

XS Edge Phase 1 – Technical Implementation Summary

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1. SYSTEM OVERVIEW

XS Edge is the runtime component of the EdgeOS ecosystem. It operates at the network edge and executes localized logic, plugin workloads, and telemetry collection with autonomous decision-making. It communicates upstream with XS Controller and XS Hub.

Goals:

- Modular and sandboxed plugin execution
- Lightweight and secure runtime (Python 3.13+)
- Real-time monitoring via APIs
- Graceful shutdown and watchdog recovery

Execution Stack:

```
[ AsyncIO Event Loop ]
|
├─ edge_core.py → Supervisor, Watchdog, Uvicorn thread
├─ edgeos_core/ → Core libraries (plugin_manager, rules_engine, etc.)
├─ plugins/ → Modular telemetry agents
└─ config/ → Rules and runtime settings
```

2. RUNTIME ARCHITECTURE

Core Components:

```
[ edge_core.py ]
├─ Initializes DB, Rules, Secure Agent, PluginManager
├─ Launches FastAPI in background thread
└─ Manages watchdog loop & graceful shutdown
```

```
[ edgeos_core/plugin_manager.py ]
├─ Loads plugin manifests
├─ Verifies SHA256
└─ Spawns async plugin loops (safe_start)
```

```
[ edgeos_core/rules_engine.py ]
├─ Loads JSON rule definitions
└─ Evaluates contexts and inserts triggered events
```

```
[ edgeos_core/secure_agent.py ]
```

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- └ Issues JWT tokens (DEV_MODE)
- └ Verifies tokens on incoming API requests

[edgeos_core/local_db.py]

- └ Handles SQLite connection
- └ Persists rule-triggered events

[edgeos_core/web_api.py]

- └ Exposes REST routes (/status, /metrics, /health)
- └ JWT auth middleware with graceful fallback
- └ Swagger docs + bearer token scheme

3. IMPLEMENTED CAPABILITIES

Capability	Description	Module
Plugin Framework	Dynamic loading & async execution	plugin_manager.py
Rules Engine	JSON-based rule evaluation	rules_engine.py
Local DB	Event persistence	local_db.py
JWT Security	Auth and signing	secure_agent.py
REST API	FastAPI with Swagger	web_api.py
Graceful Shutdown	Signal + cleanup	edge_core.py
Watchdog & Auto-Restart	Process self-healing	edge_core.py

4. SAMPLE API OUTPUT

```
/status →
{ "plugins": ["edgeline_ai", "energy_optimizer", "network_health"] }
```

```
/health →
{
  "system": "XS Edge",
  "version": "1.0.0",
  "uptime_sec": 182.4,
  "overall_status": "OK",
  "plugins": {
    "edgeline_ai": {"last_heartbeat_sec_ago": 4.8, "status": "OK"},
    "energy_optimizer": {"last_heartbeat_sec_ago": 5.1, "status": "OK"}
  }
}
```

```
/metrics →
{
  "events": [
    {"ts": 1762782271.53, "rule": "AlwaysTriggerLatency", "data": "{ 'network_latency': 175 }"}
  ]
}
```

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```
]
}
```

5. LOGGING SEQUENCE EXAMPLE

```
INFO:xs-edge:Starting XS Edge runtime...
INFO:Rules:Loaded 2 rules from config/rules_demo.json
INFO:PluginManager:Loaded plugin edgeline_ai
INFO:root:[edgeline_ai] heartbeat 1 @ 17:53:44
WARNING:Rules:Rule AlwaysTriggerLatency triggered
INFO:root:[EdgeLink] best 5G (88ms)
INFO:WebAPI:XS Edge API running on http://0.0.0.0:8000
```

6. TEST & VALIDATION

- ✓ Verified plugin heartbeats every 5–10 s
- ✓ Rules trigger correctly on threshold conditions
- ✓ Events persist in SQLite (xsedge.db)
- ✓ /health endpoint reports live plugin heartbeats
- ✓ Graceful shutdown closes DB + plugins cleanly

7. PHASE 1.5 EDGE ENHANCEMENTS (NEXT)

- Add buffered telemetry queue per plugin
- Dynamic rule reload (no restart)
- Optional HTML dashboard view for /health
- Extended rule syntax (comparisons, multiple vars)
- Config hot reload via controller hooks

8. TRANSITION TO PHASE 2 (XS CONTROLLER)

Upcoming Controller Responsibilities:

```
[ XS Controller ]
├─ Discover XS Edge nodes via REST
├─ Aggregate metrics + rule events
├─ Manage configuration + rule sync
├─ Display multi-node dashboard
└─ Coordinate updates with XS Hub
```

Interface Plan:

```
[ XS Edge ] --(REST /health,/metrics)--> [ XS Controller ]
```

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```
[ XS Controller ] --(rule push /config)--> [ XS Edge ]  
[ XS Hub ] <--> Core coordination layer
```

Environment:

- Python 3.13 / FastAPI / AsyncIO
 - SQLite local DB
 - Cross-platform (Windows & Linux)
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