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Monitoring of ePDG

Integrated VoWiFi Gateway Monitoring System (ePDG)

1. Review of the decision

The VAS Experts ePDG Monitoring system provides full operational control of the **fast-epdg** component, the VoWiFi (Voice over WiFi) gateway operating according to 3GPP TS 29.273 and TS 24.302. The gateway provides secure transmission of voice and packet traffic through untrusted Wi-Fi channels with IPsec / IKEv2 tunneling and integration with the EPC core through SWu, SWm, SWx, S2b, S6b interfaces.

The solution provides a single monitoring platform for the mobile operator's operational services — from the IPsec SA (L3 security) level to the KPI of VoWiFi subscriber experience.

Key advantages

- **Real-time monitoring** — update metrics every 10-15 seconds, directly display the status of IKE SA / Child SA and GTP tunnels in NOC dashboards without delayed aggregation (hereinafter NOC — Network Operation Center, network management center).
- **Proactive detection of anomalies** — 20+ alarms with automatic escalation in importance. PGW/AAA inaccessibility, increased IKEv2 delays, and an increase in EAP-AKA errors are detected before subscribers notice problems with calls.
- **Open integration interfaces** — Prometheus, SNMP v2c, Alertmanager webhooks, Grafana support. Integration into the existing NMS/OSS infrastructure without vendor binding.
- **Minimum external dependencies at the plugin level** — built-in /metrics endpoint in fast-epdg, without Java, without JMX, without external agents.
- **Coverage of the entire SWu → S2b stack** — IKEv2 (SWu), Diameter SWm/SWx/S6b, GTPv2-C (S2b) and GTP-U data plane — all in one place. The 33 metrics cover control plane and data plane.

2. Architecture of the monitoring system

```
flowchart TB
  subgraph DataPlane["Data Plane"]
    IPSEC["IPSec ESP IKEv2 SA / Child SA Kernel xfrm"]
    GTPU["GTP-U Tunneller S2b Data ePDG ↔ PGW"]
  end
  subgraph ControlPlane["Control Plane"]
    IKE["IKEv2 SWu EAP-AKA' auth"]
    DIAM["Diameter Client SWx/SWm/S6b"]
    GTPC["GTPv2-C S2b to PGW/SMF"]
    CTRL["ePDG Controller Attach/Detach FSM"]
  end
  subgraph Collection["Metrics Collection"]
    PROMEXP["fast-epdg /metrics endpoint"]
  end
```

```

:9817"] end subgraph Storage["Storage"] PROM["Prometheus
TSDB
15-day retention"] end subgraph Visualization["Visualization"] GRAF["Grafana
4 дашборда, 35+ панелей"] end subgraph Alerting["Alerting"] AM["Alertmanager
Routing / Inhibition"] EMAIL["Email SMTP"] SNMPGW["SNMP Trap Sender
Webhook → Trap gateway"] NMS["Внешняя NMS
SNMP v2c UDP/162"] WH["Webhooks
Telegram / PagerDuty"] end
IKE --> PROMEXP IPSEC --> PROMEXP GTPC --> PROMEXP GTPU -->
PROMEXP DIAM --> PROMEXP CTRL --> PROMEXP PROMEXP --> PROM PROM --> GRAF PROM --> AM
AM --> EMAIL AM --> SNMPGW SNMPGW --> NMS AM --> WH

```

Four-level monitoring architecture

| Level | Component | Technology |
|---------------|--------------------------------------|--|
| Collection | Built-in /metrics endpoint fast-epdg | Prometheus text format over HTTP |
| Storage | Prometheus TSDB | Local storage, 15-day storage by default |
| Visualization | Grafana + JSON support | Autodownload 4 dashboards |
| Alerting | Alertmanager + SNMP Trap Sender | PromQL rules → webhook → SNMP v2c trap |

3. Components and indicators

Monitoring coverage

```

flowchart LR
EXP["fast-epdg
/metrics :9817"] EXP --> CFG["Config
2 metrics"]
EXP --> NET["Network
1 metric"]
EXP --> PROTO["Protocols L5-L7
15 metrics"]
EXP --> SVC["Service KPI
4 metrics"]
EXP --> SESS["Session State
4 metrics"]
EXP --> APP["Application
3 metrics"]
EXP --> SYS["System
4 metrics"]
PROTO --> IKEV2["IKEv2
SWu — 3"]
PROTO --> GTPC["GTPv2-C
S2b — 4"]
PROTO --> GTPU["GTP-U
S2b data — 3"]
PROTO --> DIA["Diameter
SWm/SWx/S6b — 5"]

```

Quantitative review by category

| Category | Number of metrics | Survey interval | Key indicators |
|------------------|-------------------|-----------------|---|
| Config | 2 | 10 sec | Configuration status, reload counter |
| Network | 1 | 10 sec | Node connection status (PGW/AAA/HSS) |
| IKEv2 (SWu) | 3 | 10 sec | Reports by type (IKE_SA_INIT, IKE_AUTH, CREATE_CHILD_SA), delay diagram, errors |
| GTPv2-C (S2b) | 4 | 10 sec | Messages (Create/Modify/Delete Session), delays, errors, relays |
| GTP-U data plane | 3 | 10 sec | Packets/bytes, tunneling errors |

| Category | Number of metrics | Survey interval | Key indicators |
|-------------------------------|-------------------|-----------------|--|
| Diameter (SWm/SWx/S6b) | 5 | 10 sec | Command code messages (DER/DEA, MAR/MAA, AAR/AAA), delays, errors, watchdog, connection status |
| Service KPI | 4 | 10 sec | Percentage of successful attempts, duration histogram, service availability, uptime |
| Session State | 4 | 10 sec | IKE SA, Child SA, GTP sessions, all users |
| Application | 3 | 10 sec | Number of streams, memory, log messages by levels |
| System | 4 | 10 sec | CPU recycling, memory, memory disposal, open FD |
| Total | 33 metrics | | |

Naming principles

All metrics have the prefix `epdg_` and are organized in a hierarchy:

```

epdg_
├── config_*           # Configuration
├── network_*         # Network layer
├── ikev2_*           # SWu (IKEv2/IPSec)
├── gtp_*             # S2b control-plane GTPv2-C
├── gtpu_*            # S2b data-plane GTP-U
├── diameter_*        # SWm/SWx/S6b
├── service_*         # Service KPIs (attach, availability, uptime)
├── session_*         # Session Status (IKE SA, Child SA, GTP, subscribers)
├── app_*             # App Metrics (memory, threads, logs)
└── system_*         # System metrics (CPU, disk, network)

```

4. List of metrics

All metrics are exported through a single `/metrics` endpoint in Prometheus text format. The name follows the rules of Prometheus: `epdg_<group>_<name>[_unit]`, the Counter type has the suffix `_total`, Histogram is the suffix `_seconds/_bytes`.

4.1 Config (2)

| Name | Type | Appointment |
|---------------------------------------|---------|--|
| <code>epdg_config_status</code> | Gauge | Component configuration status (0=error, 1=ok) |
| <code>epdg_config_reload_total</code> | Counter | Configuration download counter (success/failure) |

4.2 Network (1)

| Name | Type | Appointment |
|--------------------------------|-------|---|
| epdg_network_connection_status | Gauge | TCP/UDP connection status to a node (0=down, 1=up) — applies to PGW (S2b), AAA (SWm), HSS (SWx) |

4.3 IKEv2 SWu (3)

| Name | Type | Appointment |
|-------------------------------------|-----------|--|
| epdg_ikev2_messages_total | Counter | IKEv2 Message Counter (IKE_SA_INIT / IKE_AUTH / CREATE_CHILD_SA / INFORMATIONAL) |
| epdg_ikev2_request_duration_seconds | Histogram | IKEv2 response time |
| epdg_ikev2_errors_total | Counter | IKEv2 errors (NO_PROPOSAL_CHOSEN, AUTHENTICATION_FAILED, INVALID_SYNTAX, etc.) |

4.4 GTPv2-C S2b (4)

| Name | Type | Appointment |
|-----------------------------------|-----------|--|
| epdg_gtp_messages_total | Counter | GTPv2-C (Create/Modify/Delete Session, Echo) |
| epdg_gtp_request_duration_seconds | Histogram | Waiting time request → reply |
| epdg_gtp_errors_total | Counter | GTP-C error by Cause Code |
| epdg_gtp_retransmissions_total | Counter | Redirecting GTP-C requests |

GTP-U data plane (3)

| Name | Type | Appointment |
|-------------------------|---------|--|
| epdg_gtpu_packets_total | Counter | Packages via GTP-U tunnel (uplink/downlink) |
| epdg_gtpu_bytes_total | Counter | Bytes through GTP-U tunnel |
| epdg_gtpu_errors_total | Counter | Tunneling errors (TEID mismatch, decap fail) |

4.6 Diameter SWm/SWx/S6b (5)

| Name | Type | Appointment |
|--|-----------|--|
| epdg_diameter_messages_total | Counter | DER/DEA (SWm), MAR/MAA (SWx), AAR/AAA (S6b), STR/STA |
| epdg_diameter_request_duration_seconds | Histogram | Waiting time request → reply by Diameter |
| epdg_diameter_errors_total | Counter | Errors by Experimental-Result-Code |
| epdg_diameter_watchdog_status | Gauge | DWR/DWA watchdog status to node (0=timeout, 1=ok) |
| epdg_diameter_connection_status | Gauge | Diameter connection status to node (0=disconnected, 1=connected) |

4.7 Service KPI (4)

| Name | Type | Appointment |
|--------------------------------------|-----------|--|
| epdg_service_attach_total | Counter | Attempts to connect (success/failure) via APN |
| epdg_service_attach_duration_seconds | Histogram | Duration of connection (IKE_SA_INIT → session ready) |

| Name | Type | Appointment |
|-----------------------------|-------|-----------------------------------|
| epdg_service_availability | Gauge | Accessibility flag (0=down, 1=up) |
| epdg_service_uptime_seconds | Gauge | Service availability time |

4.8 Session State (4)

| Name | Type | Appointment |
|---------------------------------|-------|-----------------------------------|
| epdg_session_ike_sa_total | Gauge | Active IKE SA |
| epdg_session_child_sa_total | Gauge | Active Child SA (IPSec tunnels) |
| epdg_session_gtp_sessions_total | Gauge | Active GTP-C sessions on S2b |
| epdg_session_subscribers_total | Gauge | Unique subscribers (UE connected) |

4.9 Application (3)

| Name | Type | Appointment |
|-----------------------------|---------|---|
| epdg_app_threads_total | Gauge | Total number of work streams |
| epdg_app_memory_bytes | Gauge | Process memory by type |
| epdg_app_log_messages_total | Counter | Log messages by level (debug/info/warn/error/fatal) |

4.10 System (4)

| Name | Type | Appointment |
|-------------------------------|-------|------------------------|
| epdg_system_cpu_usage_percent | Gauge | Download CPU |
| epdg_system_memory_bytes | Gauge | System memory |
| epdg_system_disk_bytes | Gauge | Disk space |
| epdg_system_open_fds | Gauge | Open file descriptions |

Types of metrics (reminder)

| Type | Appointment |
|------------------|--|
| Counter | Monotonically growing counter (messages, errors, reboots) |
| Gauge | Current value (active sessions, memory, status) |
| Histogram | Distribution of values with automatic slices over intervals (duration, lifetime) |

5. Integration interfaces

flowchart LR
 CORE["VAS Experts
ePDG Monitoring"] --> P["Prometheus
CNCF / OpenMetrics"]
 CORE --> S["SNMP v2c
EPDG-MIB"]
 CORE --> G["Grafana
JSON Provisioning"]
 CORE --> W["Webhooks
ChatOps"]
 CORE --> AM["Alertmanager
Routing"]
 P --> P1["Cloud-native NMS
Thanos / Cortex / Mimir"]
 S --> S1["Legacy NMS
HP OpenView, NetAct
IBM Tivoli"]
 G --> G1["NOC Wall Displays
Drill-down Analytics"]
 W --> W1["Telegram / Slack
PagerDuty / OpsGenie"]
 AM --> AM1["Smart routing"]

Severity-based"]

5.1 Prometheus (CNCF Standard)

The native `/metrics` endpoint on port **9817** is built into fast-epdg. The format is standard text format Prometheus v0.0.4 (compatible with OpenMetrics). Aggregation is supported with the central Prometheus operator; remote_write team support for long-term storage in Thanos, Cortex, Grafana Mimir.

5.2 SNMP v2c — EPDG-MIB

47 OID covers the Prometheus metric + **14 trap notifications** (with raise/clear pairs according to RFC 3877 ALARM-MIB). Compatible with HP OpenView, IBM Tivoli NetCool, Nokia NetAct, Huawei U2000.

```
flowchart TB
  IANA["IANA PEN enterprises"] --> VAS["VAS Experts"]
  VAS --> EPDG["EPDG-MIB"]
  EPDG --> EPC["EPC Monitoring"]
  EPC --> OBJ["epdgObjects"]
  OBJ --> NOTIF["epdgNotifications"]
  NOTIF --> TRAPAGR["7 raise / 7 clear pairs"]
  EPDG --> CONF["epdgConformance"]
  CONF --> SERVICE["service"]
  SERVICE --> IKE["ikev2"]
  SERVICE --> GTP["gtp"]
  SERVICE --> DIAM["diameter"]
  SERVICE --> SESS["sessions"]
  SERVICE --> SYS["system"]
  SERVICE --> NET["network"]
```

.1.3.6.1.4.1"] VAS["VAS Experts
.1.3.6.1.4.1.43823
(vas.expert)"] EPDG["EPDG-MIB
.43823.1"] EPC["EPC Monitoring
.43823.100"] IANA --> VAS VAS --> EPDG VAS --> EPC EPDG --> OBJ["epdgObjects
.43823.1.1"] EPDG --> NOTIF["epdgNotifications
.43823.1.2
14 trap types"] EPDG --> CONF["epdgConformance
.43823.1.3"] OBJ --> SERVICE["service .1.1.1
4 OID"] OBJ --> IKE["ikev2 .1.1.2
6 OID"] OBJ --> GTP["gtp .1.1.3
8 OID"] OBJ --> DIAM["diameter .1.1.4
7 OID"] OBJ --> SESS["sessions .1.1.5
8 OID"] OBJ --> SYS["system .1.1.6
8 OID"] OBJ --> NET["network .1.1.7
6 OID"] NOTIF --> TRAPAGR["7 raise / 7 clear
pairs"]

Examples of SNMP requests:

```
# The entire ePDG tree
snmpwalk -v2c -c public <host>.1.3.6.1.4.1.43823.1

# Service availability (Gauge 0..1)
snmpget -v2c -c public <host> .1.3.6.1.4.1.43823.1.1.0
```

5.3 Grafana

4 JSON dashboard support (35+ panels total):

- **ePDG Overview** — availability, KPI connections, sessions, state of interfaces
- **IKEv2 Details** — Messages, Performance, Errors, IKE SA Lifecycle
- **GTP Details** — GTPv2-C + GTP-U data on PGW nodes
- **Diameter Details** — Application messages, delays, watchdog

Automatic installation through an API that supports Grafana. Adaptive design for Network Control Center (NOC) status monitors with auto-update every 15 seconds.

5.4 Alertmanager Webhooks

Webhook interface for integration with any notification system: Telegram Bot, Slack, PagerDuty Events API v2, OpsGenie, Microsoft Teams. A separate **SNMP Trap Sender** service converts Alertmanager webhooks to SNMP v2c traps with Enterprise OID.

6. The alarm system

Alarm categories

| Criticism | Alarma | Description | Reaction |
|-----------------|--|---|---|
| Critical | ePDG_Service_Down, ePDG_High_Attach_Failure_Rate, ePDG_PGW_Unreachable, ePDG_AAA_Unreachable, ePDG_Diameter_Watchdog_Timeout | Component is unavailable, widespread connection failures, nodes are unavailable | Immediate escalation: Email + SNMP Trap + Webhook. Repeat every hour |
| Warning | ePDG_High_IKEv2_Latency, ePDG_High_GTP_Latency, ePDG_High_IKEv2_Error_Rate, ePDG_High_GTP_Error_Rate, ePDG_High_Memory_Usage, ePDG_High_CPU_Usage, ePDG_Low_Disk_Space, ePDG_High_Error_Log_Rate | Performance degradation, resource anomalies | Email. Resend every 4 hours. Suppressed if a "Critical" status is present on the same component |

Complete list of alarms (20+ rules)

```

flowchart LR
  AL["ePDG Alert Rules  
20+"] --> CR["Critical  
5 rules"]
  AL --> WR["Warning  
8 rules"]
  AL --> INFO["Recording  
34 rules"]
  CR --> C1["Service_Down  
availability == 0"]
  CR --> C2["Attach_Failure_Rate  
> 10%"]
  CR --> C3["PGW_Unreachable  
connection_status{s2b} == 0"]
  CR --> C4["AAA_Unreachable  
connection_status{swm} == 0"]
  CR --> C5["Diameter_Watchdog_Timeout  
watchdog_status == 0"]
  WR --> W1["High_IKEv2_Latency  
p95 > 1.0 s"]
  WR --> W2["High_GTP_Latency  
p95 > 0.5 s"]
  WR --> W3["High_IKEv2_Error_Rate

```

> 5%"] WR --> W4["High_GTP_Error_Rate
 > 5%"] WR --> W5["High_Memory_Usage
 > 80%"] WR --> W6["High_CPU_Usage
 > 80%"] WR --> W7["Low_Disk_Space
 < 10%"] WR --> W8["High_Error_Log_Rate
 > 10/s"] INFO --> I1["attach_success_rate
 preaggregated"] INFO --> I2["p95_p99_latency
 preaggregated"] INFO --> I3["throughput
 preaggregated"]

Alarm treatment process

sequenceDiagram participant M as Метрика (Prometheus) participant R as Alert Rule (PromQL)
 participant AM as Alertmanager participant E as Email (SMTP) participant SG as SNMP Trap Gateway
 participant NMS as Внешняя NMS participant W as Webhook (ChatOps) M->>R: The value exceeds
 the threshold R->>R: Waiting (for: 1-10 мин) R->>AM: Alert FIRING AM->>AM: Group by [alertname,
 component] AM->>AM: Inhibition check (critical overrides warning) alt severity = critical AM->>E:
 Email [CRITICAL] AM->>SG: Webhook → SNMP Trap SG->>NMS: SNMP v2c Trap (OID
 .1.3.6.1.4.1.43823.1.2.X) AM->>W: Webhook (Telegram / PagerDuty) else severity = warning
 AM->>E: Email [WARNING] end Note over M,R: The metric is returning to normal R->>AM: Alert
 RESOLVED R->>SG: clear-trap (paired notification) AM->>E: Email [RESOLVED]

Features

- **Inhibition:** Critical alarms automatically suppress Warning for the same component
- **Grouping:** Alarms are grouped into alertname + component with a 30-second window
- **Dead time / Hysteresis:** 1 to 10 minutes for prevents false positives
- **Trap pairing:** raise/clear simultaneous events for compliance with RFC 3877 ALARM-MIB

7. Visualization and operational dashboards

Composition of dashboards

| Dashboard | Panel | Purpose |
|-------------------------|-------|--|
| ePDG Overview | 10 | Service availability, connection success rate, number of active sessions, SWu/SWm/S2b status, interface bandwidth |
| IKEv2 Details | 10 | Mes per second by type, histogram of request duration, delay in the 95th percentile, error by type, IKE SA life cycle |
| GTP Details | 8 | GTPv2-C PGW messages, retransmissions, cause code errors, GTP-U (uplink/downlink) carriers |
| Diameter Details | 7 | Number of application messages (SWm/SWx/S6b), duration of requests, state of watchdog timer, distribution of result codes, chronology of connection states |

Design for Network Management Center (NOC)

flowchart TB NOC["NOC Dashboard Layer"] NOC --> OVER["ePDG Overview"]

KPI Summary"] NOC --> IKE["IKEv2 Details
Drill-down"] NOC --> GTP["GTP Details
Drill-down"] NOC --> DIA["Diameter Details
Drill-down"] OVER -->|Click attach KPI| IKE OVER -->|Click session count| GTP OVER -->|Click peer
status| DIA

- **Auto Update:** 15-second update period
- **Adaptive color scheme:** green → yellow → red by threshold values
- **Drill-down:** From Overview to Detail to Component
- **Time-range selector:** 5 minutes to 30 days of history
- **JSON provisioning:** Dashboards are automatically deployed

8. Integration into a single EPC Monitoring stack

ePDG monitoring is fully integrated into overall packet core monitoring:

```
flowchart TB
    subgraph Common ["Unified Monitoring Stack"]
        PROM["Prometheus"]
        GRAF["Grafana"]
        AM["Alertmanager"]
    end
    subgraph Sources ["Sources of EPC metrics"]
        DPI["FastDPI :9110"]
        SMF["SMF /metrics :9090"]
        PCEF["fast-pcef /metrics :9090"]
        PCRF["FastPCRF"]
        EPDG["fast-epdg :9817"]
    end
    DPI --> PROM
    SMF --> PROM
    PCEF --> PROM
    PCRF --> PROM
    EPDG --> PROM
    PROM --> GRAF
    PROM --> AM
```

The NOC operator sees **all EPC components** (DPI, SMF, PCEF, FastPCRF, ePDG) in a single Grafana interface, with a single alarm system and notification routing through one Alertmanager.

9. Coverage of metrics by OSI levels

```
graph LR
    L1["L1 Physical  
NIC counters via system"]
    L2["L2 Data Link  
MAC, VLAN"]
    L3["L3 Network  
IP, IPsec ESP, GTP-U"]
    L4["L4 Transport  
TCP/UDP/SCTP"]
    L5["L5 Session  
GTPv2-C, IKEv2"]
    L6["L6 Presentation  
IKEv2/IPsec encryption, EAP-AKA"]
    L7["L7 Application  
Diameter, service bearer ops"]
    Operations["Operations  
KPI, SLA, Capacity"]
    CX["CX Level  
Subscriber Experience"]
    L1 --> L2
    L2 --> L3
    L3 --> L4
    L4 --> L5
    L5 --> L6
    L6 --> L7
    L7 --> Operations
    Operations --> CX
    style L1 fill:#e74c3c,color:#fff
    style L2 fill:#e67e22,color:#fff
    style L3 fill:#f39c12,color:#fff
    style L4 fill:#2ecc71,color:#fff
    style L5 fill:#1abc9c,color:#fff
    style L6 fill:#3498db,color:#fff
    style L7 fill:#9b59b6,color:#fff
    style Operations fill:#34495e,color:#fff
    style CX fill:#2c3e50,color:#fff
```

Detailing metrics by level

OSI model:

| Level | Metrics | Examples |
|-----------------------------------|---------|--|
| L1/L2 Physical / Data Link | - | Covered by a separate node_exporter/OS-level analogue (not included in the ePDG metrics list) |
| L3 Network / IPSec tunnels | 3 | epdg_gtpu_packets_total, epdg_gtpu_bytes_total, epdg_gtpu_errors_total — GTP-U data plane |
| L4 Transport | 1 | epdg_network_connection_status — TCP to nodes (PGW/AAA/HSS) |
| L5 Session | 3 | |
| L6 Presentation/Security | 3 | epdg_ikev2_messages_total, epdg_ikev2_request_duration_seconds, epdg_ikev2_errors_total — IKEv2/IPSec encryption and EAP-AKA' authentication |
| L7 Application | 9 | epdg_diameter_* (SWm/SWx/S6b, 5 metrics), epdg_gtp_* (GTPv2-C, 4 metrics) |

Operator level:

| Level | Metrics | Examples |
|----------------------------|---------|---|
| Operations | 11 | epdg_service_availability, epdg_service_uptime_seconds, epdg_app_* (3), epdg_system_* (4), epdg_config_* (2) |
| Customer Experience | 3 | epdg_service_attach_duration_seconds p95, epdg_service_attach_total (success rate), epdg_ikev2_request_duration_seconds p99 |

Level 9: Quality of VoWiFi service perception

| QoE indicator | Source metrics | Interpretation |
|-----------------------------------|---|---|
| VoWiFi connection time | epdg_service_attach_duration_seconds p95 | > 3 seconds — subscriber notices delay when switching to WiFi |
| Continuity of service | epdg_session_ike_sa_total delta | Mass discharge > 50 IKE SA = accessibility issue |
| Authentication success | ePDG_High_Attach_Failure_Rate alert rate | > 5% = HSS/AAA node problem |
| Delayed appointment bearer | epdg_gtp_request_duration_seconds{msg=create-session} p99 | > 500 ms — delayed availability of voice channel |
| GTP-U tunnel | epdg_gtpu_errors_total rate / epdg_gtpu_packets_total | > 0.1% = degradation of voice quality |
| IKEv2-reliability | epdg_ikev2_errors_total by type | NO_PROPOSAL_CHOSEN / AUTHENTICATION_FAILED — problems with certs / UE |

10. Standards and compatibility

| Standard | Area | Application |
|-----------------------|-----------------------------------|--|
| 3GPP TS 29.273 | SWx/S6b/SWm | Methodology for accounting for Diameter messages and resulting codes |
| 3GPP TS 24.302 | SWu (IKEv2) | Definition of IKEv2 message types and error codes |
| 3GPP TS 33.402 | 3GPP security for non-3GPP access | EAP-AKA'/IKEv2 security parameters |

| Standard | Area | Application |
|-------------------------------------|----------------------------------|--|
| 3GPP TS 23.402 | Non-3GPP access architecture | Interface Structure (SWu/SWm/SWx/S6b/S2b) |
| 3GPP TS 32.421 | Performance Measurement | Collection methodology KPI |
| 3GPP TS 32.409 | Performance measurement charging | Counter structure |
| IETF RFC 7296 | IKEv2 | Message types, error notifications, state SA |
| IETF RFC 6733 | Diameter | Command codes, Result-Codes |
| IETF RFC 4187 | EAP-AKA | Authentication via SIM |
| IETF RFC 3877 | ALARM MIB | Enterprise MIB structure for alarms |
| IETF RFC 3418 | SNMPv2 MIB | SNMP v2c compatibility |
| Prometheus Exposition Format | Metrics (v0.0.4) | Export metric format |
| OpenMetrics | CNCF Standard | Prospective compatibility |

11. The deployment model

```

flowchart TB
    subgraph Host1 ["ePDG Server"]
        EPDG["fast-epdg (VoWiFi gateway)"]
        PLUGIN["metrics endpoint :9817"]
    end
    subgraph Host2 ["Monitoring server"]
        PROM["Prometheus"]
        GRAF["Grafana"]
        AM["Alertmanager"]
        SNMPTRAP["SNMP Trap Sender (webhook gateway)"]
    end
    subgraph Host3 ["External systems"]
        NMS["Операторская NMS (HP OpenView / NetAct / Tivoli)"]
        CHAT["ChatOps (Telegram / PagerDuty)"]
    end
    EPDG --> PLUGIN
    PLUGIN --> PROM
    PROM --> GRAF
    PROM --> AM
    PROM --> SNMPTRAP
    PROM --> NMS
    PROM --> CHAT
  
```

Deployment characteristics

| Parameter | Value |
|------------------------------|---|
| Metrics footprint | Integrated (~2 MB memory overhead) |
| External dependencies | Self-contained package fast-epdg (rpm) |
| Management | fast-epdg.service systemd |
| Configuration | monitoring section in fast-epdg.conf |
| Update | Configuration update without interruption |
| OS | |
| Port | 9817 TCP (listen 0.0.0.0, configurable) |
| Deployment time | < 5 minutes (enable plugin in config + restart) |

Accommodation options

- **On-premise** — the plugin runs in the fast-epdg address space, zero resource consumption
- **Co-located Prometheus** — Prometheus collects metrics from an application running on the same host
- **Centralized** — a single Prometheus collects from all ePDG nodes

12. Metric exporter configuration

The monitoring section in `fast-epdg.conf`:

```
monitoring {
    enabled = yes
    listen_port = 9817
    listen_address = 0.0.0.0
    update_interval = 10
    metrics {
        ikev2 = yes
        gtp = yes
        diameter = yes
        service = yes
        session = yes
        app = yes
        system = yes
    }
}
```

Each group of metrics can be independently turned on/off without recompilation.