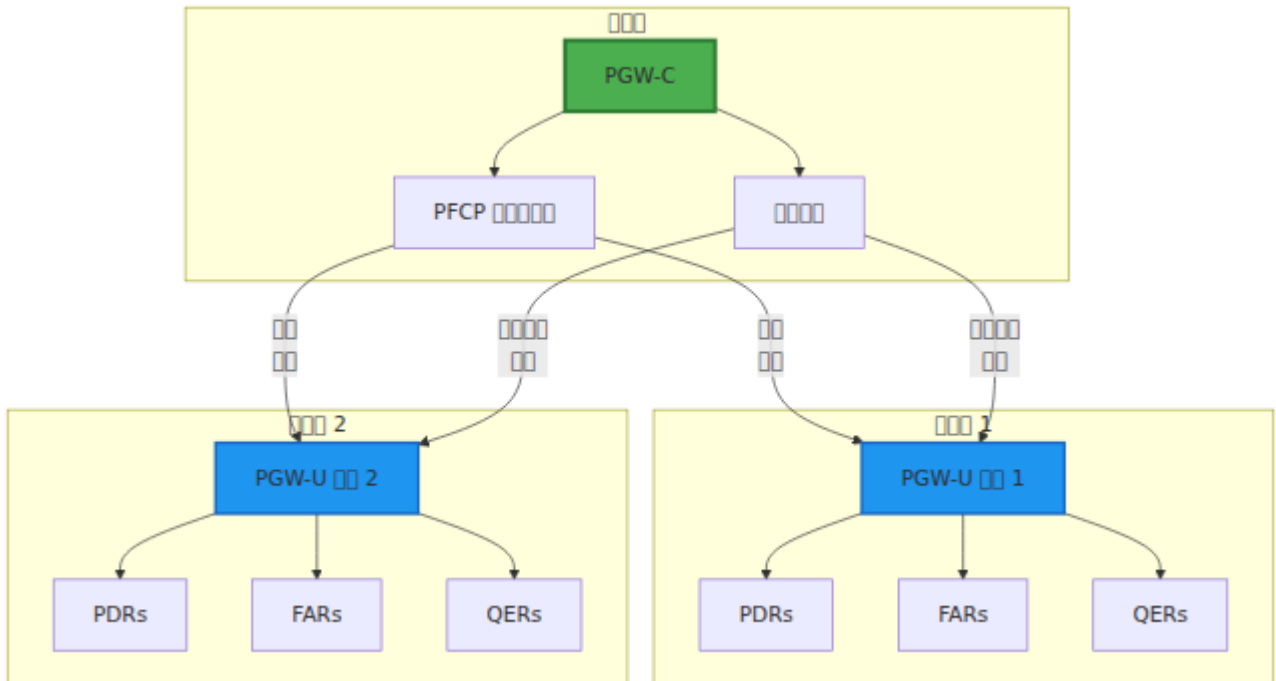
PGW-C PGW-U

- -
 - PFCP
 - PFCP
 -
 -
 - DNS UPF
 -
 -
 - Web UI - PFCP
 -
-

Sxb PFCP PGW-C PGW-U

- PGW-C
- PGW-U

PFCP



□□□□

PFCP

PGW-C □□ **PFCP** □□ 1 □ 3GPP TS 29.244 □□

□□

- □□□ UDP
- □□□□□ 8805
- □□□□□ □□ PFCP □□□□□□□□□□

□□ **ID** □□

PFCP □□□□□□□ ID □□□□□□□□□□

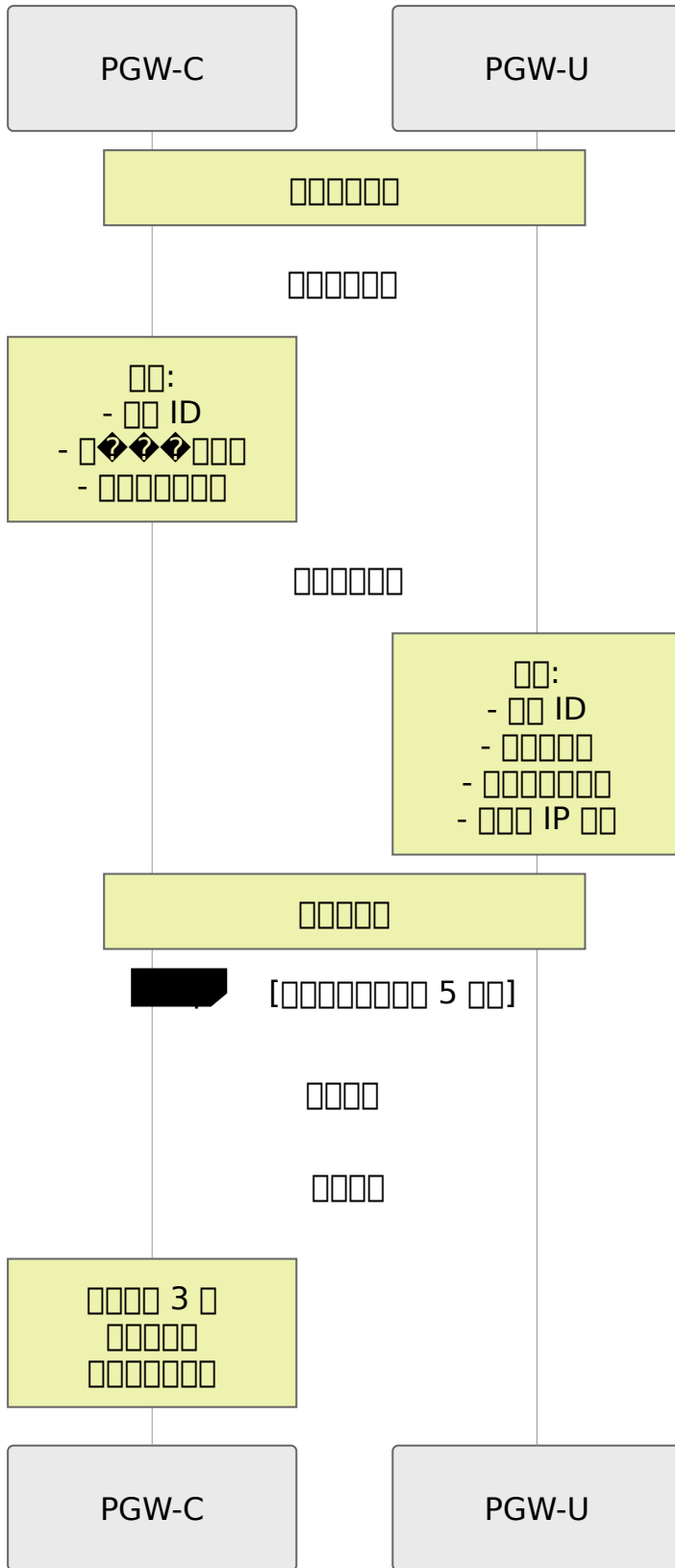
- **IPv4** □□ - □□□
- **IPv6** □□

- FQDN□□□□□□□□
-

PFCP □□□□

□□□□□□□□□□ PGW-C □ PGW-U □□□□ PFCP □□□

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□□□□□□□□

□□ PFCP □□□□□□□□

□□	□□
is_associated	□□□□□□□□□□
remote_node_id	□□□□□□ ID □ IP □ FQDN □
remote_ip_address	□□□□□ IP □□
remote_port	UDP □□□□□ 8805 □
heartbeat_period_ms	□□□□□□□□
missed_heartbeats_consecutive	□□□□□□□□
up_function_features	□□□□□□□□
up_recovery_time_stamp	□□□□□□□□□□

□□□□

□□□ □□□□□□□□□□□□□□□□

□□□

```
# config/runtime.exs
sxb: %{
  local_ip_address: "10.0.0.20"
},
upf_selection: %{
  fallback_pool: [
    %{remote_ip_address: "10.0.0.21", remote_port: 8805, weight:
100}
  ]
}
# UPF 5
```

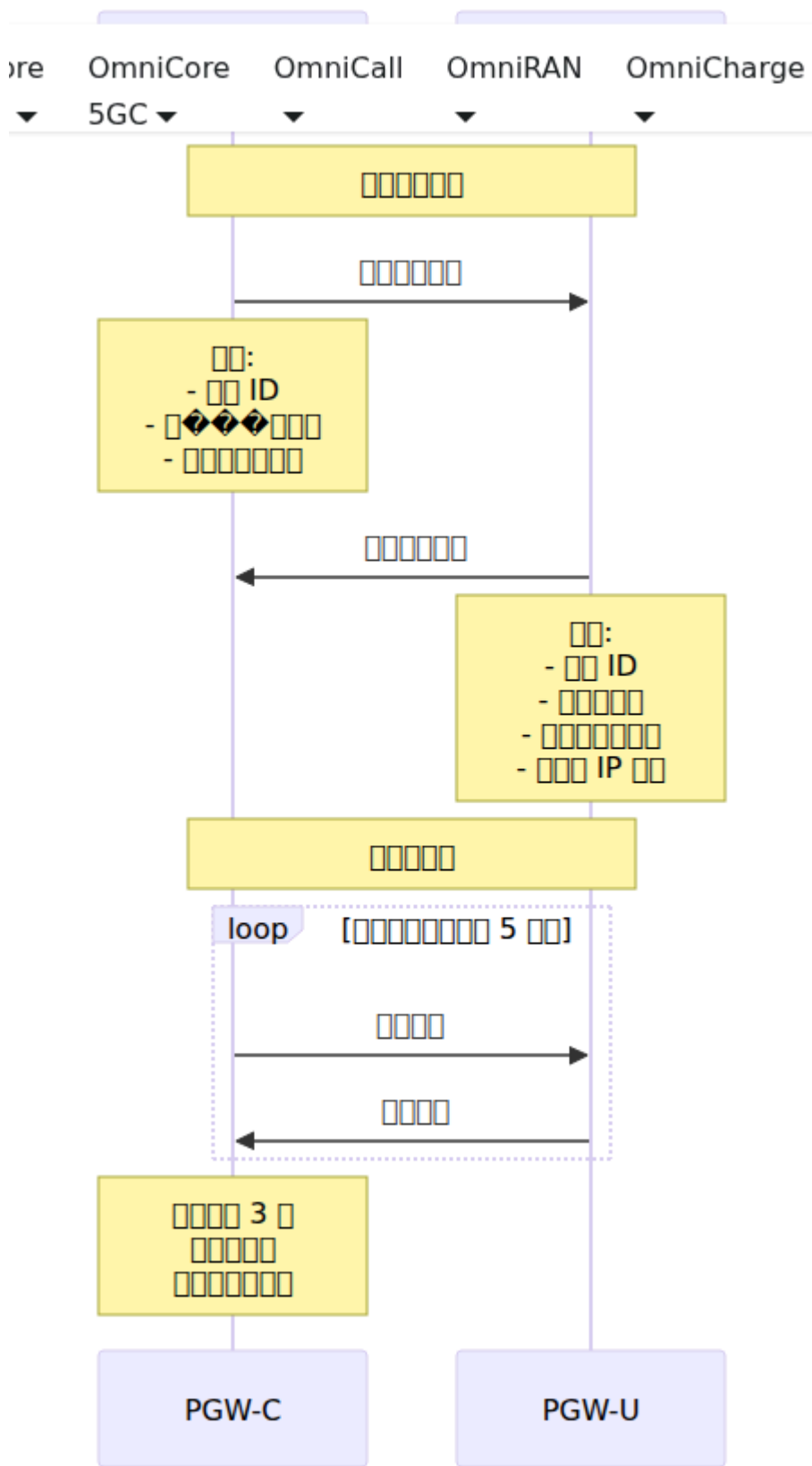
🔍

- missed_heartbeats_consecutive
- 3
-

PFCP

PFCP UE PDN

□□□□□□



□□□□

□□□ UE □□□□□ PDN □□

PGW-C □□□ PGW-U□

□□□□□□ □□□

- **SEID**□□□□□ ID□ - □□□□□□□□
- □□ **ID** - PGW-C □□□ ID
- **F-SEID** - □□□□□ SEID□□□ IP + SEID□
- **PDRs** - □□□□□□□□□□□□ 2□□□ + □□□
- **FARs** - □□□□□□□□□□□□ 2□□□ + □□□
- **QERs** - QoS □□□□□□□□□□□□
- **BAR** - □□□□□□□□□□□□□□

PGW-U □□□

□□□□□□ □□□

- □□ - □□□□□□□□
- **F-SEID** - PGW-U □□□□□□
- □□□ **PDRs** - □□□□□□□□□□
- **F-TEID** - □□□□□□ TEID □□ S5/S8 □□

□□□□□

□□□ QoS □□□□□□□□□□□□□□□□

□□□□□□□□

- □□□□□ PDRs□FARs□QERs
- □□□□□□□□
- □□□□□□□□

□□□□

□□□ UE □□□ PDN □□□□□

□□□

1. PGW-C □□□□□□□□□□ SEID
2. PGW-U □□□□□□□□□□
3. PGW-U □□□□□□□□

F-TEID □□

F-TEID □□□□□□□□□□□□ □□□□□□□□□□ GTP-U □□□□□□□□ PFCP □□□□□□□□ F-TEID □□□□
□ UPF □□□□□□□□□□□□□□□□□□□□□□□□

□□ **F-TEID** □□

□□□□□□□□ F-TEID □□□□□□

- **TEID** □□□□□□□□□□ - 32 □□□□□□□□□□
- **IP** □□ - □□□□ GTP-U □□□□ UPF □ IP □□□□

□□□ □□□ TEID □□

□□ **1□UPF** □□□□□□□□□□

- PGW-C □“□□□□□□□□ TEID”□CHOOSE □□□□
- UPF □□□□□□□□□□□□□□□□□□□□□□

□□ **2□PGW-C** □□□□□□□□□□

- PGW-C □□□□□□□□□□ TEID □□□□ UPF“□□□□□□□□□□ TEID”
- UPF □□□□□□□□□□□□□□□□□□□□□□

UPF □□□□□□□□ - □□□□

□□□□

- 在 UPF 侧进行配置
- 在 UPF 侧配置 PGW-C 侧
- 在 3GPP 侧进行配置
- 在 3GPP 侧配置 PFCP 侧

配置

- 在 UPF 侧配置 CHOOSE 侧
- 在 UPF 侧配置 "IE" 侧 UPF 侧 CHOOSE

PGW-C 配置

配置

```
sxb: %{
  allocate_uplink_f_teid: true
}
```

配置

1. PGW-C 侧配置 TEID
2. PGW-C 侧配置 TEID 侧 PFCP 侧
3. UPF 侧配置 TEID 侧
4. PGW-C 侧 UPF 侧 TEID 侧

配置

在 UPF 侧配置 CHOOSE

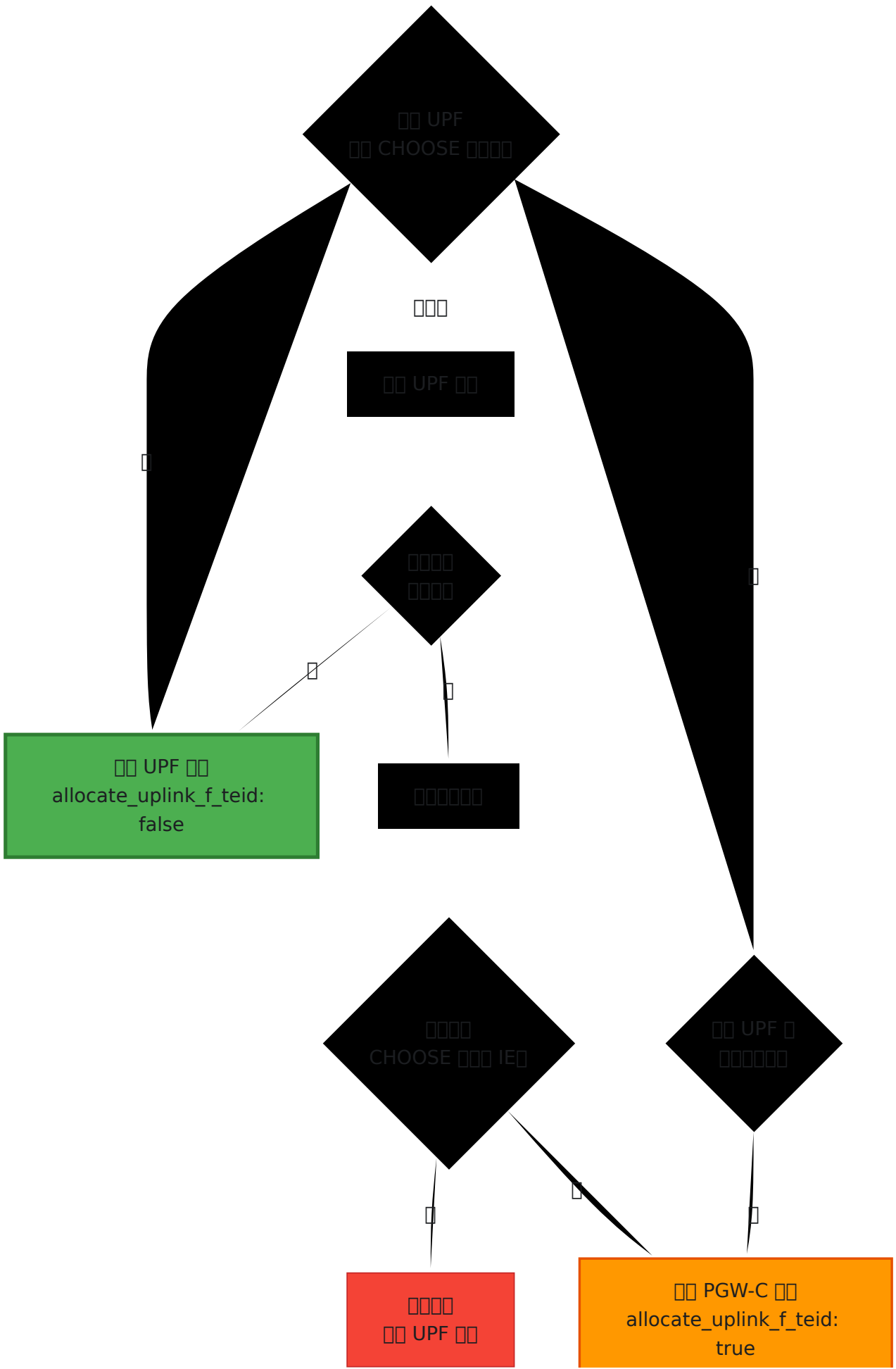
- 在 UPF 侧配置/侧
- UPF 侧 PFCP 侧 TEID
- 在 UPF 侧配置

在 TEID 侧配置

- 在 PGW-C 侧配置 TEID
- 在 PGW-C 侧配置 TEID 侧
- 在 TEID 侧配置

- □□□□□□□□ TEID

□□□□



□□□□

□□□□□□□□□□

□□ PFCP □□□

```
# □□□ CHOOSE □□□□□
grep -i "choose\|mandatory.*missing" /var/log/pgw_c.log

# □□ PFCP □□□□□□□□□□
grep "Session Establishment Response" /var/log/pgw_c.log
```

□□ **UPF** □□ **CHOOSE** □□□

- □□□□□□"□□□□ IE"□"□□ IE"
- UPF □□□□ F-TEID□□□□□ CHOOSE
- □□□□□ □□ `allocate_uplink_f_teid: true`

□□ **PGW-C** □□□□□□□

- □□□□ - TEID □□□□□40 □□□□
- □□ TEID □□□□□□□□□□□□□□□□□□

```
# □□□□□□□
grep "registered_teid_count" /var/log/pgw_c.log
```

□□□□□□□

```
# □□ config/runtime.exs
sxb: %{
  local_ip_address: "10.0.0.20",
  allocate_uplink_f_teid: false # □□ UPF □□□ CHOOSE□□□□□ true
}
```

□□□□ PGW-C□

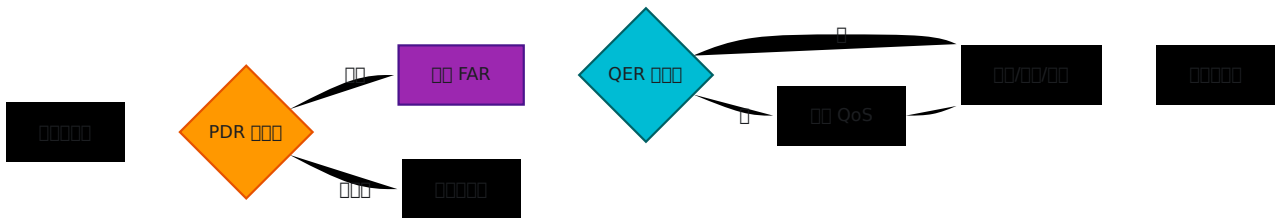
```
systemctl restart pgw_c
```

PFCP

```
# PFCP
tcpdump -i any -n port 8805 -w pfcp.pcap

# Wireshark
# F-TEID "CHOOSE"UPF
# F-TEID TEID PGW-C
```

PFCP



PDR

PGW-C

PDR #1 -

PDR ID: 1
QoS: 100
PDI: [redacted]
- [redacted]CORE [redacted]
- UE IP [redacted]100.64.1.42/32
FAR ID: 1 [redacted]

PDR #2 - [redacted]

PDR ID: 2
QoS: 100
PDI: [redacted]
- [redacted]ACCESS [redacted]SGW [redacted]
- F-TEID: <S5/S8 [redacted]>
FAR ID: 2 [redacted]
QER ID: 1 [redacted]QoS [redacted]

[redacted] PDR [redacted]

- **PDR ID** - [redacted]
- **QoS** - [redacted]
- **PDI** - [redacted]IP [redacted]TEID [redacted]
- **[redacted]** - [redacted] GTP-U [redacted]
- **FAR ID** - [redacted]
- **QER ID** - [redacted] QoS [redacted]

FAR [redacted]

[redacted] [redacted]

FAR #1 - [redacted] → UE [redacted]

QER ID: 1

□□□□□□

□□□□□□

- □□□100 Mbps

- □□□50 Mbps

□□□□□□□□□□□□ GBR □□□

- □□□10 Mbps

- □□□10 Mbps

□□ QER □□□

- **QER ID** - □□□□□□□□
- □□□ - □□□□□□□□□□□□□□
- **MBR** - □□□□□□□□/□□□
- **GBR** - □□□□□□□□□□□□□□
- **QCI** - QoS □□□□□□□□□□□□

BAR□□□□□□□□□□

□□□ □□ UE □□□□□□□□□□□□□□

□□ BAR□

BAR ID: 1

□□□□□□□□□□100ms

□□□□□□□□□□10

□□□ □□□□ DRX□□□□□□□□□□□□

□□

□□ Sxb □□

□□ `config/runtime.exs`□

```

config :pgw_c,
  sxb: %{
    # PFCP IP
    local_ip_address: "10.0.0.20",

    # PFCP port 8805
    local_port: 8805,

    # PFCP timeout 500ms
    # UPF
    # UPF
    request_timeout_ms: 500,

    # PFCP attempts 3
    # request_timeout_ms * request_attempts
    request_attempts: 3,

    # F-TEID
    # false UPF F-TEID CHOOSE
    # true PGW-C F-TEID
    # UPF CHOOSE
    allocate_uplink_f_teid: false
  },

  # UPF - UPF
  upf_selection: %{
    fallback_pool: [
      %{
        # PGW-U IP
        remote_ip_address: "10.0.0.21",

        # PFCP port 8805
        remote_port: 8805,

        # weight 100 = 1000 = 100
        weight: 100
      }
    ]
  }
}

```

□□□□□□

PCFP □□□□□□□□□□□□ UPF □□□□□□□□□□□□

□□□

□□	□□	□□□	□□
<code>request_timeout_ms</code>	□□	500	□□ UPF □□□□□□□□□□□□□□□□
<code>request_attempts</code>	□□	3	□□□□□□□□□□□□□□□□

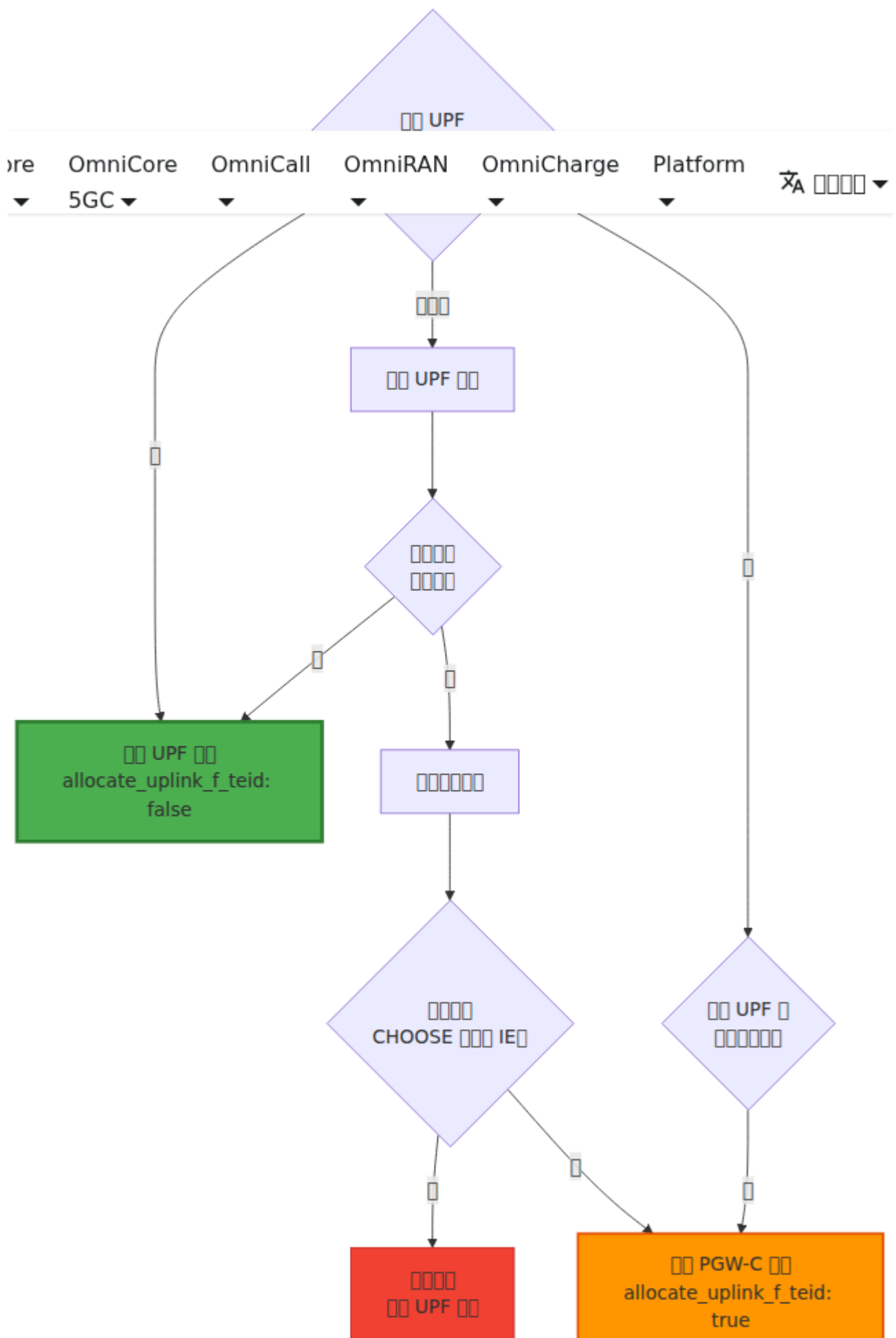
□□□□□□ `request_timeout_ms × request_attempts`

□□□□□ 500ms × 3 □□□ = **1.5** □□□□□□

□□□□□□□□□□

□□ `request_timeout_ms` □□□ UPF □□□□□□□□□□

1. PGW-C □□□□□□□□□□
2. □□□ UPF □□□□□□□
3. PGW-C □□□□□□□□□□□□□□
4. UPF □□□□□□□□□□ □□□ **PFCP** □□
5. PGW-C □□□□□□□□□□□□□□□□ ID
6. □□□□□□ UPF □□□□ □□□



□□□□

UPF □□□□	□□□ request_timeout_ms	□□□□□
□□□ < 100ms □	200-300ms	600-900ms □ 3 □□□□
□□□ 100-300ms □	500ms □□□□	1.5s □ 3 □□□□
□□ 300-500ms □	750-1000ms	2.25-3s □ 3 □□□□
□□□□ > 500ms □	1500-2000ms	4.5-6s □ 3 □□□□

□□□ □ request_timeout_ms □□□□□ 2 □□□□ **UPF** □□□□□□□□□□□□□□□□□□□□

□□ - □ **UPF**

```

sxb: %{
  local_ip_address: "10.0.0.20",
  request_timeout_ms: 1000, # □□□□ 1 □
  request_attempts: 3 # □□□□□ 3 □
}
  
```

□□□□□□

□□□□□□□□

- UPF □□□ PFCP □□□□□□□□□□
- □□□□□ UPF □□□□□□□□
- □□□□□“□□□□□□□□□□”□□□□□□□□

□□□□□

1. □□ UPF API □□□□□□□□□ UPF □□□□□
2. □ PGW-C □□□□□□□□□□□□
3. □□ UPF □□□□□□□□□□□□□□□□□□□□□

□□□□□

1. `request_timeout_ms` UPF
2. PGW-C
3. UPF

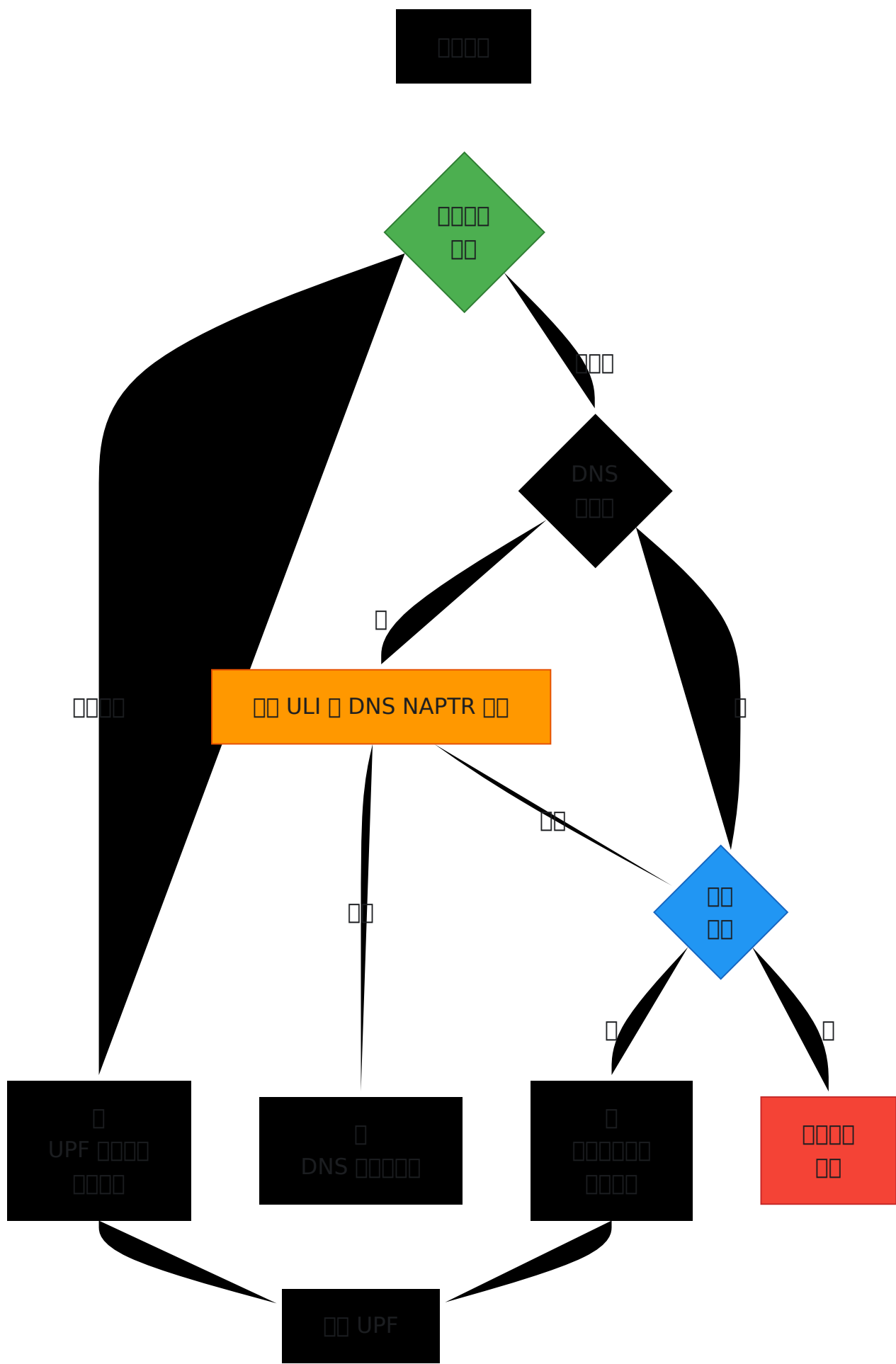
PGW-U

```
config :pgw_c,  
  sxb: %  
    local_ip_address: "10.0.0.20"  
  },  
  upf_selection: %  
    fallback_pool: [  
      %  
        remote_ip_address: "10.0.1.21", remote_port: 8805, weight:  
50}, # 50%  
      %  
        remote_ip_address: "10.0.2.21", remote_port: 8805, weight:  
50} # 50%  
    ]  
  }  
# UPF 5
```

UPF 配置

PGW-C として UPF を設定する

1. 設定ファイル - 作成
2. DNS 設定 - DNS NAPTR 設定
3. 設定ファイル - UPF 設定





□□□ **UPF** □□□□

```

config :pgw_c,
  # PFCP []
  sxb: %{
    local_ip_address: "10.0.0.20"
  },

  # UPF [] UPF []
  upf_selection: %{
    #
=====

    # [] DNS []
    #

=====

    # []ULI[] DNS
    # [] UPF []
    dns_enabled: false,
    dns_query_priority: [:ecgi, :tai, :rai, :sai, :cgi],
    dns_suffix: "epc.3gppnetwork.org",
    dns_timeout_ms: 5000,

    #

=====

    # []
    #

=====

    # []
    # [] UPF []
    rules: [
      # 1 IMS [] - []
      %{
        name: "IMS []",
        priority: 20,
        match_field: :apn,
        match_regex: "^ims",
        upf_pool: [
          weight: 80,
          %{remote_ip_address: "10.100.2.21", remote_port: 8805,
          weight: 20}
          %{remote_ip_address: "10.100.2.22", remote_port: 8805,
        ],
      # [] PCO []
      pco: %{
        p_cscf_ipv4_address_list: ["10.101.2.100", "10.101.2.101"]
      }
    ]
  }

```

```

    }
  },

  # 2 APN - 
  %{
    name: "",
    priority: 15,
    match_field: :apn,
    match_regex: "^(enterprise|corporate)\.apn",
    upf_pool: [
      weight: 100}
      %{remote_ip_address: "10.100.3.21", remote_port: 8805,
    ],
    pco: %{
      primary_dns_server_address: "192.168.1.10",
      secondary_dns_server_address: "192.168.1.11",
      ipv4_link_mtu_size: 1500
    }
  },

  # 3 - 
  %{
    name: "",
    priority: 10,
    match_field: :serving_network_plmn_id,
    match_regex: "^(310|311|312|313)", # 
    upf_pool: [
      weight: 100}
      %{remote_ip_address: "10.100.4.21", remote_port: 8805,
    ]
  },

  # 4 - 
  %{
    name: "",
    priority: 5,
    match_field: :apn,
    match_regex: "^internet",
    upf_pool: [
      weight: 33},
      %{remote_ip_address: "10.100.1.21", remote_port: 8805,
      weight: 33},
      %{remote_ip_address: "10.100.1.22", remote_port: 8805,
      weight: 33},
      %{remote_ip_address: "10.100.1.23", remote_port: 8805,

```

```

weight: 34}
  ]
}
],

#
=====
# 
#
=====
# DNS 
fallback_pool: [
  %{remote_ip_address: "127.0.0.21", remote_port: 8805, weight:
100}
]
}

```

Parameters

Parameter	Description	Value
<code>:imsi</code>	Subscriber Identity Module (SIM) number	"310260123456789"
<code>:apn</code>	Access Point Name (APN)	"internet" or "ims"
<code>:serving_network_plmn_id</code>	Serving network PLMN (MCC+MNC)	"310260" or "310260123456789"
<code>:sgw_ip_address</code>	SGW IP address	"10.0.1.50"
<code>:uli_tai_plmn_id</code>	ULI PLMN ID	"310260"
<code>:uli_ecgi_plmn_id</code>	E-UTRAN PLMN ID	"310260"

UPF Parameters

UPF Parameters

```
upf_pool: [  
  {%remote_ip_address: "10.100.1.21", remote_port: 8805, weight:  
50},  
  {%remote_ip_address: "10.100.1.22", remote_port: 8805, weight:  
30},  
  {%remote_ip_address: "10.100.1.23", remote_port: 8805, weight:  
20}  
]
```

□□□□□□□□□□

1. □□□□□□50 + 30 + 20 = 100
2. □□□□□□0.0 □ 100.0
3. □□□□□□□□□□ UPF□
 - 0-50□UPF-1□50% □□□
 - 50-80□UPF-2□30% □□□
 - 80-100□UPF-3□20% □□□

□□□

- □□□□□ □□□□□□□□33, 33, 34□
- □/□□ □□□□□80□□□□□□□□20□
- □□□□□ □□□ UPF □□□□□

PCO □□

□□□□□□ PCO□□□□□□□□□□□□

```

%{
  name: "IMS 00",
  match_field: :apn,
  match_regex: "^ims",
  upf_pool: [...],
  pco: %{
    # 00000000
    p_cscf_ipv4_address_list: ["10.101.2.100", "10.101.2.101"],
    # 00000000 PCO 00000000
  }
}

```

000 PCO 000000

- primary_dns_server_address
- secondary_dns_server_address
- primary_nbns_server_address
- secondary_nbns_server_address
- p_cscf_ipv4_address_list
- ipv4_link_mtu_size

00 DNS 000

0000PGW-C 000000000000 DNS NAPTR 000

```

upf_selection: %{
  dns_enabled: true,
  dns_query_priority: [:ecgi, :tai, :rai, :sai, :cgi],
  dns_suffix: "epc.3gppnetwork.org",
  dns_timeout_ms: 5000
}

```

000000

1. **ECGI** E-UTRAN 0000000000 - 000
2. **TAI** 0000000000 - 0000
3. **RAI** 0000000000 - 3G/2G 00
4. **SAI** 0000000000 - 3G 0000

5. CGI - 2G

DNS

```
# ECGI  
eci-1a2b3c.ecgi.epc.mnc999.mcc999.epc.3gppnetwork.org  
  
# TAI  
tac-lb64.tac-hb00.tac.epc.mnc999.mcc999.epc.3gppnetwork.org
```

DNS

- ECGI TAI
- DNS
- UPF
- DNS DNS

DNS UPF

DNS UPF

DNS UPF UE  ULI DNS NAPTR

3GPP TS 23.003 - UPF DNS

- UPF
-
-
- UPF

□□□ - LTE □□□□□

□□□

```
eci-<HEX-ECI>.ecgi.epc.mnc<MNC>.mcc<MCC>.<dns_suffix>
```

□□□

```
# □□ ID: 0x1A2B3C□1,715,004 □□□□  
# PLMN: MCC=999, MNC=999  
eci-1a2b3c.ecgi.epc.mnc999.mcc999.epc.3gppnetwork.org
```

□□□□□ LTE□4G□□□□

2. TAI□□□□□□□□□□

□□□□ - □□□□□□□□□□□□□□

□□□

```
tac-lb<LB>.tac-hb<HB>.tac.epc.mnc<MNC>.mcc<MCC>.<dns_suffix>
```

□□□

```
# TAC: 0x0064□100 □□□□  
# □□□: 0x64□□□□: 0x00  
tac-lb64.tac-hb00.tac.epc.mnc999.mcc999.epc.3gppnetwork.org
```

□□□□□ LTE□4G□□□□□

3. RAI□□□□□□□□□□

3G/2G □□□□

□□□

```
rac<RAC>.lac-lb<LB>.lac-hb<HB>.lac.raimnc<MNC>.mcc<MCC>.  
<dns_suffix>
```

□□□

```
# RAC: 0x0A10 □□□□  
# LAC: 0x12344660 □□□□  
rac0a.lac-lb34.lac-hb12.lac.raimnc999.mcc999.epc.3gppnetwork.org
```

□□□□□ 3G/2G UMTS/GPRS □□

4. SAI□□□□□□□□□□

3G □□□□

□□□

```
sac<SAC>.lac-lb<LB>.lac-hb<HB>.lac.saimnc<MNC>.mcc<MCC>.  
<dns_suffix>
```

□□□

```
# SAC: 0x0001  
# LAC: 0x1234  
sac0001.lac-lb34.lac-  
hb12.lac.saimnc999.mcc999.epc.3gppnetwork.org
```

□□□□□ 3G UMTS □□□□

5. CGI□□□□□□□□□□

2G □□□

□□□

```
ci<CI>.lac-lb<LB>.lac-hb<HB>.lac.cgi.mnc<MNC>.mcc<MCC>.  
<dns_suffix>
```

□□□

```
# CI: 0x5678  
# LAC: 0x1234  
ci5678.lac-lb34.lac-hb12.lac.cgi.mnc999.mcc999.epc.3gppnetwork.org
```

□□□□□ 2G GSM □□

DNS □□□□

NAPTR □□□□

DNS □□□□ UPF IP □□□ NAPTR □□□

```
eci-1a2b3c.ecgi.epc.mnc999.mcc999.epc.3gppnetwork.org.  
  IN NAPTR 10 50 "a" "x-3gpp-upf:x-s5-gtp:x-s8-gtp" ""  
upf1.epc.mnc999.mcc999.3gppnetwork.org.  
  
upf1.epc.mnc999.mcc999.3gppnetwork.org.  
  IN A 10.100.1.21
```

PGW-C □□□

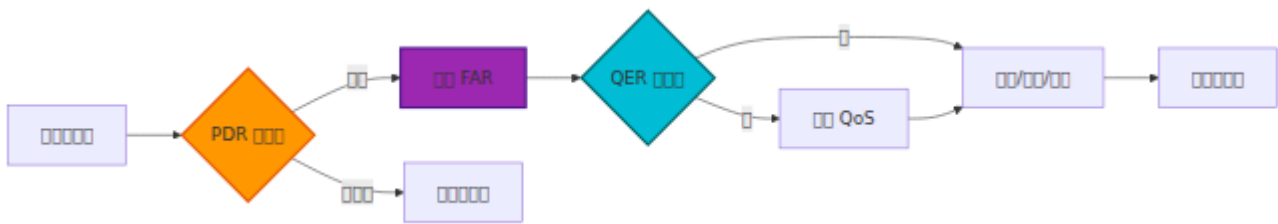
1. □□ NAPTR □□□□□ UPF IP □□
2. □ DNS □□□□□□□□□□□□
3. □□□□□□□□□□□□

□□□

```
DNS □□□ [10.100.1.21, 10.100.5.99]
```

```
□□□ 10.100.1.21□□□□□□□□□□  
□□□ □□□□ upf_selection □□□□□□□□
```

□□□□□□□□



□□

1. □□□□□□

□□□ □□□□□□□□□□ UPF

DNS □□□

```
# □□□□□□  
eci-aaa.ecgi.epc.mnc999.mcc999.epc.3gppnetwork.org → UPF-□□□  
□10.1.1.21□  
  
# □□□□□  
eci-bbb.ecgi.epc.mnc999.mcc999.epc.3gppnetwork.org → UPF-□□  
□10.2.1.21□  
  
# □□□□□□  
eci-ccc.ecgi.epc.mnc999.mcc999.epc.3gppnetwork.org → UPF-□□□  
□10.3.1.21□
```

□□□ □□□□□□□□□□ UPF□□□□□□□□□□

2. □□□□

□□□ □□□□□□□□□□□□□□□□□□□□□□ UPF

DNS □□□

```
# □□□□□□□□□□□□□□ UPF  
eci-*.ecgi.epc.mnc999.mcc999.epc.3gppnetwork.org → □□□□□ UPF
```

如何配置DNS

3. 配置DNS

如何配置DNS UPF 配置

如何配置 DNS 配置 PGW-C 配置

如何配置 DNS 配置

DNS 配置

如何

- 配置“DNS UPF 配置:nxdomain”
- 配置

如何

1. DNS 配置
2. DNS 配置 ID
3. GTP-C 配置 ULI

如何

```
# 配置 DNS 配置
dig eci-1a2b3c.ecgi.epc.mnc999.mcc999.epc.3gppnetwork.org NAPTR

# 配置 PGW-C 配置 DNS 配置
grep "DNS UPF selection: querying" /var/log/pgw_c.log

# 配置 ULI
# 配置 "uli" 配置
```

DNS 配置 UPF

如何

- DNS 配置 `upf_selection` 配置 UPF
- 配置

- DNS PFCP 10.99.1.50 UPF 10.100.1.21
- DNS PFCP 10.100.1.22

10.100.1.21

```
DNS 10.99.1.50 [10.99.1.50]
upf_selection: [10.100.1.21, 10.100.1.22]
```

10.99.1.50

- DNS PFCP 10.100.1.21
- DNS PFCP 10.100.1.22
- DNS PFCP 10.100.1.23

10.100.1.21

1. upf_selection 10.100.1.21

```
upf_selection: %{
  fallback_pool: [
    %{remote_ip_address: "10.99.1.50", remote_port: 8805, weight:
100}
  ]
}
```

2. DNS 10.99.1.50 UPF IP

3. DNS 10.99.1.50 MEC/10.100.1.21

10.100.1.21

10.100.1.21

- DNS "DNS UPF 10.99.1.50"
- DNS 10.100.1.21

10.100.1.21

```
upf_selection: %{\n  dns_timeout_ms: 10000 # 10 seconds\n}
```

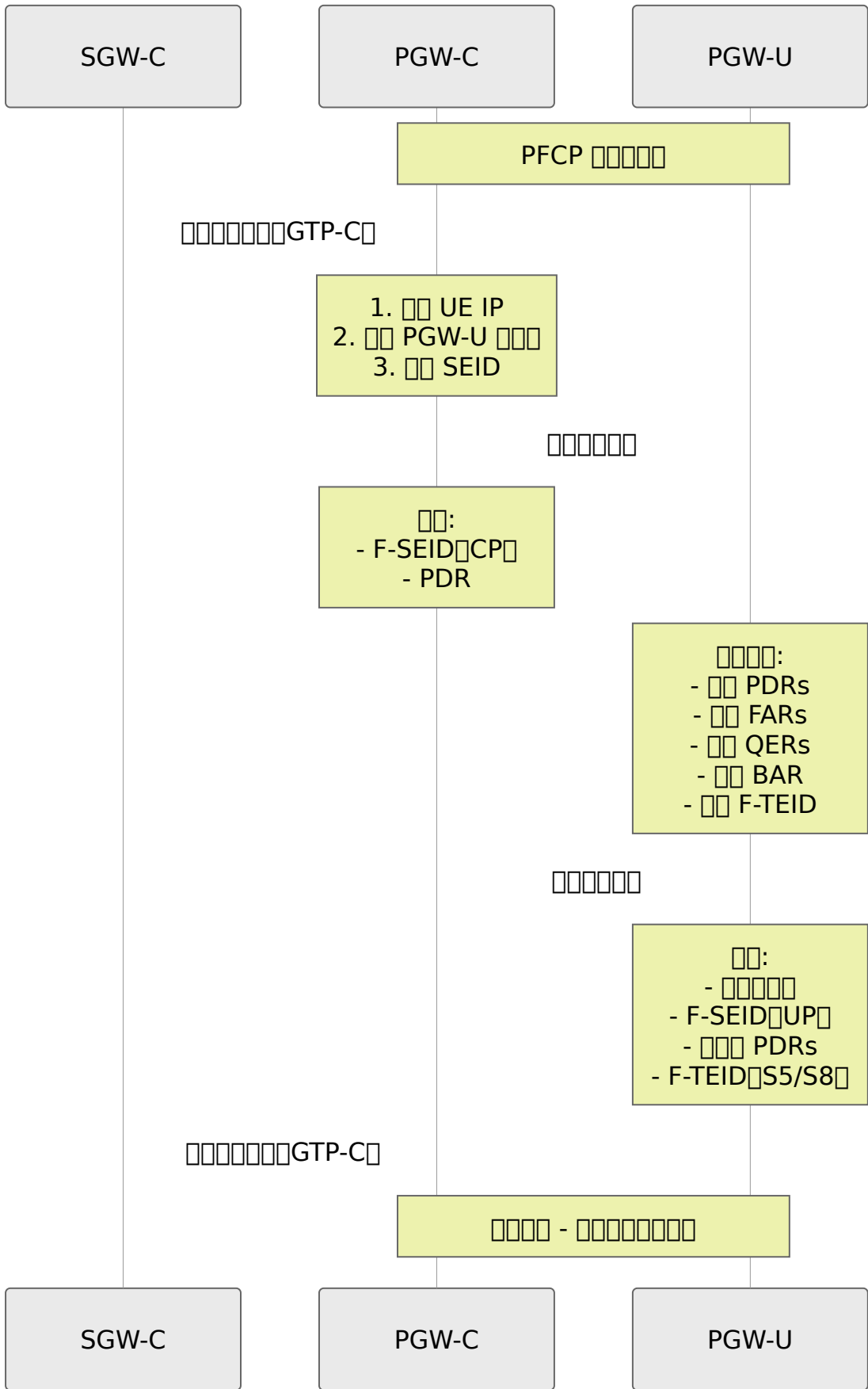
DNS

```
# DNS success rate\nrate(upf_selection_dns_success_total[5m]) /\nrate(upf_selection_dns_attempts_total[5m])\n\n# DNS 95th percentile duration\nhistogram_quantile(0.95,\nrate(upf_selection_dns_duration_seconds_bucket[5m]))\n\n# DNS fallback rate\nrate(upf_selection_fallback_used_total[5m])
```

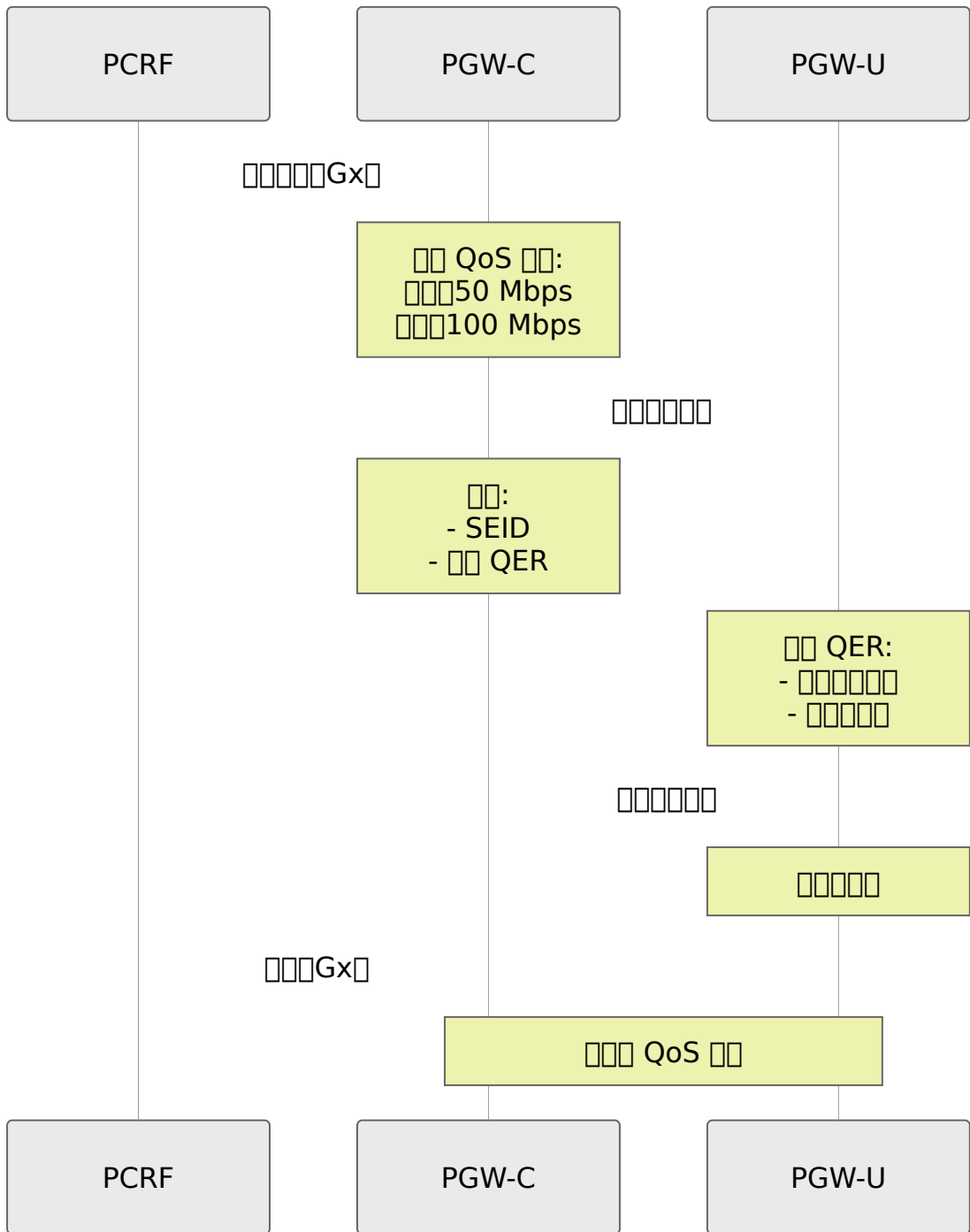
```
[debug] DNS UPF selection: querying eci-1a2b3c.ecgi.epc.mnc999.mcc999.epc.3gppnetwork.org\n[debug] DNS UPF selection: got 2 candidates from DNS\n[info] DNS UPF selection: selected 10.100.1.21
```

□□□

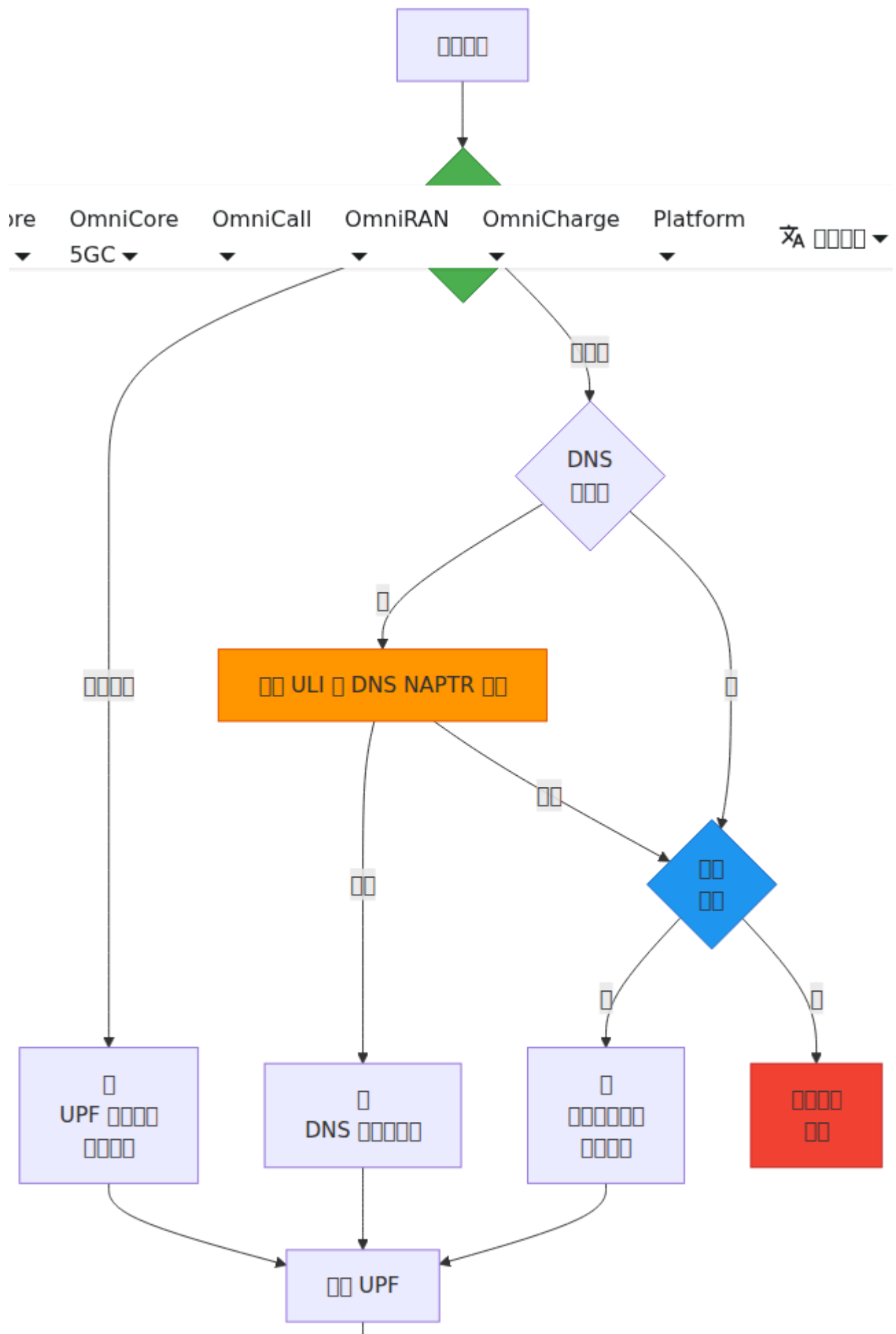
□□□□□□□

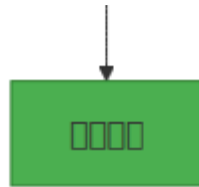


□□□□□



□□□□□





0000

0000

1. 000000

000

- 000000“PFCP 000000”
- 000000000000

00000

- PGW-U 0000000000
- PGW-U 000
- 000000 UDP 00 8805
- 00000 remote_ip_address 000

00000

```
# 00000
ping <pgw_u_ip_address>

# 00 UDP 00
nc -u -v <pgw_u_ip_address> 8805

# 00000
iptables -L -n | grep 8805
```

2. 0000

000

- SEID 00000000
- PGW-U 000 PGW-C 00

00000

- 0000 PFCP 0000000000000000
- PGW-C 0000 PGW-U 0000000000

00 **PFCP** 00

000000

```
# PFCP 00000000
pfcpeer_associated{peer="PGW-U Primary"} 1

# 00 PFCP 00
seid_registry_count 150

# PFCP 0000
rate(sxb_inbound_messages_total[5m])

# PFCP 00
rate(sxb_inbound_errors_total[5m])

# 0000
pfcpeer_consecutive_heartbeat_failures{peer="PGW-U Primary"} 0
```

00000

```
# PFCP Peer Down
- alert: PFCPAssociationDown
  expr: pfcpeer_associated == 0
  for: 1m
  annotations:
    summary: "PFCP Peer {{ $labels.peer }} Down"

# PFCP Session Establishment Failure High
- alert: PFCPSessionEstablishmentFailureHigh
  expr:
rate(sxb_inbound_errors_total{message_type="session_establishment_res
[5m]) > 0.1
  for: 5m
  annotations:
    summary: "PFCP Session Establishment Failure High"
```

Web UI - PFCP

OmniPGW Web UI PFCP/Sxb

UPF/PFCP

http://<omnipgw-ip>:<web-port>/upf_status

PGW-U PFCP

1. PGW-U

- PGW-U - PFCP
- PGW-U -
- 2

2. PGW-U

- PGW-U -
- **IP** - PGW-U IP
- PGW-U -
- **ID** - PFCP
- PGW-U -
- PGW-U -
- PGW-U -
- **UP** - PGW-U

3. PGW-U

- `omnipgw`
- `UP` `omnipgw`
- `omnipgw`
- `omnipgw`

PFCP `omnipgw`

`omnipgw` `http://<omnipgw-ip>:<web-port>/pfcpsessions`

`omnipgw` `omnipgw` OmniPGW `omnipgw` PGW-U `omnipgw` PFCP `omnipgw`

`omnipgw`

1. `omnipgw`

- `omnipgw` PFCP `omnipgw`
- `omnipgw`

2. `omnipgw` `omnipgw` PFCP `omnipgw`

- `omnipgw` - `omnipgw`
- `omnipgw` ID - `omnipgw` `omnipgw` `omnipgw`

- **IMSI** - IMSI
- IMSI - IMSI

3. IMSI IMSI

- IMSI PFCP IMSI
- PDRs/FARs/QERs/BARs
- F-SEIDs
- PGW-U IMSI

IMSI

IMSI PFCP IMSI

1. IMSI UPF IMSI
2. IMSI IMSI "IMSI"
3. IMSI IMSI = 0
4. IMSI IMSI "IMSI"
 - IMSI IP IMSI
 - IMSI IMSI
 - IMSI IMSI UDP 8805

IMSI IMSI

1. IMSI IMSI
2. IMSI PGW IMSI - IMSI
3. IMSI PFCP IMSI - PFCP IMSI
4. IMSI PFCP IMSI
 - IMSI UPF IMSI - IMSI
 - IMSI PFCP IMSI
5. IMSI PFCP IMSI
 - IMSI PDRs/FARs IMSI
 - IMSI PGW-U IMSI

IMSI IMSI

1. 网络 PGW-U 网络
2. 网络 PFCP 网络
3. 网络网络网络网络
4. 网络网络网络网络网络

网络网络

- 网络 UPF 网络
- 网络“网络”网络
- 网络网络网络网络网络
- 网络 Web UI 网络网络

网络

- 网络 - 网络网络 SSH
- 网络 - 网络网络/网络
- 网络网络 - 网络网络网络
- 网络网络 - 网络网络 PDRs/FARs/QERs
- 网络 - 网络网络

网络

网络

- 网络 - UPF 网络网络PFCP 网络
- 网络 - PDN 网络网络网络

网络

- **Diameter Gx** 网络 - 网络 PFCP QoS 网络 PCC 网络
- **Diameter Gy** 网络 - 网络 URR 网络网络
- 网络 **CDR** 网络 - 网络 PFCP 网络 CDR
- 网络 - PFCP 网络网络UPF 网络

□□□□

- **S5/S8** □□ - □□□□□□
 - **UE IP** □□ - □□ PFCP □□ UE □□□□
-

□□□□□□

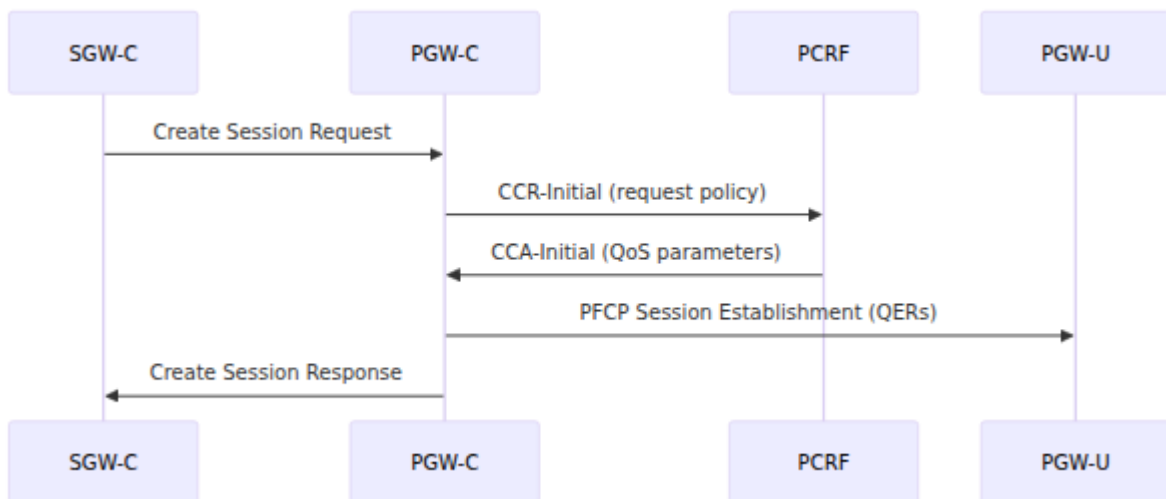
QoS

QoS

PGW-C QoS

- **Gx (Diameter)** - PCRF QoS
- **S5/S8 (GTP-C)** - SGW-C
- **Sxb (PFCP)** - QoS PGW-U

Sequence



QoS

- UE: UE PDR/FAR/QER/BAR AMBR
- EBI: EBI (EPS ID) PDR/FAR QER
- **QER (QoS)**: MBR/GBR
- PDN: PDN
- PCRF: PCRF QoS

□□

□□□□: □□ **QoS** □□

□□ QoS □□□□ Diameter Gx □□□□□□□□ PCRF□□□□ PCRF □□□□□□□□□□□□□□□□ OmniHSS□□

□□□□ `config/runtime.exs` □□□□ **PCRF** □□□□

```
config :pgw_c,  
  diameter: %{  
    listen_ip: "0.0.0.0",  
    host: "omni-pgw_c.epc.mnc999.mcc999.3gppnetwork.org",  
    realm: "epc.mnc999.mcc999.3gppnetwork.org",  
    peer_list: [  
      %{  
        host: "pcrf.epc.mnc999.mcc999.3gppnetwork.org",  
        realm: "epc.mnc999.mcc999.3gppnetwork.org",  
        ip: "192.168.1.100",  
        initiate_connection: true  
      }  
    ]  
  }  
}
```

QoS □□□□□□□□□□□□□□□□ **PCRF** □□□□□□□□□□ **PGW-C** □□□□□□□□

□□□□□□□□

□□□□□□□□

□□□□□□ PDN □□□□□□□□□□



Create Session Request

AllocateIP

UE IP assigned

RequestPolicy

CCR-Initial sent to PCRF

CreateBearer

CCA-Initial received
with QoS

ProgramUPF

PFCP Session
Establishment

Active

Delete Session Request



□□□□:

1. SGW-C □□ Create Session Request
2. PGW-C □□□□□□□□ UE IP □□
3. PGW-C □□ CCR-Initial □ PCRF□□□ IMSI□APN□IP □□
4. PCRF □□ CCA-Initial□□□ QoS □□□
 - Default-EPS-Bearer-QoS (QCI, ARP)
 - QoS-Information (AMBR □□)

5. PGW-C 消息

- ID: PDR=1 PDR=2 FAR=1 FAR=2 QER=1 BAR=1
- QER QoS MBR

6. PGW-C 到 PGW-U 的 PFCP Session Establishment Request

7. PGW-C 到 SGW-C 的 Create Session Response

消息:

- PDN
- QCI 5 到 QCI 9 GBR
- EBI
-

消息

消息 PCRF 消息

消息: 消息 PCRF 的 Re-Auth Request (RAR) 消息 Charging-Rule-Install

消息:

1. PCRF 消息 RAR 消息 Charging-Rule-Definition 消息
 - Charging-Rule-Name (消息)
 - Flow-Information (消息)
 - QoS-Information (QCI, MBR, GBR, ARP)
 - Precedence (消息)
2. PGW-C 消息 PFCP 消息
 - Flow-Information 消息 → 消息 PDR 消息 SDF 消息
 - QoS-Information → 消息 QER 消息 MBR/GBR 消息
 - Flow-Description → IP 5-消息
3. PGW-C 消息 PFCP Session Modification Request 消息 PDRs/FARs/QERs
4. PGW-C 到 SGW-C 的 Create Bearer Request
5. SGW-C 消息 Create Bearer Response 消息

消息 **Charging-Rule-Definition:**

```
Charging-Rule-Name: "video_streaming"
Flow-Information:
  - Flow-Description: "permit in ip from any to 10.0.0.1 5000-6000"
    Flow-Direction: 1 (downlink)
QoS-Information:
  QoS-Class-Identifier: 7
  Max-Requested-Bandwidth-UL: 5000000 (5 Mbps)
  Max-Requested-Bandwidth-DL: 10000000 (10 Mbps)
  Guaranteed-Bitrate-UL: 1000000 (1 Mbps)
  Guaranteed-Bitrate-DL: 2000000 (2 Mbps)
Precedence: 100
Flow-Status: 2 (ENABLED)
```

□□□□

□□ QoS □□□□□□□□□□

- **Gx RAR**□□□□□ Charging-Rule-Definition
- **PFCP Session Modification**□□□□□□□ QERs□□□□□□□□□□ FARs□□□□□□□□ PDRs□□□□□□□□□□

□□□□

□□:

- **Delete Session Request**□SGW □□□ - □□□□□□□□□□□□
- **Re-Auth Request with Charging-Rule-Remove**□PCRF □□□ - □□□□□□□

□□□□:

1. □□□□□□□□□□□□
2. □□□□□□ PDRs/FARs/QERs
3. □ SGW-C □□ Delete Bearer Request□□□□□□ PCRF □□□□
4. □□ PFCP Session Modification□□□□□□□□□□ Session Deletion□□□□□□□□□□

QoS

QCI (QoS Class Identifier)

PCRF Gx QoS-Class-Identifier AVP

QCI:

- **QCI 1:** GBR, 100ms
- **QCI 2:** GBR, 150ms
- **QCI 3:** GBR, 50ms
- **QCI 4:** GBR, 300ms
- **QCI 5:** IMS (GBR, 100ms) -
- **QCI 6:** (TCP) (GBR, 300ms)
- **QCI 7:** (GBR, 100ms)
- **QCI 8:** (TCP) YouTube (GBR, 300ms)
- **QCI 9:** (GBR, 300ms)

QCI:

- QCI PCRF QoS IE SGW-C
- PGW-C QCI - QERs MBR/GBR
- QCI
- QCI

ARP (Allocation-Retention-Priority)

PCRF Allocation-Retention-Priority AVP

ARP:

- : 1 15
- :
 - 0 =
 - 1 =
- :

- 0 = 00000000
- 1 = 11111111

0000:

- 000000: 1
- 000000: 00 (0)
- 000000: 00 (1)

000000:

- ARP → SGW-C → 00000000 eNodeB
- **PGW-C** 000000 - 000000 eNodeB 0000000000
- 000000000000000000000000
- 00000000000000 10000000000000

MBR (000000)

00: PCRF 00 Max-Requested-Bandwidth-UL 0 Max-Requested-Bandwidth-DL
AVPs

00: 0000000000 kbps: bytes / 1000

0000: 000000000000

0000:

- PGW-C 00 QER000 mbr: %Bitrate{ul: kbps_ul, dl: kbps_dl}
- QER 00 PFCP 000 PGW-U
- **PGW-U** 0000000000000000
- 00 MBR 00000000

00:

Max-Requested-Bandwidth-UL: 5000000 (5 Mbps)
Max-Requested-Bandwidth-DL: 10000000 (10 Mbps)

- QER `QER` mbr: {ul: 5000, dl: 10000} kbps
- PGW-U `PGW-U` 5 Mbps `PGW-U`
- PGW-U `PGW-U` 10 Mbps `PGW-U`

GBR ()

`QoSClass`: PCRF `QoSClass` `Guaranteed-Bitrate-UL` `Guaranteed-Bitrate-DL` AVPs

`QoSClass`: `QoSClass` kbps

`QoSClass`: `QoSClass` GBR `QoSClass`

`QoSClass`:

- `QoSClass` Charging-Rule-Definition `QoSClass` GBR `QoSClass` **GBR** `QoSClass`
- PGW-U `QoSClass` QER `QoSClass`
- `QoSClass` eNodeB `QoSClass`
- GBR `QoSClass` - `QoSClass`

`QoSClass`:

Guaranteed-Bitrate-UL: 1000000 (1 Mbps)
Guaranteed-Bitrate-DL: 2000000 (2 Mbps)

- QER `QER` gbr: {ul: 1000, dl: 2000} kbps
- `QoSClass` 1 Mbps `QoSClass` 2 Mbps `QoSClass`
- `QoSClass` VoIP `QoSClass`

`QoSClass`:

- GBR `QoSClass`
- `QoSClass` GBR `QoSClass`
- `QoSClass` `QoSClass` GBR `QoSClass`

AMBR ()

: PCRF APN-Aggregate-Max-Bitrate-UL APN-Aggregate-Max-Bitrate-DL AVPs

: GBR APN

:

- AMBR GBR
- Create Session Response SGW-C
- eNodeB/SGW
- PGW-C AMBR SGW-C

:

APN-Aggregate-Max-Bitrate-UL: 50000000 (50 Mbps)
APN-Aggregate-Max-Bitrate-DL: 100000000 (100 Mbps)

- GBR 50 Mbps / 100 Mbps
- MBR
- AMBR UE/APN

:

- HSS/PCRF
- 10 Mbps 100 Mbps
- GBR

(Gx) (PFCP)

PCRF Flow-Status AVP Charging-Rule-Definition

Flow-Status (Gx)	Gate-Status (PFCP QER)	Hex
0 = ENABLED-UPLINK	ul: OPEN, dl: CLOSED	00000000
1 = ENABLED-DOWNLINK	ul: CLOSED, dl: OPEN	00000001
2 = ENABLED	ul: OPEN, dl: OPEN	00000002
3 = DISABLED	ul: CLOSED, dl: CLOSED	00000003
4 = REMOVED	ul: CLOSED, dl: CLOSED	00000004

Hex:

- **DISABLED:** 00000003
- **ENABLED-UPLINK:** 00000000
- **ENABLED-DOWNLINK:** 00000001
- **ENABLED:** 0000

00000000

Prometheus Hex

???

```

session_registry_count # Hex (IMSI, EBI Hex)
address_registry_count # Hex UE IP
charging_id_registry_count # Hex

```

Gx Hex:

```

gx_inbound_messages_total{message_type="gx_RAR"} # [] PCRF []
[]
gx_outbound_messages_total{message_type="gx_CCR"} # [] PCRF []
[]
gx_outbound_transaction_duration_bucket # [] PCRF []

```

PCFP [] [] [] []:

```

sxb_outbound_messages_total{message_type="pfcf_session_establishment_
sxb_outbound_messages_total{message_type="pfcf_session_modification_r
sxb_outbound_transaction_duration_bucket

```

[] [] [] [] [] []:

```

s5s8_inbound_messages_total{message_type="create_session_request"}
# [] [] [] []
s5s8_outbound_messages_total{message_type="create_bearer_request"}
# [] [] [] []

```

Web UI [] []

PGW [] [] [] [] (/pgw_sessions):

- [] IMSI [] IP [] [] MSISDN [] APN []
- [] [] [] [] [] [] [] [] [] []
- [] [] [] QoS [] (QCI, MBR, GBR, AMBR)
- [] [] [] [] (2 [])

Diameter [] [] (/diameter):

- PCRF [] [] [] [] [] []
- Gx [] [] [] []
- [] [] [] [] [] [] [] [] [] []

[] [] [] [] (/logs):

- [] [] [] [] []

- "Credit Control" CCR/CCA
- "Re-Auth" RAR
- "PCFP"

```
[debug] Sending Credit Control Request: ... # CCR PCRF
[debug] Handling Credit Control Answer: ... # CCA PCRF
QoS
[debug] Handling Re-Auth Request # RAR PCRF
[debug] Sending Session Establishment Request # PCFP PGW-
UERs
[debug] Sending Session Modification Request # PCFP PGW-
UERs
```

QoS

1. Web UI → PGW
2. IMSI 999000123456789
- 3.
4. qer_map

```
qer_id: 1
gate_status: {ul: OPEN, dl: OPEN}
mbr: {ul: 50000, dl: 100000} # kbps
gbr: {ul: 10000, dl: 20000} # kbps nil GBR
```

5. PCRF

QoS

: QoS


```

# 5G S-MME inbound messages total / sec
rate(s5s8_inbound_messages_total{message_type="create_session_request"
[5m])

# 5G S-MME outbound messages total / sec
rate(s5s8_outbound_messages_total{message_type="create_bearer_request"
[5m])

# PCRF RAR messages total / sec
rate(gx_inbound_messages_total{message_type="gx_RAR"}[5m])

```

□□□□

□□□□□□:

```

# UE IP address registry count / configured pool size * 100
(address_registry_count / <configured_pool_size>) * 100

# Session registry count
session_registry_count

# PCRF P95 transaction duration bucket
histogram_quantile(0.95, gx_outbound_transaction_duration_bucket)

```

□□□□:

- `config/runtime.exs` □□□□□□ `ue.subnet_map` □
- TEID □□□32 □□40 □□□□□□□□□□□□□□□□
- □□□□□□□□□□□□□□□□□□□□

□□□□:

- □□ IP □□□□□□ - □□□ 80% □□□□□□
- □□ PCRF □□ - □□□□□□□□□□□□□□□□
- □□□□□□□□□□□□□□□□ - □□□□□□□□

□□□□

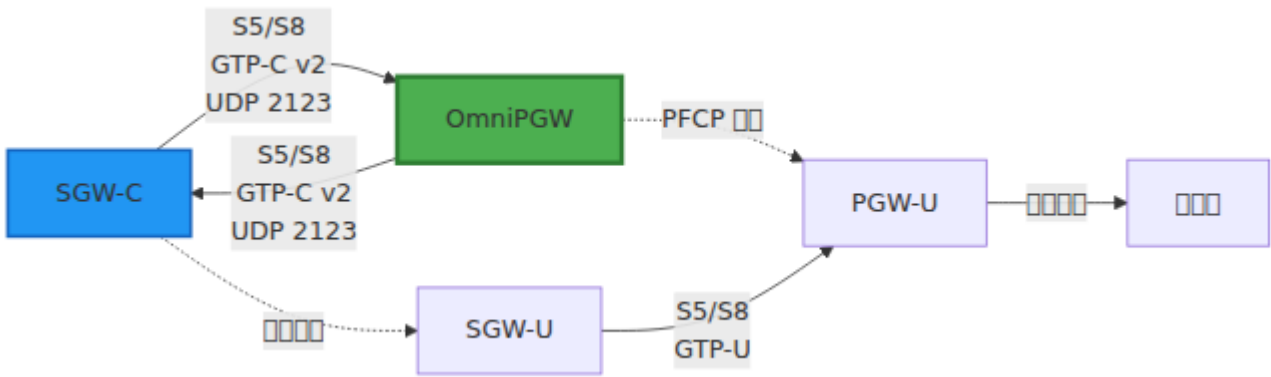
- □□□□ - PDN □□□□□□
- Diameter Gx □□ - PCRF □□□□□□□□
- PFCP □□ - □□□□□□
- □□□□ - □□□□
- □□□□ - □□□□□□□□

S5/S8

SGW-C GTP-C

OmniPGW Omnitouch

S5/S8 GTP-C v2 GPRS - OmniPGW SGW-C



GTP-C

- GTP-C v2 (3GPP TS 29.274)
- UDP
- 2123
-

TEID

TEID

- **TEID** - OmniPGW
- **TEID** - SGW-C

TEID

SGW-C → OmniPGW: TEID = OmniPGW TEID

OmniPGW → SGW-C: TEID = SGW-C TEID

TEID

TEID

```
# config/runtime.exs
config :pgw_c,
  s5s8: %{
    # S5/S8 IPv4
    local_ipv4_address: "10.0.0.20",

    # IPv6
    local_ipv6_address: nil,

    #
    local_port: 2123,

    # GTP-C
    # GTP-C
    request_timeout_ms: 500,

    # GTP-C
    # = request_timeout_ms * request_attempts
    # 500 * 3 = 1500 * 1.5
    request_attempts: 3
  }
```

TEID

S5/S8 GTP-C


```
# SGW-C GTP-C
iptables -A INPUT -p udp --dport 2123 -s <sgw_network>/24 -j
ACCEPT
```

```
# SGW-C GTP-C
iptables -A OUTPUT -p udp --dport 2123 -d <sgw_network>/24 -j
ACCEPT
```

SGW-C

```
# SGW-C
ip route add <sgw_network>/24 via <gateway_ip> dev eth0
```

SGW-C

S5/S8 SGW-C PDN GTP-C    

SGW-C

SGW-C

SGW-C → OmniPGW

SGW-C PDN

SGW-C IE

IE 名称	长度	值
IMSI	16	310260123456789
MSISDN	10	14155551234
APN	16	internet
RAT 类型	1	EUTRAN
QoS 参数	1	QoS 参数
UE 名称	16	UE 名称
ULI	16	TAI, ECGI
PLMN	6	MCC/MNC

配置

```

配置参数
├─ IMSI: 310260123456789
├─ MSISDN: 14155551234
├─ APN: internet
├─ RAT 类型: EUTRAN (6)
├─ QoS 参数
│   └─ EBI: 5
│   └─ QoS (QCI 9, ARP, 16)
│   └─ S5/S8 F-TEID (SGW-U 地址)
└─ ULI
    └─ TAI: MCC 310, MNC 260, TAC 12345
    └─ ECGI: MCC 310, MNC 260, ECI 67890

```

配置

配置 OmniPGW → SGW-C

配置 配置

□□□□□□

IE □□	□□	□□
□□	□□	□□□□□□ 
□□□□□	□□	□□□□
PDN □□□□	IP	□□□ UE IP □□□□ UE IP □□□
APN □□	□□	APN □□□□
PCO	□□	□□□□□□□□ PCO □□□

□□□□□

```
□□□□□□
├─ □□: □□□□□ (16)
├─ PDN □□□□
│   └─ IPv4: 100.64.1.42
├─ □□□□□
│   ├── EBI: 5
│   ├── □□: □□□□□
│   └─ S5/S8 F-TEID (PGW-U □□□□□□ PFCP)
├─ APN □□: Public-1 (1)
└─ PCO
    ├── DNS □□□: 8.8.8.8
    ├── DNS □□□: 8.8.4.4
    └─ □□ MTU: 1400
```

□□□□□□

□□□ SGW-C → OmniPGW

□□□ □□ PDN □□

□□□□□□□□

IE	
EBI	EPS ID
EBI	

OmniPGW → SGW-C

IE	

OmniPGW → SGW-C

PCRF

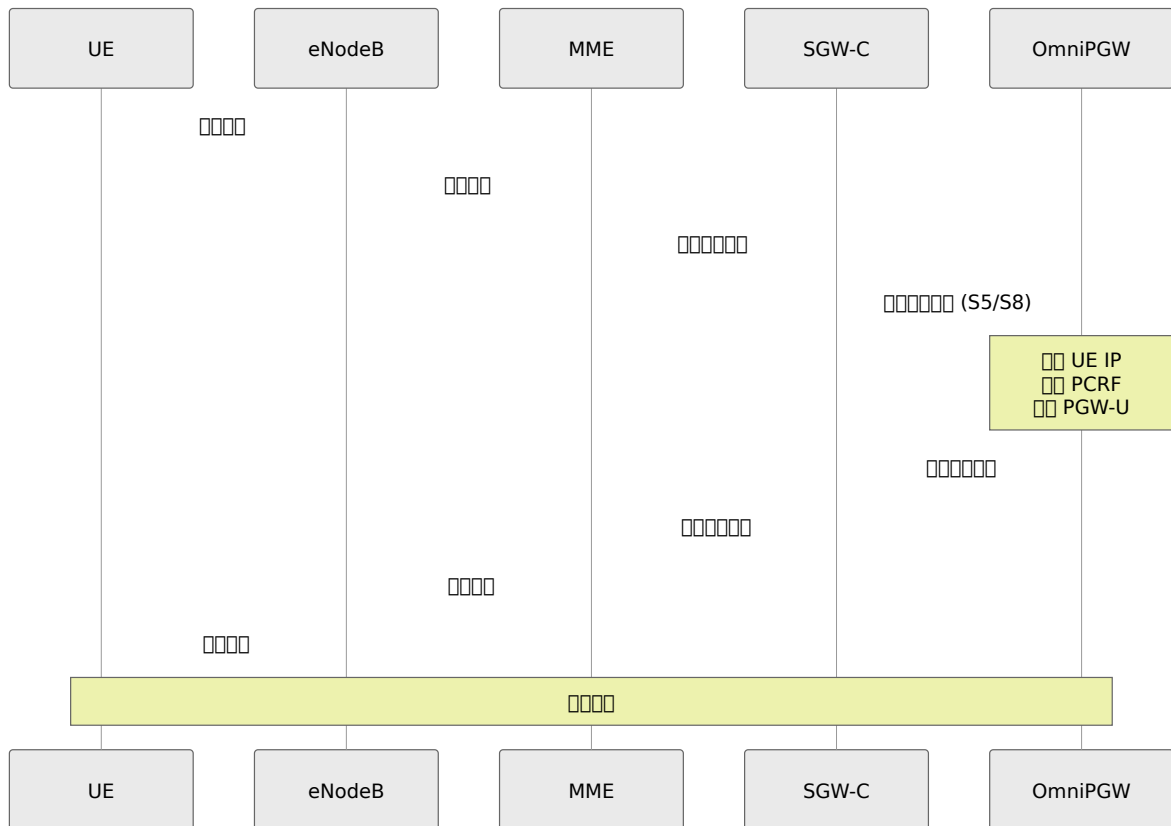
- PCRF PCC
- OmniPGW SGW-C

OmniPGW → SGW-C → SGW-C → OmniPGW

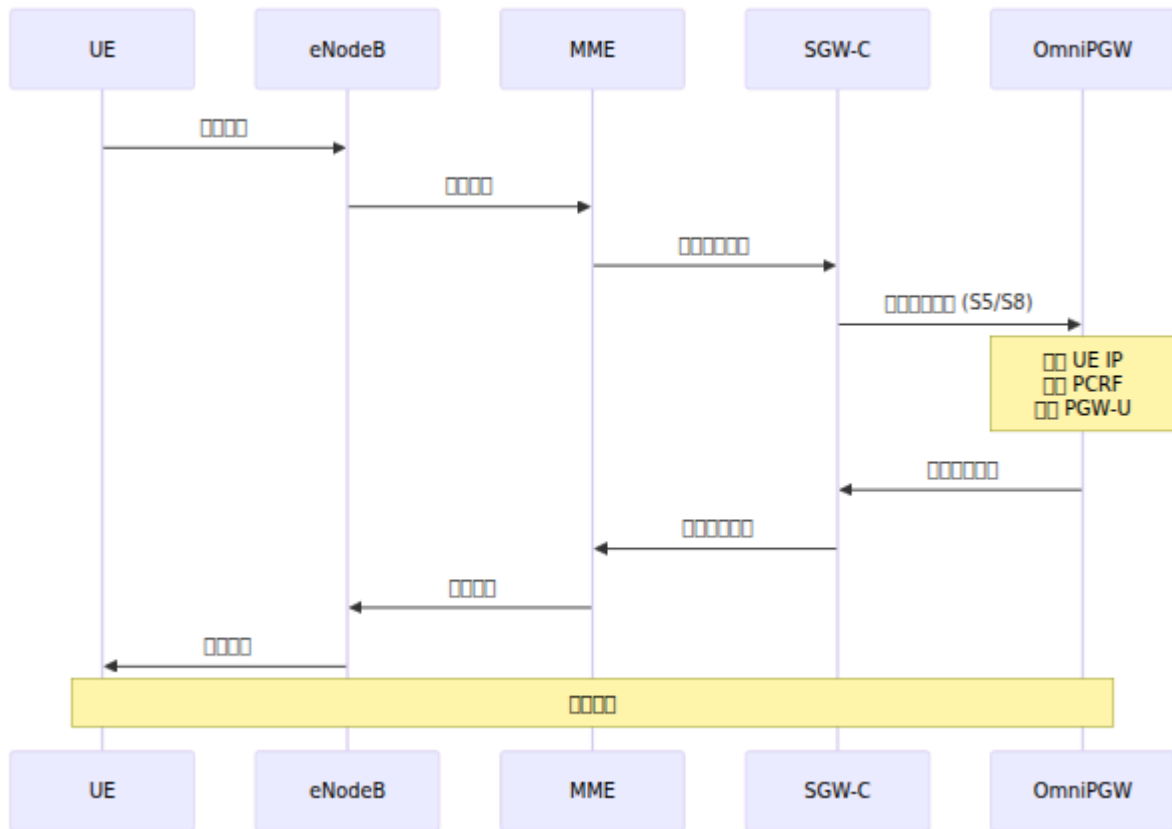
- **PGW** 与 PCRF 交互
- **SGW** 与 PGW 交互

UE

eNodeB



□□□□



□□□□

□□

□□	□□	□□
16	□□□□□	□□□□

□□□□□□□□

□□	□□	□□□□
65	□□□□	PCRF □□□IMSI □□□□
66	□□□□□	IP □□□
93	□□□□□□	□□□ APN
94	TFT □□□□□□	□□□□□□□□

□□□□□□□□

□□	□□	□□□□
72	□□□□□□□□	PCRF/PGW-U □□
73	□□□□□□□□□□	□□□□

□□

S5/S8 □□

```
# □□□□□  
s5s8_inbound_messages_total{message_type="create_session_request"}  
s5s8_inbound_messages_total{message_type="delete_session_request"}  
  
# □□□□□  
s5s8_inbound_errors_total  
  
# □□□□□□  
s5s8_inbound_handling_duration_bucket  
  
# □□ TEID  
teid_registry_count
```

□□□□□

□□□□□

```
rate(s5s8_inbound_messages_total{message_type="create_session_request"  
[5m])
```

□□□□

```
rate(s5s8_inbound_errors_total[5m])
```

□□□**p95**□□

```
histogram_quantile(0.95,  
  
rate(s5s8_inbound_handling_duration_bucket{request_message_type="crea  
[5m])  
)
```

□□□□

□□□□□□ **OmniPGW** □□□

□□□

- SGW-C □□□□□□□□
- □□□□□□
- SGW-C □□

□□□

1. □□□□□□
2. OmniPGW □□□□□ IP □□□
3. □□□□□ UDP 2123
4. □□□□ TEID □□

□□□

```
# □□ OmniPGW □□□□□□
netstat -ulnp | grep 2123

# □□□□□□□□
tcpdump -i any -n port 2123

# □□□□□
grep "local_ipv4_address" config/runtime.exs

# □□□□□□
iptables -L -n | grep 2123
```

□□□□□□□□□□

□□□

- □□□□□□□□□□□□□□
- □□□□□□

□□□□

□□ 65□□□□□□

→ PCRF □□□□

→ □□ HSS/SPR □□ IMSI

□□ 66□□□□□□

→ IP □□□

→ □□ curl http://pgw:9090/metrics | grep address_registry_count

→ □□ IP □

□□ 72□□□□□□□□□□

→ PCRF □□ PGW-U □□

→ □□ Gx □□

→ □□ PFCP □□

□□□ **TEID** □□



□□□

- □□□□□□□□□□
- □□□□

□□□

- TEID □□□□□□□□
- TEID □□□□□□

□□□□□

-   □□□□ TEID □□
 - □□ TEID □□□□□□□□
-

□□□□

□□□□

1. □□□□□□

- □ S5/S8 □□□□□ VLAN
- □□□□□□□□

2. **MTU** □□

- □□ MTU □□ GTP □
- □□ MTU□1500 □□□1464 □□ + 36 GTP□

3. □□

- □□ OmniPGW □□
- □ SGW-C □□□□ DNS □□□□□

□□

1. **UDP** □□□□□

- □□□□□□□□□□□□□□
- □□□□□□□□ 4-8 MB

2. □□□□

- □□□□□□□□□□
- □□ TEID □□□□□

□□

1. **IP** □□

- □□□□□□□□ SGW-C IP □ GTP-C
- □□ iptables □□□□ ACL

2. 詳細

- OmniPGW 詳細
 - 詳細 GTP-C 詳細
-

詳細

詳細

- 詳細 - S5/S8 詳細 IP 詳細
- 詳細 - PDN 詳細
- **UE IP** 詳細 - 詳細 IP 詳細
- **PCO** 詳細 - GTP-C 詳細 PCO 詳細

詳細

- **Gn/Gp** 詳細 - 詳細 2G/3G GGSN 詳細 GTP-C v1
- **PFCP** 詳細 - 詳細 S5/S8 詳細
- 詳細 **Gx** 詳細 - 詳細
- 詳細 **Gy** 詳細 - 詳細

詳細

- 詳細 - S5/S8 GTP-C 詳細
 - 詳細 **CDR** 詳細 - 詳細 GTP-C 詳細 CDR
-

詳細

OmniPGW S5/S8 詳細 - 詳細 *OmniTouch* 詳細

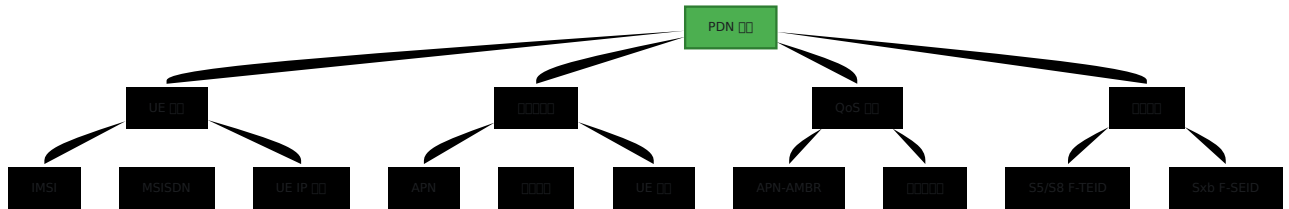
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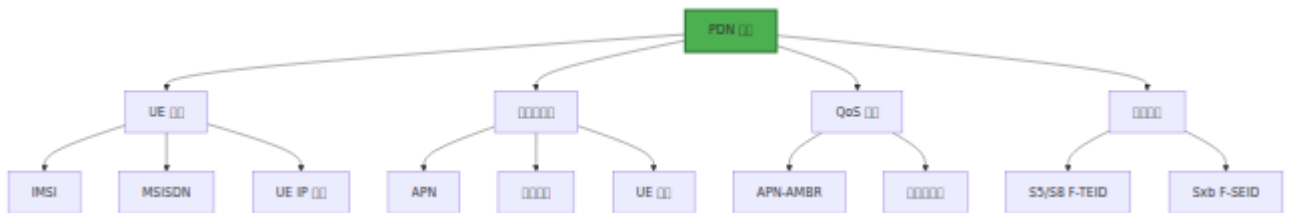
□□□	□□	□□
TEID	S5/S8 (GTP-C)	SGW-C □□□□□□□ ID
SEID	Sxb (PCFP)	PGW-U □□□□□□□ ID
Session-ID	Gx (Diameter)	PCRF □□□ Diameter □□
Charging-ID	□□	□□□□□/□□ ID

□□□□



□□□□

□□□□



□□

1. □□□□□□ (S5/S8)

□□□□□ S5/S8 □□□□ GTP-C □□□□□□□□□□ GTP-C □□□□□□□□□□ S5/S8 □□□

□□□

- IMSI, MSISDN, IMEI
- APN (□□□“internet”)
- RAT □□ (EUTRAN)
- UE □□ (TAI, ECGI)
- □□□□□ (QoS, F-TEID)

2. □□□□

- □ APN □□□□ UE IP
- □□□□ ID
- □□ Gx □□-ID
- □□ S5/S8 TEID
- □□ PGW-U □□□

3. □□□□ (Gx)

□ PCRF □□□□□

- □□ CCR-□□
- □□□□ QoS □ PCC □□□ CCA-□□

4. □□□□□□ (PFCP)

□□□□□□□□ PGW-U□

- □□□□□□□□
- □□ PDRs, FARs, QERs, BAR
- □□ S5/S8 □□□ F-TEID

5. □□ SGW-C

□□□□□□□□

- UE IP □□
 - S5/S8 F-TEID (□□ PGW-U)
 - PCO (DNS, P-CSCF, MTU)
 - □□□□
-

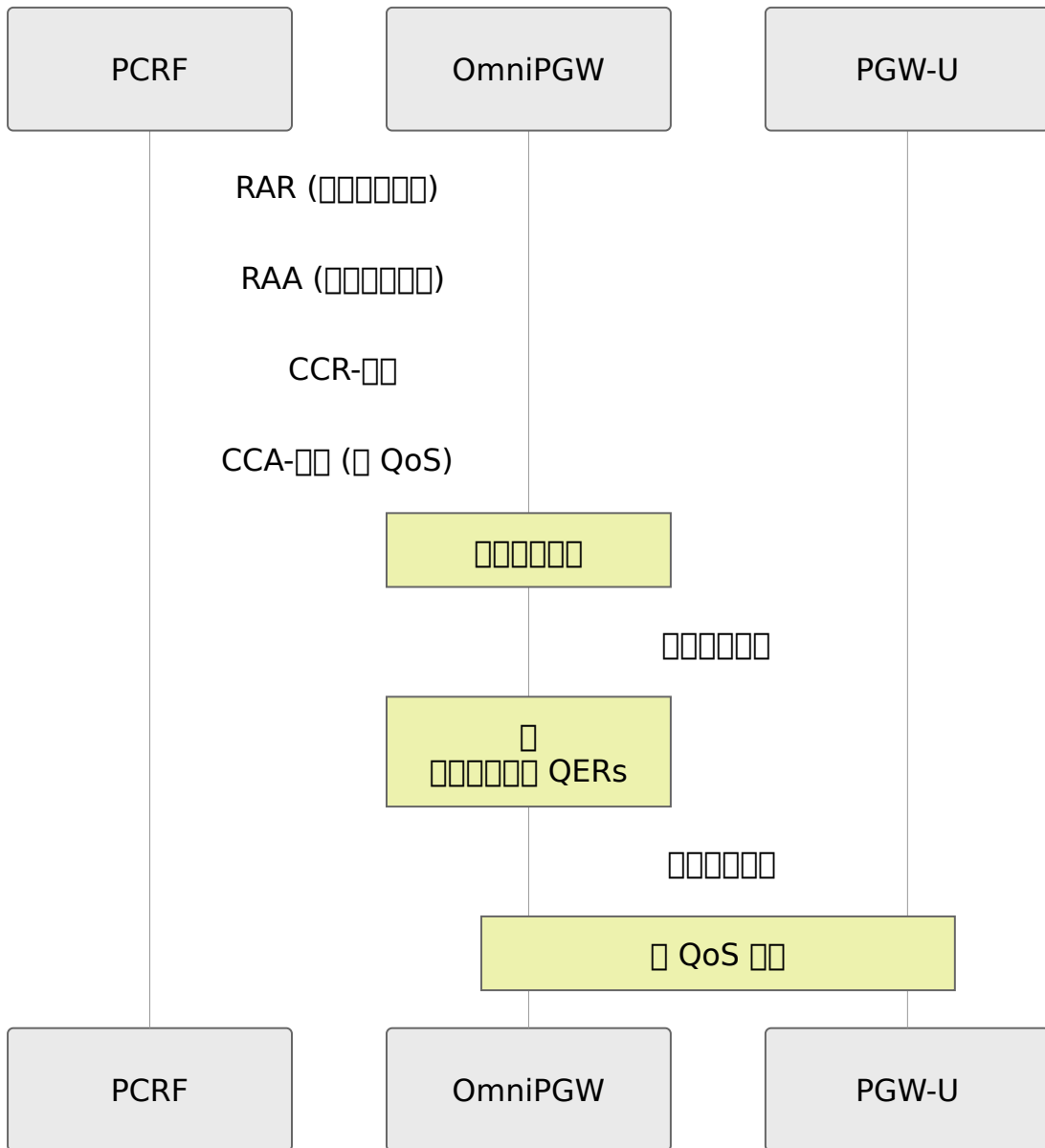
□□□□

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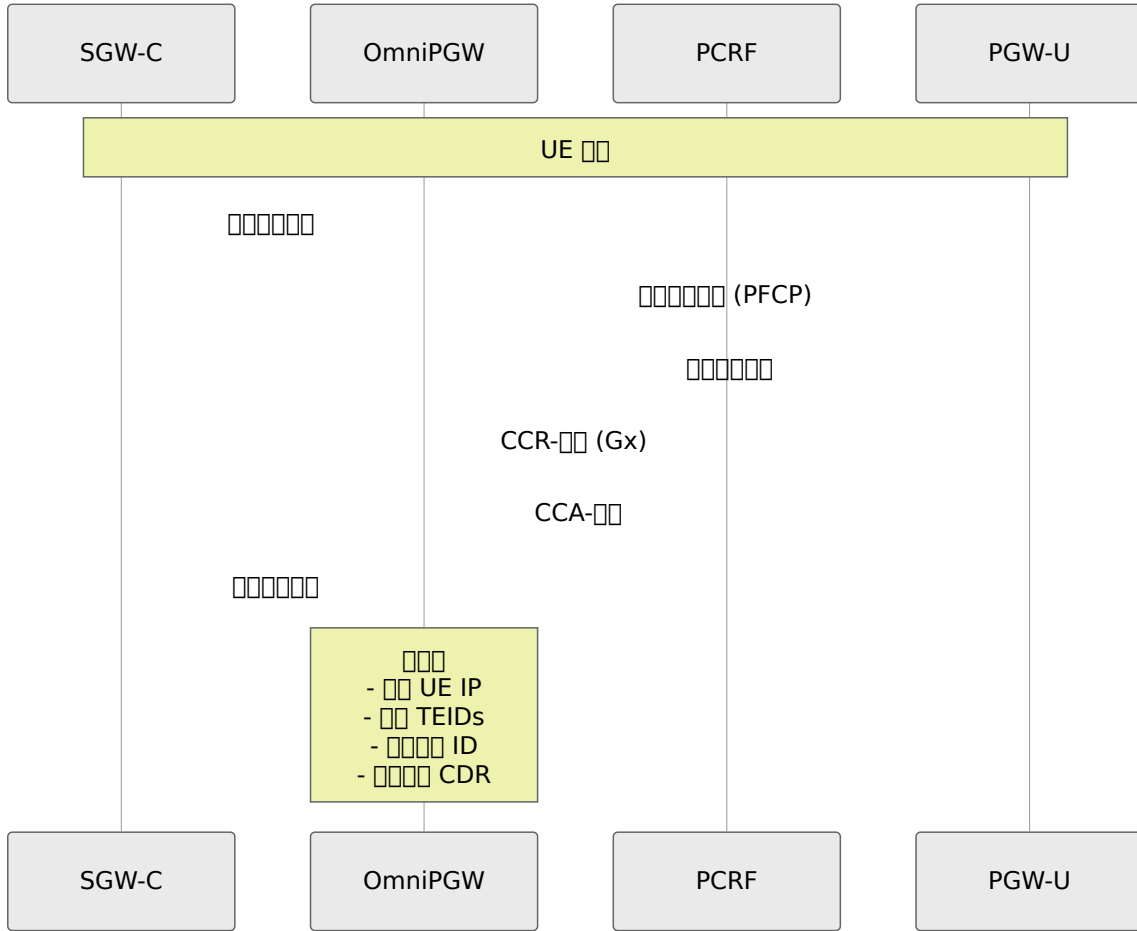
- **QoS** □□ - PCRF □□□□
- □□□□ - □□/□□□□□□
- □□ - SGW □□
- □□□□ - □□ PCRF □□ PCC □□

QoS



□□□□

□□□□



□□□□

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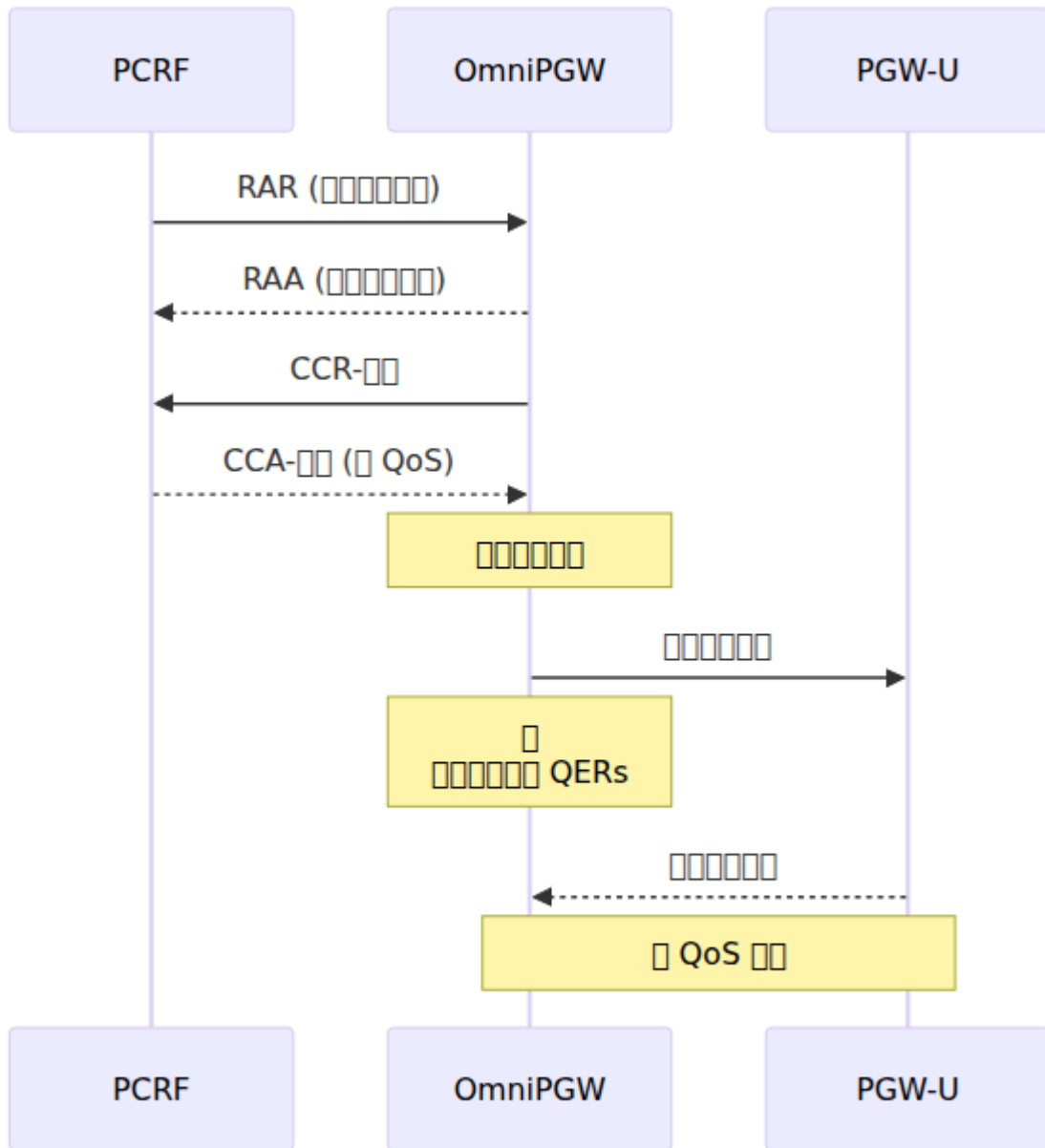
1. UE IP □□ → □□□□
2. TEID → □□□□□□
3. SEID → □□□□□□
4. □□-ID → □□□□□□
5. □□-ID → □□
6. □□□□□□

□□□□□□□□

- 0000000000 CDR (00000000) - 0000 00 CDR 00

0000

0000



0000

00000000

- TEID (S5/S8):
TEID 0x12345678 → □□ PID

- SEID (Sxb):
SEID 0xABCDEF → □□ PID

- □□-ID (Gx):
"pgw.example.com;123;456" → □□ PID

- UE IP:
100.64.1.42 → □□ PID

- IMSI + EBI:
"310260123456789" + EBI 5 → □□ PID

□□□□

□□□□□□

```
# □□□□  
teid_registry_count  
  
# PFCP □□  
seid_registry_count  
  
# Gx □□  
session_id_registry_count
```

□□□□

```
# □□□□□□
rate(s5s8_inbound_messages_total{message_type="create_session_request

# □□□□□□
rate(s5s8_inbound_messages_total{message_type="delete_session_request

# □□□□□□ (p95)
histogram_quantile(0.95,

rate(s5s8_inbound_handling_duration_bucket{request_message_type="crea
[5m])
)
```

□□□□

□□□□□□

□□□

1. **IP** □□□ - □□□□□ IP
2. **PCRF** □□◀◀◀ - Gx □□
3. **PGW-U** □□ - □□ PFCP □□□□□
4. **PCRF** □□ - □□□□□□□□

□□□

```
# □□ IP □
curl http://pgw:9090/metrics | grep address_registry_count

# □□ PCRF □□□
# □□□□□□ Gx □□

# □□ PGW-U □□
# □□ PFCP □□□□□
```

□□□□/□□

□□□

- □□□□□□□
- □□□□□
- □□□□□□□□□□□□

□□□

1. □□□□□□□□□□
2. □□□□□□□□□□□□
3. □□□□□

□□□□□

```
# □□ OmniPGW (□□□□□□□)  
# □□□□□□□□□□
```

UE □□□□□□

□□□

- UE □□□□
- □□□□□□□□□□□□

□□□□□□□□

□□□	□□	□□
□□□□□	PCRF □□ (IMSI □□□□□□□)	□□□□□□□
□□□□□□□	IP □□□	□□ IP □
□□□□□□□□□	PCRF/PGW-U □□	□□□□□
□□□□□□	□□ APN	□□ APN □

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□□□□□□□□10,000
□□□□□□□□~10KB RAM
□□□ RAM~100MB

Erlang VM □□□
- □□□□□□262,144 (□□)
- □□□□□□□□□□□□

□□□□

□□□□□□□□

1. □□□□□□□□□□
2. □□□□□□□□□□□□□□
3. □□□□□□□□□□

□□□□

□□□□□

- □□□□□□□ (□□□□□□□□)
 - □□□□□□□□□□□□□□ (□□)
 - DNS/□□□□□□□□□□□□
-

□□□□□□

□□□□□□□□□□

□□□□ PDN □□□□□□□□

UE □□□

- IMSI: "310260123456789" (□□□□)
- MSISDN: "14155551234" (□□□□)
- MEI/IMEI: □□□□□

PDN □□□□□

- APN: "internet" (□□□□)
- UE IP □□: 100.64.1.42 (□□□ IP)
- PDN □□: IPv4, IPv6 □ IPv4v6

□□□□□□

- □□ ID: □□□□□□□□
- □□□□ EBI: EPS □□□□□ (□□□ 5)

QoS □□□

- APN-AMBR: □□□□□□□□
 - □□□100 Mbps
 - □□□50 Mbps

□□□□□

- PDRs (□□□□□□□□): □□□□□
- FARs (□□□□□□□□): □□/□□□□□
- QERs (QoS □□□□□): □□□□□
- BAR (□□□□□□□□): □□□□□

□□□□□□

- S5/S8 : / TEIDs, SGW-C
 - Sxb : / SEIDs, PGW-U
 - Gx : Diameter -ID,
-

Web UI -

OmniPGW **Web UI**

UE

: `http://<omnipgw-ip>:<web-port>/ue_search`

: UE

1.

- **IMSI** (“310170123456789”)
- **MSISDN** ()

- **IP** 地址 (例如“100.64.1.42”)

2. 网络

- 网络地址
- 网络地址
- 网络地址

3. 网络地址 网络地址

a) 网络

- 网络地址
- IMSI, MSISDN, UE IP 地址
- APN, RAT 类型
- PGW TEID, SGW TEID

b) 网络地址 网络地址

- **TAC** (网络地址) - UE 网络地址
- 网络 **ID (ECI)** - E-UTRAN 网络地址
- **ECGI** - E-UTRAN 网络地址 (PLMN + ECI)
- **MCC/MNC** - 网络地址 / 网络地址

网络地址 网络地址 OpenCellID 网络地址

- 网络地址 (网络/网络)
- 网络 Google 网络地址
- UE 网络地址

网络地址 网络地址 网络地址

c) 网络 网络地址 QoS 网络

网络:

- EBI (EPS 网络地址)
- QCI (QoS 网络地址)
- 网络地址

- APN-AMBR (□□/□□)

□□□□ (□□□□)□

- EBI, QCI, □□□□□□
- MBR UL/DL (□□□□□)
- GBR UL/DL (□□□□□)

d) □□□□ (Gy □□)

- Gy □□ ID
- □□□□, □□□□
- □□□□

e) □□□□ (Gx □□)

- Gx □□ ID
- PCRF □/□□□□
- CC □□□□
- □□□□□□□□ (□□□□□ PCC □□)

f) □□□□

- □□□□□□□□
- □□□□/□□/□□□□

□□□

- □□□□□□□□
- □□□□□□
- □□□□□ IP □□
- □□□□□□

PGW □□□□

□□: `http://<omnipgw-ip>:<web-port>/pgw_sessions`

UE: 3GPP PDN UE

UE

1. UE

- IMSI (UE ID)
- UE IP
- APN - UE

2. UE ID

- **IMSI** - UE ID
- **UE IP** - UE IP
- **SGW TEID** - UE SGW S5/S8 ID
- **PGW TEID** - UE OmniPGW S5/S8 ID
- **APN** - UE

3. UE ID

- IMSI (UE ID "310260")
- UE IP (UE IP "100.64")
- MSISDN / UE ID

00: 0000000000000000

000

1. 00000

- 0000000000
- 00 PGW-C (0000) 00
- 000 HSS (00000000) 000
- 000000000

2. 0000

- 0000 (+/-)
- 000000
- 0000000000
- 000000 (00 = 00, 00 = 00)

3. 0000

- 0000000000
- 0000
- 000000000

□□□

- □□□□□□□□□□□□
- □□□□□□
- □□□□□□
- □□□□□□□□

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□□: `http://<omnipgw-ip>:<web-port>/session_history`

□□: □□□□□□□□□□□□

□□□

1. □□□□

- □□□□□□□ (□□□□, □□□□, □□□□, □)
- □□□□□□ (□□□□ / □□□□)
- □ IMSI, MSISDN, IP □□□□ TEID □□

2. □□□□

- CSV
-
-

3.

-
-
-
-

-
-
-
-
-

- 1.
2. IMSI Web UI
3. UE IP
4. QoS
- 5.

-
-
- APN

####

- 認證
- 認證 SSH/IEx
- SGW PGW TEIDs 認證
- PCRF AMBR

認證

- 認證 (認證)
- 認證
- 認證 (Mbps 認證 bps)
- 認證
- 認證

認證

OmniPGW 認證 OpenCellID 認證 UE 認證

認證

認證 UE 認證

- 認證 (認證)
- 認證 Google 認證
- 認證
- 認證

認證

認證 `http://<omnipgw-ip>:<web-port>/cell_towers` 認證 “認證” 認證

認證

- OpenCellID.org 認證

- 使用 SQLite
- 数据量 (约 10-15 万)
- 使用 Web 界面
- 使用 SQLite 数据库

数据库 使用 SQLite 数据库 “数据库”

数据库

数据库

- SQLite DB: `priv/cell_towers.db`
- CSV 文件 (约): `priv/data/cell_towers.csv.gz`
- 数据库 MCC, MNC, LAC, CellID 字段

数据库

- 从 OpenCellID.org 下载数据 107 MB
- 数据量约 10-15 万

数据库

- 数据库 (<1ms)
- 数据库
- 使用 UE 数据库

数据库

数据库

UE 数据库

- 数据库
- 使用 Google 数据库
- 数据库

Web UI

- 3GPP TS 23.122
- OpenCellID 3GPP TS 23.122 - 3GPP TS 23.122
- Web UI 3GPP TS 23.122

3GPP TS 23.122

- 3GPP TS 23.122 `priv/` 3GPP TS 23.122
- 3GPP TS 23.122 (~150 MB 3GPP TS 23.122)
- 3GPP TS 23.122 `priv/` 3GPP TS 23.122

3GPP TS 23.122

- 3GPP TS 23.122
- OpenCellID 3GPP TS 23.122
- 3GPP TS 23.122

3GPP TS 23.122

- 3GPP TS 23.122 JavaScript 3GPP TS 23.122
- 3GPP TS 23.122 Google 3GPP TS 23.122
- 3GPP TS 23.122



3GPP TS 23.122

- **PFCP** 3GPP TS 23.122 - 3GPP TS 23.122, PDRs, FARs, QERs, URRs
- **UE IP** 3GPP TS 23.122 - IP 3GPP TS 23.122, APN 3GPP TS 23.122
- **PCO** 3GPP TS 23.122 - 3GPP TS 23.122 UE 3GPP TS 23.122 DNS, P-CSCF, MTU 3GPP TS 23.122
- 3GPP TS 23.122 - UPF 3GPP TS 23.122, 3GPP TS 23.122

3GPP TS 23.122

- **Diameter Gx** 3GPP TS 23.122 - PCRF 3GPP TS 23.122, PCC 3GPP TS 23.122, QoS 3GPP TS 23.122
- **Diameter Gy** 3GPP TS 23.122 - OCS 3GPP TS 23.122, 3GPP TS 23.122

- **CDR** -

- **S5/S8** - GTP-C, SGW-C
- **QoS** - QoS

- - , ,
- **P-CSCF** - IMS

OmniPGW - *Omnitouch*

OmniPGW

OmniPGW

OmniPGW

OmniPGW

- OmniPGW
- OmniPGW
- OmniPGW
- PFCP / OmniPGW
- Diameter (Gx/Gy) OmniPGW
- IP OmniPGW
- OmniPGW

OmniPGW

OmniPGW

- OmniPGW
- OmniPGW
- OmniPGW
- OmniPGW
- OmniPGW

OmniPGW

- OmniPGW - Prometheus
- OmniPGW -

□□□□□□

Web UI

□□□□ `http://<omnipgw_ip>:4000`

□□□□

- **/pgw_sessions** - □□□□□□□□ IMSI□IP□MSISDN□APN □□□
- **/diameter** - Diameter □□□□Gx PCRF□Gy OCS□
- **/pfcpeers** - PFCP □□□□PGW-U □□□□
- **/logs** - □□□□□□□□□□

Prometheus □□

□□□□ `http://<omnipgw_ip>:9090/metrics`

□□□□

- `teid_registry_count` - □□□□
- `address_registry_count` - □□□ UE IP
- `sxb_inbound_errors_total` - PFCP □□
- `gx_inbound_errors_total` - Diameter Gx □□
- `gy_inbound_errors_total` - Diameter Gy □□

□□□ □□□□ □□□□□□□□□□

□□□□

Web UI □ □□ **/logs** □□□□□□□□□□

□□□□□□□□

- "create_session_request" - □□□□
- "Credit Control" - Gx/Gy □□
- "PFCP Session" - □□□□□□
- "error" □ "ERROR" - □□□□

- "timeout" - 0000
-

00000000

00000000000000000000 "00000000"

000

- SGW-C 000000000000 "00000000" (73)
- 000000000000
- 0000000000
- 000 [PGW-C] 0000000000 - 000000

Wireshark 0000000000000000 "00000000"

000000

- OmniPGW 0000000000
- 000000000000

000

1. 0000000000

```
license_status
```

- 0 0

2. 0

- "license" "License"
- "0" 0

3. 0

- `config/runtime.exs` `:license_client` URL
- `https://localhost:10443/api`

0

1. 0

```
curl -k https://<license_server_ip>:10443/api/status
```

2. 0 `config/runtime.exs` 0

```
config :license_client,  
  license_server_api_urls:  
  ["https://<license_server_ip>:10443/api"],  
  licensee: "0"
```

3. 0

- `omnipgw`
- Omnitouch 0

4. 0 **OmniPGW**

0

- `license_status` 0
- 0

- `address_registry_count`
-

?? ? ? ? ? ? ?

??

- SGW-C `s5s8_inbound_errors_total`
- PDN
- `s5s8_inbound_errors_total`

??

1. IP
2. PCRF (Gx)
3. PGW-U (PFCP)
4. APN

??

1. **IP**

```
address_registry_count
```

-

2. **PCRF**

- Web UI → **/diameter**
- PCRF = "disconnected"
- "Credit Control Answer"

3. **PFCP**

- Web UI → **/pfcp_peers**
- "Association: DOWN"
- `pfcp_peer_associated = 0`

4. **APN** **IP**

- `config/runtime.exs` `ue.apn_map`
- `ue.apn_map` APN `subnet_map`

`ue.apn_map`

IP **IP**

1. `Web UI` → `/pgw_sessions`
2. `config/runtime.exs` `IP`

```
config :pgw_c,  
  ue: %{  
    subnet_map: %{  
      "internet" => "10.0.0.0/23" # /24 /23  
    }  
  }  
}
```

3. **OmniPGW**

4. `curl http://<ip>:9090/metrics | grep address_registry_count`

PCRF **IP**

1. `ping <pcrf_ip>`
2. `PCRF Diameter` `telnet <pcrf_ip> 3868`
3. `config/runtime.exs` `Diameter`
4. `OmniPGW`
5. `Web UI` → `/diameter` `"connected"`

PFCP **IP**

- `PFCP /` `IP`

`IP`

- `IP` `80%`
 - `PCRF` `Diameter`
 - `IP`
-

PGW Sessions

Overview

- PGW Web UI
- PCRF CCR-Initial
- Gx

Sequence

1. PCRF CCR-Initial
2. PCRF CCR-Initial
3. Gx
4. Gx

Steps

1. PGW Web UI
 - /pgw_sessions → IMSI
 - pfcpc_seid PCRF
 - gx_session_id Gx
2. IMSI
 - IMSI
 - "PCRF"
 - "Gx"
 -
3. Gx

```
# PGW TEID PCRF
teid_registry_count - seid_registry_count

# PGW TEID Gx
teid_registry_count - session_id_registry_count
```

□□□□

1. □□ PFCP □□□□

- □□ PGW-U □□□□□□
- □□ PFCP □□□ Web UI → **/pfcpeers**
- □ SGW-C □□□□□□□□□□

2. □□ Gx □□□□

- □□ PCRF □□□ `histogram_quantile(0.95, rate(gx_outbound_transaction_duration_bucket[5m]))`
- □□□□□□ `config/runtime.exs` □□□ Gx □□
- □□□□□□□□□□□□

3. □□□□□□□□□□

- □□□□□□ OmniPGW □□□□□□□□
- □□□□□□□□ `teid_registry_count` □□□□□□

□□□

- □□ PFCP □ Gx □□□□
- □□□□□□□□□□□□□□□□
- □□□□□□□□□□□□

PFCP / □□□□□□

□□□ PFCP □□□□

□□□

- Web UI → **/pfcpeers** □□ "Association: DOWN"
- □□□□□□□□□□
- □□□ `pfcpeers_associated` = 0
- □□□ "PFCP □□□□" □ "□□□□□□"

□□□□❓❓❓

1. PGW-U □□□□□□□□□□
2. PGW-U □□□□□
3. PFCP □□□□□□IP□□□□
4. □□□□□ UDP 8805

□□□

1. □□□□□□□

```
ping <pgw_u_ip>  
nc -u -v <pgw_u_ip> 8805
```

2. □□ **PFCP** □□□

- □□ `config/runtime.exs` □□ `upf.peer_list`
- □□ IP □□□□□ ID □□□ PGW-U □□□□□

3. □□ **PGW-U** □□□

- □□ PGW-U □□□
- □□ PGW-U □□□□□□□□ `systemctl status omnipgw_u`□□□□□□□□□□

4. □□□□□

```
# □□□□  
pfcpc_consecutive_heartbeat_failures  
  
# PFCP □□□  
rate(sxb_inbound_errors_total[5m])
```

□□□□□

1. □□□□□□□

- □□□□□ `traceroute <pgw_u_ip>`
- □□□□□□□□□□□□□□□□ UDP 8805

- `pfcp_peer_associated`

2. `PGW-U` `PFCP`

- `PGW-U` `PFCP`
- `30` `PFCP`
- `Web UI` → `/pfcp_peers` `Association: UP`

3. `PFCP`

- `config/runtime.exs` `PFCP`
- `OmniPGW`
- `PFCP`

`PFCP`

- `pfcp_peer_associated` `PFCP`
- `pfcp_consecutive_heartbeat_failures` `> 2` `PFCP`
- `PGW-U` `PFCP`
- `PFCP` `PFCP`

`PFCP` `PFCP`

`PFCP`

- `PFCP`
- `QoS` `PCRF` `RAR`
- `"PFCP"`
- `PFCP`
`sxb_inbound_errors_total{message_type="session_modification_response"}`

`PFCP`

1. `PFCP` `PDR/FAR/QR`
2. `PGW-U` `PFCP`
3. `ID`

4. PGW-U

1.

- "SEID" SEID
- PFCP
- "ID" "ID"

2. PGW-U

- PFCP
- CPU

3. Web UI

- /pgw_sessions → IMSI
- pdr_map far_map qer_map
- ID

1.

-
- UE

2. PGW-U

- PGW-U PDR
- PGW-U
- PGW-U

3.

- Web UI
- PFCP
-

□□□

- □□ PGW-U □□□□□
- □□□□□□□□□□□□□□□□
- □□ `sxb_inbound_errors_total` □□□□□

Diameter (Gx/Gy) □□

□□□ PCRF □□□□□ Gx□

□□□

- Web UI → **/diameter** □□ PCRF □□ "disconnected"
- □□□□□□□ QoS □□□□□□□ QCI=5□
- □□□ "Diameter □□□□□□□" □ "CER/CEA □□"

□□□□□

1. PCRF □□□□□□□□□□□
2. PCRF □□□□□
3. Diameter □□□□□□□ Origin-Host□ Realm□
4. □□□□□ TCP 3868

□□□

1. □□□□□□□□

```
ping <pcrf_ip>
telnet <pcrf_ip> 3868
```

2. □□ **Diameter** □□□

- □□ `config/runtime.exs` □□ `diameter.peer_list`
- □□ `host` □ `realm` □ `ip` □□□□ PCRF □□□□□
- □□ `origin_host` □□□□ PCRF □□□□□

3. PCRF

- PGW-C CER
-

4.

```
# Diameter  
diameter_peer_connected{peer="<pcrf_host>"}
```

1.

- PCRF
- TCP 3868
- `nc -v <pcrf_ip> 3868`

2. PCRF

- PCRF
- 30
- Web UI → **diameter**

3.

- `config/runtime.exe` Diameter

```
config :pgw_c,  
  diameter: %{  
    host: "pgw-c.epc.mnc999.mcc999.3gppnetwork.org", # 000  
    PCRF 0000  
    realm: "epc.mnc999.mcc999.3gppnetwork.org",  
    peer_list: [  
      %{  
        host: "pcrf.epc.mnc999.mcc999.3gppnetwork.org",  
        realm: "epc.mnc999.mcc999.3gppnetwork.org",  
        ip: "192.168.1.100",  
        initiate_connection: true  
      }  
    ]  
  }  
}
```

- 00 OmniPGW
- 0000000000

000

- 00 Diameter 00000000000000
- 0000 PCRF 0000000000
- 0000000000 Diameter 00

000 CCR/CCA 000 Gx 000000

000

- 00000000 > 5 00
- 000 "0000000000"
- 000 gx_outbound_transaction_duration 0000 > 5s
- 0000000000 QoS 0000000000

00000

1. PCRF 00
2. PCRF 000000
3. 0000

4. PCRF 配置

配置

1. 配置 Gx 配置

```
# P95 配置  
histogram_quantile(0.95,  
rate(gx_outbound_transaction_duration_bucket[5m]))  
  
# P99 配置  
histogram_quantile(0.99,  
rate(gx_outbound_transaction_duration_bucket[5m]))
```

2. 配置 PCRF 配置

- 配置 PCRF 配置
- 配置 CPU 配置
- 配置 PCRF 配置

3. 配置配置

```
ping -c 100 <pcrf_ip> | tail -1 # 配置配置
```

4. 配置配置

- 配置 CCR/CCA 配置 "配置"
- 配置 "配置 CCR" 与 "配置 CCA" 配置

配置配置

1. 配置 PCRF 配置

- 配置 PCRF 配置
- 配置 CCR 配置
- 配置 PCRF 配置/配置

2. 配置配置

- 設定値を調整する
- 設定 PGW-C の PCRF 設定値

3. 設定値を調整する

- 設定 `config/runtime.exs`

```
config :pgw_c,
  diameter: %{
    transaction_timeout_ms: 10000 # 設定 5000 秒
  }
```

- 設定 OmniPGW
- 設定 設定値を調整する

設定

- 設定 Gx 設定値 > 1s > 5s
- 設定 PCRF 設定
- 設定 PCRF 設定

設定 OCS 設定 Gy

設定

- Web UI → **/diameter** 設定 OCS 設定 "disconnected"
- 設定
- 設定 "Gy 設定"

設定

設定 PCRF 設定 Gy 設定

設定

- 設定 TCP 3868 設定 Gx 設定
- 設定
- 設定 `diameter.peer_list` 設定 OCS 設定

IP Diagrams

Diagram IP Diagrams

Diagram

- Diagrams "Diagram"
- Diagram `address_registry_count` Diagrams
- Web UI → `/pgw_sessions` Diagrams
- Diagram "IP Diagrams"

Diagram

1. Diagrams
2. Diagrams IP Diagrams
3. Diagrams
4. IP Diagrams

Diagram

1. Diagrams

```
# Diagram /24 Diagrams254 Diagrams IP  
(address_registry_count / 254) * 100
```

2. Diagrams

- Diagram `config/runtime.exs` Diagram `ue.subnet_map`
- Diagram "10.0.0.0/24" = 254 Diagrams IP

3. Diagrams **IP** Diagrams

```
# teid_registry_count  
teid_registry_count  
address_registry_count
```

4. `teid_registry_count`

- Web UI → `/pgw_sessions`
- `teid_registry_count`
- `address_registry_count`

`teid_registry_count`

`address_registry_count`

1. `config/runtime.exs`

```
config :pgw_c,  
  ue: %{  
    subnet_map: %{  
      "internet" => "10.0.0.0/22" # 1022 IP /24 = 254 IP  
    }  
  }  
}
```

2. `OmniPGW`

3. `teid_registry_count`

`teid_registry_count`

1. `Web UI` `teid_registry_count`
2. `SGW-C` `teid_registry_count`
3. `PCRF/SGW` `teid_registry_count`
4. `address_registry_count` `teid_registry_count`

`teid_registry_count`

- `IP`
 - `> 70%`
 - `> 85%`

- 0000000000
- 0000000000
- 00❓❓0000

0000000000 IP 00

000

- UE 00 IP 0000
- 000"IP 000" 00
- Web UI 000000000000 IP 00

00000

1. 0000000000
2. 000000000000
3. 00000000

000

1. 0 **Web UI** 000 IP
 - /pgw_sessions → 0 IP 0000
 - 00000000 IMSI 00000 IP
2. 000000
 - 00 IP 00
 - 00 "IP 00" 00

00000

1. 0000000000
 - 00000000 IP 000 IMSI
2. 00000000
 - 0 SGW-C 00000000000000000000 IMSI

- □□□□□□□□

3. UE □□□□

- UE □□□□□□
- □□□□□□ IP

4. □□□□□□

- □□ OmniPGW □□□ IP □□□
- □□□□□□□□□□□□□□

□□□

- □□□□□□□□□□□□□□
 - □□□□□□□□□□□□□□
-



□□ Prometheus □□

```
# □□□□  
teid_registry_count  
  
# □□□□□□□□□□  
rate(s5s8_inbound_messages_total{message_type="create_session_request"  
  
# IP □□□□□□□□ /24 □□□  
(address_registry_count / 254) * 100  
  
# P95 □□□□□□  
histogram_quantile(0.95,  
rate(s5s8_inbound_handling_duration_bucket{request_message_type="crea  
[5m]))  
  
# □□□  
rate(s5s8_inbound_errors_total[5m])  
  
# PCRF □□  
histogram_quantile(0.95, rate(gx_outbound_transaction_duration_bucket  
  
# PFCP □□□□  
pfcf_peer_associated
```

Web UI

項目	値
IMSI	XXXXXXXXXX
"create_session"	XXXXXXXX
"delete_session"	XXXXXXXX
"Credit Control"	Gx PCRF 項目
"PFCP Session"	XXXXXXXX
"error"	XXXXXXXX
"timeout"	XXXX
"Association"	PFCP 項目

📄📄📄📄

```
# 📄📄📄📄
systemctl status omnipgw_c

# 📄📄 Web UI
curl http://<omnipgw_ip>:4000

# 📄📄📄📄
curl http://<omnipgw_ip>:9090/metrics

# 📄📄📄📄
curl http://<omnipgw_ip>:9090/metrics | grep teid_registry_count

# 📄📄 PFCP 📄📄
curl http://<omnipgw_ip>:9090/metrics | grep pfcpeer_associated

# 📄📄 IP 📄📄📄📄
curl http://<omnipgw_ip>:9090/metrics | grep
address_registry_count
```

📄📄📄📄

- 📄📄📄📄 - Prometheus 📄📄 Grafana 📄📄📄📄
- 📄📄📄📄 - 📄📄📄📄📄
- 📄📄📄📄 - 📄📄📄📄📄📄
- **PFCP 📄📄** - PFCP 📄📄📄📄📄
- **Diameter Gx 📄📄** - Gx 📄📄📄📄📄
- **Diameter Gy 📄📄** - Gy 📄📄📄📄📄
- **QoS 📄📄📄📄** - QoS 📄📄📄

📄📄📄📄

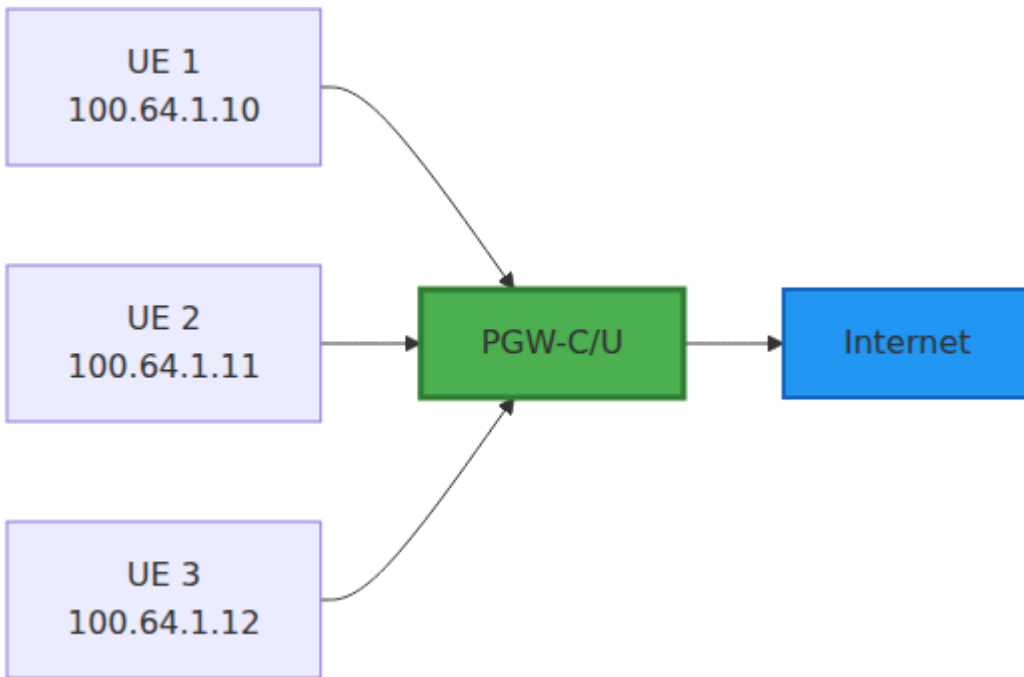
UE IP

IP

- 1.
 2. IP
 - 3.
 - 4.
 - 5.
 - 6.
 - 7.
-

PGW-C UE PDN IP

UE IP 주소



UE IP 주소 PGW-C 주소 IP 주소

- 주소
- 주소
- 주소
- PDN 주소

UE IP

IP		
IPv4		IPv4
IPv6		IPv6
IPv4v6		IPv4 IPv6

IP 地址

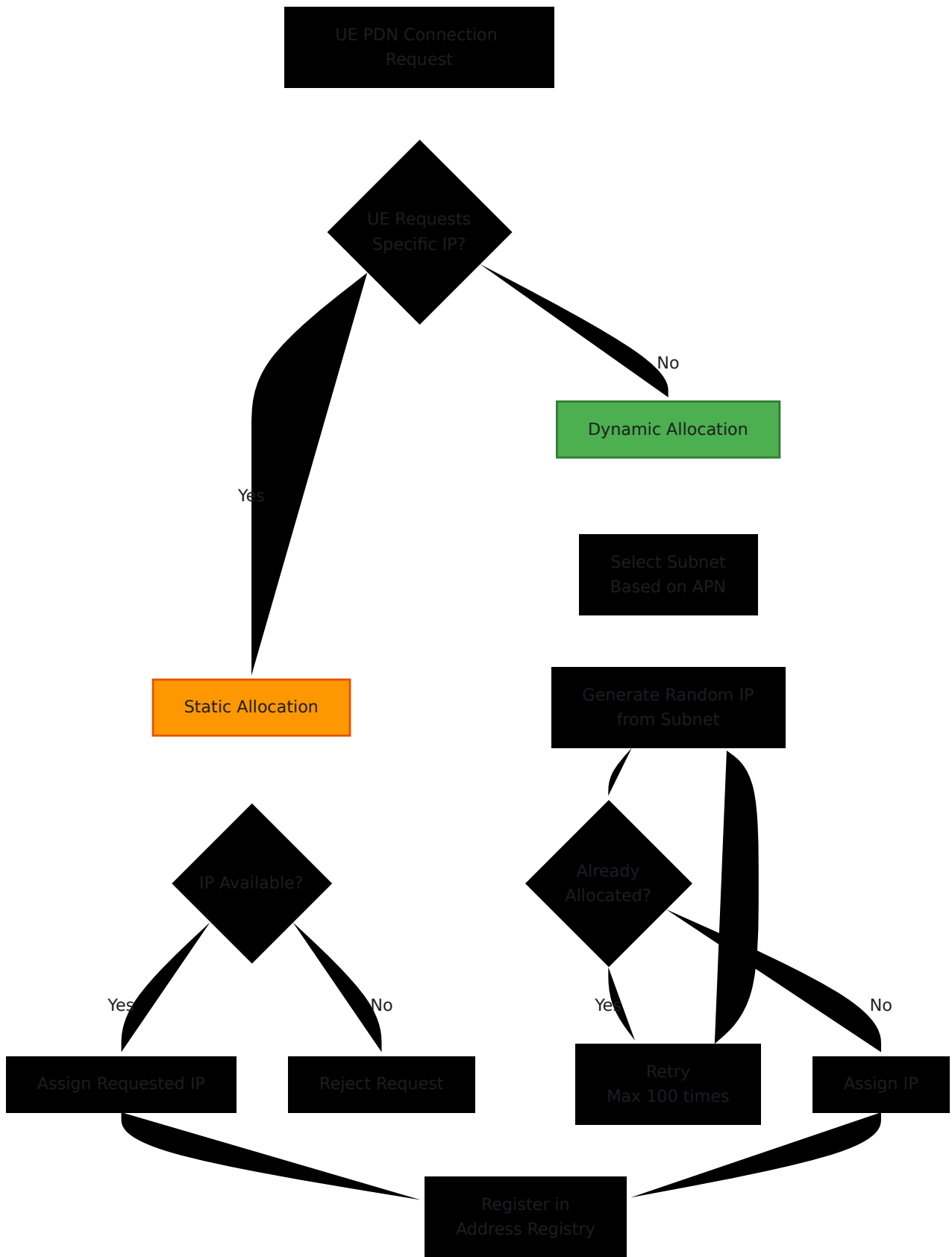
PDN 类型

UE 的 PDN 类型由 PDN 类型决定

PDN 类型	地址	地址范围
IPv4	IPv4 地址	IPv4 地址
IPv6	IPv6 地址	IPv6 地址/64
IPv4v6	地址	IPv4 地址 IPv6 地址

地址

PGW-C 地址 IP 地址



1. IP Allocation

- PGW-C IP Allocation
- IP Allocation

- □□□□□□□□

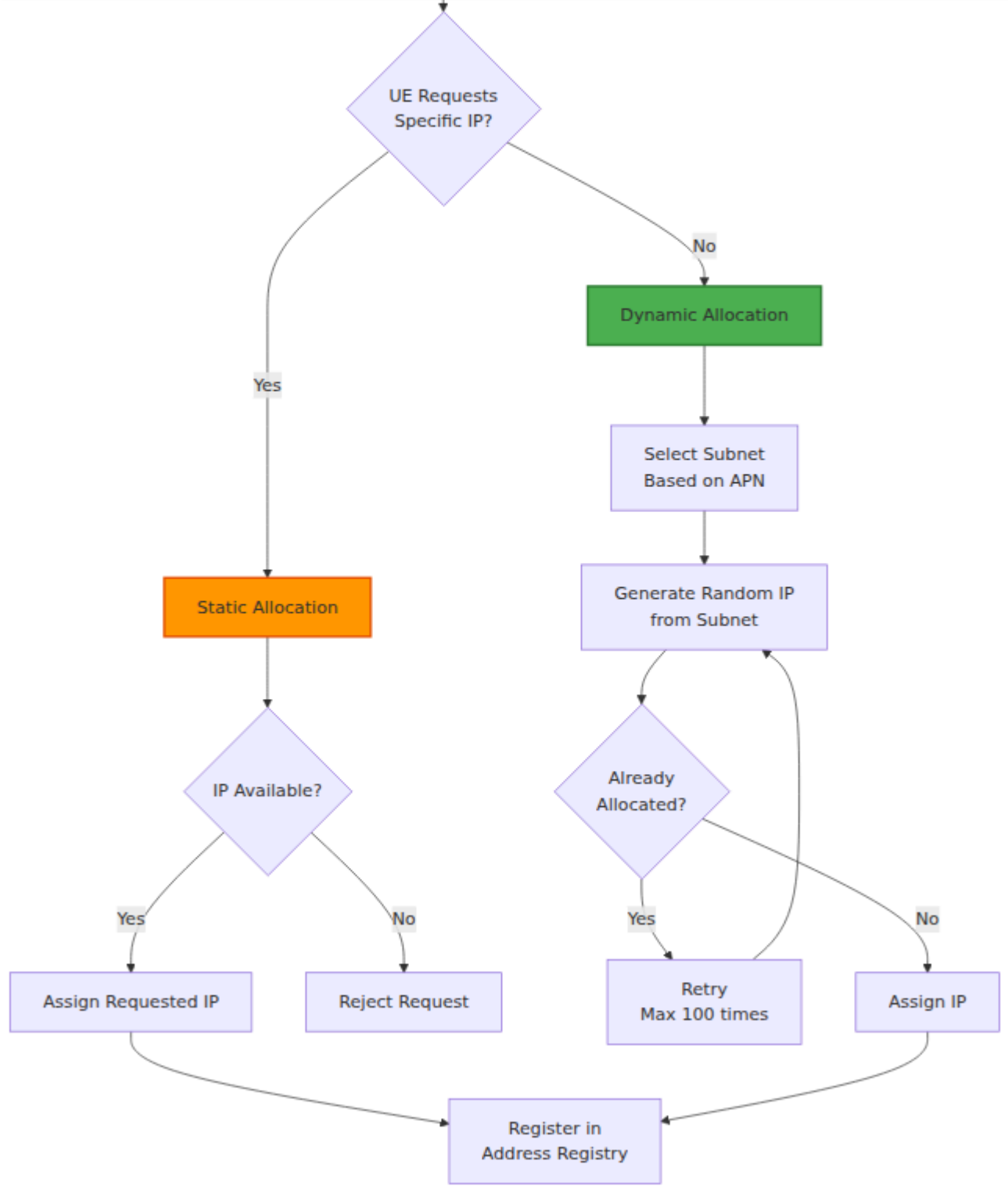
2. □□□□

- UE □ GTP-C □□□□□□ IP
- PGW-C □□□□
- □□□□□□ IP □□□□

□□ **APN** □□□□

□□ **APN**□□□□□□ □□□□□□ IP □□

UE IPM Connection



□□□

- □□□□ - □□ APN □□□□□□□□
- □□❓❓□□ - □□□□ APN □□□□□□□□

- 0000 - 0000000000000000
- 00 - 000000000000

0000

0000 000000 IP

00	00
00	00 UE IP → 0000 PID
00	00 UE IP 0000
00	00000000 IP
0000	000000

00

0000

00 `config/runtime.exs`


```

config :pgw_c,
  ue: %{
    subnet_map: %{
      # IMS APN
      "ims" => ["ims.apn" => ["ims.something.else"
        "ims" => [
          "100.64.10.0/24"
        ],

        # M2M APNs
        "m2m." => ["m2m.test" => ["m2m.prod"
          "m2m." => [
            "100.64.20.0/24"
          ],

          # Enterprise
          "enterprise.corp" => [
            "enterprise.corp" => [
              "10.100.0.0/16"
            ],

            # Default APN
            default: [
              "42.42.42.0/24"
            ]
          ]
        }
      }
    }
  }

```

References

- [Elixir/Erlang](#)
- [Elixir](#)
- [^](#)
-
-

References

Regex	Pattern	Matches
ims	"^ims"	ims, ims.apn, ims.anything
corp	"^.*\\.corp\$"	foo.corp, bar.corp
test	"^.*test.*"	test, foo.test.bar, testing
internet.apn	"^internet\\.apn\$"	internet.apn

Regex

Regex for .corp APN: `^.*\\.suffix$`

```

subnet_map: %{
  # .corp APN
  "^.*\\.corp$" => ["10.100.0.0/16"],

  # .iot APN
  "^.*\\.iot$" => ["10.200.0.0/16"],

  default: ["42.42.42.0/24"]
}

```

Regex

APN	Regex	IP Range
ims	^ims	100.64.10.0/24
ims.apn	^ims	100.64.10.0/24
ims.something.else	^ims	100.64.10.0/24
m2m.test	^m2m\.	100.64.20.0/24
m2m	default	42.42.42.0/24
enterprise.corp	enterprise.corp	10.100.0.0/16
foo.corp	^.*\.corp\$	10.100.0.0/16
unknown.apn	default	42.42.42.0/24

Regex

CIDR <network>/<prefix_length>

CIDR	IP Count	IP Range
/24	254	100.64.1.1 - 100.64.1.254
/23	510	100.64.0.1 - 100.64.1.254
/22	1022	100.64.0.1 - 100.64.3.254
/20	4094	100.64.0.1 - 100.64.15.254
/16	65534	100.64.0.1 - 100.64.255.254

IP

- 100.64.1.0/24
- 100.64.1.255/24
- PGW-C `<network> + 1` `<broadcast> - 1`

APN

```
config :pgw_c,
  ue: %{
    subnet_map: %{
      "internet" => [
        "100.64.1.0/24",
        "100.64.2.0/24",
        "100.64.3.0/24",
        "100.64.4.0/24"
      ]
    }
  }
}
```

- PGW-C
-
-

-
-
-

□□□□□□

```
config :pgw_c,  
  ue: %{  
    subnet_map: %{  
      # □□□□□□□□  
      "internet" => [  
        "100.64.0.0/20"      # 4094 □ IP □□□□□□  
      ],  
  
      # IMS□□□□ LTE □□□□  
      "ims" => [  
        "100.64.16.0/22"    # 1022 □ IP □□ IMS  
      ],  
  
      # □□ APN  
      "enterprise.corp" => [  
        "10.100.0.0/16"     # 65534 □ IP □□□□  
      ],  
  
      # □□□□□□□□□□□□  
      "iot.m2m" => [  
        "100.64.20.0/22"   # 1022 □ IP □□□□□□  
      ],  
  
      # □□□□  
      default: [  
        "42.42.42.0/24"    # 254 □ IP □□□□ APN  
      ]  
    }  
  }  
}
```

IPv6

```
config :pgw_c,  
  ue: %{\br/>    subnet_map: %{\br/>      "internet" => [  
        # IPv4  
        "100.64.1.0/24"  
      ],  
      "internet.ipv6" => [  
        # IPv6  
        "2001:db8:1::/48"  
      ],  
      default: [  
        "42.42.42.0/24"  
      ]  
    }  
  }  
}
```

IPv6

- UE /64
- UE IP
- UE `2001:db8:1:a::/64`

IPv4v6

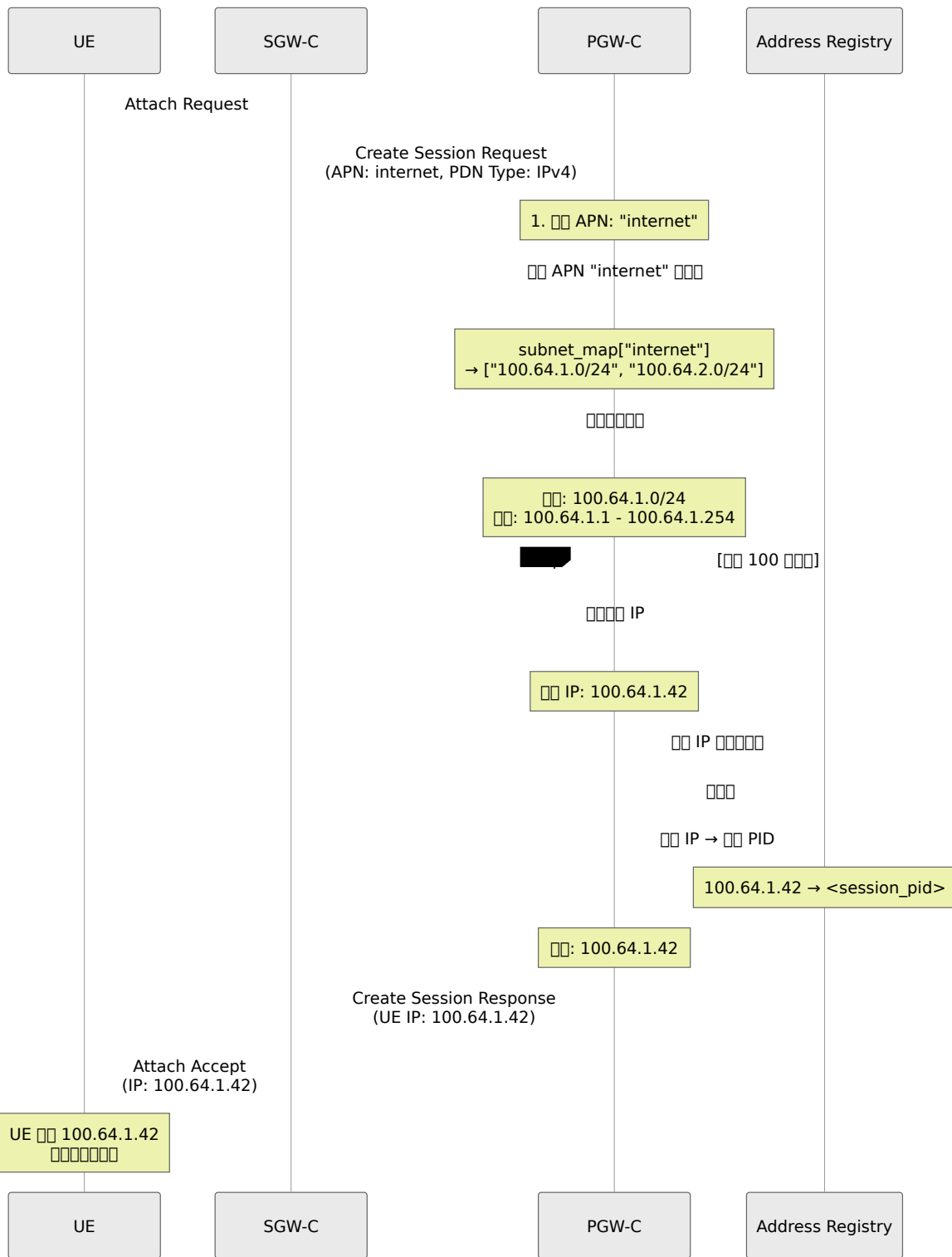
```
config :pgw_c,  
  ue: %{\br/>    subnet_map: %{\br/>      "internet" => [  
        "100.64.1.0/24", # IPv4  
        "2001:db8:1::/48" # IPv6  
      ],  
    }  
  }  
}
```

- UE 通过 PDN 连接 IPv4v6
 - PGW-C 支持 IPv4 和 IPv6 地址
 - 网络地址转换
-

网络

IP 地址由 PGW-C 在 S5/S8 接口分配给 UE。GTP-C 在 S5/S8 接口使用 UDP 传输。

IPv4



□□□□

□□□□□□

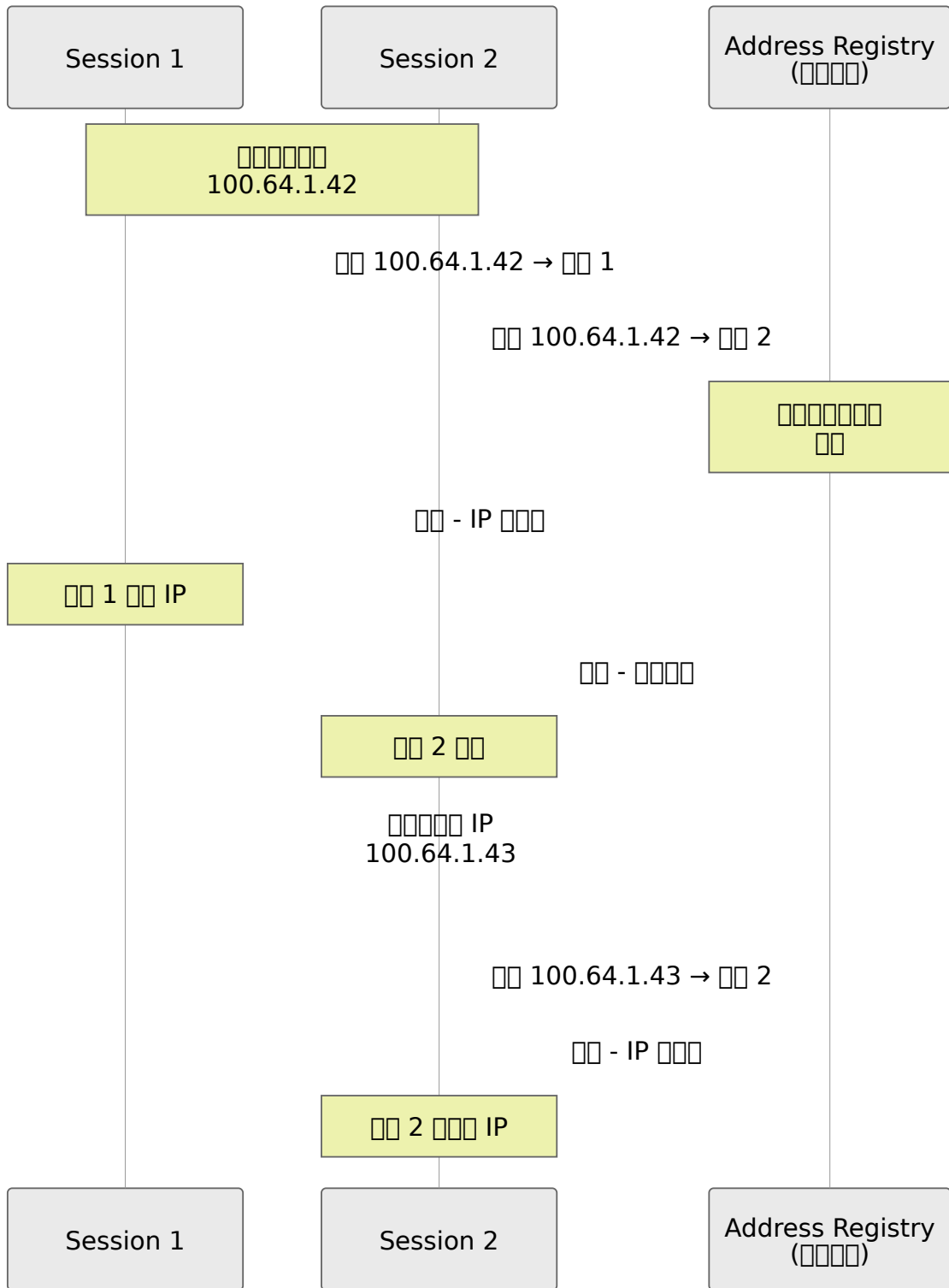
1. 查詢 查詢 APN 查詢
2. 查詢 查詢
3. **IP** 查詢 查詢 IP
4. 查詢 查詢 IP 查詢
5. 查詢 查詢 100 查詢 查詢 IP
6. 查詢 查詢 IP 查詢

查詢

- 查詢 **100** 查詢 查詢
- 查詢 查詢 IP 查詢
- 查詢 查詢
- 查詢 查詢 APN 查詢

查詢

查詢 查詢 IP



□□□□□□□□

- □□□□□□□□□□□□□□□□
- □□□□□□□□□□
- □□□□□□□□ IP □□
- □□□□□□□□ IP □□□□
- □□□□□□□□□□□□□□ IP

□□□□□□

□□□ UE □□□□ APN

□□□□□

```
# □□  
subnet_map: %{  
  "internet" => ["100.64.1.0/24"],  
  default: ["42.42.42.0/24"]  
}
```

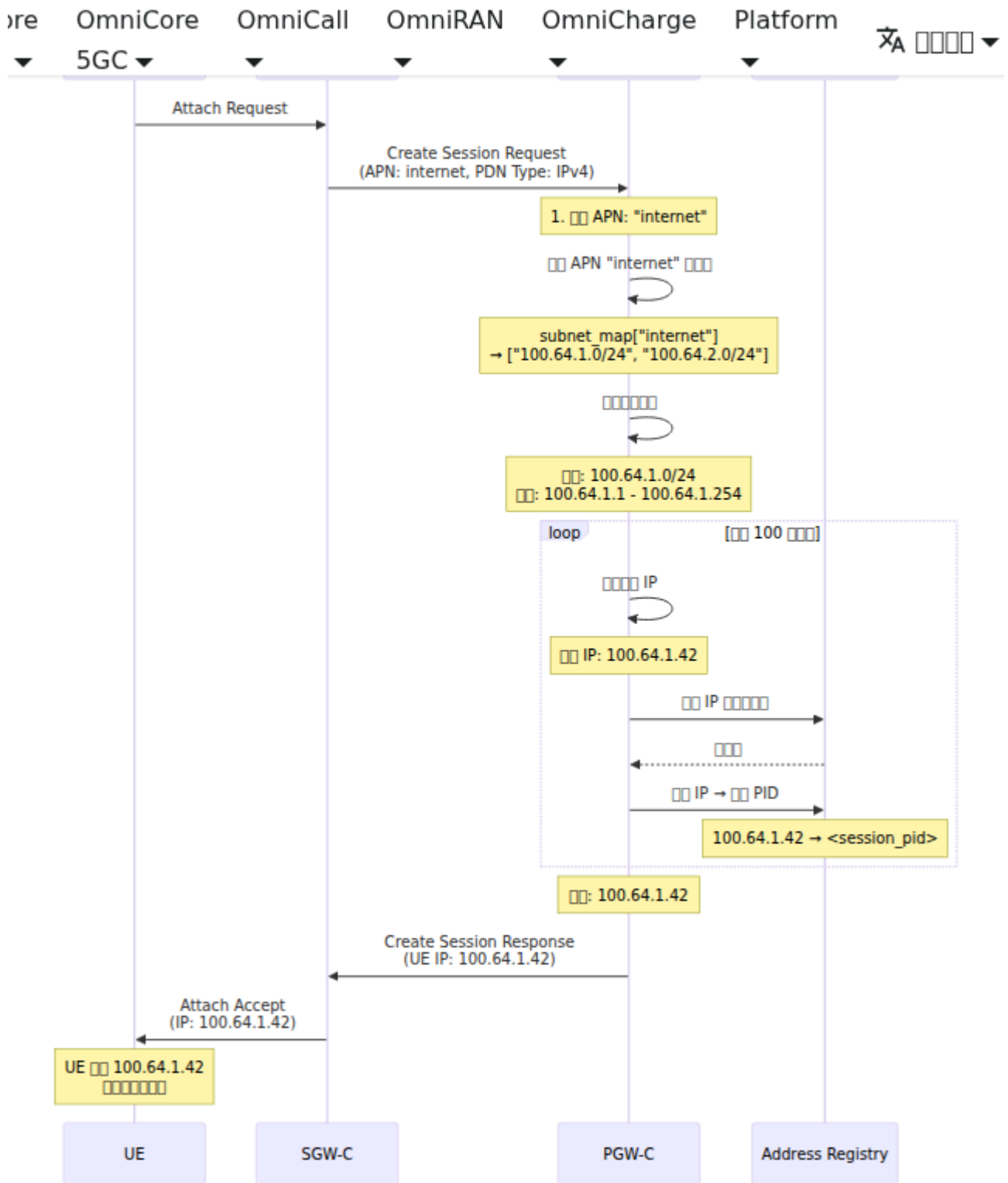
□◀◀◀□

- UE □□ APN: "unknown.apn"
- □□□ subnet_map □□□ "unknown.apn"
- □□□□□□□□□□□□□□
- □ 42.42.42.0/24 □□ IP

□□□□□

1. □□□□□□□□□□□□□□ APN □□
2. □□□□□□□□□□ default □
3. □□□□□□□□□□□□□□

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- □□□□□□□□□□□□□□
- IP □□□□□□□□
- □□□□□□

IP Pool

Overview

IP Pool Management

```
Pool: 100.64.1.0/24 (254 IP)
Size: 254 IP
Usage: 100% → Full
```

Configuration

- PGW-C pool 100 IP
- IP Pool
- Error: `{:error, :ue_ip_address_allocation_failed}`
- Usage
- SGW-C pool

Monitoring

```
# Pool Usage
address_registry_count / total_pool_size > 0.8 # 80% Full

# IP Pools
"internet" => [
  "100.64.1.0/24",
  "100.64.2.0/24", # Pool
  "100.64.3.0/24"
]
```

IP Pool

IP Pool Management

GTP-C Pool

Create Session Request

- |— IMSI: 310260123456789
- |— APN: enterprise.corp
- |— PDN 0000 (IE)
 - | |— PDN 00: IPv4
 - | |— IPv4 00: 10.100.0.50 ← UE 0000 IP

OmniPGW 000

1. 00000 IP 0000000 PDN 0000 IE
2. 00 IP 000000 IP 0000 APN 000000
3. 000000 00 IP 000000000000
4. 000000
 - o 0000000000 IP 0000000
 - o 000000000000000000000000

000000

- 000 UE 0000000000 IP 00
- 000IP 000000 000000 - IP 0000
- 000IP 0000000 000000 - IP 00000000

IPv6 0000

UE 00 IPv6

Create Session Request

- |~~000~~— PDN 00: IPv6

PGW-C 00 /64 000

Network: 2001:db8:1:a::/64

UE Network

- 2001:db8:1:a::1
- 2001:db8:1:a::2
- ... (18 quintillion)

Network

- UE Network IP Network
- SLAAC Network
- NAT Network

Network

UE Network IPv4v6

Create Session Request

└─ PDN Network: IPv4v6

PGW-C Network

IPv4: 100.64.1.42

IPv6: 2001:db8:1:a::/64

Network

- IPv4 Network IPv4 Network
- IPv6 Network IPv6 Network
- Network
- Network GTP Network

Network **IP** Network

Network **IP** Network **RFC 1918** Network

```
# 子网映射配置
subnet_map: %{
  "internet" => [
    "10.0.0.0/8",
    "172.16.0.0/12",
    "192.168.0.0/16"
  ]
}
```

配置 **PGW-U** 的 **NAT** 规则

配置 **IP** 池

```
# 配置 IP 池
subnet_map: %{
  "internet" => [
    "203.0.113.0/24" # 公网 IP 池
  ]
}
```

配置 **NAT** - 子网映射

配置

- 配置 **IP RFC 6598** 池 `100.64.0.0/10` 用于 NAT
- 配置 **IP** 池

配置

Web UI - IP 池

OmniPGW 的 Web 界面 IP 池配置

配置 `http://<omnipgw-ip>:<web-port>/ip_pools`

□□□

1. □□□

- □□□□□ IP □
- □□□□□□□□
- □□□□ IP
- □□□□□□□□

2. □□ **APN** □□□ □□□□□□□□

- □□□ - APN □□□□□□□□“default”□“ims.something.else”□“Internet”□
- **APN** □□ - □□□ APN □□□□
- **IP** □□ - □□□□□□□□ CIDR □□□
- □□□ - □□□□□□□□□□□□□□
- □□□□□
 - □□□□□□□ IP □□
 - □□□□□□□□□□ IP
 - □□□□□□□□□□ IP

3. □□□□

- 2 个 IP
- 100 个 IP
- 100 个 IP

IP

- 100 个 IP
- 100 个 IP
- 100 个 IP
- 1 APN 100 个 IP

IP

100 个 IP

```
# 100 个 IP
address_registry_count

# 100 个 IP
address_registry_count / <total_pool_size> * 100
```

IP

```
IP: 100.64.1.0/24 (254 个 IP)
IP: 150 个 IP
IP: 150 / 254 = 59%
```

00

```
# 0000000000
- alert: UEIPPoolUtilizationHigh
  expr: address_registry_count > 200 # 00 /24 0
  for: 10m
  annotations:
    summary: "UE IP 000000 80%"
    description: "00: {{ $value }} / 254 0 IP 0000"

# 00000000
- alert: UEIPPoolExhausted
  expr: address_registry_count >= 254 # 00 /24 0
  for: 1m
  annotations:
    summary: "UE IP 000 - 0000 IP"

# 0000000000
- alert: UEIPAllocationFailures
  expr: rate(ue_ip_allocation_failures_total[5m]) > 0
  for: 5m
  annotations:
    summary: "UE IP 000000"
```

Grafana 000

00 1 IP 0000

```
# 0000000000
(address_registry_count / 254) * 100
```

00 2 0000000000 IP

```
# 0000
address_registry_count
```

00 3 0000

```
# 查看速率  
rate(address_registry_count[5m])
```

查看 4 小时速率

```
# 查看速率与总容量的差值  
(254 - address_registry_count) / rate(address_registry_count[1h])
```

查看 IP

查看 1 小时内所有 IP

查看

- 查看速率 "速率"
- 查看 "UE IP 速率"

查看

1. 查看

```
# 查看速率  
curl http://<pgw_c_ip>:42069/metrics | grep  
address_registry_count
```

2. 查看

```
# 例
config :pgw_c,
  ue: %{
    subnet_map: %{
      "internet" => [
        "100.64.1.0/24" # CIDR
      ]
    }
  }
}
```

3. APN 例

```
# APN 例
# 例
subnet_map: %{
  default: ["42.42.42.0/24"]
}
```

例

- 例
- 例 PGW-C 例 IP
- 例 `runtime.exs` 例

例 2例 IP 例

例

- 例 UE 例 IP 例
- 例

例

- 例

例

```
# 检查 IP
grep "already_registered" /var/log/pgw_c.log
```

检查

- 检查 IP
- 检查 IP

3 IP

检查

- UE IP
- APN "internet" 或 "ims" IP

检查

- 检查

检查

```
# 检查 APN 检查
subnet_map: %{
  "internet" => [...], # 检查
  "Internet" => [...] # 检查 APN!
}
```

检查

- APN 检查
- 检查

4 IPv6

检查

- UE IPv6 检查

□□□□

1. □□ IPv6 □

```
# □□ IPv6 □  
subnet_map: %  
  "internet" => [  
    "100.64.1.0/24" # □ IPv4  
  ]  
}
```

2. □□ IPv6 □

```
# □□□□□□ /48 □□□□  
"internet" => [  
  "2001:db8::/128" # □□ - □□□□□□  
]
```

□□□□

```
# □□ IPv6 □  
subnet_map: %  
  "internet" => [  
    "100.64.1.0/24",  
    "2001:db8:1::/48" # IPv6 □  
  ]  
}
```

□□ 5□□□□□□

□□

- □□□□
- `address_registry_count` □□□□

□□□□

1. □□□□

```
"internet" => [
  "100.64.1.0/24", # []
  "100.64.2.0/24", # [] 254 [] IP
  "100.64.3.0/24" # [] 254 [] IP
]
```

2. [] [] [] [] [] []

```
# [] /24 000 [] /22
"internet" => [
  "100.64.0.0/22" # 1022 [] IP
]
```

3. [] [] [] []

- [] [] [] [] []
- [] [] [] [] [] [] [] [] [] [] [] []

[] [] [] []

[] [] [] []

[] [] [] [] [] [] [] []

```

[] [] [] [] 10,000
[] [] [] 30% 3,000 [] [] [] []
[] [] [] 50%
[] IP 3,000 * 1.5 = 4,500 [] IP

```

```

[] [] /20 4,094 [] [] IP - []
[] [] /19 8,190 [] [] IP - []

```

[] [] [] []

[] [] []

- 100.64.0.0/10 RFC 6598 - NAT
- 400 IP
- NAT

□□□

- IP
- VPN

□□□□

```

config :pgw_c,
  ue: %{
    subnet_map: %{
      # APN - 
      "internet" => [
        "100.64.0.0/18" # 16,382 IP
      ],

      # IMS - 
      "ims" => [
        "100.64.64.0/22" # 1,022 IP
      ],

      # - 
      "enterprise.corp" => [
        "100.64.68.0/22" # 1,022 IP
      ],

      # - 
      "iot.m2m" => [
        "100.64.72.0/20" # 4,094 IP
      ],

      # - 
      default: [
        "100.64.127.0/24" # 254 IP
      ]
    }
  }

```

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□□

- □□□□ - UE IP □□□□APN □□□□
- **PCO** □□ - □ IP □□□□□□□□ DNS□P-CSCF□MTU
- □□□□ - □□□□□□□□PDN □□□□□ IP □□
- **PFCP** □□ - □□ PFCP □ UPF □□ UE □□

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- **S5/S8** □□ - □□ GTP-C □□ IP □□
- **Diameter Gx** □□ - IP □□□□□□□□

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- □□□□ - IP □□□□□□□□□□□□
- □□ **CDR** □□ - CDR □□ UE IP □□□□□□□□

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