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

## 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
<b>Counter</b>	Monotonically growing counter (messages, errors, reboots)
<b>Gauge</b>	Current value (active sessions, memory, status)
<b>Histogram</b>	Distribution of values with automatic slices over intervals (duration, lifetime)

## 5. Integration interfaces

flowchart LR
 CORE["VAS Experts  
ePDG Monitoring"]
 CORE --> 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
<b>Critical</b>	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
<b>Warning</b>	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
<b>ePDG Overview</b>	10	Service availability, connection success rate, number of active sessions, SWu/SWm/S2b status, interface bandwidth
<b>IKEv2 Details</b>	10	Mes per second by type, histogram of request duration, delay in the 95th percentile, error by type, IKE SA life cycle
<b>GTP Details</b>	8	GTPv2-C PGW messages, retransmissions, cause code errors, GTP-U (uplink/downlink) carriers
<b>Diameter Details</b>	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 --> L3 --> L4 --> L5 --> L6 --> L7 --> 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
<b>L1/L2 Physical / Data Link</b>	-	Covered by a separate node_exporter or equivalent at the OS level (not included in the ePDG metrics list)
<b>L3 Network / IPSec tunnels</b>	3	epdg_gtpu_packets_total, epdg_gtpu_bytes_total, epdg_gtpu_errors_total — GTP-U data plane
<b>L4 Transport</b>	1	epdg_network_connection_status — TCP connections to nodes (PGW/AAA/HSS)
<b>L5 Session</b>	3	epdg_session_ike_sa_total, epdg_session_child_sa_total, epdg_session_gtp_sessions_total
<b>L6 Presentation/Security</b>	3	epdg_ikev2_messages_total, epdg_ikev2_request_duration_seconds, epdg_ikev2_errors_total — IKEv2/IPSec encryption and EAP-AKA authentication
<b>L7 Application</b>	9	epdg_diameter_* (SWm/SWx/S6b, 5 metrics), epdg_gtp_* (GTPv2-C, 4 metrics)

Operator level:

Level	Metrics	Examples
<b>Operations</b>	11	epdg_service_availability, epdg_service_uptime_seconds, epdg_app_* (3), epdg_system_* (4), epdg_config_* (2)
<b>Customer Experience</b>	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
<b>VoWiFi connection time</b>	epdg_service_attach_duration_seconds p95	> 3 seconds — subscriber notices delay when switching to WiFi
<b>Continuity of service</b>	epdg_session_ike_sa_total delta	Mass discharge > 50 IKE SA = accessibility issue
<b>Authentication success</b>	ePDG_High_Attach_Failure_Rate alert rate	> 5% = HSS/AAA node problem
<b>Delayed appointment bearer</b>	epdg_gtp_request_duration_seconds{msg=create-session} p99	> 500 ms — delayed availability of voice channel
<b>GTP-U tunnel</b>	epdg_gtpu_errors_total rate / epdg_gtpu_packets_total	> 0.1% = degradation of voice quality
<b>IKEv2-reliability</b>	epdg_ikev2_errors_total by type	NO_PROPOSAL_CHOSEN / AUTHENTICATION_FAILED — problems with certs / UE

## 10. Standards and compatibility

Standard	Area	Application
<b>3GPP TS 29.273</b>	SWx/S6b/SWm	Methodology for accounting for Diameter messages and resulting codes
<b>3GPP TS 24.302</b>	SWu (IKEv2)	Definition of IKEv2 message types and error codes

Standard	Area	Application
<b>3GPP TS 33.402</b>	3GPP security for non-3GPP access	EAP-AKA'/IKEv2 security parameters
<b>3GPP TS 23.402</b>	Non-3GPP access architecture	Interface Structure (SWu/SWm/SWx/S6b/S2b)
<b>3GPP TS 32.421</b>	Performance Measurement	Collection methodology KPI
<b>3GPP TS 32.409</b>	Performance measurement charging	Counter structure
<b>IETF RFC 7296</b>	IKEv2	Message types, error notifications, state SA
<b>IETF RFC 6733</b>	Diameter	Command codes, Result-Codes
<b>IETF RFC 4187</b>	EAP-AKA	Authentication via SIM
<b>IETF RFC 3877</b>	ALARM MIB	Enterprise MIB structure for alarms
<b>IETF RFC 3418</b>	SNMPv2 MIB	SNMP v2c compatibility
<b>Prometheus Exposition Format</b>	Metrics (v0.0.4)	Export metric format
<b>OpenMetrics</b>	CNCF Standard	Prospective compatibility

## 11. The deployment model

```

flowchart TB
    subgraph Host1 ["ePDG Server"]
        EPDG["fast-epdg (VoWiFi gateway)"]
        PLUGIN["metrics endpoint :9817"]
        EPDG --> PLUGIN
    end
    subgraph Host2 ["Monitoring server"]
        PROM["Prometheus"]
        GRAF["Grafana"]
        AM["Alertmanager"]
        SNMPTRAP["SNMP Trap Sender (webhook gateway)"]
        PROM --> GRAF
        PROM --> AM
        AM --> SNMPTRAP
    end
    subgraph Host3 ["External systems"]
        NMS["Операторская NMS (HP OpenView / NetAct / Tivoli)"]
        CHAT["ChatOps (Telegram / PagerDuty)"]
    end
    PLUGIN --> |HTTP :9817/metrics| PROM
    SNMPTRAP --> |UDP 162| NMS
    AM --> |Webhook| CHAT

```

### Deployment characteristics

Parameter	Value
<b>Metrics footprint</b>	Integrated (~2 MB memory overhead)
<b>External dependencies</b>	

```

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.