# Benchmarks

This directory contains performance benchmarks for the SMS-C system using Benchee.

# Available Benchmarks

## 1. Raw SMS Benchmark (`raw_sms_bench.exs`)

Benchmarks the `submit_message_raw` API endpoint using real SMS PDUs.

**Features:**

- Uses real SMS PDUs (add your PDUs to the `@sample_pdus` list in the file)
- Disables duplicate detection by clearing fingerprints before each iteration
- Outputs both console and HTML reports

**Usage:**

```
mix run benchmarks/raw_sms_bench.exs
```

**Output:** `benchmarks/output/raw_sms_benchmark.html`

## 2. Message API Benchmark (`message_api_bench.exs`)

Benchmarks various message API operations including insert, retrieval, and routing.

**Features:**

- Tests insert_message (simple and with routing)
- Tests get_messages_for_smsc
- Tests list_message_queues

- Pre-populates database with test data for realistic scenarios

**Usage:**

```
mix run benchmarks/message_api_bench.exs
```

**Output:** `benchmarks/output/message_api_benchmark.html`

# Configuration

All benchmarks use Benchee with the following default settings:

- Warmup: 2 seconds
- Time: 10 seconds
- Memory time: 2 seconds
- Extended statistics enabled
- HTML reports auto-generated

# Outputs

HTML benchmark reports are generated in `benchmarks/output/` and include:

- Detailed performance metrics
- Comparison charts
- Memory usage statistics
- Statistical analysis

# SMS-C Operations Documentation

**← Back to Main README**

Welcome to the SMS-C operations documentation. This comprehensive guide covers all aspects of configuring, operating, monitoring, and troubleshooting the SMS-C system.

## Documentation Overview

### Getting Started

- **Configuration Reference** - Complete configuration options and examples

### Day-to-Day Operations

- **Operations Guide** - Daily tasks, monitoring, and maintenance
- **SMS Routing Guide** - Route management and configuration
- **API Reference** - Complete API documentation with examples

### Performance & Monitoring

- **Performance Tuning** - Optimization for different workloads
- **Metrics Guide** - Prometheus metrics and monitoring

### Troubleshooting

- **Troubleshooting Guide** - Common issues and solutions

## Compliance & Regulatory

- **ANSSI R226 Interception Compliance** - French lawful interception technical specifications
  - Multi-protocol frontend integration (IMS/SIP, SMPP, SS7/MAP)
  - ETSI X1/X2/X3 lawful interception interfaces
  - Mnesia + SQL two-tier storage architecture
  - CDR schema for lawful interception queries
  - Encryption and cryptanalysis capabilities

# Quick Links

## Common Tasks

- Submitting a Message
- Creating a Route
- Checking Message Status
- Monitoring System Health
- Handling Delivery Failures

## Configuration Examples

- Message Storage & Retention
- CDR Export Setup
- Privacy Controls
- High-Volume Configuration
- Geographic Routing
- Load Balancing
- ENUM/NAPTR Setup
- OCS Charging
- Number Translation

## Monitoring & Alerts

- Key Metrics
- Recommended Alerts
- Dashboard Templates

# System Architecture Overview

The SMS-C is a distributed, high-performance message routing platform with the following key components:

## Core Components

- **Message Storage** - Mnesia-based fast storage with configurable retention and CDR export
- **Routing Engine** - Mnesia-based routing rules with prefix matching and load balancing
- **Number Translation** - Regex-based number normalization with priority ordering
- **Charging Integration** - OCS online charging with route-based policies
- **ENUM Lookup** - DNS-based number routing with caching
- **Event Logging** - Message lifecycle tracking
- **CDR Export** - Automatic export to SQL database for long-term billing/analytics

## External Interfaces

- **REST API** - Message submission and management (HTTPS)
- **Web UI** - Route management, message browser, monitoring
- **Prometheus** - Metrics exposure for monitoring
- **OCS** - Charging/billing integration
- **DNS** - ENUM/NAPTR lookups for routing

## Distribution & HA

- **Multi-Node Clustering** - Distributed message processing
- **Mnesia Replication** - Route synchronization across nodes
- **Automatic Failover** - Node failure handling
- **Load Balancing** - Weighted route distribution

# Related Documentation

- **Performance Benchmarks** - Performance testing and results
- **CDR Schema Reference** - Complete CDR database schema with SQL examples

# System Requirements

## Minimum Requirements

- **CPU**: 2 cores
- **RAM**: 4 GB
- **Disk**: 50 GB (grows with message retention)
- **OS**: Linux (recommended), macOS (development)
- **Erlang/OTP**: 26.x or later
- **Elixir**: 1.15.x or later
- **SQL Database**: MySQL 8.0+, MariaDB 10.5+, or PostgreSQL 13+ (for CDR storage)

## Recommended Production

- **CPU**: 8+ cores
- **RAM**: 16+ GB
- **Disk**: 500+ GB SSD
- **Network**: 1 Gbps+
- **SQL Database**: Dedicated server with replication (for CDR storage)

## Network Ports

- **80/443** - Web UI (HTTP/HTTPS)
- **8443** - API (HTTPS)
- **4369** - Erlang Port Mapper (clustering)
- **9100-9200** - Erlang distribution (clustering)
- **9568** - Prometheus metrics

# Support & Resources

## Logs

- **Application Logs**: `/var/log/sms_c/` (production) or console (development)
- **Web UI Logs**: Real-time log viewer at `/logs`
- **Event Logs**: Per-message event tracking via API

## Diagnostics

- **Health Check**: `GET /api/status`
- **Metrics**: `GET http://localhost:9568/metrics` (Prometheus format)
- **Frontend Status**: Web UI at `/frontend_status`
- **Message Queue**: Web UI at `/message_queue`

## Getting Help

1. Check the Troubleshooting Guide
2. Review application logs
3. Check Prometheus metrics for anomalies
4. Use the routing simulator to test routing logic
5. Examine per-message event logs

# Version Information

This documentation is current as of:

- **Last Updated**: 2025-10-30
- **SMS-C Version**: Latest development build
- **Supported Elixir**: 1.15.x - 1.17.x
- **Supported Erlang/OTP**: 26.x - 27.x

# Documentation Conventions

Throughout this documentation:

- **Configuration examples** show typical values; adjust for your environment
- **API examples** use `curl` command-line format
- **IP addresses and domains** are examples only; replace with your actual values
- **Metric names** follow Prometheus naming conventions
- **All timestamps** are in UTC unless otherwise specified

# Quick Start

1. **Configuration**: Configure via `config/runtime.exs` - see Configuration Reference
2. **Initial Routes**: Create routing rules via Web UI or configuration file - see SMS Routing Guide
3. **Submit Test Message**: Use API or Web UI - see API Reference
4. **Monitor**: Set up Prometheus scraping - see Metrics Guide

# Documentation Feedback

This documentation is maintained alongside the SMS-C codebase. For corrections or improvements, please update the markdown files in the `docs/` directory.

# ANSSI R226 Interception Compliance Documentation

**Document Purpose:** This document provides technical specifications required for ANSSI R226 authorization under Articles R226-3 and R226-7 of the French Penal Code for the OmniMessage SMS Service Center (SMSc).

**Classification:** Regulatory Compliance Documentation

**Target Authority:** Agence nationale de la sécurité des systèmes d'information (ANSSI)

**Regulation:** R226 - Protection of Correspondence Privacy and Lawful Interception

---

# 1. DETAILED TECHNICAL SPECIFICATIONS

## 1.1 Commercial Technical Datasheet

**Product Name:** OmniMessage SMSc (SMS Service Center) **Product Type:** Telecommunications Message Center **Primary Function:** SMS message routing, storage, and delivery **Network Protocols:** REST API (HTTPS), SMS protocols (SMPP, IMS, SS7/MAP via external frontends) **Deployment Model:** On-premises server application **Technology Stack:** Elixir/Erlang, Phoenix Framework, Mnesia, MySQL/PostgreSQL

**Core Capabilities**

**Message Processing:**

- Centralized SMS message queue with REST API
- Protocol-agnostic design supporting SMPP, IMS, SS7/MAP frontends
- Dynamic routing engine with prefix-based routing
- Retry logic with exponential backoff
- Message expiration and dead letter queue handling
- Call Detail Record (CDR) generation and archival
- Performance: ~1,750 messages/second insert rate, 150 million messages/day capacity

**Message Storage:**

- **Active Message Queue:** Mnesia in-memory database with optional disc persistence
  - Primary storage: RAM for ultra-fast access (sub-millisecond latency)
  - Disc backup: `disc_copies` mode writes to disk for crash recovery
  - Automatic recovery: Messages survive system restarts
  - Retention: Configurable (default 24 hours), then automatic cleanup
- **Long-term CDR Archive:** MySQL/PostgreSQL database (separate from message queue)
  - CDRs written when messages are delivered, expired, failed, or rejected
  - SQL database used ONLY for CDR export/archival, NOT for active message operations
  - No performance impact on message routing (async write)
- **Two-tier Architecture Benefits:**
  - Active queue: Blazing fast (1,750 msg/sec) with no SQL bottleneck
  - CDR archive: Long-term retention (months/years) for billing and lawful interception
  - Clean separation: Message operations never touch SQL
- Cluster support for high availability (Mnesia replication across nodes)

**Network Interfaces:**

- **REST API:** HTTPS (port 8443) for external frontend communication
- **Control Panel:** HTTPS (port 8086) for web-based management

- **Frontend Protocols:** SMPP, IMS, SS7/MAP (via external gateway applications)
- **Database:** MySQL/PostgreSQL for CDR storage

**Routing and Processing:**

- Dynamic SMS routing with runtime configuration updates
- Prefix-based matching (calling/called numbers)
- Source SMSC and type filtering
- Priority and weight-based load balancing
- Number translation and normalization
- ENUM (E.164 Number Mapping) DNS lookup support
- Auto-reply and message drop capabilities
- Per-route charging control (CGRates integration)

 **Complete architecture and features documented in README.md**

# 1.2 Interception Capabilities

### 1.2.1 Message Acquisition

**SMS Message Capture:**

- The OmniMessage SMSc processes all SMS messages between subscribers and external networks
- Full access to message metadata and content including:
  - Source MSISDN (mobile number)
  - Destination MSISDN (mobile number)
  - Source IMSI (International Mobile Subscriber Identity)
  - Destination IMSI
  - Message body (text content)
  - Raw PDU (Protocol Data Unit) data
  - TP-DCS (Data Coding Scheme) information
  - Message encoding (GSM7, UCS-2, 8-bit, Latin-1)
  - Multipart message indicators and reassembly data
  - User Data Header (UDH) information

**Message Metadata Acquisition:**

- Complete Call Detail Records (CDR) stored in database with:
  - Message ID (unique identifier)
  - Calling number (source MSISDN)
  - Called number (destination MSISDN)
  - Submission timestamp (when message entered system)
  - Delivery timestamp (when message was delivered)
  - Expiry timestamp (when message expired if undeliverable)
  - Status (delivered, expired, failed, rejected)
  - Delivery attempts count
  - Message parts (for concatenated/multi-part SMS)
  - Source SMSC identifier
  - Destination SMSC identifier
  - Origin node (Erlang cluster node name)
  - Destination node (for distributed deployments)
  - Deadletter flag (retry exhaustion indicator)

**Complete CDR schema documented in CDR_SCHEMA.md**

**Message Queue Access:**

- Real-time message queue monitoring
- REST API endpoints for message retrieval
- Database queries for historical message search
- Filter capabilities by:
  - Phone number (source/destination)
  - SMSC gateway
  - Time range
  - Message status
  - Delivery attempts

**Complete API documentation in API_REFERENCE.md**

### 1.2.2 Data Processing Capabilities

**Message Storage Architecture (Two-Tier System):**

The SMSc uses a sophisticated two-tier storage architecture that separates operational message processing from long-term archival:

**Tier 1: Active Message Queue (Mnesia)**

- **Purpose:** Real-time message routing and delivery operations
- **Technology:** Erlang Mnesia distributed database
- **Storage Mode:** In-memory with disc_copies backup
  - Primary storage in RAM for maximum speed
  - Automatic disc synchronization for crash recovery
  - Messages persist across system restarts
- **Performance:** Sub-millisecond read/write operations
- **Retention:** Short-term (default 24 hours), configurable
- **Cleanup:** Automatic archival to CDR database, then deletion from Mnesia
- **Operations:** All message queue operations (insert, update, delivery status, routing)
- **Critical Feature:** SQL database is NEVER queried during message routing/delivery

**Tier 2: CDR Archive (MySQL/PostgreSQL)**

- **Purpose:** Long-term storage for billing, analytics, and lawful interception
- **Technology:** Traditional SQL database (MySQL or PostgreSQL)
- **Write Trigger:** CDRs written ONLY when messages reach final state:
  - Message delivered successfully
  - Message expired (exceeded validity period)
  - Message permanently failed
  - Message rejected by routing rules
- **Write Mode:** Asynchronous batch writing (no impact on message routing performance)
- **Retention:** Long-term (months to years), configurable per regulatory requirements
- **Operations:** Historical queries, reporting, compliance, lawful interception
- **Access:** SQL queries, REST API (future), CSV/JSON export

**Key Architectural Benefits:**

1. **Performance:** Active routing operations never touch SQL (no database bottleneck)
2. **Scalability:** Mnesia handles 1,750+ messages/second without SQL overhead
3. **Reliability:** Disc_copies mode ensures no message loss on crash
4. **Compliance:** CDR database provides permanent audit trail
5. **Separation of Concerns:** Operational data vs. archival data clearly separated

**Message Lifecycle:**

```
1. Message submitted → Stored in Mnesia (RAM + disc backup)
2. Message routed → Mnesia query (ultra-fast)
3. Message delivered/expired → CDR written to SQL (async)
4. After 24h → Message deleted from Mnesia (cleanup worker)
5. CDR remains in SQL → Available for lawful interception queries
(years)
```

**Data Retention and Retrieval:**

- Configurable message body retention or deletion for privacy
- Binary data preservation (raw PDU storage in both Mnesia and CDR)
- Full-text search capability (if enabled on CDR database)
- Indexed CDR fields for fast lawful interception queries

**Frontend Tracking:**

- Real-time tracking of external SMSC frontends (SMPP, IMS, MAP gateways)
- Frontend registration with heartbeat monitoring
- Health status tracking (active/expired)
- Uptime/downtime history
- IP address and hostname tracking
- Frontend-specific configuration logging

### 1.2.3 Analysis Capabilities

**Real-Time Monitoring:**

- Web UI dashboard showing:
  - Active message queue
  - Message submission and delivery
  - Routing decisions and gateway selection
  - Frontend gateway status
  - System resource utilization
- Prometheus metrics integration for operational monitoring
- Performance metrics (throughput, latency, success rates)

**Complete monitoring guide in OPERATIONS_GUIDE.md Metrics documentation in METRICS.md**

**Historical Analysis:**

- CDR database queryable by:
  - Time range
  - Calling/called party number
  - Message status
  - SMSC gateway
  - Delivery attempts
  - Message content (full-text search if enabled)
- Statistical analysis capabilities:
  - Message volume by hour/day/month
  - Success/failure rates by route
  - Average delivery times
  - Multi-part message analysis
  - Failed delivery patterns

**Subscriber Tracking:**

- Message history by phone number (MSISDN)
- IMSI-based tracking (when available from IMS/MAP frontends)
- Call pattern analysis
- Communication party correlation

- Temporal analysis (message frequency, timing patterns)

**Network Analytics:**

- Route performance metrics
- Gateway availability and health
- Message flow visualization
- Cluster node distribution (multi-node deployments)
- Delivery attempt analysis
- Retry pattern analysis

**Number Intelligence:**

- E.164 number normalization
- Country/region identification from number prefix
- Number translation and rewriting rules
- ENUM DNS lookup for routing intelligence
- Prefix-based routing decisions

**Number translation guide in number_translation_guide.md Routing guide in sms_routing_guide.md**

# 1.3 Countermeasure Capabilities

### 1.3.1 Privacy Protection Mechanisms

**Communication Confidentiality:**

- HTTPS/TLS for REST API communications
- Certificate-based authentication
- Database connection encryption (TLS support)
- Configurable message body deletion after delivery

**Access Control:**

- Web UI access control
- API authentication mechanisms

- Database access controls
- Frontend registration authentication

**Audit Logging:**

- Complete system event logging
- Message submission/delivery logging
- Configuration change tracking
- Administrative action logging
- Structured logging with configurable levels

### 1.3.2 Data Protection Features

**Message Privacy:**

- Configurable message body deletion after delivery
- Message body excluded from UI display (optional)
- Message body excluded from exports (optional)
- CDR message body field can be set to NULL for privacy

**Database Security:**

- MySQL table encryption support (ENCRYPTION='Y')
- PostgreSQL transparent data encryption support
- Database access role separation
- Read-only user accounts for analytics
- Restricted access to message content

**System Hardening:**

- Minimal exposed network ports
- TLS certificate management
- Secure configuration storage
- Environment-based configuration separation
- Cluster security with Erlang distribution protocol

# 1.4 Storage Architecture: Mnesia + SQL Two-Tier Design

### Overview

The OmniMessage SMSc employs a unique two-tier storage architecture specifically designed to separate high-performance operational message processing from long-term compliance and archival storage.

### Tier 1: Mnesia In-Memory Message Queue

#### What is Mnesia?

- Distributed database built into Erlang/OTP runtime
- Hybrid storage: Primary in-memory with automatic disc backup
- ACID-compliant transactions
- Cluster replication across multiple nodes

#### Storage Mode: disc_copies

- **In-Memory Primary:** All active messages stored in RAM
  - Lightning-fast read/write operations (sub-millisecond)
  - No disk I/O during normal message routing operations
  - Enables 1,750+ messages/second throughput
- **Disc Backup (Automatic):** Mnesia synchronizes RAM to disk
  - Writes happen asynchronously in background
  - Disk copy updated on every transaction commit
  - Crash recovery: System restarts with all messages intact
  - Location: `Mnesia.*/` directory in application data

#### Message Lifecycle in Mnesia:

1. Message arrives via REST API → Inserted into Mnesia RAM + disc backup
2. Routing engine queries Mnesia → Instant response (memory access)
3. External gateway polls for messages → Mnesia query (memory access)
4. Gateway updates delivery status → Mnesia update (memory + disc)
5. After delivery/expiry → Message marked for cleanup

6. Cleanup worker (24h default) → Message deleted from Mnesia

**Critical Performance Feature:**

- **ZERO SQL database queries** during active message routing/delivery
- SQL is completely bypassed for operational message processing
- This eliminates the traditional SMS-C bottleneck (database I/O)

**Tier 2: SQL Database for CDR Export/Archival**

**What is CDR (Call Detail Record)?**

- Permanent audit record of message metadata and content
- Written to MySQL or PostgreSQL database
- Used for billing, analytics, compliance, and lawful interception

**When CDRs are Written:** CDR records are created ONLY when messages reach a final state:

- □ Message delivered successfully
- □ Message expired (exceeded validity period without delivery)
- □ Message permanently failed (invalid number, routing error)
- □ Message rejected (routing rules, validation failure)

**How CDRs are Written:**

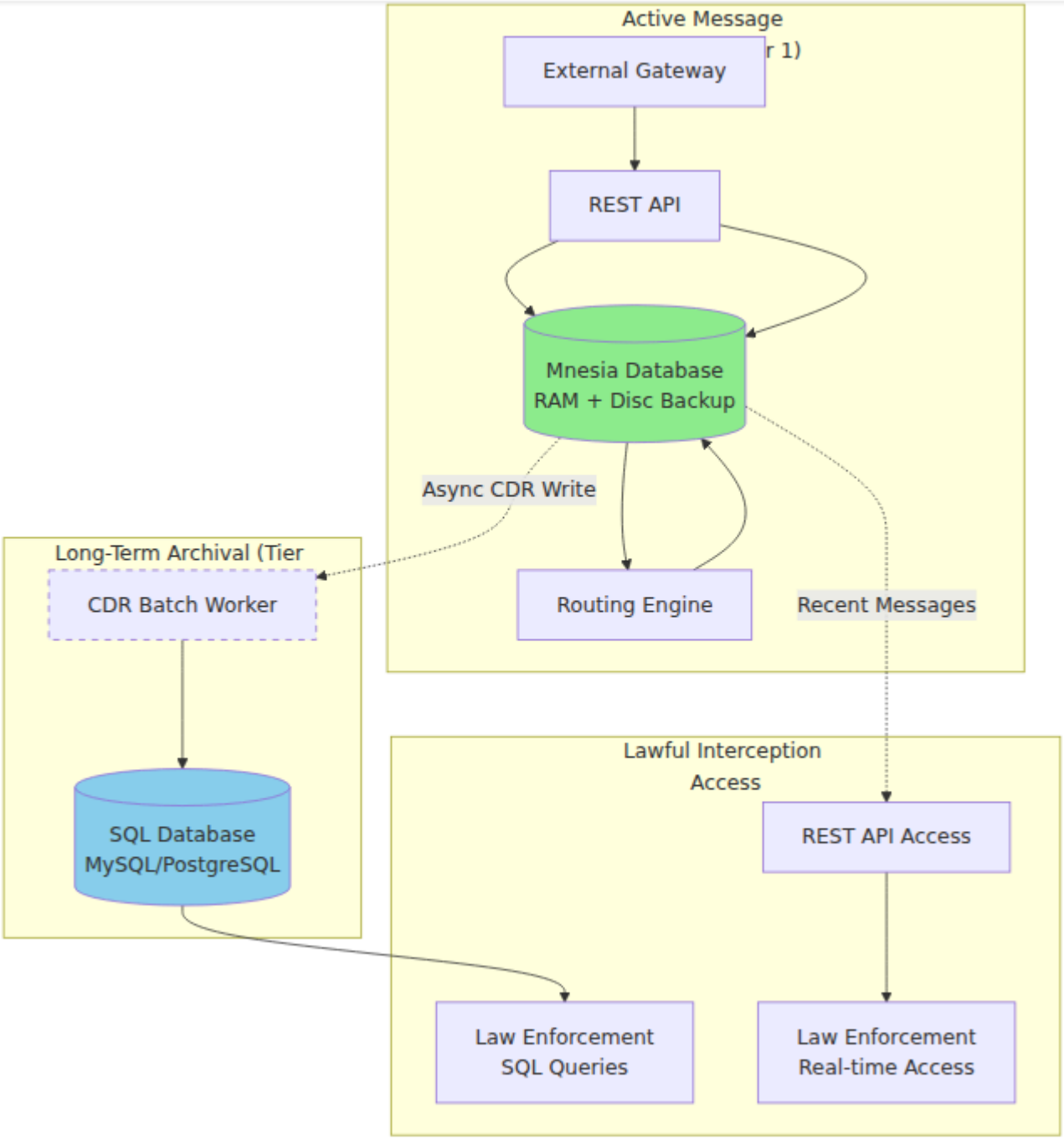
- **Asynchronous batch writing:** CDRs written in background worker process
- **No blocking:** Message routing never waits for SQL write
- **Batched inserts:** Multiple CDRs grouped (default 100) and written together
- **Flush interval:** 100ms default (configurable)
- **Error handling:** Failed CDR writes logged, message processing continues

```
# Configuration in config/runtime.exs
config :sms_c,
  batch_insert_batch_size: 100,          # Batch size for CDR
writes
  batch_insert_flush_interval_ms: 100    # Flush interval
```

**SQL Database Purpose:**

- □ NOT used for: Active message queue operations
- □ NOT used for: Message routing decisions
- □ NOT used for: Real-time message delivery
- □ ONLY used for: Long-term CDR archival and historical queries
- □ ONLY used for: Lawful interception queries (months/years of history)
- □ ONLY used for: Billing and analytics reports

**Architecture Diagram**




**Legend:**

- Solid lines: Synchronous operations (real-time)
- Dashed lines: Asynchronous operations (background)
- Green: High-performance tier (in-memory)
- Blue: Archival tier (persistent SQL)

**Lawful Interception Implications**

**Recent Messages (< 24 hours):**

- Accessible via Mnesia (REST API queries)
- Ultra-fast retrieval
- Full message content available
- Real-time monitoring possible

**Historical Messages (> 24 hours):**

- Accessible via SQL database (CDR table)
- Standard SQL query performance
- Full message metadata always available
- Message body available (unless privacy mode enabled)

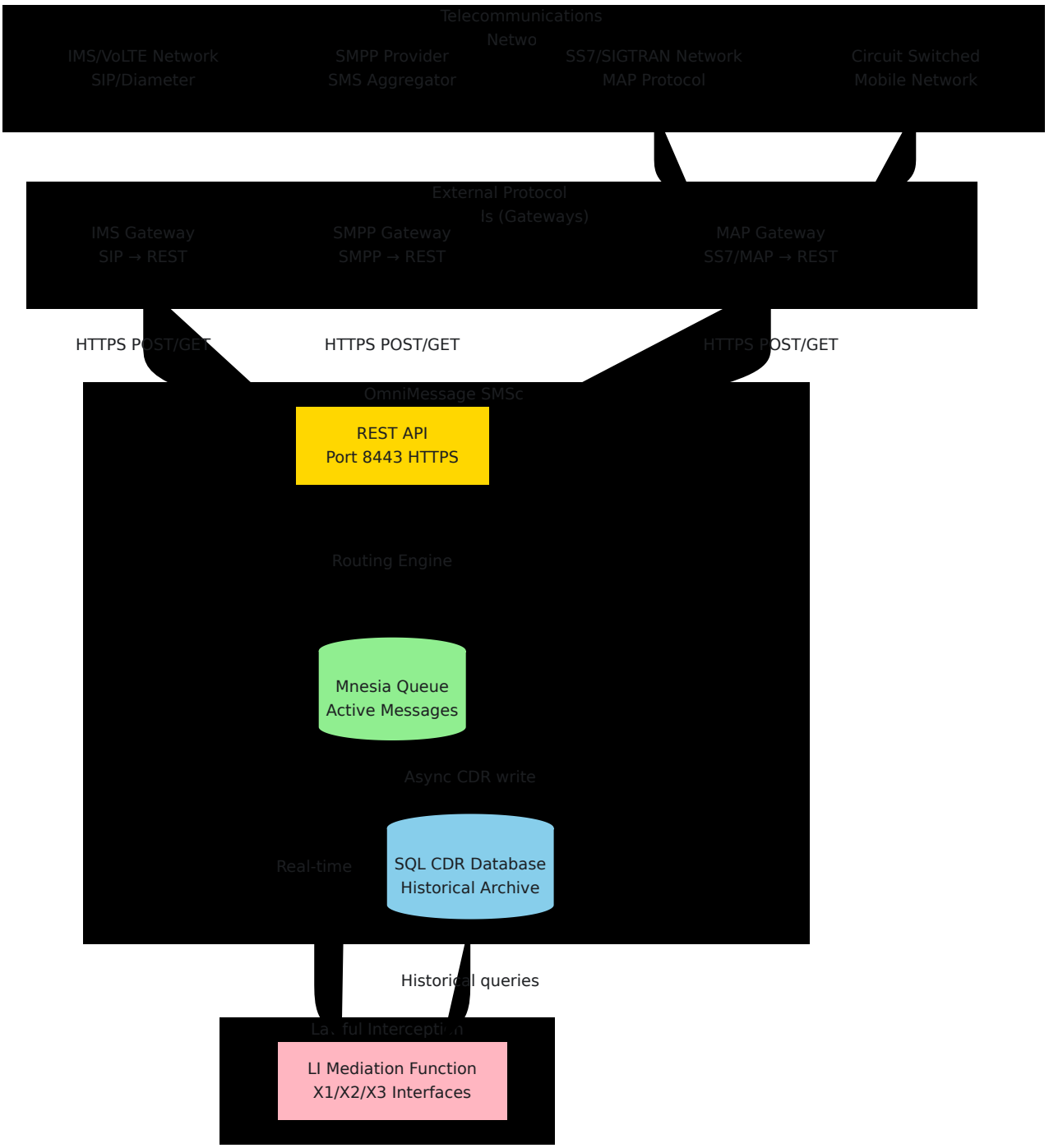
**Compliance Benefits:**

1. **No data loss:** Disc_copies mode ensures messages survive crashes
2. **Permanent audit trail:** CDRs retained for years in SQL database
3. **Performance:** Lawful interception queries don't impact message routing
4. **Flexibility:** Recent messages (Mnesia) + historical messages (SQL) both accessible

# 1.5 Multi-Protocol Frontend Integration Architecture

The OmniMessage SMSc employs a protocol-agnostic core design that interfaces with external protocol-specific gateways (frontends) via a unified REST API. This architecture allows lawful interception to capture messages regardless of which telecommunications protocol was used to send or receive them.

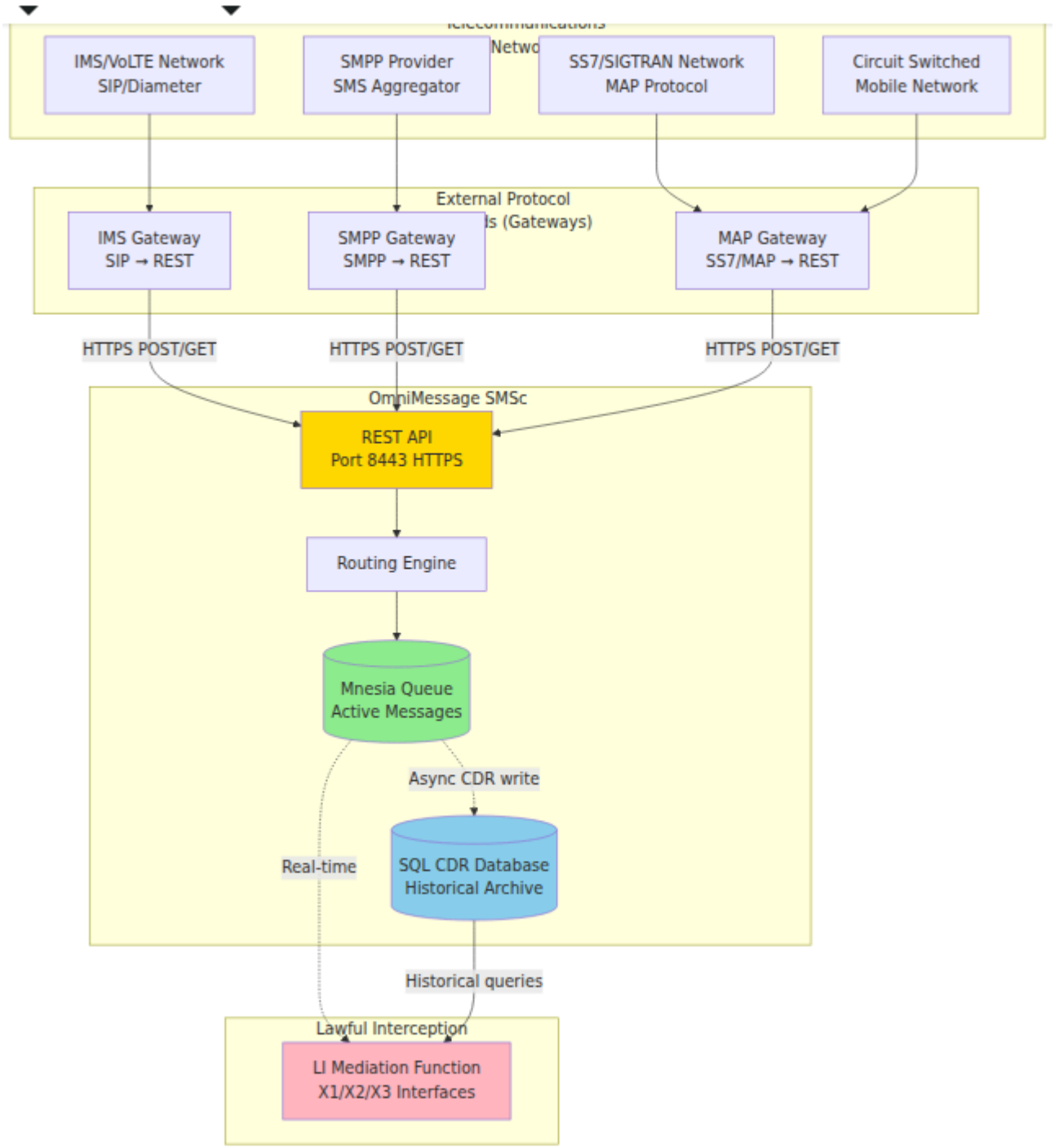
**Architecture Overview**




## Frontend Protocol Integration Details

### 1. IMS/SIP Frontend Integration

IMS networks use SIP protocol for SMS-over-IP messaging. The IMS gateway translates between SIP and the SMSc REST API.

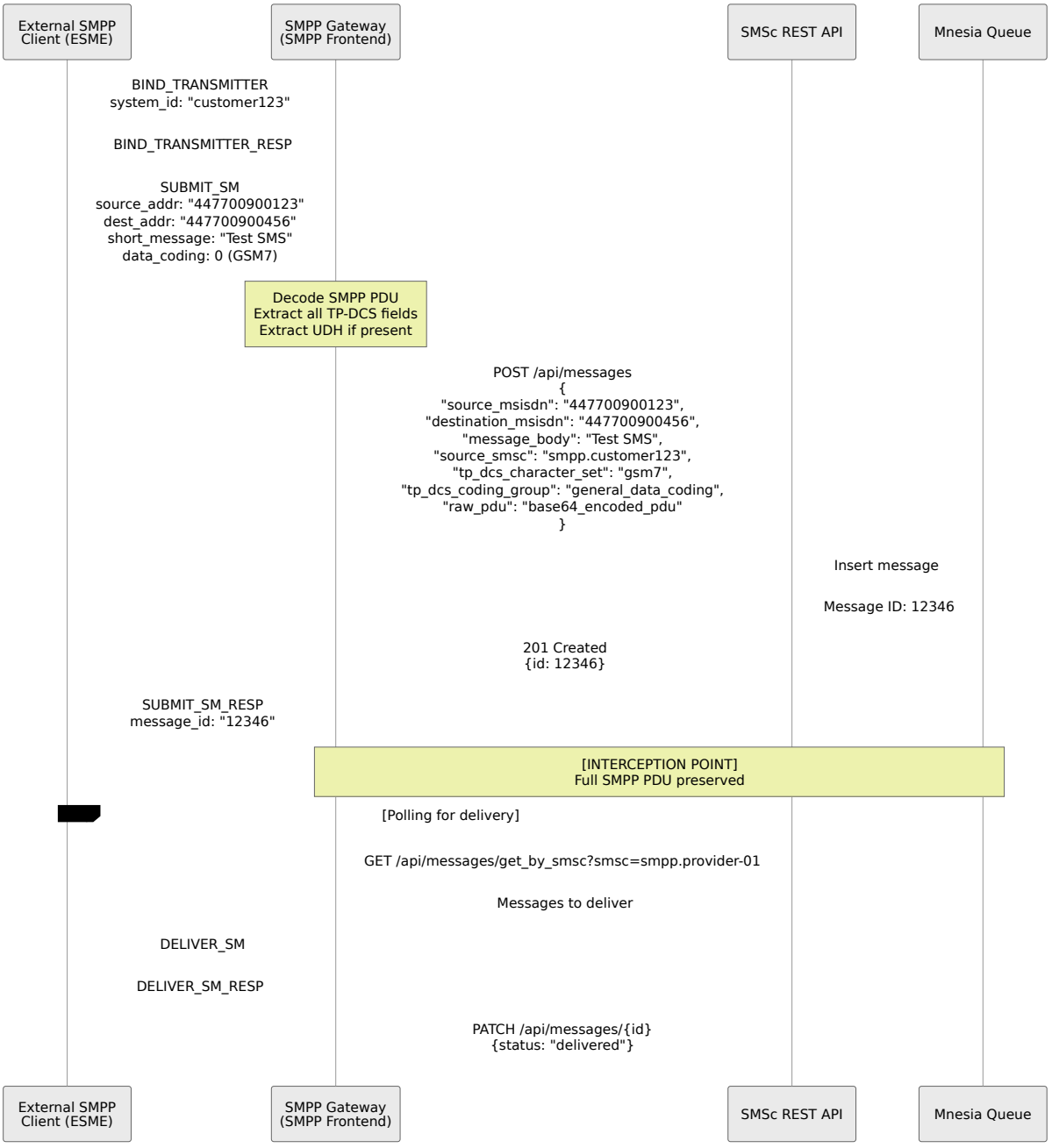



**IMS-Specific Interception Data:**

- Source/Destination IMSI (from IMS registration)
- P-Asserted-Identity SIP headers
- SIP Call-ID for correlation
- IMS network location (P-Access-Network-Info)
- Subscriber profiles from IMS HSS

**2. SMPP Frontend Integration**

SMPP is the industry-standard protocol for SMS aggregators and service providers. The SMPP gateway translates PDU-based SMPP messages to REST API calls.



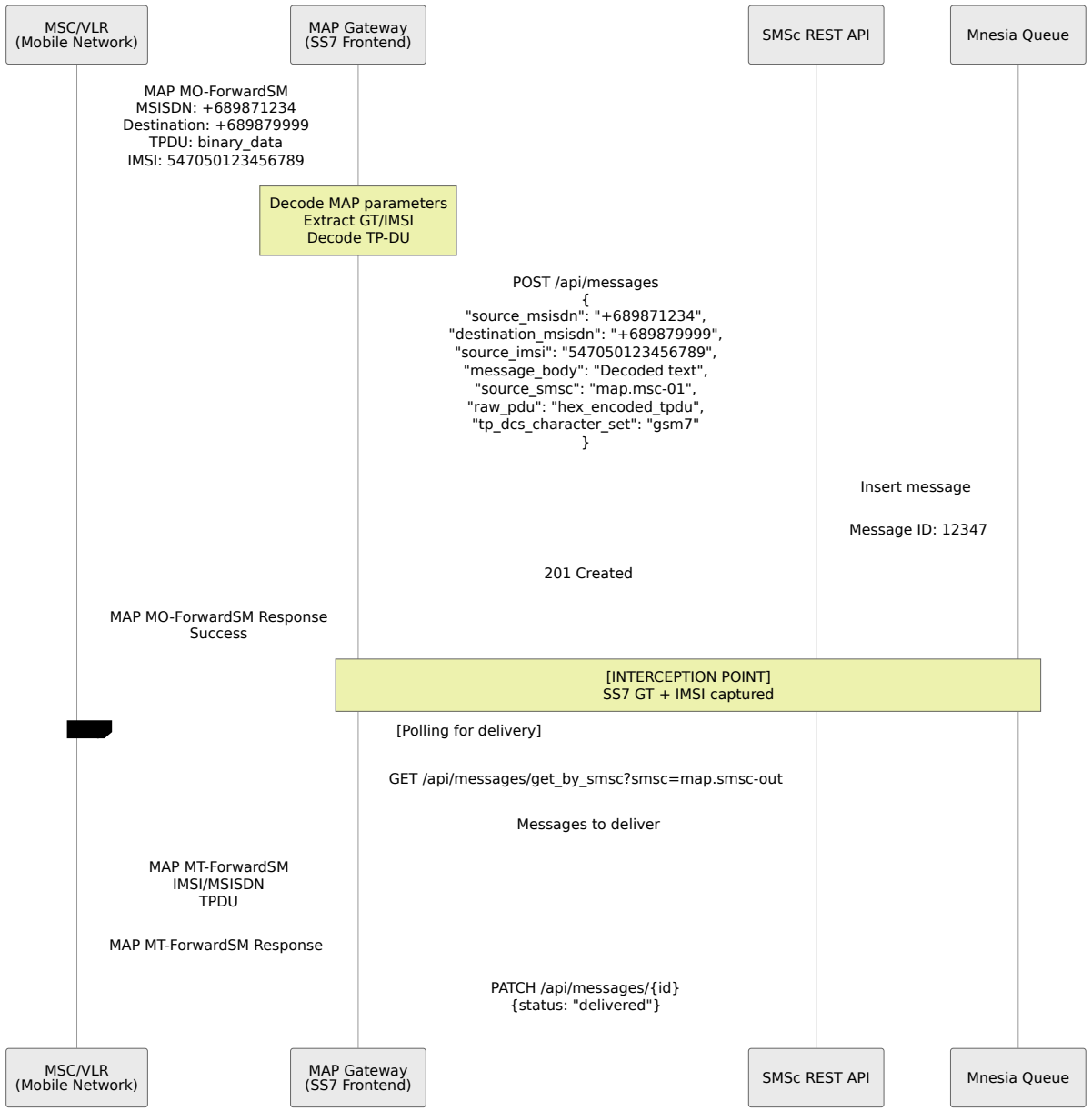

## SMPP-Specific Interception Data:

- Complete SMPP PDU (binary format preserved)
- Data Coding Scheme (DCS) details
- User Data Header (UDH) for concatenated messages
- ESME system_id (customer identification)
- TON/NPI numbering plan information

- Registered delivery flags

## 3. SS7/MAP Frontend Integration

Legacy circuit-switched networks use SS7 MAP protocol for SMS. The MAP gateway translates between SS7 signaling and REST API.




## SS7/MAP-Specific Interception Data:

- IMSI from MAP messages
- Global Title (GT) addresses
- MSC/VLR address (network element identification)
- SCCP calling/called party addresses

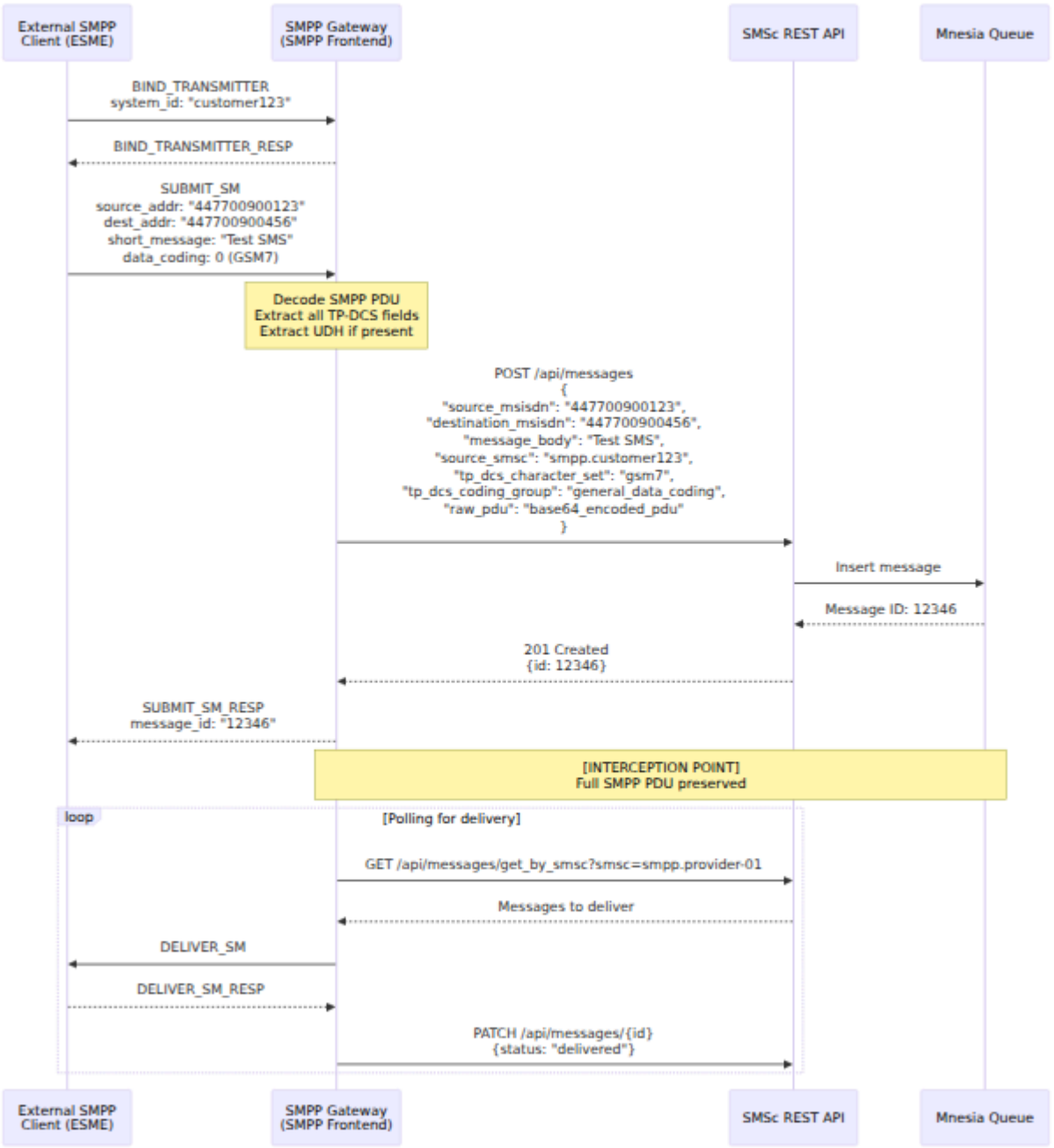
- MAP operation codes
- TP-User-Data binary format

**Unified Interception Across All Protocols**

**Key Benefit for Lawful Interception:** Regardless of which protocol was used (IMS/SIP, SMPP, or SS7/MAP), all messages converge in the SMSc core with normalized data structure, enabling:

1. **Protocol-Agnostic Monitoring:** Single interception point captures all message types
2. **Unified CDR Format:** All protocols write to same CDR schema
3. **Cross-Protocol Correlation:** Track messages across protocol boundaries
4. **Complete Metadata Preservation:** Protocol-specific fields preserved in CDR

**Data Flow Summary:**




**Protocol Identification in CDR:**

- `source_smsc` field indicates frontend protocol (e.g., "ims.gateway-01", "smpp.customer123", "map.msc-01")
- Enables filtering and analysis by protocol type
- Lawful interception queries can target specific protocols or all protocols

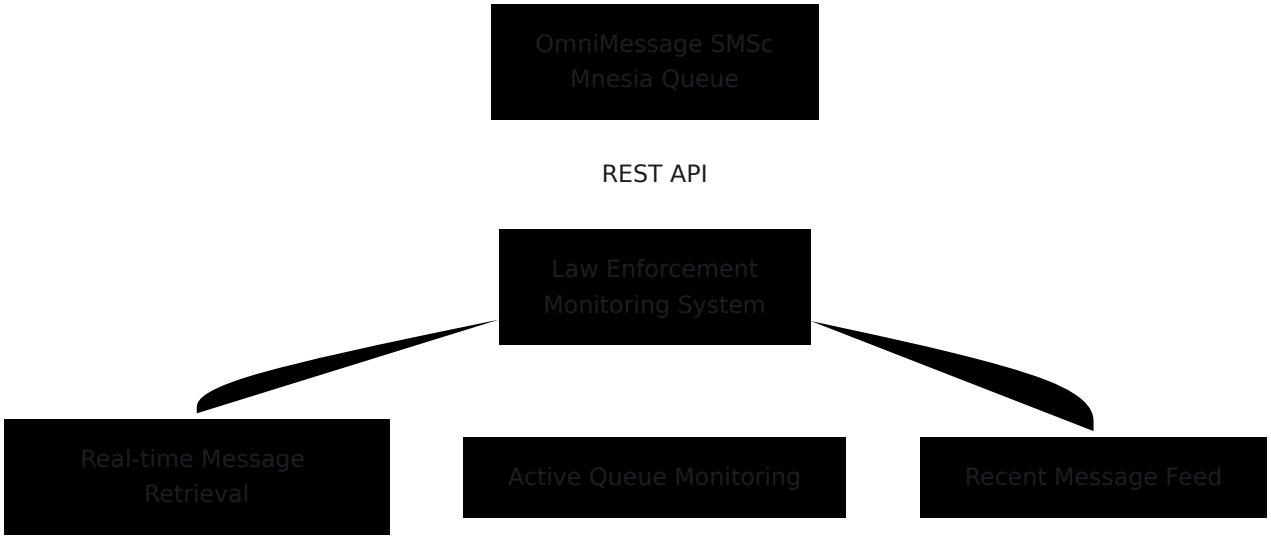
# 1.6 Technical Architecture for Lawful Interception

### Lawful Interception Integration Points

The two-tier storage architecture provides multiple access points for lawful interception, optimized for both real-time monitoring (Mnesia) and historical analysis (SQL).

### 1. REST API Access for Recent Messages (Mnesia):

Access to active messages in the Mnesia queue (typically last 24 hours):




**API Endpoints for Real-Time Interception:**

- `GET /api/messages` - List active messages with filtering
- `GET /api/messages/{id}` - Get specific message details (from Mnesia)
- `GET /api/messages/get_by_smsc?smsc=X` - Get messages by gateway
- All queries hit Mnesia (in-memory) for instant response

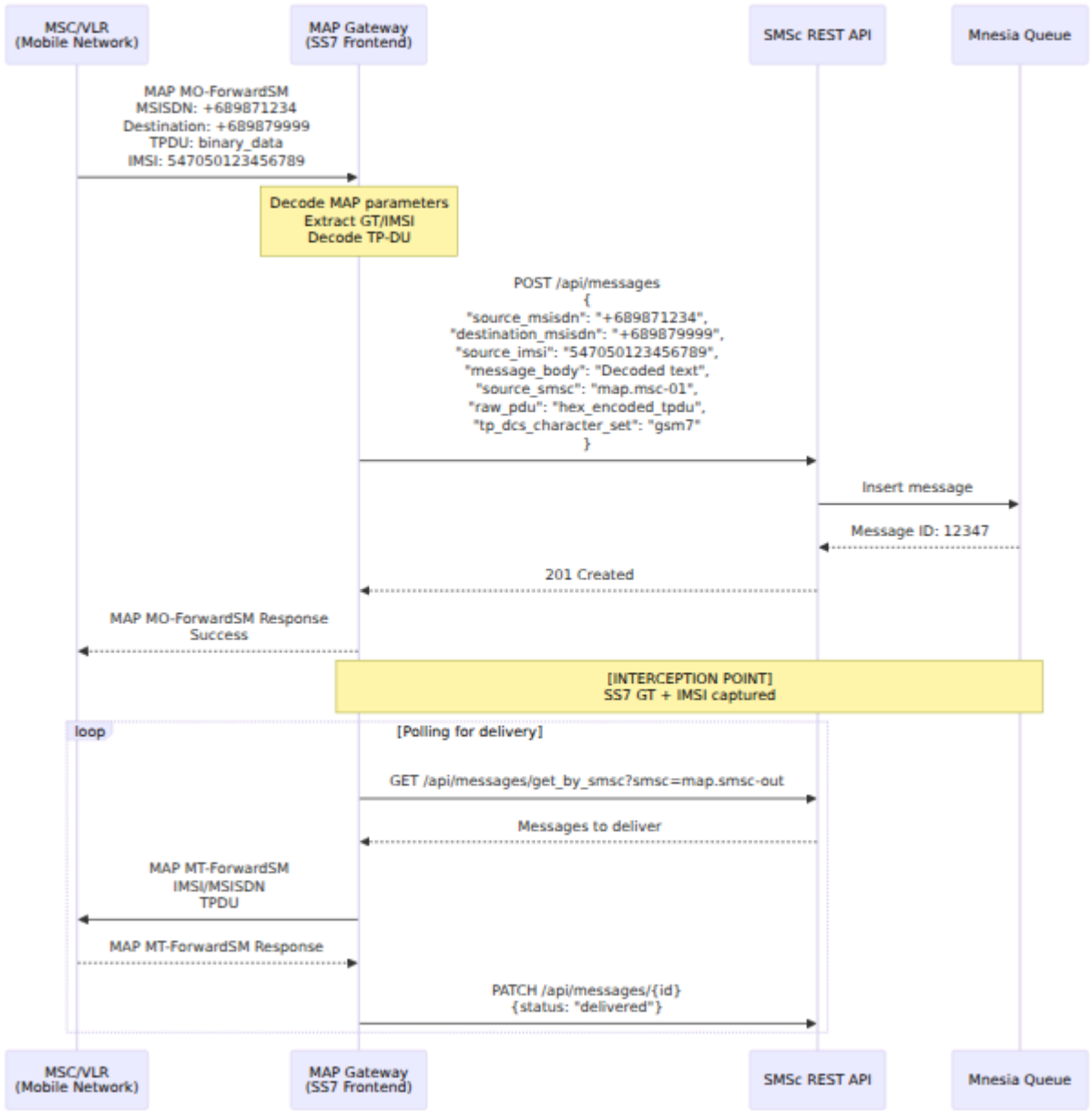
**Note:** These endpoints query the active Mnesia message queue, providing access to messages currently being processed or recently delivered (within retention period).

**Query Parameters:**

- Filter by source/destination MSISDN
- Filter by time range
- Filter by SMSC gateway
- Filter by message status
- Sort and pagination support

### 2. CDR Database Direct Access for Historical Messages (SQL):

Access to archived messages in the SQL database (all delivered/expired/failed messages):




**Direct SQL Access:**

- Read-only database credentials for authorized systems
- SQL query access to `cdrs` table (permanent audit trail)
- **Access Method:** Standard SQL client (mysql, psql, DBeaver, etc.)
- **Data Source:** Only archived messages (not active queue)
- Indexed fields for efficient searching:
  - `calling_number` (indexed) - Source phone number

- `called_number` (indexed) - Destination phone number
- `message_id` (indexed) - Unique message identifier
- `submission_time` (indexed) - When message entered system
- `status` (indexed) - Final delivery status
- `dest_smsc` (indexed) - Gateway used for delivery

**Note:** CDR database contains permanent records of all processed messages. This is the primary data source for historical lawful interception queries (months/years of data).

**3. Real-Time Message Feed (PubSub):**

- Phoenix PubSub integration for real-time events
- Message submission notifications
- Message delivery notifications
- Message status change events
- Configurable event filtering by criteria
- WebSocket support for live monitoring

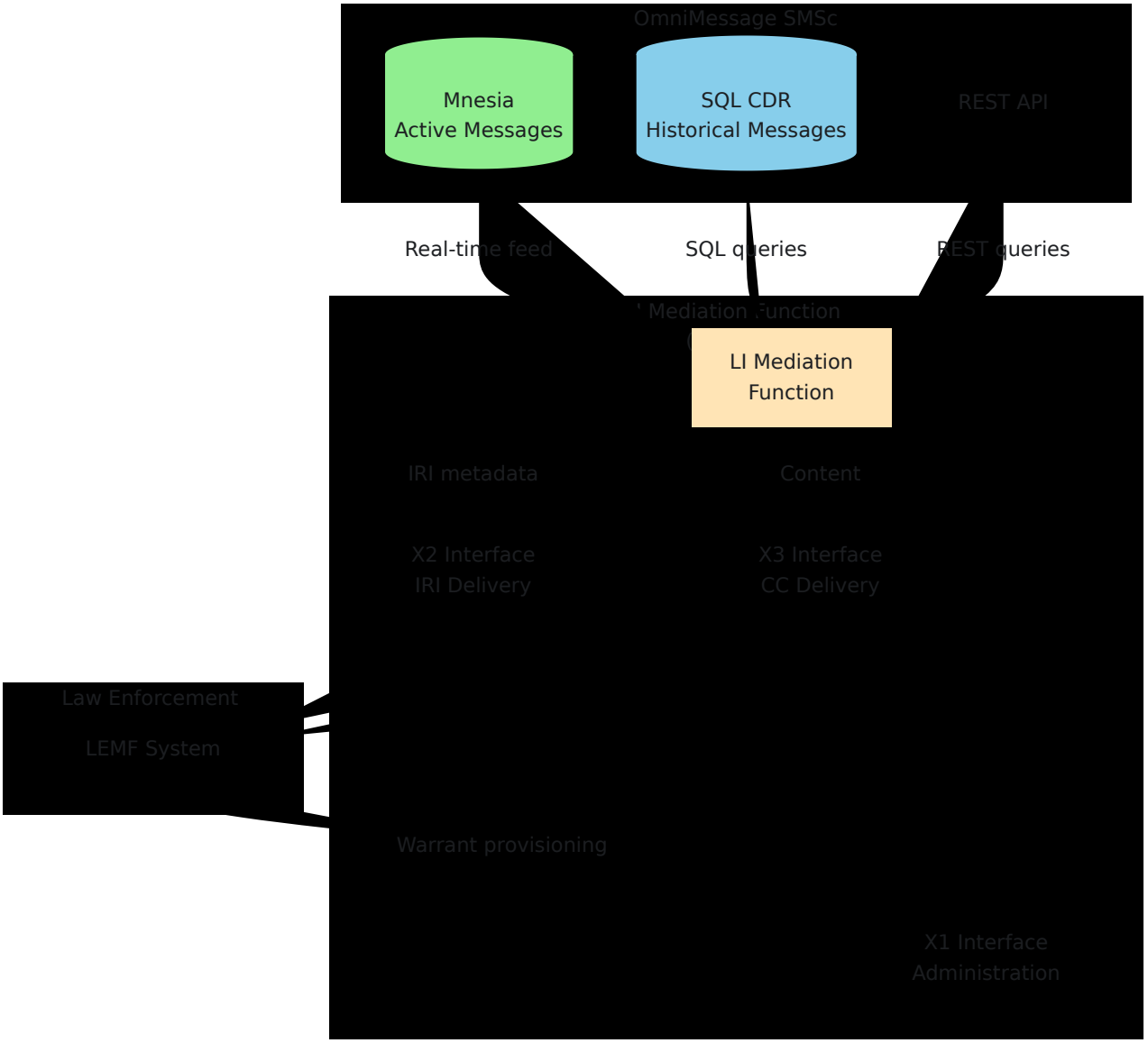
**4. Batch Export Interface:**

- CSV export of CDR records
- JSON export for programmatic access
- Configurable export fields
- Time-range based exports
- Privacy-aware exports (optional message body exclusion)

**ETSI Lawful Interception Standard Interfaces**

The OmniMessage SMSc provides the foundation for implementing ETSI-compliant lawful interception interfaces. While the SMSc core does not natively implement X1/X2/X3 interfaces, it provides all necessary data access points that can be integrated with external Lawful Interception Mediation Function (LIMF) systems.

**Standard ETSI LI Interfaces:**




**Interface Descriptions:**

**X1 Interface - Administration Function:**

- **Purpose:** Warrant and target provisioning from law enforcement to interception system
- **Direction:** LEMF → LIMF (bidirectional)
- **Functions:**
  - Activate/deactivate interception for specific targets (MSISDNs, IMSIs)
  - Set interception duration and validity period
  - Configure filtering criteria (phone numbers, time windows)
  - Retrieve interception status
- **Integration with SMSc:**
  - LIMF maintains target list (warrant database)

    - LIMF queries SMSc CDR/API for matching messages
    - LIMF filters based on X1 provisioned criteria

**X2 Interface - IRI (Intercept Related Information) Delivery:**

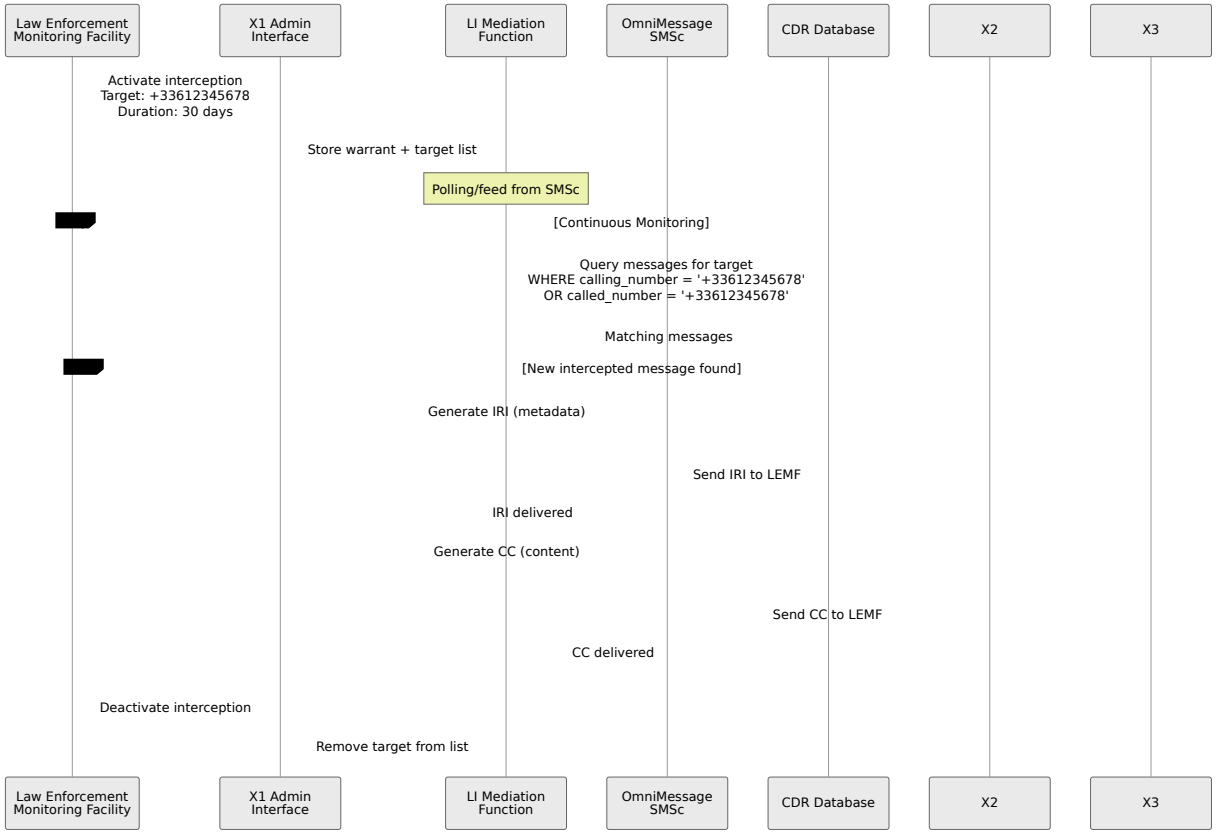
- **Purpose:** Deliver message metadata to law enforcement
- **Direction:** LIMF → LEMF (one-way)
- **Data Format:** ETSI TS 102 232-x compliant XML/ASN.1
- **Content from SMSc CDR:**
    - Message ID
    - Calling number (source MSISDN)
    - Called number (destination MSISDN)
    - IMSI (source and destination, if available)
    - Submission timestamp
    - Delivery timestamp
    - Message status (delivered/failed/expired)
    - Delivery attempts
    - SMSC gateway information (source/destination)
    - Network location (if available)
- **Integration with SMSc:**
    - LIMF queries CDR database for target phone numbers
    - LIMF transforms CDR records into ETSI IRI format
    - LIMF delivers IRI to LEMF via X2

**X3 Interface - CC (Content of Communication) Delivery:**

- **Purpose:** Deliver actual message content to law enforcement
- **Direction:** LIMF → LEMF (one-way)
- **Data Format:** ETSI TS 102 232-x compliant
- **Content from SMSc:**
    - Message body (text content)
    - Raw PDU (binary SMS data)
    - Character encoding information
    - Multipart message segments
    - TP-DCS information

    - User Data Header (UDH)
- **Integration with SMSc:**
    - LIMF retrieves message content from CDR `message_body` field
    - LIMF retrieves raw PDU data if available
    - LIMF packages content in ETSI CC format
    - LIMF delivers CC to LEMF via X3

## Implementation Architecture:




## SMSc Data Mapping to LI Interfaces:

| SMSc Data Field | X2 (IRI) | X3 (CC) | CDR Table Column |
|---|---|---|---|
| Message ID | □ Correlation ID | □ Reference | `message_id` |
| Calling Number | □ Party A | - | `calling_number` |
| Called Number | □ Party B | - | `called_number` |
| Submission Time | □ Timestamp | - | `submission_time` |
| Delivery Time | □ Completion | - | `delivery_time` |
| Status | □ Result | - | `status` |
| Message Body | - | □ Content | `message_body` |
| Raw PDU | - | □ Binary | (Mnesia/CDR) |
| Source SMSC | □ Network element | - | `source_smsc` |
| Dest SMSC | □ Network element | - | `dest_smsc` |
| IMSI | □ Subscriber ID | - | (Via frontends) |

**LIMF Integration Options:**

**Option 1: Polling Architecture**

- LIMF periodically queries CDR database (every 1-60 seconds)
- SQL query filters by target phone numbers from X1 warrant list
- Low complexity, easy to implement
- Slight delay between message delivery and LI delivery

**Option 2: Real-Time Feed Architecture**

- SMSc PubSub publishes message events
- LIMF subscribes to real-time message stream
- LIMF filters based on target list
- Near-zero latency for lawful interception
- Requires custom integration development

**Option 3: Hybrid Architecture**

- Recent messages: Real-time PubSub feed (< 24 hours)
- Historical messages: CDR database polling
- Optimal balance of latency and reliability

**Interception Triggering Mechanisms**

**Target-Based Interception:**

- Phone number matching (MSISDN)
- IMSI-based targeting (when available)
- Configurable watch lists
- Database views for target isolation
- API filtering by target identifiers

**Event-Based Interception:**

- All messages to/from specific numbers
- Messages via specific SMSC gateways
- Messages with specific characteristics (multi-part, failed delivery, etc.)
- Geographic routing (via ENUM or prefix matching)

**Time-Based Interception:**

- Date/time range filtering in CDR queries
- Retention period enforcement
- Automatic archival of old messages
- Configurable data retention policies

**Example SQL Queries for Lawful Interception:**

```sql
-- Get all messages for target number
SELECT * FROM cdrs
WHERE calling_number = '+33612345678'
   OR called_number = '+33612345678'
ORDER BY submission_time DESC;

-- Get messages in specific time window
SELECT * FROM cdrs
WHERE (calling_number = '+33612345678' OR called_number =
'+33612345678')
  AND submission_time BETWEEN '2025-11-01 00:00:00' AND '2025-11-
30 23:59:59'
ORDER BY submission_time;

-- Get conversation between two parties
SELECT * FROM cdrs
WHERE (calling_number = '+33612345678' AND called_number =
'+33687654321')
   OR (calling_number = '+33687654321' AND called_number =
'+33612345678')
ORDER BY submission_time;
```

---

# 2. ENCRYPTION AND CRYPTANALYSIS CAPABILITIES

## 2.1 Cryptographic Capabilities Overview

The OmniMessage SMSc implements cryptographic mechanisms for securing communications and protecting sensitive data. This section documents all cryptographic capabilities in accordance with ANSSI requirements.

## 2.2 Transport Layer Encryption

### 2.2.1 TLS/SSL Implementation

**Supported Protocols:**

- TLS 1.2 (RFC 5246)
- TLS 1.3 (RFC 8446) - Recommended
- SSL 2.0/3.0: NOT SUPPORTED (known vulnerabilities)
- TLS 1.0/1.1: DEPRECATED (not recommended)

**Implementation:**

- Erlang/OTP SSL/TLS library (cryptographically validated)
- Cowboy web server with TLS support
- Phoenix Framework HTTPS endpoints

**Cipher Suites:**

The system uses Erlang/OTP's default secure cipher suite selection, which includes:

**Preferred - TLS 1.3:**

- TLS_AES_256_GCM_SHA384
- TLS_AES_128_GCM_SHA256
- TLS_CHACHA20_POLY1305_SHA256

**Supported - TLS 1.2:**

- ECDHE-RSA-AES256-GCM-SHA384
- ECDHE-RSA-AES128-GCM-SHA256
- DHE-RSA-AES256-GCM-SHA384
- DHE-RSA-AES128-GCM-SHA256

**Security Features:**

- Perfect Forward Secrecy (PFS) via ECDHE/DHE key exchange
- Strong Diffie-Hellman groups (2048-bit minimum)
- Elliptic Curve Cryptography support
- Server Name Indication (SNI) support

**Certificate Management:**

- X.509 certificate support
- RSA key sizes: 2048-bit minimum, 4096-bit recommended
- ECDSA support
- Certificate chain validation
- Self-signed certificates (development only)
- External CA integration

**TLS Configuration Location:**

```
# config/runtime.exs
config :api_ex,
  api: %{
    enable_tls: true,
    tls_cert_path: "priv/cert/omnitouch.crt",
    tls_key_path: "priv/cert/omnitouch.pem"
  }
```

 **Complete configuration reference in CONFIGURATION.md**

**Applications:**

- HTTPS for REST API (port 8443)
- HTTPS for web control panel (port 8086)
- Database connections (MySQL/PostgreSQL over TLS)

# 2.3 Data Encryption at Rest

### 2.3.1 Database Encryption

**MySQL/MariaDB Encryption:**

- Table-level encryption support
- AES-256 encryption algorithm
- Transparent data encryption (TDE)

```
-- Enable encryption for CDR table
ALTER TABLE cdrs ENCRYPTION='Y';
```

**PostgreSQL Encryption:**

- Transparent data encryption support
- Filesystem-level encryption
- Column-level encryption (pgcrypto extension)

### 2.3.2 Mnesia Disc Storage

**Mnesia Database:**

- Disc copies storage for message persistence
- File system-level encryption recommended (LUKS, dm-crypt)
- Memory protection via Erlang VM isolation

### 2.3.3 File System Encryption

**Sensitive Data Storage:**

- Configuration files: Filesystem encryption recommended
- Private keys: File permissions (0600) + filesystem encryption
- Log files: Configurable encryption for archived logs
- CDR exports: Encrypted storage for sensitive exports

**Key Storage:**

- TLS certificates and keys stored in `priv/cert/`
- File-based keystores with restricted permissions
- Secure key rotation procedures

## 2.4 Authentication and Access Control

### 2.4.1 API Authentication

**REST API Security:**

- HTTPS/TLS transport encryption mandatory
- Header-based authentication (SMSc header for frontend identification)
- IP-based access control (firewall level)
- Certificate-based client authentication (optional)

**Frontend Registration:**

- Unique frontend identification (name, type, IP, hostname)
- Heartbeat-based authentication
- Expiration-based session management (90-second timeout)
- Frontend tracking and monitoring

### 2.4.2 Database Authentication

**Database Access Control:**

- Username/password authentication
- TLS/SSL connection support
- IP-based connection restrictions
- Role-based access control (RBAC)

**Configuration:**

```
# config/runtime.exs
config :sms_c, SmsC.Repo,
  username: "omnitouch",
  password: "omnitouch2024",  # Should use strong passwords in
production
  hostname: "localhost",
  ssl: true  # Enable TLS for database connections
```

**Access Control Recommendations:**

```
-- Create read-only user for law enforcement access
CREATE USER 'li_readonly'@'%' IDENTIFIED BY 'secure_password';
GRANT SELECT ON sms_c.cdrs TO 'li_readonly'@'%';

-- Create limited user without message body access
CREATE USER 'analytics'@'%' IDENTIFIED BY 'secure_password';
GRANT SELECT (id, message_id, calling_number, called_number,
              source_smsc, dest_smsc, submission_time,
delivery_time,
              status, delivery_attempts)
ON sms_c.cdrs TO 'analytics'@'%';
```

## 2.5 Cryptographic Algorithm Details

### 2.5.1 Hashing Algorithms

**Available in Erlang/OTP:**

- SHA-256, SHA-384, SHA-512 (recommended)
- SHA-1 (deprecated, legacy compatibility only)
- MD5 (deprecated, not used for security)
- BLAKE2 (available in modern OTP versions)

**Usage:**

- Message fingerprinting (duplicate detection)
- Data integrity verification
- Audit log integrity

### 2.5.2 Symmetric Encryption

**Available Algorithms:**

- AES (Advanced Encryption Standard)
  - AES-128-GCM
  - AES-256-GCM
  - AES-128-CBC
  - AES-256-CBC

- ChaCha20-Poly1305

**Key Sizes:**

- 128-bit (minimum)
- 256-bit (recommended)

**Usage:**

- TLS session encryption
- Database encryption at rest
- Optional message body encryption

### 2.5.3 Asymmetric Encryption

**Supported Algorithms:**

- RSA (2048-bit minimum, 4096-bit recommended)
- ECDSA (Elliptic Curve Digital Signature Algorithm)
  - P-256, P-384, P-521 curves
- Ed25519 (EdDSA)

**Usage:**

- TLS certificate authentication
- Digital signatures
- Key exchange

# 2.6 SMS Protocol Security

### 2.6.1 SMS Message Encoding

**Character Encoding Support:**

- GSM 7-bit (standard SMS encoding)
- UCS-2 (Unicode, 16-bit)
- 8-bit binary data
- Latin-1

**TP-DCS (Data Coding Scheme):**

- Message class indication
- Compression flags
- Coding group specification
- Character set identification

**No Native SMS Encryption:**

- SMS protocol does not provide end-to-end encryption
- Message content accessible at SMSc level
- Enables lawful interception as required

### 2.6.2 Protocol Security Considerations

**SMPP Protocol (External Frontend):**

- Username/password authentication at SMPP level
- TLS support available (SMPP over TLS)
- Bind authentication

**IMS Protocol (External Frontend):**

- SIP-based messaging
- SIP authentication mechanisms
- Integration with IMS core network security

**SS7/MAP Protocol (External Frontend):**

- SS7 network security
- MAP protocol authentication
- SCCP/TCAP layer security

**Note:** Protocol-specific security is implemented in external frontend gateways, not in the SMSc core.

# 2.7 Cryptanalysis and Security Assessment Capabilities

### 2.7.1 Protocol Analysis Tools

**Built-in Debugging Capabilities:**

- Comprehensive logging system
- Message flow tracing
- API request/response logging
- Database query logging
- Error and exception tracking

**External Integration:**

- Standard logging output (stdout/files)
- PCAP capture support for network analysis
- Database query logging for forensics
- Prometheus metrics export

### 2.7.2 Vulnerability Assessment Considerations

**Known Limitations:**

- SMS protocol inherently unencrypted (by design, enables lawful interception)
- Database credentials in configuration files (should use secrets management)
- Self-signed certificate support (development/testing only)

**Security Hardening Recommendations:**

- Use strong TLS cipher suites
- Implement database connection encryption
- Use external secrets management (Vault, AWS Secrets Manager)
- Regular security updates for Erlang/OTP and dependencies
- Firewall restrictions on API ports

- IP whitelisting for frontend access

**Security Testing:**

- Regular dependency vulnerability scanning
- Penetration testing support
- TLS configuration validation
- Database security audits
- Access control review

# 2.8 Key Management Infrastructure

### 2.8.1 Key Generation

**TLS Certificate Generation:**

```
# Generate private key (RSA 4096-bit)
openssl genrsa -out omnitouch.pem 4096

# Generate certificate signing request
openssl req -new -key omnitouch.pem -out omnitouch.csr

# Self-signed certificate (development)
openssl x509 -req -days 365 -in omnitouch.csr -signkey
omnitouch.pem -out omnitouch.crt

# Production: Obtain certificate from trusted CA
```

**Random Number Generation:**

- Erlang/OTP CSPRNG (Cryptographically Secure Pseudo-Random Number Generator)
- System entropy pool (/dev/urandom)
- Strong randomness for session keys, IDs, tokens

### 2.8.2 Key Storage and Protection

**Private Key Storage:**

- File system with restricted permissions (0600)
- Stored in `priv/cert/` directory
- PEM format (optionally encrypted)
- Secure backup procedures

**Key Rotation:**

- TLS certificate renewal (annually recommended)
- Database credential rotation
- API token rotation (if implemented)

### 2.8.3 Key Distribution

**Certificate Distribution:**

- Manual installation in `priv/cert/`
- Configuration file references
- ACME protocol support possible (Let's Encrypt)

**Symmetric Key Distribution:**

- Out-of-band key exchange for database credentials
- Diffie-Hellman key agreement in TLS
- No cleartext key transmission

## 2.9 Compliance and Standards

This section documents compliance with international telecommunications standards, regulatory frameworks, and security specifications applicable to SMS processing across all supported protocols.

### 2.9.1 SMS over SS7/MAP Protocol Compliance

**3GPP and ETSI Standards:**

- **3GPP TS 23.040:** Technical realization of Short Message Service (SMS) - Core SMS protocol specification

- **3GPP TS 23.038:** Alphabets and language-specific information - Character encoding (GSM7, UCS-2)
- **3GPP TS 29.002:** Mobile Application Part (MAP) specification - SS7 signaling for SMS
- **3GPP TS 23.003:** Numbering, addressing and identification - MSISDN, IMSI formats
- **ETSI TS 100 901:** Point-to-Point Short Message Service specification
- **ETSI TS 100 902:** Cell Broadcast Short Message Service specification

**SS7 Signaling Standards:**

- **ITU-T Q.711-Q.716:** Signaling Connection Control Part (SCCP)
- **ITU-T Q.771-Q.775:** Transaction Capabilities Application Part (TCAP)
- **ITU-T Q.701-Q.710:** Message Transfer Part (MTP) Levels 1-3
- **ETSI EN 300 356:** Signaling System No.7 - ISDN User Part (ISUP)

**Security Standards for SS7/MAP:**

- **GSMA FS.07:** SS7 and Diameter Signaling Security - Baseline security controls
- **GSMA FS.11:** SS7 Security Monitoring Guidelines
- **3GPP TS 33.117:** Catalogue of general security assurance requirements
- **ETSI TS 133 210:** Network domain security - IP network layer security

**Lawful Interception for SS7/MAP:**

- **ETSI TS 101 671:** Lawful Interception (LI); Handover interface for the lawful interception of telecommunications traffic
- **ETSI TS 102 232-1:** Lawful Interception (LI); Handover specification - Part 1: Handover interface for LI management
- **3GPP TS 33.107:** Lawful Interception architecture and functions for 3G networks

### 2.9.2 SMS over IMS Protocol Compliance

**3GPP IMS Standards:**

- **3GPP TS 23.228:** IP Multimedia Subsystem (IMS) - Stage 2 architecture

- **3GPP TS 24.229:** IP Multimedia Call Control Protocol - SIP and SDP procedures
- **3GPP TS 24.341:** Support of SMS over IP networks - Stage 3 specification
- **3GPP TS 23.204:** Support of Short Message Service (SMS) over generic 3GPP IP access - Stage 2
- **3GPP TS 29.228:** IP Multimedia (IM) Subsystem Cx and Dx interfaces

**IMS Security Standards:**

- **3GPP TS 33.203:** 3G security; Access security for IP-based services (IMS AKA)
- **3GPP TS 33.210:** 3G security; Network Domain Security (NDS); IP network layer security (IPsec)
- **3GPP TS 33.310:** Network Domain Security (NDS); Authentication Framework (AF)
- **ETSI TS 133 203:** Access security for IP-based services

**SIP Protocol Standards:**

- **RFC 3261:** SIP: Session Initiation Protocol - Core specification
- **RFC 3428:** SIP Extension for Instant Messaging - MESSAGE method
- **RFC 3325:** Private Extensions to SIP for Asserted Identity
- **RFC 5765:** Security Issues and Solutions in Peer-to-Peer Systems

**Lawful Interception for IMS:**

- **ETSI TS 102 232-5:** Lawful Interception (LI); Handover specification - Part 5: Service-independent LI for IP Multimedia Subsystem services
- **3GPP TS 33.107:** Lawful Interception requirements and architecture
- **3GPP TS 33.108:** Handover interface for Lawful Interception (LI)

### 2.9.3 SMPP Protocol Compliance

**SMPP Specification:**

- **SMPP v3.4:** Short Message Peer-to-Peer Protocol Specification - Industry standard
- **SMPP v5.0:** Extended SMPP protocol with enhanced features

**SMPP Security Guidelines:**

- **TLS over SMPP:** Transport layer security for SMPP connections (SMPP over TLS)
- **SMPP Bind Authentication:** System ID and password authentication
- **IP-based Access Control:** Network-level restrictions for SMPP connections

**Interoperability Standards:**

- **GSM 03.40 (ETSI TS 100 901):** Technical realization of SMS Point-to-Point (PP)
- **GSM 03.38 (ETSI TS 100 900):** Alphabets and language-specific information
- **GSM 04.11 (ETSI TS 100 942):** Point-to-Point SMS support on mobile radio interface

**Message Encoding Compliance:**

- **ITU-T T.50:** International Alphabet No. 5 (IA5)
- **ISO/IEC 8859-1:** Latin-1 character encoding
- **ISO/IEC 10646:** Universal Character Set (UCS-2/UTF-16)

### 2.9.4 Cryptographic Standards Compliance

**TLS and Network Security:**

- **NIST SP 800-52:** Guidelines for the Selection, Configuration, and Use of TLS Implementations
- **NIST SP 800-131A:** Transitioning the Use of Cryptographic Algorithms and Key Lengths
- **RFC 7525:** Recommendations for Secure Use of TLS and DTLS
- **RFC 8446:** The Transport Layer Security (TLS) Protocol Version 1.3

**Cryptographic Algorithm Standards:**

- **FIPS 197:** Advanced Encryption Standard (AES)
- **FIPS 180-4:** Secure Hash Standard (SHA-2 family)

- **NIST SP 800-38D:** Recommendation for Block Cipher Modes of Operation: GCM Mode
- **RFC 7539:** ChaCha20 and Poly1305 for IETF Protocols

**Key Management:**

- **NIST SP 800-57:** Recommendation for Key Management
- **RFC 5280:** Internet X.509 Public Key Infrastructure Certificate and CRL Profile

# 2.10 Cryptanalysis Resistance

### 2.10.1 Design Principles

**Defense Against Cryptanalysis:**

- No custom/proprietary cryptographic algorithms
- Industry-standard, peer-reviewed algorithms only
- Regular security updates for cryptographic libraries
- Deprecation of weak algorithms
- Use of authenticated encryption (GCM, Poly1305)

### 2.10.2 Operational Security

**Key Rotation:**

- TLS certificate renewal procedures
- Session key rotation (per-session for TLS)
- Database credential rotation policies

**Monitoring and Detection:**

- Failed authentication logging
- Certificate expiration monitoring
- TLS handshake failure logging
- Anomaly detection for encryption failures
- Security event alerting

---

# 3. INTERCEPTION CONTROL AND AUTHORIZATION

## 3.1 Access Control for Lawful Interception

**Administrative Authorization:**

- System administrator access required for configuration
- Database-level access controls for CDR queries
- API access restricted by IP/authentication
- Audit logging of all access

**Legal Framework Integration:**

- Interception warrant tracking (external system integration)
- Target identifier authorization lists (database views)
- Time-limited queries (SQL WHERE clauses)
- Automatic enforcement via access policies

## 3.2 Data Retention and Privacy

**Retention Policies:**

- Active message retention: Configurable (default 24 hours in Mnesia)
- CDR retention: Configurable (typical 6 months to 2 years)
- Automatic archival from Mnesia to SQL
- Automatic purging of old CDRs (cron-based)

**Privacy Protections:**

- Message body deletion option after delivery
- Message body exclusion from UI/exports
- Database encryption at rest
- Access logging and monitoring
- Minimal data collection principle

**Configuration:**

```
# config/runtime.exs
config :sms_c,
  # Mnesia message retention before archival
  message_retention_hours: 24,

  # Delete message body after delivery for privacy
  delete_message_body_after_delivery: false,  # Set true for
privacy mode

  # CDR writing control
  cdr_enabled: true,

  # Batch archival settings
  batch_insert_batch_size: 100,
  batch_insert_flush_interval_ms: 100
```

 **See CONFIGURATION.md for all retention settings**

## 3.3 Handover Interfaces for Law Enforcement

**Standard Interfaces:**

**1. REST API Access:**

- HTTPS endpoints for message retrieval
- JSON format data exchange
- Authentication and authorization
- Query filtering by target criteria

**2. Direct Database Access:**

- Read-only SQL credentials
- Standard SQL queries
- CDR table access
- Indexed search capabilities

**3. Batch Export:**

- CSV export format
- JSON export format
- Time-range based exports
- Configurable field selection

**Delivery Formats:**

**IRI (Intercept Related Information):**

- CDR metadata fields:
  - Message ID
  - Calling/called numbers
  - Timestamps (submission, delivery, expiry)
  - Status
  - Delivery attempts
  - SMSC routing information
  - Node information (cluster tracking)

**CC (Content of Communication):**

- Message body (text content)
- Raw PDU data
- Encoding information
- Multipart message assembly

**Export Example:**

```
# CSV export for law enforcement
mysql -u li_readonly -p -D sms_c -e "
SELECT
  message_id,
  calling_number,
  called_number,
  message_body,
  submission_time,
  delivery_time,
  status
FROM cdrs
WHERE (calling_number = '+33612345678' OR called_number =
'+33612345678')
  AND submission_time BETWEEN '2025-11-01' AND '2025-11-30'
ORDER BY submission_time
" --batch --silent | sed 's/\t/,/g' > interception_report.csv
```

---

# 4. SYSTEM SECURITY AND INTEGRITY

## 4.1 Application Security

**Elixir/Erlang Security:**

- Erlang VM isolation and sandboxing
- Process isolation and supervision
- Crash recovery and fault tolerance
- No buffer overflow vulnerabilities (managed runtime)

**Dependency Management:**

- Dependency version locking (mix.lock)
- Security vulnerability scanning
- Regular dependency updates
- Minimal dependency footprint

## 4.2 Network Security

**Network Exposure:**

- Minimal exposed ports:
  - 8443 (HTTPS REST API)
  - 8086 (HTTPS Control Panel)
- Firewall configuration recommended
- IP whitelisting for frontend access
- DMZ deployment for internet-facing services

**Network Segmentation:**

- Separate management network
- Isolated database network
- Frontend gateway network separation
- Cluster communication network (Erlang distribution)

## 4.3 Monitoring and Intrusion Detection

**Logging Capabilities:**

- Structured application logging
- Configurable log levels
- Log rotation and archival
- Syslog integration support
- Centralized logging (ELK stack compatible)

**Security Event Monitoring:**

- Failed authentication attempts
- Unusual message patterns
- Database connection failures
- TLS handshake failures
- System resource anomalies

**Metrics and Alerting:**

- Prometheus metrics export
- Message throughput monitoring
- Error rate tracking
- System resource utilization
- Custom alert rules

**Complete monitoring documentation in OPERATIONS_GUIDE.md and METRICS.md**

## 4.4 High Availability and Disaster Recovery

**Cluster Support:**

- Erlang distributed cluster capability
- Mnesia replication across nodes
- Automatic failover
- Node discovery and joining

**Data Redundancy:**

- Mnesia disc_copies on all cluster nodes
- SQL database replication (MySQL/PostgreSQL native)
- CDR backup procedures
- Configuration backup

**Recovery Procedures:**

- Database backup and restore
- Mnesia table recovery
- Configuration restoration
- Node replacement procedures

---

# 5. DOCUMENTATION REFERENCES

## 5.1 Technical Manuals

Available documentation in the project repository:

- **README.md** - System overview, architecture, and features
- **CONFIGURATION.md** - Complete configuration reference
- **API_REFERENCE.md** - REST API documentation
- **OPERATIONS_GUIDE.md** - Operational procedures and monitoring
- **CDR_SCHEMA.md** - Call Detail Record database schema
- **sms_routing_guide.md** - SMS routing configuration
- **number_translation_guide.md** - Number normalization
- **METRICS.md** - Prometheus metrics and monitoring
- **PERFORMANCE_TUNING.md** - Performance optimization
- **TROUBLESHOOTING.md** - Common issues and solutions

## 5.2 Security Certifications

- **Penetration Test Reports:** [To be provided upon request]
- **Security Audit Reports:** [To be provided upon request]
- **Vulnerability Assessments:** [To be provided upon request]
- **Erlang/OTP Cryptographic Validation:** Industry-standard cryptographic library

## 5.3 Compliance Documentation

- **ANSSI R226 Authorization Request:** This document
- **Lawful Interception Compliance:** As required by French telecommunications regulations
- **Data Protection Compliance:** GDPR considerations for message data

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# 6. CONTACT INFORMATION

**Vendor/Operator Information:**

- Company Name: Omnitouch Network Services Pty Ltd
- Address: PO BOX 296, QUINNS ROCKS WA 6030, AUSTRALIA
- Contact Person: Compliance Team
- Email: compliance@omnitouch.com.au

**Technical Security Contact:**

- Name: Compliance Team
- Email: compliance@omnitouch.com.au

**Legal/Compliance Contact:**

- Name: Compliance Team
- Email: compliance@omnitouch.com.au

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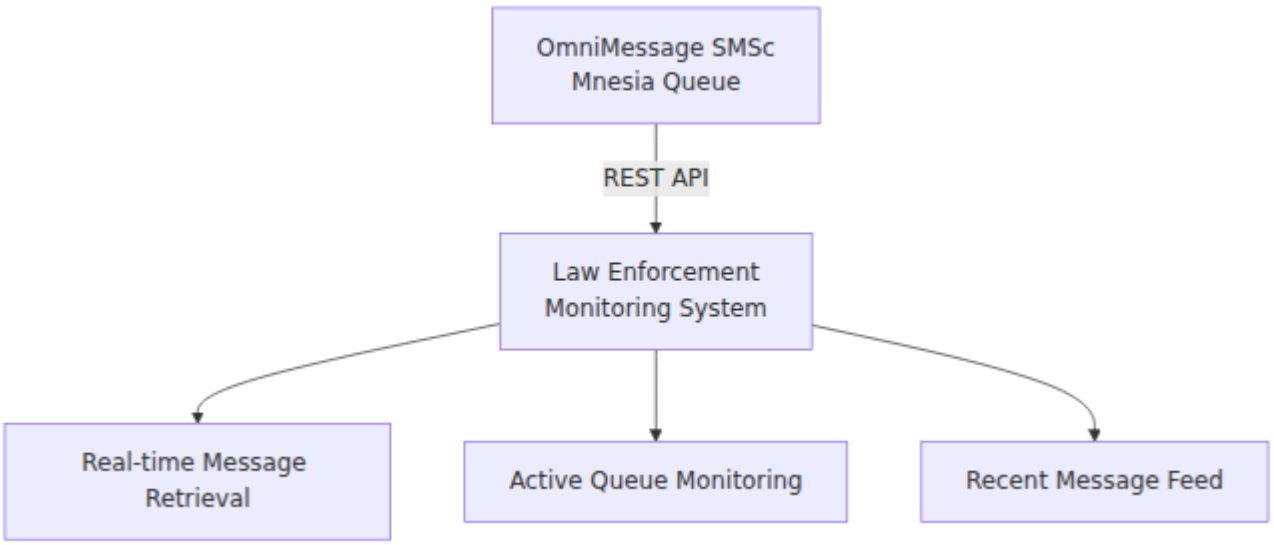
# APPENDICES

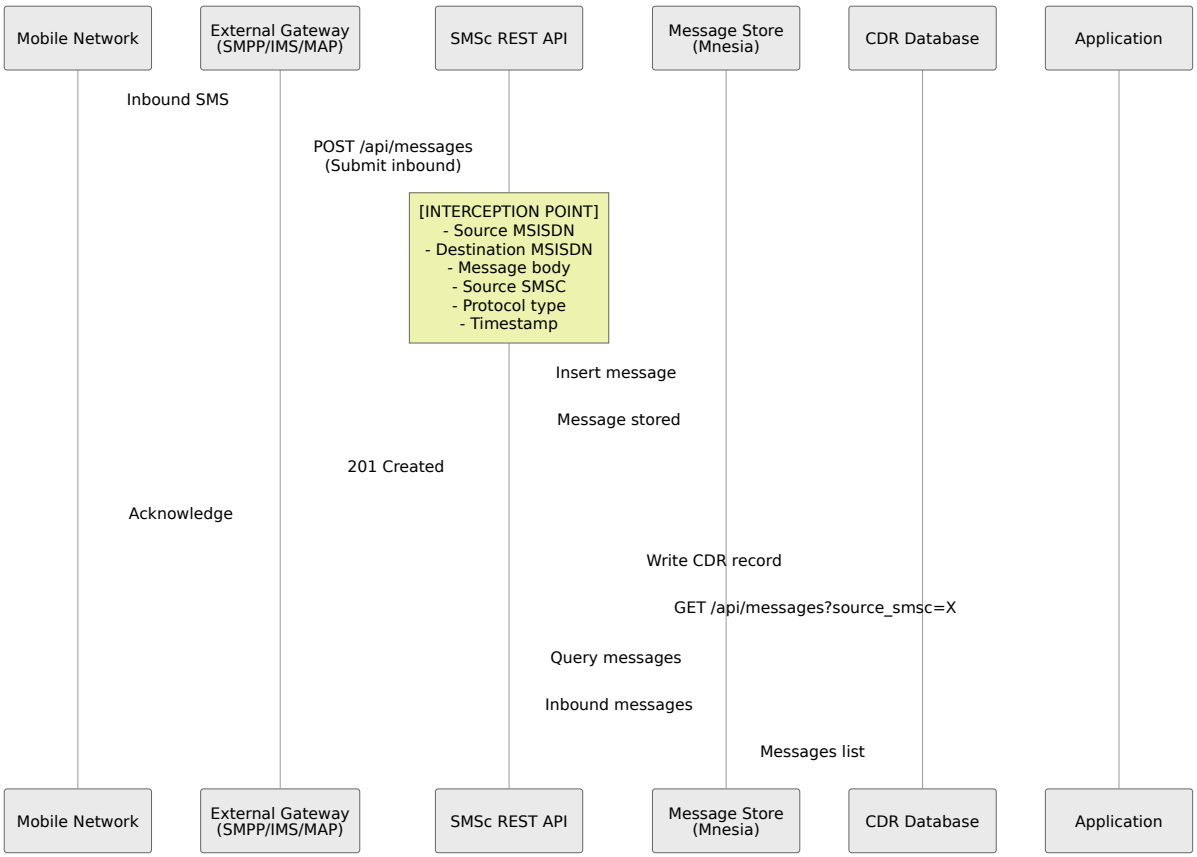
## Appendix A: SMS Message Flow with Interception Points

### A.1 Outbound SMS Flow (Mobile Terminated)




**Legend:** `[INTERCEPTION POINT]` = Points where lawful interception data is captured and stored

## A.2 Inbound SMS Flow (Mobile Originated)



# Appendix B: CDR Schema for Lawful Interception

The OmniMessage SMSc stores Call Detail Records in a SQL database (MySQL or PostgreSQL) for long-term retention and lawful interception access.

### B.1 Key CDR Fields for Lawful Interception

| Field Name | Type | Description | |
|---|---|---|---|
| `id` | BIGINT | Auto-incrementing primary key | |
| `message_id` | BIGINT | Unique message identifier | |
| `calling_number` | VARCHAR(255) | Source MSISDN | |
| `called_number` | VARCHAR(255) | Destination MSISDN | |
| `source_smsc` | VARCHAR(255) | Source gateway identifier | |
| `dest_smsc` | VARCHAR(255) | Destination gateway identifier | |
| `origin_node` | VARCHAR(255) | Erlang cluster node (origination) | |
| `destination_node` | VARCHAR(255) | Erlang cluster node (delivery) | |
| `submission_time` | DATETIME | Message submission timestamp | |
| `delivery_time` | DATETIME | Message delivery timestamp | |
| `expiry_time` | DATETIME | Message expiry timestamp | |

| Field Name | Type | Description | |
|---|---|---|---|
| `status` | VARCHAR(50) | Message status (delivered/expired/failed/rejected) | |
| `delivery_attempts` | INT | Number of delivery attempts | |
| `message_parts` | INT | Number of SMS segments | |
| `deadletter` | BOOLEAN | Dead letter queue flag | |
| `message_body` | TEXT | SMS message content | |
| `inserted_at` | DATETIME | CDR creation timestamp | |
| `updated_at` | DATETIME | CDR update timestamp | |

**📖 Complete schema documentation with SQL examples in CDR_SCHEMA.md**

### B.2 CDR Query Examples for Lawful Interception

**Query all messages for target number:**

```sql
SELECT * FROM cdrs
WHERE calling_number = '+33612345678'
   OR called_number = '+33612345678'
ORDER BY submission_time DESC;
```

**Query messages within time window:**

```
SELECT * FROM cdrs
WHERE (calling_number = '+33612345678' OR called_number =
'+33612345678')
  AND submission_time BETWEEN '2025-11-01 00:00:00' AND '2025-11-
30 23:59:59'
ORDER BY submission_time;
```

**Export to CSV for law enforcement:**

```
.mode csv
.output /tmp/interception_report.csv
SELECT message_id, calling_number, called_number, message_body,
       submission_time, delivery_time, status
FROM cdrs
WHERE calling_number = '+33612345678'
ORDER BY submission_time DESC;
```

### B.3 CDR Database Access Methods

**1. Direct SQL Access:**

- Read-only database credentials
- Standard SQL queries
- JDBC/ODBC connectivity
- Database client tools (MySQL Workbench, pgAdmin)

**2. REST API Access:**

- Future enhancement: REST API for CDR queries
- JSON format responses
- Authentication and authorization
- Query parameter filtering

**3. Batch Export:**

- CSV export via mysql/psql command-line
- Automated export scripts
- Scheduled exports via cron

### B.4 CDR Retention and Privacy

**Retention Configuration:**

```
# config/runtime.exs
config :sms_c,
  # Delete message body after delivery (privacy mode)
  delete_message_body_after_delivery: false,  # true for privacy

  # Enable/disable CDR writing
  cdr_enabled: true,

  # Mnesia to CDR archival settings
  message_retention_hours: 24
```

**Privacy Options:**

- Message body can be set to NULL after delivery
- Database table encryption (MySQL ENCRYPTION='Y')
- Column-level access restrictions
- Masked exports for analytics

## Appendix C: REST API Reference for Interception

### C.1 Message Retrieval Endpoints

**Get all messages:**

```
GET /api/messages
Authorization: Bearer <token>
```

**Get messages by SMSC:**

```
GET /api/messages/get_by_smsc?smsc=gateway-name
```

**Get specific message:**

```
GET /api/messages/{id}
```

**Response Format:**

```
{
  "status": "success",
  "data": [
    {
      "id": 12345,
      "message_id": 12345,
      "source_msisdn": "+33612345678",
      "destination_msisdn": "+33687654321",
      "message_body": "Message content here",
      "source_smsc": "ims.gateway",
      "dest_smsc": "smpp.provider",
      "status": "delivered",
      "delivery_attempts": 1,
      "inserted_at": "2025-11-29T10:30:00Z",
      "deliver_time": "2025-11-29T10:30:05Z",
      "expires": "2025-11-30T10:30:00Z"
    }
  ]
}
```

**📖 Complete API documentation in API_REFERENCE.md**

### C.2 Filtering and Search

**Query Parameters:**

- `source_smsc` - Filter by source gateway
- `dest_smsc` - Filter by destination gateway
- Time-range filtering (via CDR database queries)
- Status filtering (via CDR database queries)

**Future Enhancements:**

- REST API for CDR queries
- Advanced filtering by phone number

- Date range filtering
- Full-text search on message body

# Appendix D: Configuration Examples

### D.1 TLS Certificate Configuration

**Generate TLS Certificate:**

```
# Generate 4096-bit RSA private key
openssl genrsa -out priv/cert/omnitouch.pem 4096

# Generate certificate signing request
openssl req -new -key priv/cert/omnitouch.pem -out
priv/cert/omnitouch.csr \
  -subj "/C=FR/ST=IDF/L=Paris/O=Omnitouch/CN=smsc.example.com"

# Self-signed certificate (development/testing)
openssl x509 -req -days 365 -in priv/cert/omnitouch.csr \
  -signkey priv/cert/omnitouch.pem -out priv/cert/omnitouch.crt

# Production: Submit CSR to trusted CA for signing
```

**Configure in application:**

```
# config/runtime.exs
config :api_ex,
  api: %{
    enable_tls: true,
    tls_cert_path: "priv/cert/omnitouch.crt",
    tls_key_path: "priv/cert/omnitouch.pem"
  }
```

### D.2 Database Encryption Configuration

**MySQL Table Encryption:**

```sql
-- Enable encryption for CDR table
ALTER TABLE cdrs ENCRYPTION='Y';

-- Verify encryption status
SELECT TABLE_NAME, CREATE_OPTIONS
FROM information_schema.TABLES
WHERE TABLE_SCHEMA = 'sms_c' AND TABLE_NAME = 'cdrs';
```

**PostgreSQL Connection Encryption:**

```
# config/runtime.exs
config :sms_c, SmsC.Repo,
  username: "omnitouch",
  password: "secure_password",
  hostname: "localhost",
  database: "sms_c",
  ssl: true,
  ssl_opts: [
    verify: :verify_peer,
    cacertfile: "/path/to/ca.crt",
    certfile: "/path/to/client.crt",
    keyfile: "/path/to/client.key"
  ]
```

### D.3 Privacy Configuration

**Enable Message Body Deletion:**

```
# config/runtime.exs
config :sms_c,
  # Delete message body after successful delivery
  delete_message_body_after_delivery: true,

  # Hide message body in UI
  hide_message_body_in_ui: true,

  # Hide message body in exports
  hide_message_body_in_export: true
```

**Create Privacy-Preserving Database View:**

```
-- Create view without message bodies for general analytics
CREATE VIEW cdrs_metadata AS
SELECT
  id, message_id, calling_number, called_number,
  source_smsc, dest_smsc, origin_node, destination_node,
  submission_time, delivery_time, expiry_time,
  status, delivery_attempts, message_parts, deadletter,
  inserted_at, updated_at
FROM cdrs;

-- Grant access to analytics users
GRANT SELECT ON cdrs_metadata TO 'analytics'@'%';
```

# Appendix E: Glossary

### Regulatory and Standards Bodies

- **ANSSI:** Agence nationale de la sécurité des systèmes d'information - French National Cybersecurity Agency
- **ETSI:** European Telecommunications Standards Institute
- **3GPP:** 3rd Generation Partnership Project - Mobile telecommunications standards
- **IETF:** Internet Engineering Task Force - Internet standards body

### Telecommunications Terms

- **SMSc:** SMS Service Center - Central system for SMS message routing and delivery
- **SMPP:** Short Message Peer-to-Peer protocol - Industry standard for SMS exchange
- **ESME:** External Short Message Entity - SMPP client application
- **IMS:** IP Multimedia Subsystem - All-IP network architecture for multimedia services
- **SIP:** Session Initiation Protocol - Signaling protocol for IMS messaging
- **P-CSCF:** Proxy Call Session Control Function - IMS network entry point

- **S-CSCF:** Serving Call Session Control Function - IMS session control
- **HSS:** Home Subscriber Server - IMS subscriber database
- **SS7/MAP:** Signaling System 7 / Mobile Application Part - Legacy mobile signaling protocols
- **MSC:** Mobile Switching Center - Circuit-switched network element
- **VLR:** Visitor Location Register - Subscriber location database
- **GT:** Global Title - SS7 addressing scheme
- **SCCP:** Signaling Connection Control Part - SS7 network layer
- **TCAP:** Transaction Capabilities Application Part - SS7 application layer
- **MSISDN:** Mobile Station International Subscriber Directory Number - Phone number
- **IMSI:** International Mobile Subscriber Identity - Unique subscriber identifier
- **E.164:** International numbering plan for telephone numbers
- **ENUM:** E.164 Number Mapping - DNS-based phone number to URI mapping
- **PDU:** Protocol Data Unit - Binary encoded SMS message
- **TP-DCS:** Transfer Protocol Data Coding Scheme - SMS encoding specification
- **TP-DU:** Transfer Protocol Data Unit - SMS-specific PDU format
- **UDH:** User Data Header - Header for concatenated/special SMS messages
- **TON/NPI:** Type of Number / Numbering Plan Indicator - Number format classification
- **GSM7:** GSM 7-bit default alphabet - Standard SMS character encoding
- **UCS-2:** Universal Character Set 2-byte - Unicode encoding for SMS

### System Components

- **Mnesia:** Erlang distributed database system - In-memory/disc storage
- **CDR:** Call Detail Record - Billing and analytics record for messages
- **REST API:** Representational State Transfer - HTTP-based API architecture
- **Phoenix:** Elixir web framework
- **Cowboy:** Erlang HTTP server
- **Ecto:** Elixir database wrapper and query language
- **PubSub:** Publish-Subscribe messaging pattern

### Lawful Interception

- **LI:** Lawful Interception - Legal monitoring of telecommunications
- **LIMF:** Lawful Interception Mediation Function - System that interfaces between telecom network and law enforcement
- **LEMF:** Law Enforcement Monitoring Facility - Law enforcement system receiving intercepted data
- **IRI:** Intercept Related Information - Call/message metadata for law enforcement
- **CC:** Content of Communication - Actual message content
- **X1 Interface:** ETSI LI administrative interface - Warrant provisioning and target activation
- **X2 Interface:** ETSI LI interface for IRI delivery - Metadata handover to law enforcement
- **X3 Interface:** ETSI LI interface for CC delivery - Content handover to law enforcement
- **R226:** Articles R226-3 and R226-7 of French Penal Code governing interception equipment
- **ETSI:** European Telecommunications Standards Institute - Defines LI standards
- **ETSI TS 102 232:** Technical specification for lawful interception handover interfaces

### Message Processing

- **MT:** Mobile Terminated - Outbound message to mobile subscriber
- **MO:** Mobile Originated - Inbound message from mobile subscriber
- **DLR:** Delivery Receipt - Confirmation of message delivery
- **Dead Letter:** Message that failed delivery after all retry attempts
- **Exponential Backoff:** Increasing retry delay (2min, 4min, 8min, etc.)

### Security and Encryption

- **TLS:** Transport Layer Security - Encryption protocol
- **PFS:** Perfect Forward Secrecy - Cryptographic property for session key security
- **AES:** Advanced Encryption Standard
- **RSA:** Rivest-Shamir-Adleman - Public key cryptography

- **ECDSA:** Elliptic Curve Digital Signature Algorithm
- **SHA:** Secure Hash Algorithm
- **X.509:** Certificate standard
- **CA:** Certificate Authority
- **CSPRNG:** Cryptographically Secure Pseudo-Random Number Generator

**Database Terms**

- **MySQL:** Open-source relational database
- **PostgreSQL:** Open-source object-relational database
- **TDE:** Transparent Data Encryption
- **RBAC:** Role-Based Access Control

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**Document Version:** 1.0 **Date:** 2025-11-29 **Prepared for:** ANSSI R226 Authorization Application **Document Classification:** Regulatory Compliance - Confidential

# SMS-C API Reference

**← Back to Documentation Index** | **Main README**

Complete reference for all SMS-C REST API endpoints with request/response examples.

## Table of Contents



## API Overview

The SMS-C REST API provides programmatic access to message submission, routing, and management functions.

## Base URL

```
https://api.example.com:8443/api
```

**Default Port**: 8443 (configurable) **Protocol**: HTTPS (TLS required in production)

## Content Type

All requests and responses use JSON:

```
Content-Type: application/json
```

## API Versioning

The current API is version 1 (implicit). Future versions will use URL versioning:

```
https://api.example.com:8443/api/v2/...
```

# Authentication

## TLS Client Certificates (Recommended)

Production deployments should use TLS client certificate authentication:

```
curl --cert client.crt --key client.key \
  https://api.example.com:8443/api/status
```

## API Key Authentication

Custom API key authentication via `X-API-Key` header:

```
curl -H "X-API-Key: your_api_key_here" \
  https://api.example.com:8443/api/status
```

### IP Whitelisting

Restrict API access to trusted IP addresses at the firewall level.

## Common Response Formats

### Success Response

```
{
  "data": {
    ...
  }
}
```

### Error Response

```
{
  "errors": {
    "detail": "Error message describing what went wrong"
  }
}
```

### List Response

```
{
  "data": [
    {...},
    {...}
  ]
}
```

# Status Endpoint

Health check endpoint for monitoring and load balancers.

## Get API Status

**Request**:

```
GET /api/status
```

**Response** (200 OK):

```
{
  "status": "ok",
  "application": "OmniMessage",
  "timestamp": "2025-10-30T12:34:56Z"
}
```

**Example**:

```
curl https://api.example.com:8443/api/status
```

**Use Cases**:

- Load balancer health checks
- Monitoring system connectivity
- Service availability verification

# Message Queue API

Core message submission and management endpoints.

# List Messages

Retrieve messages from the queue.

**Request**:

```
GET /api/messages
```

**Optional Headers**:

- `smsc: frontend_name` - Filter by destination SMSC
- `include-unrouted: true|false|1|0` - Include messages without location registration (default: false)
  - `false` (default): Only return messages with explicit routing or location registration
  - `true`: Include messages without location registration (backward compatible mode)

**Query Parameters**:

- `status` - Filter by status: `pending`, `delivered`, `expired`, `dropped`
- `source_smsc` - Filter by source SMSC
- `dest_smsc` - Filter by destination SMSC
- `limit` - Limit results (default: 100, max: 1000)
- `offset` - Pagination offset

**Response** (200 OK):

```
{
  "data": [
    {
      "id": 12345,
      "source_msisdn": "+15551234567",
      "destination_msisdn": "+447700900000",
      "message_body": "Hello World",
      "source_smsc": "api_client",
      "dest_smsc": "uk_gateway",
      "status": "pending",
      "send_time": "2025-10-30T12:00:00Z",
      "deliver_time": null,
      "delivery_attempts": 0,
      "inserted_at": "2025-10-30T12:00:00Z"
    }
  ]
}
```


**Examples**:

Get pending messages for specific SMSC (only with explicit routing or location):

```
curl -H "smsc: uk_gateway" \
  https://api.example.com:8443/api/messages
```

Get pending messages including unrouted messages (backward compatible):

```
curl -H "smsc: uk_gateway" \
  -H "include-unrouted: true" \
  https://api.example.com:8443/api/messages
```

Get all delivered messages:

```
curl "https://api.example.com:8443/api/messages?
status=delivered&limit=50"
```

## Get Single Message

Retrieve details for a specific message.

**Request**:

```
GET /api/messages/:id
```

**Response** (200 OK):


```
{
  "data": {
    "id": 12345,
    "source_msisdn": "+15551234567",
    "destination_msisdn": "+447700900000",
    "message_body": "Hello World",
    "source_smsc": "api_client",
    "dest_smsc": "uk_gateway",
    "source_imsi": null,
    "dest_imsi": null,
    "message_parts": 1,
    "message_part_number": 1,
    "tp_data_coding_scheme": "00",
    "tp_user_data_header": null,
    "status": "pending",
    "send_time": "2025-10-30T12:00:00Z",
    "deliver_time": null,
    "expires": "2025-10-31T12:00:00Z",
    "deadletter": false,
    "delivery_attempts": 0,
    "charge_failed": false,
    "deliver_after": "2025-10-30T12:00:00Z",
    "raw_data_flag": false,
    "raw_sip_flag": false,
    "raw_pdu": null,
    "inserted_at": "2025-10-30T12:00:00Z",
    "updated_at": "2025-10-30T12:00:00Z"
  }
}
```

**Example**:

```
curl https://api.example.com:8443/api/messages/12345
```

## Submit Message (Synchronous)

Submit a message and receive the message ID immediately.

**Request**:

```
POST /api/messages
Content-Type: application/json
```

**Body**:

```
{
  "source_msisdn": "+15551234567",
  "destination_msisdn": "+447700900000",
  "message_body": "Hello World",
  "source_smsc": "api_client"
}
```

**Optional Fields**:

- `dest_smsc` - Override routing decision
- `send_time` - Schedule for future delivery (ISO 8601)
- `message_parts` - Total parts for multi-part message
- `message_part_number` - Part number (1-indexed)
- `tp_data_coding_scheme` - SMS DCS (default: "00")
- `source_imsi` - Source subscriber IMSI
- `dest_imsi` - Destination subscriber IMSI

**Response** (201 Created):

```
{
  "data": {
    "id": 12345,
    "source_msisdn": "+15551234567",
    "destination_msisdn": "+447700900000",
    "message_body": "Hello World",
    "source_smsc": "api_client",
    "dest_smsc": "uk_gateway",
    "status": "pending",
    "send_time": "2025-10-30T12:00:00Z",
    "inserted_at": "2025-10-30T12:00:00Z"
  }
}
```

**Example**:

```
curl -X POST https://api.example.com:8443/api/messages \
  -H "Content-Type: application/json" \
  -d '{
    "source_msisdn": "+15551234567",
    "destination_msisdn": "+447700900000",
    "message_body": "Hello World",
    "source_smsc": "api_client"
  }'
```

**Performance**: ~70 messages/second, 14ms average response time

**Use When**:

- Need message ID immediately
- Processing messages/second
- Require immediate confirmation

## Submit Message (Asynchronous)

Submit a message with high throughput (batch processing).

**Request**:

```
POST /api/messages/create_async
Content-Type: application/json
```

**Body**: Same as synchronous endpoint

**Response** (202 Accepted):

```
{
  "data": {
    "status": "accepted",
    "message": "Message queued for processing"
  }
}
```

**Example**:

```
curl -X POST
https://api.example.com:8443/api/messages/create_async \
  -H "Content-Type: application/json" \
  -d '{
    "source_msisdn": "+15551234567",
    "destination_msisdn": "+447700900000",
    "message_body": "Bulk notification message",
    "source_smsc": "bulk_api"
  }'
```

**Performance**: ~4,650 messages/second, 0.22ms average response time

**Latency**: Message appears in database within 100ms (configurable)

**Use When**:

- High-volume bulk messaging ( > 100 msg/sec)
- Don't need message ID in API response
- Throughput more important than instant confirmation

# Update Message

Partially update message fields.

**Request**:

```
PATCH /api/messages/:id
Content-Type: application/json
```

**Body**:

```
{
  "dest_smsc": "alternate_gateway",
  "deliver_after": "2025-10-30T14:00:00Z"
}
```

**Updatable Fields**:

- `dest_smsc` - Change destination
- `deliver_after` - Delay delivery
- `message_body` - Update message text
- `status` - Change status

**Response** (200 OK):

```
{
  "data": {
    "id": 12345,
    "dest_smsc": "alternate_gateway",
    "deliver_after": "2025-10-30T14:00:00Z",
    ...
  }
}
```

**Example**:

```
curl -X PATCH https://api.example.com:8443/api/messages/12345 \
  -H "Content-Type: application/json" \
  -d '{
    "dest_smsc": "backup_gateway"
  }'
```

## Mark Message Delivered

Mark a message as successfully delivered.

**Request**:

```
POST /api/messages/:id/mark_delivered
Content-Type: application/json
```

**Body**:

```
{
  "dest_smsc": "uk_gateway"
}
```

**Response** (200 OK):

```
{
  "data": {
    "id": 12345,
    "status": "delivered",
    "deliver_time": "2025-10-30T12:05:30Z",
    "dest_smsc": "uk_gateway",
    ...
  }
}
```

**Example**:

```
curl -X POST
https://api.example.com:8443/api/messages/12345/mark_delivered \
  -H "Content-Type: application/json" \
  -d '{
    "dest_smsc": "uk_gateway"
  }'
```

**Use Case**: Called by frontend systems after successful delivery

## Increment Delivery Attempt

Increment retry counter and apply exponential backoff.

**Request**:

```
PUT /api/messages/:id
```

**Response** (200 OK):

```
{
  "data": {
    "id": 12345,
    "delivery_attempts": 2,
    "deliver_after": "2025-10-30T12:08:00Z",
    ...
  }
}
```

**Backoff Calculation**:

```
deliver_after = now + 2^(delivery_attempts) minutes
```

**Example**:

```
curl -X PUT https://api.example.com:8443/api/messages/12345
```

**Use Case**: Called by frontend after delivery failure to schedule retry

## Delete Message

Remove message from queue.

**Request**:

```
DELETE /api/messages/:id
```

**Response** (204 No Content)

**Example**:

```
curl -X DELETE https://api.example.com:8443/api/messages/12345
```

**Warning**: Deleting messages removes them permanently. Use with caution.

# Raw SMS PDU API

Submit SMS messages as raw PDU (Protocol Data Unit) for maximum compatibility with legacy systems.

## Submit Raw SMS (Synchronous)

**Request**:

```
POST /api/messages_raw
Content-Type: application/json
```

**Body**:

```
{
  "pdu": "0001000B916407007009F0000004D4F29C0E",
  "source_smsc": "legacy_system"
}
```

**PDU Format**: Hex-encoded SMS TPDU (Transport Protocol Data Unit)

**Response** (201 Created):

```
{
  "data": {
    "id": 12346,
    "source_msisdn": "+447700900000",
    "destination_msisdn": "+447700900000",
    "message_body": "Test",
    "source_smsc": "legacy_system",
    "raw_pdu": "0001000B916407007009F0000004D4F29C0E",
    ...
  }
}
```

**Example**:

```
curl -X POST https://api.example.com:8443/api/messages_raw \
  -H "Content-Type: application/json" \
  -d '{
    "pdu": "0001000B916407007009F0000004D4F29C0E",
    "source_smsc": "legacy_system"
  }'
```

## Submit Raw SMS (Asynchronous)

**Request**:

```
POST /api/messages_raw/async
Content-Type: application/json
```

**Body**: Same as synchronous

**Response** (202 Accepted):

```
{
  "data": {
    "status": "accepted",
    "message": "PDU queued for processing"
  }
}
```

**Example**:

```
curl -X POST https://api.example.com:8443/api/messages_raw/async \
  -H "Content-Type: application/json" \
  -d '{
    "pdu": "0001000B916407007009F0000004D4F29C0E",
    "source_smsc": "legacy_gateway"
  }'
```

# PDU Handling

The system automatically:

1. Decodes PDU using SMS standards (3GPP TS 23.040)
2. Extracts phone numbers, message text, DCS
3. Detects delivery reports (CP-ACK, RP-ACK, etc.)
4. Performs IMSI to MSISDN lookup if needed
5. Applies routing rules
6. Stores original PDU for reference

**Delivery Report Detection**:

- CP-ACK, CP-ERROR - Connection Protocol acknowledgments
- RP-ACK, RP-ERROR, RP-SMMA - Relay Protocol responses
- Delivery reports are logged but not stored as messages

# Location Management API

Manage subscriber location information for mobile-terminated message delivery.

## List Locations

**Request**:

```
GET /api/locations
```

**Response** (200 OK):


```
{
  "data": [
    {
      "id": 1,
      "msisdn": "+15551234567",
      "imsi": "001001000000001",
      "location": "msc1.region1.example.com",
      "ran_location": "cell_tower_12345",
      "imei": "123456789012345",
      "ims_capable": true,
      "csfb": false,
      "registered": true,
      "expires": "2025-10-30T13:00:00Z",
      "user_agent": "Samsung Galaxy",
      "inserted_at": "2025-10-30T12:00:00Z",
      "updated_at": "2025-10-30T12:00:00Z"
    }
  ]
}
```


**Example**:

```
curl https://api.example.com:8443/api/locations
```

## Get Location

**Request**:

```
GET /api/locations/:id
```

**Response** (200 OK):

```
{
  "data": {
    "id": 1,
    "msisdn": "+15551234567",
    "imsi": "001001000000001",
    ...
  }
}
```

**Example**:

```
curl https://api.example.com:8443/api/locations/1
```

## Create/Update Location

Creates new location or updates existing based on IMSI (unique identifier).

**Request**:

```
POST /api/locations
Content-Type: application/json
```

**Body**:

```
{
  "msisdn": "+15551234567",
  "imsi": "001001000000001",
  "location": "msc1.region1.example.com",
  "ran_location": "cell_tower_12345",
  "imei": "123456789012345",
  "ims_capable": true,
  "csfb": false,
  "registered": true,
  "expires": "2025-10-30T13:00:00Z",
  "user_agent": "Samsung Galaxy"
}
```

**Required Fields**:

- `imsi` - Unique subscriber identifier
- `msisdn` - Phone number

**Optional Fields**:

- `location` - MSC/VLR address
- `ran_location` - Cell tower/sector ID
- `imei` - Device identifier
- `ims_capable` - IMS VoLTE capability
- `csfb` - Circuit-switched fallback flag
- `registered` - Currently registered
- `expires` - Registration expiry
- `user_agent` - Device model/info

**Response** (201 Created or 200 OK):

```
{
  "data": {
    "id": 1,
    "msisdn": "+15551234567",
    ...
  }
}
```

**Example**:

```
curl -X POST https://api.example.com:8443/api/locations \
  -H "Content-Type: application/json" \
  -d '{
    "msisdn": "+15551234567",
    "imsi": "001001000000001",
    "location": "msc1.region1.example.com",
    "ims_capable": true,
    "registered": true
  }'
```

**Use Case**: Called by mobility management systems (HSS, MME, etc.) when subscriber registers

## Update Location

**Request**:

```
PATCH /api/locations/:id
Content-Type: application/json
```

**Body**: Partial update with any location fields

**Response** (200 OK):

```
{
  "data": {
    "id": 1,
    ...
  }
}
```

**Example**:

```
curl -X PATCH https://api.example.com:8443/api/locations/1 \
  -H "Content-Type: application/json" \
  -d '{
    "location": "msc2.region2.example.com",
    "ran_location": "cell_tower_67890"
  }'
```

## Delete Location

**Request**:

```
DELETE /api/locations/:id
```

**Response** (204 No Content)

**Example**:

```
curl -X DELETE https://api.example.com:8443/api/locations/1
```

**Use Case**: Called when subscriber de-registers or times out

# Frontend Registration API

Track and manage frontend SMSC connections.

## List All Frontends

**Request**:

```
GET /api/frontends
```

**Response** (200 OK):

```
{
  "data": [
    {
      "id": 1,
      "frontend_name": "uk_gateway_1",
      "frontend_type": "smpp",
      "ip_address": "10.0.1.50",
      "hostname": "gateway1.uk.example.com",
      "uptime_seconds": 86400,
      "configuration": {
        "max_throughput": 1000,
        "bind_type": "transceiver"
      },
      "status": "active",
      "expires_at": "2025-10-30T12:02:00Z",
      "last_seen_at": "2025-10-30T12:00:30Z",
      "inserted_at": "2025-10-29T12:00:00Z",
      "updated_at": "2025-10-30T12:00:30Z"
    }
  ]
}
```


**Example**:

```
curl https://api.example.com:8443/api/frontends
```

## List Active Frontends Only

**Request**:

```
GET /api/frontends/active
```

**Response** (200 OK): Same format, only active frontends

**Example**:

```
curl https://api.example.com:8443/api/frontends/active
```

**Use Case**: Get list of available destinations for routing

## Get Frontend Statistics

**Request**:

```
GET /api/frontends/stats
```

**Response** (200 OK):

```
{
  "data": {
    "active_count": 5,
    "expired_count": 2,
    "unique_frontends": 7,
    "total_registrations": 1523
  }
}
```

**Example**:

```
curl https://api.example.com:8443/api/frontends/stats
```

## Get Frontend History

**Request**:

```
GET /api/frontends/history/:name
```

**Response** (200 OK):

```
{
  "data": [
    {
      "id": 1,
      "frontend_name": "uk_gateway_1",
      "status": "active",
      "inserted_at": "2025-10-30T12:00:00Z",
      ...
    },
    {
      "id": 2,
      "frontend_name": "uk_gateway_1",
      "status": "expired",
      "inserted_at": "2025-10-29T12:00:00Z",
      ...
    }
  ]
}
```


**Example**:

```
curl
https://api.example.com:8443/api/frontends/history/uk_gateway_1
```

## Register Frontend

Register or update frontend connection.

**Request**:

```
POST /api/frontends/register
Content-Type: application/json
```

**Body**:

```
{
  "frontend_name": "uk_gateway_1",
  "frontend_type": "smpp",
  "ip_address": "10.0.1.50",
  "hostname": "gateway1.uk.example.com",
  "uptime_seconds": 86400,
  "configuration": {
    "max_throughput": 1000,
    "bind_type": "transceiver",
    "system_id": "gateway1"
  }
}
```

**Required Fields**:

- `frontend_name` - Unique identifier for frontend
- `frontend_type` - Type: `smpp`, `sip`, `http`, etc.

**Optional Fields**:

- `ip_address` - Frontend IP
- `hostname` - Frontend hostname
- `uptime_seconds` - Uptime since start
- `configuration` - Custom config object

**Response** (201 Created):

```
{
  "data": {
    "id": 1,
    "frontend_name": "uk_gateway_1",
    "status": "active",
    "expires_at": "2025-10-30T12:01:30Z",
    ...
  }
}
```

**Example**:

```
curl -X POST https://api.example.com:8443/api/frontends/register \
  -H "Content-Type: application/json" \
  -d '{
    "frontend_name": "uk_gateway_1",
    "frontend_type": "smpp",
    "ip_address": "10.0.1.50",
    "hostname": "gateway1.uk.example.com"
  }'
```

**Registration Timeout**: 90 seconds (frontends must re-register every 60-90 seconds)

**Use Case**: Called periodically by frontend systems to maintain active status

# Event Logging API

Track message lifecycle events.

## Get Message Events

**Request**:

```
GET /api/events/:message_id
```

**Response** (200 OK):

```
{
  "data": [
    {
      "event_epoch": 1698672000,
      "name": "message_inserted",
      "description": "Message inserted into queue",
      "event_source": "node1@server.example.com"
    },
    {
      "event_epoch": 1698672001,
      "name": "message_routed",
      "description": "Routed to uk_gateway via route_id=42",
      "event_source": "node1@server.example.com"
    },
    {
      "event_epoch": 1698672005,
      "name": "message_delivered",
      "description": "Successfully delivered",
      "event_source": "node2@server.example.com"
    }
  ]
}
```


**Example**:

```
curl https://api.example.com:8443/api/events/12345
```

**Event Types**:

- `message_inserted` - Message created
- `message_routed` - Routing decision made
- `message_delivered` - Successful delivery
- `message_failed` - Delivery failed
- `message_dropped` - Dropped by route
- `auto_reply_sent` - Auto-reply triggered
- `number_translated` - Number transformation applied
- `routing_failed` - No route found
- `charging_failed` - Charging error

# Record Event

**Request**:

```
POST /api/events
Content-Type: application/json
```

**Body**:

```
{
  "message_id": 12345,
  "name": "custom_event",
  "description": "Custom event description",
  "event_source": "external_system"
}
```

**Response** (201 Created):

```
{
  "data": {
    "message_id": 12345,
    "name": "custom_event",
    "description": "Custom event description",
    "event_source": "external_system",
    "event_epoch": 1698672010
  }
}
```

**Example**:

```
curl -X POST https://api.example.com:8443/api/events \
  -H "Content-Type: application/json" \
  -d '{
    "message_id": 12345,
    "name": "external_delivery_confirmed",
    "description": "Confirmed by downstream system"
  }'
```

**Event Retention**: 7 days (configurable)

# MMS Message API

Manage Multimedia Messaging Service (MMS) messages.

## List MMS Messages

**Request**:

```
GET /api/mms_messages
```

**Response** (200 OK): Similar to SMS messages with additional MMS fields

## Create MMS Message

**Request**:

```
POST /api/mms_messages
Content-Type: application/json
```

**Body**:

```
{
  "source_msisdn": "+15551234567",
  "destination_msisdn": "+447700900000",
  "subject": "Photo",
  "content_type": "image/jpeg",
  "content_location": "https://cdn.example.com/media/12345.jpg",
  "message_size": 524288
}
```

**Response** (201 Created): Full MMS message object

# SS7 Event API

Track SS7 signaling events.

## List SS7 Events

**Request**:

```
GET /api/ss7_events
```

**Response** (200 OK):

```
{
  "data": [
    {
      "id": 1,
      "event_type": "MAP_UPDATE_LOCATION",
      "imsi": "001001000000001",
      "msisdn": "+15551234567",
      "timestamp": "2025-10-30T12:00:00Z",
      ...
    }
  ]
}
```

## Create SS7 Event

**Request**:

```
POST /api/ss7_events
Content-Type: application/json
```

**Body**:

```
{
  "event_type": "MAP_UPDATE_LOCATION",
  "imsi": "001001000000001",
  "msisdn": "+15551234567"
}
```

**Response** (201 Created): Full event object

# Error Codes

## HTTP Status Codes

| Code | Meaning | Description |
|---|---|---|
| 200 | OK | Request successful |
| 201 | Created | Resource created successfully |
| 202 | Accepted | Request accepted for processing |
| 204 | No Content | Successful deletion |
| 400 | Bad Request | Invalid request format |
| 401 | Unauthorized | Authentication required |
| 403 | Forbidden | Insufficient permissions |
| 404 | Not Found | Resource doesn't exist |
| 422 | Unprocessable Entity | Validation errors |
| 429 | Too Many Requests | Rate limit exceeded |
| 500 | Internal Server Error | Server error |
| 503 | Service Unavailable | Temporarily unavailable |

## Error Response Format

```
{
  "errors": {
    "detail": "Validation failed: destination_msisdn is required"
  }
}
```

## Common Error Messages

| Error | Cause | Solution |
|---|---|---|
| "destination_msisdn is required" | Missing required field | Include destination_msisdn in request |
| "Invalid phone number format" | Malformed number | Use E.164 format: +15551234567 |
| "Message too long" | Exceeds size limit | Split into multiple parts |
| "No route found" | Routing failed | Check routing configuration |
| "Charging failed" | OCS error | Verify charging system connectivity |
| "Message not found" | Invalid message ID | Verify ID exists |
| "Frontend not registered" | Unknown SMSC | Register frontend first |

# Rate Limiting

## Default Limits

| Endpoint | Limit | Window |
|---|---|---|
| POST /api/messages | 100 req/sec | Per IP |
| POST /api/messages/create_async | 1000 req/sec | Per IP |
| POST /api/messages_raw | 100 req/sec | Per IP |
| GET /api/* | 1000 req/sec | Per IP |

## Rate Limit Headers

```
X-RateLimit-Limit: 100
X-RateLimit-Remaining: 95
X-RateLimit-Reset: 1698672060
```

## Rate Limit Exceeded

**Response** (429 Too Many Requests):

```
{
  "errors": {
    "detail": "Rate limit exceeded. Retry after 5 seconds."
  }
}
```

# Best Practices

## Message Submission

1. **Use Async for Bulk**: Use `/create_async` for > 100 msg/sec
2. **Include source_smsc**: Always identify your system
3. **Validate Numbers**: Use E.164 format (+country code)
4. **Handle Errors**: Implement retry logic for 5xx errors
5. **Check Routing**: Test routes before bulk submission

## Frontend Integration

1. **Register Regularly**: Re-register every 60 seconds
2. **Poll for Messages**: Query with `smsc` header for your messages
3. **Use include-unrouted Wisely**: By default, only messages with explicit routing or location registration are returned. Set `include-unrouted: true` only if you need backward compatible behavior to receive all unrouted messages
4. **Mark Delivered**: Always call mark_delivered after success
5. **Increment on Failure**: Use PUT endpoint for retry logic
6. **Monitor Events**: Check event log for delivery issues

## Performance

1. **Connection Pooling**: Reuse HTTP connections
2. **Batch Requests**: Group multiple messages per request
3. **Parallel Processing**: Make concurrent API calls
4. **Monitor Metrics**: Watch Prometheus for bottlenecks
5. **Set Timeouts**: Use 30-second timeout for API calls

## Security

1. **Use TLS**: Always use HTTPS in production
2. **Validate Certificates**: Don't skip certificate validation

3. **Rotate API Keys**: Change keys regularly
4. **IP Whitelist**: Restrict to known sources
5. **Log API Activity**: Monitor for suspicious patterns

## Error Handling

1. **Retry 5xx Errors**: Server errors are usually temporary
2. **Don't Retry 4xx**: Client errors need code fixes
3. **Exponential Backoff**: Wait longer between retries
4. **Circuit Breaker**: Stop after repeated failures
5. **Alert on Patterns**: Monitor error rates

## Example Integration (Python)

```python
import requests
import time

class SMSCClient:
    def __init__(self, base_url, api_key=None):
        self.base_url = base_url
        self.session = requests.Session()
        if api_key:
            self.session.headers.update({"X-API-Key": api_key})

    def submit_message(self, from_num, to_num, text,
async_mode=False):
        endpoint = "/messages/create_async" if async_mode else
"/messages"
        url = f"{self.base_url}{endpoint}"

        payload = {
            "source_msisdn": from_num,
            "destination_msisdn": to_num,
            "message_body": text,
            "source_smsc": "python_client"
        }

        try:
            response = self.session.post(url, json=payload,
timeout=30)
            response.raise_for_status()
            return response.json()["data"]
        except requests.exceptions.RequestException as e:
            print(f"API Error: {e}")
            return None

    def get_pending_messages(self, smsc_name,
include_unrouted=False):
        url = f"{self.base_url}/messages"
        headers = {"smsc": smsc_name}

        # Include unrouted messages if requested (backward
compatible mode)
        if include_unrouted:
            headers["include-unrouted"] = "true"
```

```
        try:
            response = self.session.get(url, headers=headers,
timeout=30)
            response.raise_for_status()
            return response.json()["data"]
        except requests.exceptions.RequestException as e:
            print(f"API Error: {e}")
            return []

    def mark_delivered(self, message_id, smsc_name):
        url = f"
{self.base_url}/messages/{message_id}/mark_delivered"
        payload = {"dest_smsc": smsc_name}

        try:
            response = self.session.post(url, json=payload,
timeout=30)
            response.raise_for_status()
            return True
        except requests.exceptions.RequestException as e:
            print(f"API Error: {e}")
            return False

# Usage
client = SMSCClient("https://api.example.com:8443/api",
api_key="your_key")

# Submit single message
result = client.submit_message("+15551234567", "+447700900000",
"Hello")
print(f"Message ID: {result['id']}")

# Submit bulk messages (async)
for i in range(1000):
    client.submit_message("+15551234567", f"+44770090{i:04d}",
f"Bulk {i}", async_mode=True)

# Frontend polling loop
while True:
    # Get messages with explicit routing or location registration
    messages = client.get_pending_messages("my_gateway")

    # Or use include_unrouted=True for backward compatible
```

```
behavior
    # messages = client.get_pending_messages("my_gateway",
include_unrouted=True)

    for msg in messages:
        # Deliver message via your protocol
        success = deliver_via_smpp(msg)

        if success:
            client.mark_delivered(msg["id"], "my_gateway")
        else:
            # Increment for retry
            requests.put(f"
{client.base_url}/messages/{msg['id']}")

    time.sleep(5)  # Poll every 5 seconds
```

# API Changelog

## Version 1 (Current)

- Initial release
- Message queue CRUD
- Raw PDU submission
- Location management
- Frontend registration
- Event logging

## Planned Features

- Batch message submission (single request, multiple messages)
- Message templates
- Scheduled delivery API
- Real-time webhooks for events
- GraphQL API endpoint
- OAuth2 authentication

For questions or issues with the API, check the Troubleshooting Guide or contact support.

# CDR (Call Detail Record) Schema Reference

**← Back to Documentation Index** | **Main README**

Complete reference for the CDR database table used for long-term message storage, billing, and analytics.

## Table of Contents



## Overview

The `cdrs` table stores Call Detail Records for all SMS messages processed by the system. CDRs are written when:

- Messages are successfully delivered
- Messages expire without delivery
- Messages fail permanently
- Messages are rejected

CDRs provide long-term storage separate from the operational Mnesia database, enabling:

- Billing and invoicing
- Analytics and reporting
- Compliance and auditing
- Message history beyond Mnesia retention period

# Table Schema

## MySQL / MariaDB

```
CREATE TABLE cdrs (
  id BIGINT AUTO_INCREMENT PRIMARY KEY,

  -- Message identification
  message_id BIGINT NOT NULL,

  -- Phone numbers
  calling_number VARCHAR(255) NOT NULL,
  called_number VARCHAR(255) NOT NULL,

  -- SMSC routing
  source_smsc VARCHAR(255),
  dest_smsc VARCHAR(255),

  -- Node information (for clustered deployments)
  origin_node VARCHAR(255),
  destination_node VARCHAR(255),

  -- Timestamps
  submission_time DATETIME NOT NULL,
  delivery_time DATETIME,
  expiry_time DATETIME,

  -- Status and metadata
  status VARCHAR(50) NOT NULL,
  delivery_attempts INT DEFAULT 0,
  message_parts INT,
  deadletter BOOLEAN DEFAULT FALSE,

  -- Optional message body (privacy controls)
  message_body TEXT,

  -- Audit timestamps
  inserted_at DATETIME NOT NULL,
  updated_at DATETIME NOT NULL,

  -- Indexes
  INDEX idx_cdrs_message_id (message_id),
```

```
  INDEX idx_cdrs_calling_number (calling_number),
  INDEX idx_cdrs_called_number (called_number),
  INDEX idx_cdrs_status (status),
  INDEX idx_cdrs_submission_time (submission_time),
  INDEX idx_cdrs_dest_smsc (dest_smsc)
);
```

## PostgreSQL

```sql
CREATE TABLE cdrs (
  id BIGSERIAL PRIMARY KEY,

  -- Message identification
  message_id BIGINT NOT NULL,

  -- Phone numbers
  calling_number VARCHAR(255) NOT NULL,
  called_number VARCHAR(255) NOT NULL,

  -- SMSC routing
  source_smsc VARCHAR(255),
  dest_smsc VARCHAR(255),

  -- Node information (for clustered deployments)
  origin_node VARCHAR(255),
  destination_node VARCHAR(255),

  -- Timestamps
  submission_time TIMESTAMP NOT NULL,
  delivery_time TIMESTAMP,
  expiry_time TIMESTAMP,

  -- Status and metadata
  status VARCHAR(50) NOT NULL,
  delivery_attempts INTEGER DEFAULT 0,
  message_parts INTEGER,
  deadletter BOOLEAN DEFAULT FALSE,

  -- Optional message body (privacy controls)
  message_body TEXT,

  -- Audit timestamps
  inserted_at TIMESTAMP NOT NULL,
  updated_at TIMESTAMP NOT NULL
);

-- Indexes
CREATE INDEX idx_cdrs_message_id ON cdrs(message_id);
CREATE INDEX idx_cdrs_calling_number ON cdrs(calling_number);
CREATE INDEX idx_cdrs_called_number ON cdrs(called_number);
```

```
CREATE INDEX idx_cdrs_status ON cdrs(status);
CREATE INDEX idx_cdrs_submission_time ON cdrs(submission_time);
CREATE INDEX idx_cdrs_dest_smsc ON cdrs(dest_smsc);
```

# Field Descriptions

## Primary Key

| Field | Type | Nullable | Description |
|---|---|---|---|
| `id` | BIGINT | NO | Auto-incrementing primary key for the CDR record |

## Message Identification

| Field | Type | Nullable | Description |
|---|---|---|---|
| `message_id` | BIGINT | NO | Unique message identifier from the SMS-C message queue. References the original message ID in Mnesia. |

## Phone Numbers

| Field | Type | Nullable | Description |
|---|---|---|---|
| `calling_number` | VARCHAR(255) | NO | Source MSISDN (mobile number) of the message sender. Typically in E.164 format (e.g., +15551234567). |
| `called_number` | VARCHAR(255) | NO | Destination MSISDN (mobile number) of the message recipient. Typically in E.164 format (e.g., +15551234567). |

## SMSC Routing

| Field | Type | Nullable | Description |
|---|---|---|---|
| `source_smsc` | VARCHAR(255) | YES | Name or identifier of the source SMSC that submitted the message. NULL if submitted via API or other non-SMSC interface. |
| `dest_smsc` | VARCHAR(255) | YES | Name or identifier of the destination SMSC that delivered (or attempted to deliver) the message. NULL if message was never routed. |

## Node Information

For clustered deployments, tracks which nodes handled the message:

| Field | Type | Nullable | Description |
| --- | --- | --- | --- |
| `origin_node` | VARCHAR(255) | YES | Erlang node name where message was originally received (e.g., "sms@node1.example.cor Useful for troubleshooting and load distribution analysis. |
| `destination_node` | VARCHAR(255) | YES | Erlang node name where message was delivered fr (if different from origin). NULL for single-node deployments or if messag never delivered. |

## Timestamps

All timestamps are stored in UTC:

| Field | Type | Nullable | Description |
|---|---|---|---|
| `submission_time` | DATETIME | NO | When the message was first submitted to the SMS-C. Used as the start time for billing calculations. |
| `delivery_time` | DATETIME | YES | When the message was successfully delivered. NULL if message expired, failed, or was rejected. |
| `expiry_time` | DATETIME | YES | When the message expired (became undeliverable). NULL if message was delivered or is still pending. |

**Delivery Duration Calculation:**

```
TIMESTAMPDIFF(SECOND, submission_time, delivery_time) AS
delivery_duration_seconds
```

## Status and Metadata

| Field | Type | Nullable | Description |
|---|---|---|---|
| `status` | VARCHAR(50) | NO | Final message status. Valid values: `delivered`, `expired`, `failed`, `rejected` |
| `delivery_attempts` | INT | NO | Number of delivery attempts made before final status. Default: 0. Range: 0-255 typically. |
| `message_parts` | INT | YES | Number of SMS segments for concatenated messages. 1 for single-part messages, 2+ for multi-part. NULL if unknown. |
| `deadletter` | BOOLEAN | NO | Whether message was moved to dead letter queue. TRUE indicates message couldn't be delivered and exhausted all retries. Default: FALSE |

**Status Values:**

| Status | Description | Billable | Delivery Time |
|---|---|---|---|
| `delivered` | Successfully delivered to recipient | Yes | Set |
| `expired` | Exceeded validity period without delivery | Depends on billing policy | NULL |
| `failed` | Permanent delivery failure (invalid number, etc.) | Depends on billing policy | NULL |
| `rejected` | Rejected by routing rules or validation | No | NULL |

## Message Body

| Field | Type | Nullable | Description |
|---|---|---|---|
| `message_body` | TEXT | YES | The actual SMS message content. Can be NULL if `delete_message_body_after_delivery` is enabled for privacy. Max length varies by database (typically 65,535 characters for TEXT type). |

**Privacy Modes:**

- **Full retention:** Message body stored in CDR for compliance/archival
- **Privacy mode:** Message body set to NULL when `delete_message_body_after_delivery: true`
- **Compliance mode:** Body stored encrypted or hashed (requires custom implementation)

## Audit Timestamps

| Field | Type | Nullable | Description |
|---|---|---|---|
| `inserted_at` | DATETIME | NO | When the CDR record was first inserted into the database. Typically same as or shortly after delivery_time/expiry_time. |
| `updated_at` | DATETIME | NO | When the CDR record was last updated. Same as inserted_at if never updated. |

# SQL Examples

## Basic Queries

**Find all CDRs for a specific phone number:**

```sql
SELECT * FROM cdrs
WHERE calling_number = '+15551234567'
   OR called_number = '+15551234567'
ORDER BY submission_time DESC
LIMIT 100;
```

**Count messages by status:**

```sql
SELECT status, COUNT(*) as count
FROM cdrs
GROUP BY status;
```

**Average delivery time for delivered messages:**

```
SELECT AVG(TIMESTAMPDIFF(SECOND, submission_time, delivery_time))
AS avg_delivery_seconds
FROM cdrs
WHERE status = 'delivered'
  AND delivery_time IS NOT NULL;
```

## Billing Queries

**Daily message volume by destination SMSC:**

```
SELECT
  DATE(submission_time) AS date,
  dest_smsc,
  COUNT(*) AS message_count,
  SUM(CASE WHEN status = 'delivered' THEN 1 ELSE 0 END) AS
delivered_count,
  SUM(message_parts) AS total_segments
FROM cdrs
WHERE submission_time >= DATE_SUB(NOW(), INTERVAL 30 DAY)
GROUP BY DATE(submission_time), dest_smsc
ORDER BY date DESC, message_count DESC;
```

**Billable messages for a customer (by calling number prefix):**

```
SELECT
  DATE(submission_time) AS date,
  COUNT(*) AS message_count,
  SUM(message_parts) AS total_segments,
  SUM(message_parts) * 0.01 AS total_cost
FROM cdrs
WHERE calling_number LIKE '+1555%'
  AND status = 'delivered'
  AND submission_time >= '2025-10-01'
  AND submission_time < '2025-11-01'
GROUP BY DATE(submission_time);
```

**Route performance analysis:**

```sql
SELECT
  dest_smsc,
  COUNT(*) AS total_messages,
  SUM(CASE WHEN status = 'delivered' THEN 1 ELSE 0 END) AS
delivered,
  ROUND(100.0 * SUM(CASE WHEN status = 'delivered' THEN 1 ELSE 0
END) / COUNT(*), 2) AS delivery_rate_pct,
  AVG(delivery_attempts) AS avg_attempts,
  AVG(TIMESTAMPDIFF(SECOND, submission_time, delivery_time)) AS
avg_delivery_seconds
FROM cdrs
WHERE submission_time >= DATE_SUB(NOW(), INTERVAL 7 DAY)
  AND dest_smsc IS NOT NULL
GROUP BY dest_smsc
ORDER BY delivery_rate_pct DESC;
```

## Analytics Queries

**Messages by hour of day (traffic pattern):**

```sql
SELECT
  HOUR(submission_time) AS hour,
  COUNT(*) AS message_count
FROM cdrs
WHERE submission_time >= DATE_SUB(NOW(), INTERVAL 7 DAY)
GROUP BY HOUR(submission_time)
ORDER BY hour;
```

**Multi-part message analysis:**

```
SELECT
  message_parts,
  COUNT(*) AS message_count,
  AVG(TIMESTAMPDIFF(SECOND, submission_time, delivery_time)) AS
avg_delivery_seconds
FROM cdrs
WHERE message_parts IS NOT NULL
  AND status = 'delivered'
GROUP BY message_parts
ORDER BY message_parts;
```

**Failed message analysis:**

```
SELECT
  called_number,
  COUNT(*) AS failure_count,
  AVG(delivery_attempts) AS avg_attempts,
  MAX(submission_time) AS last_failure
FROM cdrs
WHERE status IN ('failed', 'expired')
  AND submission_time >= DATE_SUB(NOW(), INTERVAL 7 DAY)
GROUP BY called_number
HAVING failure_count >= 5
ORDER BY failure_count DESC;
```

## Compliance and Audit Queries

**Find all messages between two parties in a time range:**

```
SELECT
  submission_time,
  calling_number,
  called_number,
  status,
  message_body,
  delivery_time
FROM cdrs
WHERE (
    (calling_number = '+15551234567' AND called_number =
'+15559876543')
    OR
    (calling_number = '+15559876543' AND called_number =
'+15551234567')
  )
  AND submission_time >= '2025-10-01'
  AND submission_time < '2025-11-01'
ORDER BY submission_time;
```

**Retention policy enforcement (delete old CDRs):**

```
-- Find records older than retention period (example: 2 years)
SELECT COUNT(*) FROM cdrs
WHERE submission_time < DATE_SUB(NOW(), INTERVAL 2 YEAR);

-- Delete old records (use with caution!)
DELETE FROM cdrs
WHERE submission_time < DATE_SUB(NOW(), INTERVAL 2 YEAR)
LIMIT 10000;  -- Batch delete to avoid locking
```

# Cluster Analysis

**Message distribution across nodes:**

```sql
SELECT
  origin_node,
  COUNT(*) AS message_count,
  SUM(CASE WHEN status = 'delivered' THEN 1 ELSE 0 END) AS
delivered_count
FROM cdrs
WHERE submission_time >= DATE_SUB(NOW(), INTERVAL 1 DAY)
GROUP BY origin_node;
```

# Indexes

The following indexes are created to optimize common queries:

| Index Name | Columns | Purpose |
|---|---|---|
| `PRIMARY` | `id` | Primary key, ensures unique record |
| `idx_cdrs_message_id` | `message_id` | Lookup CDR by original message ID |
| `idx_cdrs_calling_number` | `calling_number` | Find messages from a specific sender |
| `idx_cdrs_called_number` | `called_number` | Find messages to a specific recipient |
| `idx_cdrs_status` | `status` | Filter by delivery status |
| `idx_cdrs_submission_time` | `submission_time` | Time-based queries, billing periods |
| `idx_cdrs_dest_smsc` | `dest_smsc` | Route performance analysis |

## Additional Index Recommendations

For high-volume deployments, consider these additional indexes:

**Composite index for billing queries:**

```
CREATE INDEX idx_cdrs_billing ON cdrs(calling_number,
submission_time, status);
```

**Composite index for route analysis:**

```
CREATE INDEX idx_cdrs_route_perf ON cdrs(dest_smsc,
submission_time, status);
```

**Composite index for compliance searches:**

```
CREATE INDEX idx_cdrs_party_time ON cdrs(calling_number,
called_number, submission_time);
```

**Full-text index for message body searches (MySQL):**

```
ALTER TABLE cdrs ADD FULLTEXT INDEX idx_cdrs_message_body_ft
(message_body);

-- Usage:
SELECT * FROM cdrs
WHERE MATCH(message_body) AGAINST('keyword' IN NATURAL LANGUAGE
MODE);
```

# Data Types by Database

Field type mappings across supported databases:

| Field | MySQL/MariaDB | PostgreSQL | Notes |
|---|---|---|---|
| `id` | BIGINT AUTO_INCREMENT | BIGSERIAL | 64-bit integer, auto-incrementing |
| `message_id` | BIGINT | BIGINT | 64-bit integer |
| String fields | VARCHAR(255) | VARCHAR(255) | Variable-length string, max 255 chars |
| `message_body` | TEXT | TEXT | Large text, up to 65,535 bytes (MySQL), unlimited (PostgreSQL) |
| Timestamps | DATETIME | TIMESTAMP | UTC timestamps recommended |
| Integers | INT | INTEGER | 32-bit signed integer |
| Booleans | BOOLEAN (TINYINT(1)) | BOOLEAN | MySQL stores as 0/1 |

# Privacy Considerations

The CDR table may contain sensitive personal information (phone numbers, message content). Consider these privacy measures:

## 1. Message Body Privacy

**Configuration options in `config/runtime.exs`:**

```
config :sms_c,
  # Delete message body after successful delivery
  delete_message_body_after_delivery: true,

  # Hide message body in UI
  hide_message_body_in_ui: true,

  # Hide message body in exports
  hide_message_body_in_export: true
```

## 2. Phone Number Masking

For analytics that don't require full numbers:

```
-- Mask last 4 digits of phone numbers
SELECT
  CONCAT(SUBSTRING(calling_number, 1, LENGTH(calling_number) - 4),
'XXXX') AS masked_calling,
  CONCAT(SUBSTRING(called_number, 1, LENGTH(called_number) - 4),
'XXXX') AS masked_called,
  COUNT(*) AS message_count
FROM cdrs
GROUP BY masked_calling, masked_called;
```

## 3. Database Encryption

Enable encryption at rest for the database server:

**MySQL:**

```
-- Enable table encryption
ALTER TABLE cdrs ENCRYPTION='Y';
```

**PostgreSQL:** Use PostgreSQL transparent data encryption (TDE) or filesystem-level encryption.

### 4. Access Controls

Restrict CDR table access:

```
-- Create read-only billing user
CREATE USER 'billing_ro'@'%' IDENTIFIED BY 'secure_password';
GRANT SELECT ON sms_c.cdrs TO 'billing_ro'@'%';

-- Create limited analytics user (no message body access)
CREATE USER 'analytics'@'%' IDENTIFIED BY 'secure_password';
GRANT SELECT (id, message_id, calling_number, called_number,
source_smsc,
              dest_smsc, submission_time, delivery_time, status,
              delivery_attempts, message_parts)
ON sms_c.cdrs TO 'analytics'@'%';
```

# Retention and Archival

## Retention Policies

Define retention periods based on regulatory and business requirements:

| Industry | Typical Retention | Regulatory Basis |
|---|---|---|
| Telecom (US) | 18-24 months | FCC, state laws |
| Telecom (EU) | 6 months - 2 years | GDPR, ePrivacy |
| Financial | 5-7 years | SOX, SEC |
| Healthcare | 6 years | HIPAA |

## Archival Strategy

#### 1. Partition by Date (MySQL 8.0+, PostgreSQL 11+)

```sql
-- MySQL partitioning by month
ALTER TABLE cdrs PARTITION BY RANGE (TO_DAYS(submission_time)) (
  PARTITION p202510 VALUES LESS THAN (TO_DAYS('2025-11-01')),
  PARTITION p202511 VALUES LESS THAN (TO_DAYS('2025-12-01')),
  PARTITION p202512 VALUES LESS THAN (TO_DAYS('2026-01-01')),
  PARTITION p_future VALUES LESS THAN MAXVALUE
);

-- Drop old partition (fast archival)
ALTER TABLE cdrs DROP PARTITION p202510;
```

**2. Archive to Cold Storage**

```sql
-- Export old CDRs to archive table
CREATE TABLE cdrs_archive LIKE cdrs;

INSERT INTO cdrs_archive
SELECT * FROM cdrs
WHERE submission_time < DATE_SUB(NOW(), INTERVAL 2 YEAR);

-- Verify and delete from main table
DELETE FROM cdrs
WHERE submission_time < DATE_SUB(NOW(), INTERVAL 2 YEAR);
```

**3. Automated Cleanup Script**

```
#!/bin/bash
# cleanup_old_cdrs.sh - Run via cron

MYSQL_USER="cleanup_user"
MYSQL_PASS="secure_password"
MYSQL_DB="sms_c"
RETENTION_DAYS=730  # 2 years

# Archive old records
mysql -u"$MYSQL_USER" -p"$MYSQL_PASS" "$MYSQL_DB" <<EOF
INSERT INTO cdrs_archive
SELECT * FROM cdrs
WHERE submission_time < DATE_SUB(NOW(), INTERVAL $RETENTION_DAYS
DAY)
LIMIT 100000;

DELETE FROM cdrs
WHERE submission_time < DATE_SUB(NOW(), INTERVAL $RETENTION_DAYS
DAY)
LIMIT 100000;
EOF
```

**Cron entry:**

```
# Run daily at 2 AM
0 2 * * * /usr/local/bin/cleanup_old_cdrs.sh >>
/var/log/sms_c/cleanup.log 2>&1
```

# Billing Integration

## Rate Card Schema

Create a separate rates table for billing:

```sql
CREATE TABLE billing_rates (
  id INT AUTO_INCREMENT PRIMARY KEY,
  destination_prefix VARCHAR(20) NOT NULL,
  description VARCHAR(255),
  rate_per_message DECIMAL(10, 6) NOT NULL,
  rate_per_segment DECIMAL(10, 6) NOT NULL,
  currency VARCHAR(3) DEFAULT 'USD',
  effective_date DATE NOT NULL,
  expiry_date DATE,
  INDEX idx_prefix (destination_prefix),
  INDEX idx_dates (effective_date, expiry_date)
);

-- Example rates
INSERT INTO billing_rates (destination_prefix, description,
rate_per_message, rate_per_segment, effective_date) VALUES
('+1', 'United States/Canada', 0.0050, 0.0050, '2025-01-01'),
('+44', 'United Kingdom', 0.0080, 0.0080, '2025-01-01'),
('+61', 'Australia', 0.0100, 0.0100, '2025-01-01'),
('+', 'International default', 0.0150, 0.0150, '2025-01-01');
```

## Billing Query

Join CDRs with rates for invoicing:

```
SELECT
  DATE(c.submission_time) AS date,
  c.dest_smsc AS route,
  LEFT(c.called_number,
    CASE
      WHEN c.called_number LIKE '+1%' THEN 2
      WHEN c.called_number LIKE '+%' THEN
LENGTH(SUBSTRING_INDEX(c.called_number, '', 4))
      ELSE 0
    END
  ) AS destination_prefix,
  COUNT(*) AS message_count,
  SUM(c.message_parts) AS segment_count,
  COALESCE(r.rate_per_segment, 0.015) AS rate,
  SUM(c.message_parts) * COALESCE(r.rate_per_segment, 0.015) AS
total_cost
FROM cdrs c
LEFT JOIN billing_rates r ON c.called_number LIKE
CONCAT(r.destination_prefix, '%')
  AND c.submission_time >= r.effective_date
  AND (r.expiry_date IS NULL OR c.submission_time < r.expiry_date)
WHERE c.status = 'delivered'
  AND c.submission_time >= '2025-10-01'
  AND c.submission_time < '2025-11-01'
GROUP BY date, route, destination_prefix
ORDER BY date DESC, total_cost DESC;
```

## Export for Billing Systems

**CSV Export:**

```
mysql -u billing_ro -p -D sms_c -e "
SELECT
  id,
  message_id,
  calling_number,
  called_number,
  dest_smsc,
  submission_time,
  delivery_time,
  status,
  message_parts
FROM cdrs
WHERE submission_time >= '2025-10-01'
  AND submission_time < '2025-11-01'
  AND status = 'delivered'
" --batch --silent | sed 's/\t/,/g' > billing_export_202510.csv
```

# See Also

- Configuration Guide - Configure CDR export settings
- Operations Guide - CDR maintenance procedures
- API Reference - Query CDRs via REST API

# SMS-C Configuration Reference

**← Back to Documentation Index** | **Main README**

Complete reference for all SMS-C configuration options with examples for common deployment scenarios.

## Table of Contents



## Configuration Files

The SMS-C uses three main configuration files:

### config/config.exs

Static configuration loaded at compile time. Contains:

- Application-wide defaults
- Logger configuration
- Development/test settings
- Performance tuning parameters

## config/runtime.exs

Runtime configuration loaded at startup. Contains:

- Database connection settings
- Cluster configuration
- External service integration (OCS, ENUM)
- Initial routes and translation rules
- Environment-specific settings

## config/prod.exs (optional)

Production-specific overrides.

**Best Practice**: Use environment variables in `runtime.exs` for sensitive values like passwords and API keys.

# SQL CDR Storage Configuration

The SMS-C uses **Mnesia** for operational data (message queue, routing rules, number translations) and supports external **SQL databases** for long-term CDR (Call Detail Record) storage, billing, and analytics.

## Supported SQL Databases

The system supports the following SQL databases for CDR export:

| Database | Version | Adapter | Default Port | Best For |
|---|---|---|---|---|
| **MySQL** | 8.0+ | `Ecto.Adapters.MyXQL` | 3306 | General purpose, proven reliability |
| **MariaDB** | 10.5+ | `Ecto.Adapters.MyXQL` | 3306 | MySQL-compatible open source |
| **PostgreSQL** | 13+ | `Ecto.Adapters.Postgres` | 5432 | Advanced features, JSON support |

**Note**: Mnesia is used automatically for operational data (message queue, routing, translations) and requires no configuration. The SQL database is **only** used for CDR export and long-term storage.

## MySQL / MariaDB Configuration

```
# config/runtime.exs
config :sms_c, SmsC.Repo,
  adapter: Ecto.Adapters.MyXQL,
  username: System.get_env("DB_USERNAME") || "sms_user",
  password: System.get_env("DB_PASSWORD") || "secure_password",
  hostname: System.get_env("DB_HOSTNAME") || "localhost",
  port: String.to_integer(System.get_env("DB_PORT") || "3306"),
  database: System.get_env("DB_NAME") || "sms_c_prod",
  pool_size: String.to_integer(System.get_env("DB_POOL_SIZE") ||
"20")
```

## PostgreSQL Configuration

```
# config/runtime.exs
config :sms_c, SmsC.Repo,
  adapter: Ecto.Adapters.Postgres,
  username: System.get_env("DB_USERNAME") || "sms_user",
  password: System.get_env("DB_PASSWORD") || "secure_password",
  hostname: System.get_env("DB_HOSTNAME") || "localhost",
  port: String.to_integer(System.get_env("DB_PORT") || "5432"),
  database: System.get_env("DB_NAME") || "sms_c_prod",
  pool_size: String.to_integer(System.get_env("DB_POOL_SIZE") ||
"20")
```

## Choosing a SQL Database

**MySQL/MariaDB** - Recommended for most deployments:

- Excellent performance for CDR writes
- Proven reliability in telecom environments
- Wide tooling support for billing systems
- Easy replication setup

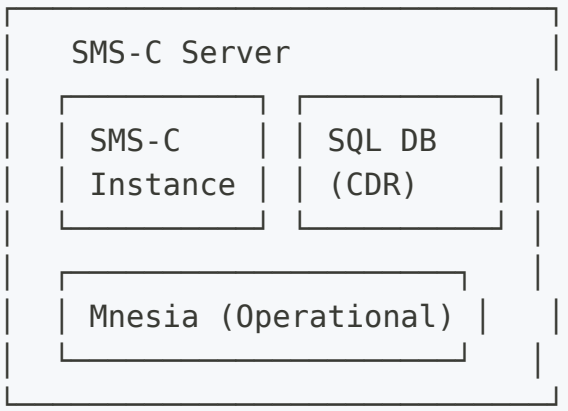
**PostgreSQL** - Consider if you need:

- Advanced JSON/JSONB features for analytics
- Complex queries on CDR data
- Existing PostgreSQL infrastructure
- PostGIS for geographic analysis

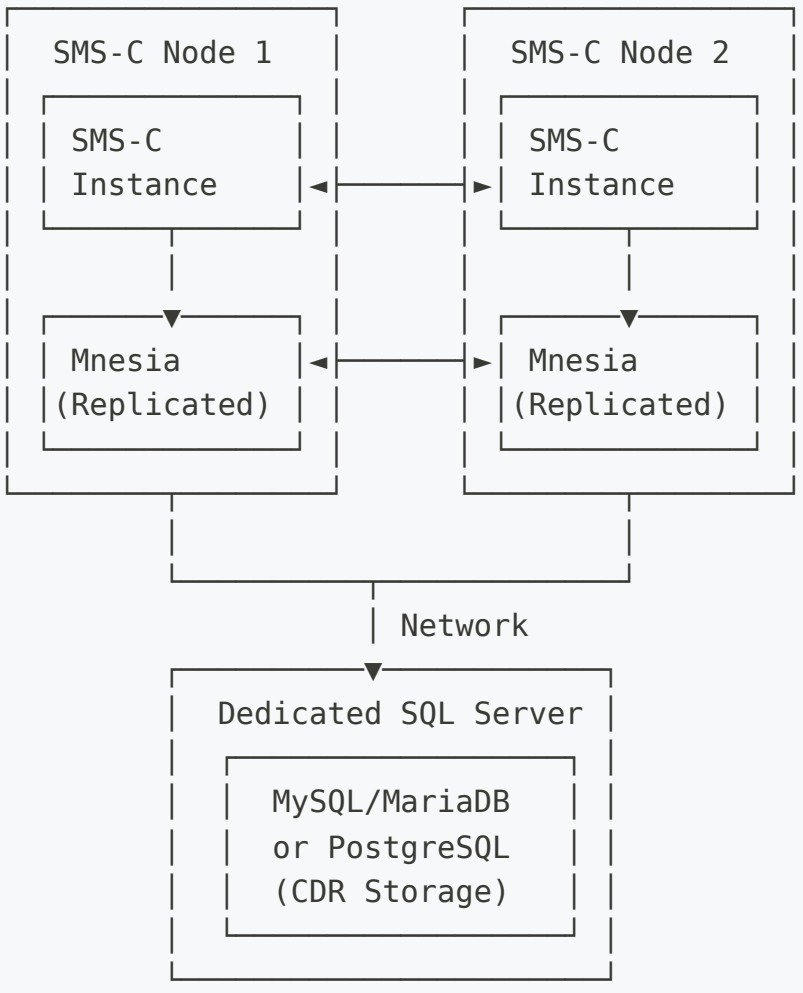
## Deployment Topologies

**Important**: The SQL CDR database can run on a **separate server** from your SMS-C instance(s). This is the recommended approach for production deployments.

**Single-Server Deployment** (Development/Testing):




**Distributed Deployment** (Production - Recommended):




**Benefits of Separate SQL Server**:

- **Performance Isolation**: CDR writes don't impact message processing

- **Scalability**: Independently scale database and message processing
- **Reliability**: Database maintenance doesn't affect SMS-C uptime
- **Data Management**: Centralized CDR storage for multiple SMS-C instances
- **Backup Flexibility**: Independent backup schedules and retention policies

## Pool Size Guidelines

| Workload | Pool Size | Description |
|---|---|---|
| Development | 5-10 | Minimal concurrency |
| Low Volume (< 100 msg/sec) | 10-15 | Small deployments |
| Medium Volume (100-1000 msg/sec) | 20-30 | Typical production |
| High Volume ( > 1000 msg/sec) | 40-100 | High-throughput scenarios |

**Calculation**: `pool_size = (expected concurrent DB operations) * 1.5`

## Database Connection Examples

**Using Environment Variables** (Recommended for Production):

```
# Set environment variables
export DB_USERNAME=sms_prod_user
export DB_PASSWORD=strong_password_here
export DB_HOSTNAME=db-primary.internal.example.com
export DB_PORT=3306
export DB_NAME=sms_c_production
export DB_POOL_SIZE=30
```

**Direct Configuration** (Development Only):

```
config :sms_c, SmsC.Repo,
  username: "dev_user",
  password: "dev_password",
  hostname: "localhost",
  database: "sms_c_dev",
  pool_size: 5
```

## Connection Pool Monitoring

Monitor pool usage via Prometheus metrics:

- `ecto_pools_queue_time` - Time waiting for connection
- `ecto_pools_query_time` - Query execution time
- `ecto_pools_connected_count` - Active connections

Alert if wait time exceeds 100ms consistently - indicates need for larger pool.

# API Configuration

The REST API provides message submission and management capabilities.

## Basic API Configuration

```
# config/runtime.exs
config :api_ex,
  port: String.to_integer(System.get_env("API_PORT") || "8443"),
  listen_ip: System.get_env("API_LISTEN_IP") || "0.0.0.0",
  enable_tls: System.get_env("API_ENABLE_TLS") != "false"
```

## TLS/SSL Configuration

**Production Setup with TLS** (Recommended):

```
config :api_ex,
  port: 8443,
  listen_ip: "0.0.0.0",
  enable_tls: true,
  tls_cert_path: "/etc/sms_c/certs/server.crt",
  tls_key_path: "/etc/sms_c/certs/server.key"
```

**Development Setup without TLS**:

```
config :api_ex,
  port: 8080,
  listen_ip: "127.0.0.1",
  enable_tls: false
```

# API Certificate Setup

Generate self-signed certificate for testing:

```
# Create certificate directory
mkdir -p priv/cert

# Generate private key
openssl genrsa -out priv/cert/server.key 2048

# Generate certificate signing request
openssl req -new -key priv/cert/server.key -out
priv/cert/server.csr \
  -subj "/C=US/ST=State/L=City/O=Organization/CN=sms-
api.example.com"

# Generate self-signed certificate (valid 365 days)
openssl x509 -req -days 365 -in priv/cert/server.csr \
  -signkey priv/cert/server.key -out priv/cert/server.crt

# Set permissions
chmod 600 priv/cert/server.key
chmod 644 priv/cert/server.crt
```

For production, use certificates from a trusted CA (Let's Encrypt, commercial CA, etc.).

## API Access Control

**IP Whitelisting** (Application Firewall):

```
# Using iptables (Linux)
iptables -A INPUT -p tcp --dport 8443 -s 10.0.0.0/8 -j ACCEPT
iptables -A INPUT -p tcp --dport 8443 -j DROP

# Using firewalld (Red Hat/CentOS)
firewall-cmd --permanent --add-rich-rule='rule family="ipv4"
source address="10.0.0.0/8" port protocol="tcp" port="8443"
accept'
firewall-cmd --reload
```

**API Key Authentication** (Application Level):

Configure via custom plug in router - see Operations Guide for implementation details.

# Web UI Configuration

The web interface provides route management, message browsing, and monitoring.

## Basic Web UI Configuration

```
# config/runtime.exs
config :control_panel,
  port: String.to_integer(System.get_env("WEB_PORT") || "80"),
  hostname: System.get_env("WEB_HOSTNAME") || "localhost",
  enable_tls: System.get_env("WEB_ENABLE_TLS") == "true"
```

## Production Web UI Setup

```
config :control_panel,
  port: 443,
  hostname: "sms-admin.example.com",
  enable_tls: true,
  tls_cert_path: "/etc/sms_c/certs/web.crt",
  tls_key_path: "/etc/sms_c/certs/web.key"
```

## Reverse Proxy Setup (Recommended)

Use Nginx or Apache as reverse proxy for additional security and features:

**Nginx Configuration Example**:

```
upstream sms_web {
  server 127.0.0.1:4000;
  keepalive 32;
}

server {
  listen 80;
  server_name sms-admin.example.com;
  return 301 https://$server_name$request_uri;
}

server {
  listen 443 ssl http2;
  server_name sms-admin.example.com;

  ssl_certificate /etc/letsencrypt/live/sms-
admin.example.com/fullchain.pem;
  ssl_certificate_key /etc/letsencrypt/live/sms-
admin.example.com/privkey.pem;
  ssl_protocols TLSv1.2 TLSv1.3;
  ssl_ciphers HIGH:!aNULL:!MD5;

  # Basic auth for additional security
  auth_basic "SMS-C Admin";
  auth_basic_user_file /etc/nginx/.htpasswd;

  location / {
    proxy_pass http://sms_web;
    proxy_http_version 1.1;
    proxy_set_header Upgrade $http_upgrade;
    proxy_set_header Connection "upgrade";
    proxy_set_header Host $host;
    proxy_set_header X-Real-IP $remote_addr;
    proxy_set_header X-Forwarded-For $proxy_add_x_forwarded_for;
    proxy_set_header X-Forwarded-Proto $scheme;
  }

  # WebSocket support for LiveView
  location /live {
    proxy_pass http://sms_web;
    proxy_http_version 1.1;
    proxy_set_header Upgrade $http_upgrade;
    proxy_set_header Connection "upgrade";
```

```
    proxy_read_timeout 86400;
  }
}
```

# Cluster Configuration

The SMS-C supports multi-node clustering for high availability and load distribution.

## Single Node Setup

```
# config/runtime.exs
config :sms_c,
  cluster_nodes: [],  # Empty list = single node mode
  smsc_node_name: "node1"
```

## Multi-Node Static Cluster

```
# Node 1: config/runtime.exs
config :sms_c,
  cluster_nodes: [
    :"sms@node1.internal.example.com",
    :"sms@node2.internal.example.com",
    :"sms@node3.internal.example.com"
  ],
  smsc_node_name: "node1"

# Node 2: config/runtime.exs
config :sms_c,
  cluster_nodes: [
    :"sms@node1.internal.example.com",
    :"sms@node2.internal.example.com",
    :"sms@node3.internal.example.com"
  ],
  smsc_node_name: "node2"
```

## DNS-Based Auto-Discovery

```
config :sms_c,
  dns_cluster_query: "sms-cluster.internal.example.com",
  smsc_node_name: System.get_env("NODE_NAME") || "node1"
```

**DNS Setup for Auto-Discovery**:

```
# Configure SRV or A records for cluster nodes
# SRV record (preferred):
_sms._tcp.sms-cluster.internal.example.com. IN SRV 0 0 0
node1.internal.example.com.
_sms._tcp.sms-cluster.internal.example.com. IN SRV 0 0 0
node2.internal.example.com.
_sms._tcp.sms-cluster.internal.example.com. IN SRV 0 0 0
node3.internal.example.com.

# A records (alternative):
sms-cluster.internal.example.com. IN A 10.0.1.10
sms-cluster.internal.example.com. IN A 10.0.1.11
sms-cluster.internal.example.com. IN A 10.0.1.12
```

## Erlang Distribution Configuration

**Start Nodes with Proper Names**:

```
# Node 1
export NODE_NAME=sms@node1.internal.example.com
export ERLANG_COOKIE=shared_secret_cookie_here
elixir --name $NODE_NAME --cookie $ERLANG_COOKIE -S mix phx.server

# Node 2
export NODE_NAME=sms@node2.internal.example.com
export ERLANG_COOKIE=shared_secret_cookie_here
elixir --name $NODE_NAME --cookie $ERLANG_COOKIE -S mix phx.server
```

**Important**: All nodes in a cluster MUST use the same Erlang cookie for security.

## Cluster Network Requirements

Open these ports between cluster nodes:

| Port Range | Protocol | Purpose |
|---|---|---|
| 4369 | TCP | Erlang Port Mapper Daemon (EPMD) |
| 9100-9200 | TCP | Erlang distribution |

**Firewall Configuration Example**:

```
# Allow cluster traffic from internal network
iptables -A INPUT -p tcp -s 10.0.0.0/8 --dport 4369 -j ACCEPT
iptables -A INPUT -p tcp -s 10.0.0.0/8 --dport 9100:9200 -j ACCEPT
```

# Message Queue Configuration

Controls message retention and expiration behavior.

## Message Expiration

```
# config/runtime.exs
config :sms_c,
  dead_letter_time_minutes: 1440  # 24 hours
```

**Common Values**:

- **60** - 1 hour (testing/development)
- **1440** - 24 hours (typical production)
- **4320** - 3 days (extended retention)
- **10080** - 7 days (maximum retention)

Messages older than this value become undeliverable and are marked for cleanup.

# Delivery Retry Configuration

Retry behavior uses exponential backoff:

```
Retry Delay = 2^(attempt_count) minutes
```

| Attempt | Delay |
|---|---|
| 1 | 2 minutes |
| 2 | 4 minutes |
| 3 | 8 minutes |
| 4 | 16 minutes |
| 5 | 32 minutes |
| 6 | 64 minutes |
| 7 | 128 minutes |
| 8 | 256 minutes |

Maximum attempts before dead letter: Limited by `dead_letter_time_minutes`.

# Cleanup Configuration

```
# config/config.exs
config :sms_c,
  cleanup_interval_minutes: 10,
  fingerprint_ttl_minutes: 5,
  event_ttl_days: 7
```

**Cleanup Intervals**:

- **cleanup_interval_minutes**: How often cleanup worker runs (default: 10)
- **fingerprint_ttl_minutes**: Duplicate detection window (default: 5)
- **event_ttl_days**: Event log retention (default: 7)

# Charging Configuration

Integration with OCS for online charging and billing.

## Enable Charging

```
# config/runtime.exs
config :sms_c,
  default_charging_enabled: true,
  ocs_url: "http://ocs.internal.example.com:2080/jsonrpc",
  ocs_tenant: "sms.example.com",
  ocs_destination: "default",
  ocs_source: "sms_platform",
  ocs_subject: "sms_user",
  ocs_account: "default_account"
```

## Disable Charging

```
# config/runtime.exs
config :sms_c,
  default_charging_enabled: false
```

When disabled, all messages are processed without charging checks.

## Per-Tenant Charging Configuration

```
config :sms_c,
  ocs_url: System.get_env("OCS_URL") ||
"http://localhost:2080/jsonrpc",
  ocs_tenant: System.get_env("OCS_TENANT") ||
"tenant1.example.com",
  ocs_account: System.get_env("OCS_ACCOUNT") || "default"
```

**Environment Variables by Tenant**:

```
# Tenant 1
export OCS_TENANT=tenant1.example.com
export OCS_ACCOUNT=tenant1_account

# Tenant 2
export OCS_TENANT=tenant2.example.com
export OCS_ACCOUNT=tenant2_account
```

## Charging Failure Behavior

Configure what happens when charging fails:

```
config :sms_c,
  charging_failure_action: :allow  # or :deny
```

- **:allow** - Process message even if charging fails (log error)
- **:deny** - Reject message if charging fails

## OCS Connection Example

**Test OCS Connectivity**:

```
# Test OCS API
curl -X POST http://ocs.internal.example.com:2080/jsonrpc \
  -H "Content-Type: application/json" \
  -d '{
    "method": "SessionSv1.AuthorizeEvent",
    "params": [{
      "Tenant": "sms.example.com",
      "Account": "test_account",
      "Destination": "1234567890",
      "Usage": 100
    }],
    "id": 1
  }'
```

Expected response:

```
{
  "id": 1,
  "result": {
    "Attributes": {},
    "MaxUsage": 100,
    ...
  }
}
```

# ENUM Configuration

DNS-based E.164 number lookups for intelligent routing.

## Disable ENUM (Default)

```
# config/runtime.exs
config :sms_c,
  enum_enabled: false
```

## Enable ENUM with Default DNS

```
config :sms_c,
  enum_enabled: true,
  enum_domains: ["e164.arpa", "e164.org"],
  enum_dns_servers: [],  # Use system default DNS
  enum_timeout: 5000  # 5 seconds
```

## Enable ENUM with Custom DNS Servers

```
config :sms_c,
  enum_enabled: true,
  enum_domains: ["e164.internal.example.com", "e164.arpa"],
  enum_dns_servers: [
    {"10.0.1.53", 53},  # Internal DNS server
    {"8.8.8.8", 53},    # Google Public DNS (fallback)
    {"1.1.1.1", 53}     # Cloudflare DNS (fallback)
  ],
  enum_timeout: 3000  # 3 seconds (faster failover)
```

## ENUM Domain Priority

Domains are queried in order until a successful lookup:

```
config :sms_c,
  enum_domains: [
    "e164.internal.example.com",  # Try internal first
    "e164.carrier.net",            # Then carrier
    "e164.arpa"                    # Then public registry
  ]
```

## ENUM Performance Tuning

**For Low-Latency Networks**:

```
enum_timeout: 2000  # 2 seconds
```

**For High-Latency/Satellite Links**:

```
enum_timeout: 10000  # 10 seconds
```

## ENUM DNS Setup Example

**Configure Private ENUM Zone** (BIND9 format):

```
; Zone file for e164.internal.example.com
$ORIGIN e164.internal.example.com.
$TTL 300

; Number: +1-555-0100 becomes
0.0.1.0.5.5.5.1.e164.internal.example.com
0.0.1.0.5.5.5.1.e164.internal.example.com. IN NAPTR 100 10 "u"
"E2U+sip" "!^.*$!sip:15550100@voip-gateway.example.com!" .
0.0.1.0.5.5.5.1.e164.internal.example.com. IN NAPTR 100 20 "u"
"E2U+pstn" "!^.*$!pstn:gateway-a.example.com!" .

; Number: +1-555-0200
0.0.2.0.5.5.5.1.e164.internal.example.com. IN NAPTR 100 10 "u"
"E2U+sip" "!^.*$!sip:15550200@voip-gateway.example.com!" .
```

**Test ENUM Resolution**:

```
# Query ENUM domain
dig @10.0.1.53 NAPTR 0.0.1.0.5.5.5.1.e164.internal.example.com

# Expected output includes NAPTR records:
# 0.0.1.0.5.5.5.1.e164.internal.example.com. 300 IN NAPTR 100 10
"u" "E2U+sip" "!^.*$!sip:15550100@voip-gateway.example.com!" .
```

# Number Translation Configuration

Regex-based number normalization applied before routing.

# Disable Number Translation

```
# config/runtime.exs
config :sms_c,
  translation_rules: []
```

# Basic Number Translation Examples

**Add Country Code to Local Numbers**:

```
config :sms_c,
  translation_rules: [
    %{
      calling_prefix: nil,
      called_prefix: "",
      source_smsc: nil,
      calling_match: "^(\d{10})$",           # Match 10-digit
numbers
      calling_replace: "+1\1",                # Prepend +1
      called_match: "^(\d{10})$",
      called_replace: "+1\1",
      priority: 100,
      description: "Add +1 to 10-digit North American numbers",
      enabled: true
    }
  ]
```

**Normalize International Format**:

```
%{
  calling_prefix: nil,
  called_prefix: nil,
  source_smsc: nil,
  calling_match: "^00(\d+)$",                # Match 00 prefix
  calling_replace: "+\1",                    # Replace with +
  called_match: "^00(\d+)$",
  called_replace: "+\1",
  priority: 10,
  description: "Convert 00 international prefix to +",
  enabled: true
}
```

**Remove Formatting Characters**:

```
%{
  calling_prefix: nil,
  called_prefix: nil,
  source_smsc: nil,
  calling_match: "^\+?1?[\s\-\.\(\)]*(\d{3})[\s\-\.\)\(]*(\d{3})
[\s\-\.\(\)]*(\d{4})$",
  calling_replace: "+1\1\2\3",
  called_match: "^\+?1?[\s\-\.\(\)]*(\d{3})[\s\-\.\)\(]*(\d{3})
[\s\-\.\(\)]*(\d{4})$",
  called_replace: "+1\1\2\3",
  priority: 50,
  description: "Normalize US phone number formatting",
  enabled: true
}
```

# Carrier-Specific Translation

**Route Code Stripping**:

```
%{
  calling_prefix: nil,
  called_prefix: "101",                        # Only for 101
prefix
  source_smsc: "carrier_a",                    # Only from this
carrier
  calling_match: nil,                          # Don't change
calling
  calling_replace: nil,
  called_match: "^101(\d+)$",                 # Strip 101 route
code
  called_replace: "\1",
  priority: 5,
  description: "Strip carrier route code from called number",
  enabled: true
}
```

## Multi-Rule Translation

Rules are evaluated in priority order (lower number = higher priority):

```
config :sms_c,
  translation_rules: [
    # Priority 1: Most specific rules first
    %{
      calling_prefix: "1555",
      called_prefix: nil,
      source_smsc: nil,
      calling_match: "^(1555\d{7})$",
      calling_replace: "+\1",
      called_match: nil,
      called_replace: nil,
      priority: 1,
      description: "Premium number normalization",
      enabled: true
    },

    # Priority 50: General rules
    %{
      calling_prefix: nil,
      called_prefix: nil,
      source_smsc: nil,
      calling_match: "^(\d{10})$",
      calling_replace: "+1\1",
      called_match: "^(\d{10})$",
      called_replace: "+1\1",
      priority: 50,
      description: "General 10-digit normalization",
      enabled: true
    }
  ]
```

# Routing Configuration

Initial routing rules loaded on first startup. See SMS Routing Guide for complete routing documentation.

## Load Routes from Configuration

```
# config/runtime.exs
config :sms_c,
  sms_routes: [
    # Geographic routing example
    %{
      calling_prefix: nil,
      called_prefix: "+1",
      source_smsc: nil,
      dest_smsc: "north_america_gateway",
      source_type: nil,
      enum_domain: nil,
      auto_reply: false,
      auto_reply_message: nil,
      drop: false,
      charged: :default,
      weight: 100,
      priority: 50,
      description: "North America routing",
      enabled: true
    },

    # Load balanced routing example
    %{
      calling_prefix: nil,
      called_prefix: "+44",
      source_smsc: nil,
      dest_smsc: "uk_gateway_1",
      source_type: nil,
      enum_domain: nil,
      auto_reply: false,
      auto_reply_message: nil,
      drop: false,
      charged: :default,
      weight: 70,
      priority: 50,
      description: "UK primary gateway (70%)",
      enabled: true
    },
    %{
      calling_prefix: nil,
      called_prefix: "+44",
```

```
      source_smsc: nil,
      dest_smsc: "uk_gateway_2",
      source_type: nil,
      enum_domain: nil,
      auto_reply: false,
      auto_reply_message: nil,
      drop: false,
      charged: :default,
      weight: 30,
      priority: 50,
      description: "UK backup gateway (30%)",
      enabled: true
    }
  ]
```

## Skip Initial Route Loading

```
# Don't load routes from config (manage via Web UI only)
config :sms_c,
  sms_routes: []
```

Routes defined in configuration are ONLY loaded if the routing table is empty (first startup).

# Performance Tuning Configuration

See Performance Tuning Guide for detailed optimization strategies.

## Batch Insert Worker

```
# config/config.exs
config :sms_c,
  batch_insert_batch_size: 100,           # Messages per batch
  batch_insert_flush_interval_ms: 100     # Max wait time in ms
```

**Performance Profiles**:

| Profile | Batch Size | Interval | Throughput | Latency |
|---|---|---|---|---|
| High Volume | 200 | 200ms | ~5,000 msg/sec | Up to 200ms |
| Balanced | 100 | 100ms | ~4,500 msg/sec | Up to 100ms |
| Low Latency | 50 | 20ms | ~3,000 msg/sec | Up to 20ms |
| Real-time | 10 | 10ms | ~1,500 msg/sec | Up to 10ms |

# Logging Configuration

## Log Levels

```
# config/config.exs
config :logger, :console,
  level: :info,  # :debug, :info, :warning, :error
  format: "$time $metadata[$level] $message\n",
  metadata: [:request_id, :message_id, :route_id]
```

**Production Recommended**: `:info` or `:warning` **Development Recommended**: `:debug`

## Log Output Destinations

**Console Only** (Development):

```
config :logger,
  backends: [:console]
```

**File Logger** (Production):

```
config :logger,
  backends: [:console, {LoggerFileBackend, :file_log}]

config :logger, :file_log,
  path: "/var/log/sms_c/application.log",
  level: :info,
  format: "$time $metadata[$level] $message\n",
  metadata: [:request_id, :message_id]
```

## Log Rotation

**Using logrotate** (Linux):

```
# /etc/logrotate.d/sms_c
/var/log/sms_c/*.log {
    daily
    rotate 30
    compress
    delaycompress
    notifempty
    create 0644 sms_user sms_group
    sharedscripts
    postrotate
        # Signal application to reopen log file
        systemctl reload sms_c
    endscript
}
```

# Common Configuration Scenarios

## High-Volume Aggregator

Optimize for maximum throughput (5,000+ messages/second):

```
# Database
config :sms_c, SmsC.Repo,
  pool_size: 50

# Batch worker
config :sms_c,
  batch_insert_batch_size: 200,
  batch_insert_flush_interval_ms: 200

# Message retention
config :sms_c,
  dead_letter_time_minutes: 1440  # 24 hours

# Charging (disabled for performance)
config :sms_c,
  default_charging_enabled: false

# Cleanup (extended intervals)
config :sms_c,
  cleanup_interval_minutes: 30
```

## Enterprise Real-Time Messaging

Optimize for low latency (< 20ms):

```
# Database
config :sms_c, SmsC.Repo,
  pool_size: 20

# Batch worker (low latency)
config :sms_c,
  batch_insert_batch_size: 20,
  batch_insert_flush_interval_ms: 10

# Message retention
config :sms_c,
  dead_letter_time_minutes: 4320  # 3 days

# Charging (enabled)
config :sms_c,
  default_charging_enabled: true,
  ocs_url: "http://ocs.local:2080/jsonrpc"
```

## Development/Testing

Optimize for debugging and visibility:

```
# Database
config :sms_c, SmsC.Repo,
  pool_size: 5

# Batch worker (immediate)
config :sms_c,
  batch_insert_batch_size: 1,
  batch_insert_flush_interval_ms: 10

# Logging (verbose)
config :logger, :console,
  level: :debug

# Message retention (short)
config :sms_c,
  dead_letter_time_minutes: 60  # 1 hour

# Charging (disabled)
config :sms_c,
  default_charging_enabled: false
```

## Multi-Tenant Service Provider

Separate configuration per tenant:

```
# Tenant 1 environment
export DB_NAME=sms_c_tenant1
export OCS_TENANT=tenant1.example.com
export OCS_ACCOUNT=tenant1_account
export NODE_NAME=sms_tenant1@node1.example.com

# Tenant 2 environment
export DB_NAME=sms_c_tenant2
export OCS_TENANT=tenant2.example.com
export OCS_ACCOUNT=tenant2_account
export NODE_NAME=sms_tenant2@node1.example.com
```

### Geographic Redundancy

Cluster across regions:

```
# US East cluster
config :sms_c,
  cluster_nodes: [
    :"sms@us-east-1a.example.com",
    :"sms@us-east-1b.example.com",
    :"sms@us-west-1a.example.com"  # Cross-region for DR
  ],
  smsc_node_name: "us-east-1a"
```

# Configuration Validation

Test configuration before deployment:

```
# Check configuration syntax
mix compile

# Validate database connection
mix ecto.create
mix ecto.migrate

# Test OCS connectivity (if enabled)
curl -X POST http://localhost:2080/jsonrpc -H "Content-Type:
application/json" \
  -d '{"method":"SessionSv1.Ping","params":[],"id":1}'

# Start application in interactive mode
iex -S mix phx.server
```

# Environment Variables Reference

Common environment variables used in configuration:

| Variable | Purpose | Example |
|---|---|---|
| `DB_USERNAME` | Database username | `sms_prod_user` |
| `DB_PASSWORD` | Database password | `strong_password` |
| `DB_HOSTNAME` | Database host | `db.internal.example.com` |
| `DB_PORT` | Database port | `3306` |
| `DB_NAME` | Database name | `sms_c_production` |
| `DB_POOL_SIZE` | Connection pool size | `30` |
| `API_PORT` | API listen port | `8443` |
| `API_LISTEN_IP` | API listen IP | `0.0.0.0` |
| `WEB_PORT` | Web UI port | `443` |
| `NODE_NAME` | Erlang node name | `sms@node1.example.com` |
| `ERLANG_COOKIE` | Cluster secret | `shared_cookie_value` |
| `OCS_URL` | OCS API URL | `http://ocs.local:2080/jsonrpc` |
| `OCS_TENANT` | OCS tenant | `sms.example.com` |

# Configuration Best Practices

1. **Use Environment Variables** for sensitive values (passwords, API keys)
2. **Test Configuration Changes** in staging before production
3. **Document Custom Settings** in deployment notes
4. **Version Control Config Files** (excluding secrets)
5. **Monitor After Changes** for performance regressions

6. **Keep Backups** of working configurations
7. **Validate Before Restart** to avoid startup failures
8. **Use Consistent Naming** across environments
9. **Set Resource Limits** appropriate to hardware
10. **Review Periodically** to remove unused features

# Troubleshooting Configuration Issues

| Symptom | Likely Cause | Solution |
|---|---|---|
| Application won't start | Syntax error in config | Check logs, validate syntax |
| Database connection fails | Wrong credentials/host | Verify DB_* environment variables |
| API not accessible | Wrong port/IP binding | Check API_PORT and listen_ip |
| Cluster nodes won't connect | Cookie mismatch, firewall | Verify ERLANG_COOKIE, check ports 4369, 9100-9200 |
| Charging failures | OCS unreachable | Test connectivity to ocs_url |
| ENUM lookups fail | DNS server unreachable | Test DNS connectivity, check timeout |
| Poor performance | Wrong batch settings | Review Performance Tuning Guide |
| Messages not routing | Routes not loaded | Check sms_routes config or Web UI |

For additional help, see the Troubleshooting Guide.

# Message Storage Configuration (Mnesia)

## Message Retention

Messages are stored in Mnesia for fast access with configurable automatic cleanup.

```
config :sms_c,
  # How long to keep messages in Mnesia (hours)
  message_retention_hours: 24,

  # How often to check for old messages (minutes)
  retention_check_interval_minutes: 60
```

**Recommendations:**

- **Production:** 24-72 hours (balance operational needs vs memory)
- **Development:** 4-8 hours (faster cleanup for testing)
- **High volume:** 12-24 hours (conserve memory)

**Memory Impact:**

- Average message: ~1KB
- 10,000 messages: ~10MB
- 100,000 messages: ~100MB

## CDR (Call Detail Record) Export

When messages are delivered or expired, CDRs can be automatically written to your Ecto database for long-term storage and billing analytics.

```
config :sms_c,
  # Enable/disable CDR writing
  cdr_enabled: true
```

**CDR Records Include:**

- Message ID, calling/called numbers
- Source/destination SMSC
- Origin/destination node (for clusters)
- Submission, delivery, expiry timestamps
- Status, delivery attempts
- Optional message body (see privacy controls)

**When to Disable:**

- Testing environments where CDRs aren't needed
- Temporary troubleshooting to reduce database load

# Privacy Controls

Configure message body visibility and retention for privacy compliance.

```
config :sms_c,
  # Delete message body from Mnesia after successful delivery
  delete_message_body_after_delivery: false,

  # Hide message body in web UI
  hide_message_body_in_ui: false,

  # Hide message body in CSV exports
  hide_message_body_in_export: false
```

**Use Cases:**

| Configuration | Use Case |
| --- | --- |
| `delete_message_body_after_delivery: true` | Save Mnesia space, privacy compliance |
| `hide_message_body_in_ui: true` | Prevent operator viewing of message content |
| `hide_message_body_in_export: true` | Data export compliance, sanitized reports |

**Example Configurations:**

*Maximum Privacy (Compliance)*

```
config :sms_c,
  delete_message_body_after_delivery: true,
  hide_message_body_in_ui: true,
  hide_message_body_in_export: true,
  cdr_enabled: true  # Keep CDRs without bodies
```

*Development (Full Visibility)*

```
config :sms_c,
  delete_message_body_after_delivery: false,
  hide_message_body_in_ui: false,
  hide_message_body_in_export: false,
  cdr_enabled: true
```

# Startup Logging

On application startup, configuration status is logged:

```
[info] Message storage: Mnesia (retention: 24h)
[info] CDR export: ENABLED
[info] Body deletion after delivery: DISABLED
[info] OCS charging: ENABLED (url: http://..., tenant: ...)
```

This provides immediate visibility into active features.

# SMS-C Prometheus Metrics Documentation

**← Back to Documentation Index** | **Main README**

## Overview

This document describes all Prometheus metrics exposed by the SMS-C system. These metrics are designed for operations staff to monitor system health, performance, and troubleshoot issues.

## Accessing Metrics

The Prometheus metrics endpoint is available at:

```
http://localhost:9568/metrics
```

This endpoint exposes metrics in Prometheus text format that can be scraped by a Prometheus server. The metrics are updated in real-time as the system processes messages.

## Metric Naming Convention

All metrics follow the pattern: `sms_c.<category>.<metric_name>.<type>`

Categories:

- `license` - License status metrics
- `message` - Message processing metrics
- `routing` - Routing decision metrics
- `enum` - ENUM/NAPTR lookup metrics

- `delivery` - Message delivery metrics
- `queue` - Queue management metrics
- `charging` - Billing/charging metrics
- `mnesia` - Database metrics
- `frontend` - Frontend connection metrics
- `location` - Location/registration metrics
- `phoenix.endpoint` - HTTP API request metrics
- `vm` - Erlang VM system metrics

# License Metrics

## sms_c_license_status

**Type**: Gauge

**Description**: Current license status of the OmniMessage SMS-C system.

**Values**:

- `1` - Valid license
- `0` - Invalid/expired license

**Labels**: None

**Product Name**: `omnimessage`

**Use Case**: Monitor license validity to ensure system is operating with a valid license. When invalid, messages are still received but routed to destination "NOLICENCE" instead of normal routing.

**Behavior When License Invalid**:

- Inbound messages are **accepted** and stored
- Message destination (`dest_smsc`) is **automatically set to "NOLICENCE"**
- Normal routing is **bypassed**
- UI and monitoring remain **accessible**

- Database and all services remain **operational**

**Alerting**:

```
- alert: SMS_C_License_Invalid
  expr: sms_c_license_status == 0
  for: 1m
  labels:
    severity: critical
  annotations:
    summary: "SMS-C license invalid or expired"
    description: "License status is invalid - messages being
routed to NOLICENCE"
```

**Example Prometheus Queries**:

```
# Check if license is valid
sms_c_license_status == 1

# Alert on invalid license
sms_c_license_status == 0

# Count messages routed to NOLICENCE (indicates license issue)
sms_c_routing_route_matched_count{dest_smsc="NOLICENCE"}
```

---

# Message Processing Metrics

## sms_c_message_received_count

**Type**: Counter

**Description**: Total number of messages received by the SMS-C from all sources.

**Labels**:

- `source_smsc`: Name of the source SMSC that sent the message

- `source_type`: Type of source connection (ims, circuit_switched, smpp)
- `message_type`: Type of message (sms, mms)

**Use Case**: Monitor incoming message volume by source and type. Use to detect traffic patterns, identify busy periods, and spot anomalies in message flow.

**Alerting**: Set alerts for sudden drops (potential source connectivity issues) or spikes (potential attack/spam).

---

## sms_c_message_validated_count

**Type**: Counter

**Description**: Total number of message validations performed.

**Labels**:

- `valid`: Whether validation passed (true or false)

**Use Case**: Track validation success/failure rates. High failure rates may indicate malformed messages or integration issues.

**Alerting**: Alert when validation failure rate exceeds threshold (e.g., > 5% failures).

---

## sms_c_message_processing_stop_duration

**Type**: Histogram

**Description**: Time taken to process a message from receipt to completion (includes validation, routing, and queueing).

**Unit**: Milliseconds

**Buckets**: 10, 50, 100, 250, 500, 1000, 2500, 5000 ms

**Labels**:

- `success`: Whether processing succeeded (true or false)

**Use Case**: Monitor end-to-end message processing performance. Identify slowdowns in the processing pipeline.

**Alerting**: Alert when p95 or p99 latency exceeds SLA thresholds.

---

# Routing Metrics

## sms_c_routing_route_matched_count

**Type**: Counter

**Description**: Total number of times a specific route was matched and selected for message routing.

**Labels**:

- `route_id`: Unique identifier of the matched route
- `dest_smsc`: Destination SMSC selected by the route
- `priority`: Priority value of the matched route

**Use Case**: Understand which routes are being used most frequently. Identify underutilized or overloaded routes. Useful for capacity planning and route optimization.

**Alerting**: Alert if high-priority routes are rarely matched (may indicate routing misconfiguration).

---

## sms_c_routing_failed_count

**Type**: Counter

**Description**: Total number of routing failures where no suitable route could be found.

**Labels**:

- `reason`: Failure reason (no_route_found, validation_failed, etc.)

**Use Case**: Track routing failures to identify configuration gaps or unexpected traffic patterns.

**Alerting**: Alert on any routing failures as they indicate messages cannot be delivered.

---

## sms_c_routing_action_count

**Type**: Counter

**Description**: Total number of special routing actions taken.

**Labels**:

- `action`: Type of action (drop, auto_reply, forward)
- `route_id`: Route that triggered the action

**Use Case**: Monitor drop rules (anti-spam), auto-reply usage, and forwarding patterns.

**Alerting**: Alert on unexpected spikes in drop actions (may indicate spam attack).

---

## sms_c_routing_stop_duration

**Type**: Histogram

**Description**: Time taken to evaluate all routes and select the best match.

**Unit**: Milliseconds

**Buckets**: 1, 5, 10, 25, 50, 100, 250, 500 ms

**Labels**:

- `dest_smsc`: Selected destination SMSC

**Use Case**: Monitor routing engine performance. Slow routing indicates too many routes or complex matching logic.

**Alerting**: Alert when routing takes consistently longer than expected (e.g., p95 > 50ms).

---

# ENUM/NAPTR Lookup Metrics

## sms_c_enum_cache_hit_count

**Type**: Counter

**Description**: Total number of ENUM lookups served from cache (did not require DNS query).

**Labels**:

- `domain`: ENUM domain queried

**Use Case**: Monitor cache effectiveness. High cache hit rates reduce DNS load and improve performance.

**Alerting**: Alert if cache hit rate drops below threshold (may indicate cache issues or unusual traffic).

---

## sms_c_enum_cache_miss_count

**Type**: Counter

**Description**: Total number of ENUM lookups that required a DNS query (not in cache).

**Labels**:

- `domain`: ENUM domain queried

**Use Case**: Track cache misses to understand cache effectiveness. Use with hit count to calculate hit rate.

**Calculation**: `cache_hit_rate = hits / (hits + misses)`

---

## sms_c_enum_cache_size_size

**Type**: Gauge

**Description**: Current number of entries in the ENUM cache.

**Use Case**: Monitor cache size to ensure it's not growing unbounded. Help tune cache TTL settings.

**Alerting**: Alert if cache size exceeds expected bounds (may indicate memory leak).

---

## sms_c_enum_lookup_stop_duration

**Type**: Histogram

**Description**: Time taken to complete an ENUM lookup (including DNS query if not cached).

**Unit**: Milliseconds

**Buckets**: 10, 50, 100, 250, 500, 1000, 2500, 5000 ms

**Labels**:

- `domain`: ENUM domain queried
- `success`: Whether lookup succeeded (true or false)
- `cache_hit`: Whether result was served from cache (true or false)

**Use Case**: Monitor ENUM lookup performance. Identify slow DNS servers or network issues.

**Alerting**: Alert when p95 lookup time exceeds timeout threshold.

---

## sms_c_enum_naptr_records_record_count

**Type**: Histogram

**Description**: Number of NAPTR records returned by a successful ENUM lookup.

**Buckets**: 0, 1, 2, 3, 5, 10

**Labels**:

- `domain`: ENUM domain queried

**Use Case**: Understand ENUM record distribution. Most lookups should return 1-3 records.

**Alerting**: Alert if frequently returning 0 records (DNS configuration issue).

---

# Delivery Metrics

## sms_c_delivery_queued_count

**Type**: Counter

**Description**: Total number of messages queued for delivery to a destination SMSC.

**Labels**:

- `dest_smsc`: Destination SMSC name

**Use Case**: Monitor message flow to each destination. Useful for capacity planning.

**Alerting**: Compare with delivery success/failure counts to detect accumulation.

---

## sms_c_delivery_attempted_count

**Type**: Counter

**Description**: Total number of delivery attempts made (includes retries).

**Labels**:

- `dest_smsc`: Destination SMSC name

**Use Case**: Track delivery attempt volume. High attempt count relative to queued count indicates retry behavior.

---

## sms_c_delivery_succeeded_count

**Type**: Counter

**Description**: Total number of messages successfully delivered to destination SMSC.

**Labels**:

- `dest_smsc`: Destination SMSC name

**Use Case**: Track successful deliveries per destination. Primary success metric.

**Alerting**: Alert if success rate drops below SLA threshold.

**Calculation**: `success_rate = succeeded / queued`

---

## sms_c_delivery_failed_count

**Type**: Counter

**Description**: Total number of messages that failed delivery after all retry attempts.

**Labels**:

- `dest_smsc`: Destination SMSC name
- `reason`: Failure reason

**Use Case**: Track delivery failures to identify problematic destinations or failure patterns.

**Alerting**: Alert on elevated failure rates or specific failure reasons.

---

## sms_c_delivery_dead_letter_count

**Type**: Counter

**Description**: Total number of messages moved to dead letter queue (undeliverable).

**Labels**:

- `reason`: Reason for dead letter (e.g., `max_retries_exceeded`, `expired`)

**Use Case**: Monitor undeliverable messages requiring manual intervention.

**Alerting**: Alert on any dead letter events as they represent complete delivery failure.

---

## sms_c_delivery_succeeded_attempt_count

**Type**: Histogram

**Description**: Number of delivery attempts required before successful delivery.

**Buckets**: 1, 2, 3, 5, 10

**Labels**:

- `dest_smsc`: Destination SMSC name

**Use Case**: Understand retry behavior. Most deliveries should succeed on first attempt.

**Alerting**: Alert if average attempt count exceeds 2 (indicates destination reliability issues).

---

## sms_c_delivery_failed_attempt_count

**Type**: Histogram

**Description**: Number of delivery attempts made before final failure.

**Buckets**: 1, 2, 3, 5, 10

**Labels**:

- `dest_smsc`: Destination SMSC name

**Use Case**: Understand how many retries occur before giving up.

---

## sms_c_delivery_time_delta_delta_ms

**Type**: Histogram

**Description**: Time from message submission to delivery confirmation. This metric captures the complete end-to-end latency from when a message enters the SMS-C to when delivery is confirmed, with detailed labels for analysis by source, destination, and retry behavior.

**Unit**: Milliseconds

**Buckets**: 50, 100, 250, 500, 1000, 2000, 5000, 10000, 20000, 60000, 600000 ms (50ms to 10 minutes)

**Labels**:

- `source_smsc`: Source SMSC that submitted the message
- `dest_smsc`: Destination SMSC that delivered the message
- `delivery_attempts`: Number of delivery attempts required (0 = first attempt success)

**Use Case**: Analyze end-to-end delivery performance by source-destination pair. Identify slow paths, problematic SMSC combinations, and correlate latency with retry behavior. Essential for SLA monitoring and capacity planning.

**Alerting**:

- Alert when p95 exceeds SLA threshold for specific source/dest combinations
- Alert when messages consistently require multiple attempts

**Example Prometheus Queries**:

```
# P95 delivery time by source and destination SMSC
histogram_quantile(0.95,
  sum by (source_smsc, dest_smsc, le) (
    rate(sms_c_delivery_time_delta_delta_ms_bucket[5m])
  )
)

# P99 delivery time overall
histogram_quantile(0.99,
  sum by (le) (
    rate(sms_c_delivery_time_delta_delta_ms_bucket[5m])
  )
)

# Average delivery time by source SMSC
sum by (source_smsc) (rate(sms_c_delivery_time_delta_delta_ms_sum[5m]
/
sum by (source_smsc)
(rate(sms_c_delivery_time_delta_delta_ms_count[5m]))

# Delivery time for messages requiring retries vs first-attempt succe
histogram_quantile(0.95,
  sum by (le)
(rate(sms_c_delivery_time_delta_delta_ms_bucket{delivery_attempts="0"
[5m]))
)
histogram_quantile(0.95,
  sum by (le)
(rate(sms_c_delivery_time_delta_delta_ms_bucket{delivery_attempts!="0
[5m]))
)

# Slowest source-destination pairs (by p95)
topk(10,
  histogram_quantile(0.95,
    sum by (source_smsc, dest_smsc, le) (
      rate(sms_c_delivery_time_delta_delta_ms_bucket[1h])
    )
  )
)

# Percentage of messages delivered within 2 seconds
sum(rate(sms_c_delivery_time_delta_delta_ms_bucket{le="2000"}[5m])) /
```

```
sum(rate(sms_c_delivery_time_delta_delta_ms_count[5m])) * 100

# Messages delivered within 2 seconds by destination
sum by (dest_smsc)
(rate(sms_c_delivery_time_delta_delta_ms_bucket{le="2000"}[5m])) /
sum by (dest_smsc) (rate(sms_c_delivery_time_delta_delta_ms_count[5m]
* 100
```

---

# Queue Metrics

## sms_c_queue_size_size

**Type**: Gauge

**Description**: Current total number of messages in queue (all states combined).

**Labels**:

- `queue_type`: Type of queue (message_queue, dead_letter)

**Use Case**: Monitor queue depth to detect backlogs or processing issues.

**Alerting**: Alert when queue size exceeds capacity thresholds.

---

## sms_c_queue_size_pending

**Type**: Gauge

**Description**: Current number of messages pending delivery (not yet attempted).

**Labels**:

- `queue_type`: Type of queue

**Use Case**: Monitor pending message count. High pending counts indicate processing delays.

**Alerting**: Alert when pending count exceeds threshold for extended period.

---

## sms_c_queue_size_failed

**Type**: Gauge

**Description**: Current number of messages in failed state (awaiting retry).

**Labels**:

- `queue_type`: Type of queue

**Use Case**: Monitor failed message accumulation. Indicates delivery issues.

**Alerting**: Alert on elevated failed count as it impacts delivery rates.

---

## sms_c_queue_size_delivered

**Type**: Gauge

**Description**: Current number of delivered messages awaiting cleanup/removal from queue.

**Labels**:

- `queue_type`: Type of queue

**Use Case**: Monitor cleanup lag. High counts indicate cleanup process is falling behind.

**Alerting**: Alert if delivered messages accumulate significantly.

---

## sms_c_queue_oldest_message_age_seconds

**Type**: Gauge

**Description**: Age (in seconds) of the oldest message currently in pending state.

**Labels**:

- `queue_type`: Type of queue

**Use Case**: Detect message aging and processing stalls. Critical for SLA monitoring.

**Alerting**: Alert when oldest message age exceeds SLA threshold (e.g., > 300 seconds).

---

# Charging Metrics

## sms_c_charging_requested_count

**Type**: Counter

**Description**: Total number of charging/billing requests made to OCS or billing system.

**Labels**:

- `account`: Account identifier being charged

**Use Case**: Track charging volume per account. Useful for billing reconciliation.

---

## sms_c_charging_succeeded_count

**Type**: Counter

**Description**: Total number of successful charging operations.

**Labels**:

- `account`: Account identifier charged

**Use Case**: Monitor charging success rate per account.

**Calculation**: `success_rate = succeeded / requested`

---

## sms_c_charging_failed_count

**Type**: Counter

**Description**: Total number of failed charging operations.

**Labels**:

- `account`: Account identifier
- `reason`: Failure reason

**Use Case**: Identify charging failures that may impact revenue or require account intervention.

**Alerting**: Alert on elevated charging failure rates.

---

## sms_c_charging_succeeded_duration

**Type**: Histogram

**Description**: Time taken to complete a successful charging request.

**Unit**: Milliseconds

**Buckets**: 10, 50, 100, 250, 500, 1000, 2500, 5000 ms

**Labels**:

- `account`: Account identifier

**Use Case**: Monitor billing system performance. Slow charging can delay message delivery.

**Alerting**: Alert when p95 charging time exceeds threshold.

---

# System Health Metrics

## sms_c_mnesia_table_size_record_count

**Type**: Gauge

**Description**: Current number of records in each Mnesia database table. Polled every 10 seconds.

**Labels**:

- `table`: Table name

**Tracked Tables**:

- `sms_route` - SMS routing rules
- `message_store` - Message queue (pending, delivered, failed messages)
- `location_store` - Subscriber location/registration data
- `frontend_store` - Frontend/SMSC registrations
- `translation_rule` - Number translation rules
- `cell_tower_store` - Cell tower location data
- `message_events` - Message event logs

**Use Case**: Monitor database growth. Detect unexpected data accumulation. Capacity planning.

**Alerting**: Alert on unexpected table growth rates or when approaching capacity limits.

**Example Prometheus Queries**:

```
# All table sizes
sms_c_mnesia_table_size_record_count

# Message queue size
sms_c_mnesia_table_size_record_count{table="message_store"}

# Active subscriber registrations
sms_c_mnesia_table_size_record_count{table="location_store"}

# Routing rules count
sms_c_mnesia_table_size_record_count{table="sms_route"}
```

---

## sms_c_frontend_status_count

**Type**: Gauge

**Description**: Number of frontends in each connection status.

**Labels**:

- `frontend_name`: Frontend identifier
- `status`: Connection status (connected, disconnected)

**Use Case**: Monitor frontend connectivity. Detect connection failures.

**Alerting**: Alert when expected frontends disconnect.

---

## sms_c_location_registered_count

**Type**: Counter

**Description**: Total number of location/subscriber registrations received by the system.

**Labels**:

- `location`: Frontend/SMSC name where subscriber is registered

- `ims_capable`: Whether the subscriber supports IMS (true/false)

**Use Case**: Monitor subscriber registration activity. Track IMS vs non-IMS subscribers. Detect registration storms or failures.

**Alerting**: Set alerts for:

- Registration rate drops (may indicate network issues)
- Unusual spikes in registrations
- High ratio of non-IMS registrations (legacy device influx)

**Example Query**:

```
# Registration rate per minute
rate(sms_c_location_registered_count[1m])

# IMS vs non-IMS registration ratio
sum(rate(sms_c_location_registered_count{ims_capable="true"}[5m]))
/
sum(rate(sms_c_location_registered_count[5m]))
```

---

## sms_c_location_active_registrations_count

**Type**: Gauge

**Description**: Current number of active subscriber registrations, grouped by location (frontend/SMSC) and IMS capability. This metric is polled every 10 seconds and reflects the current state of the location store.

**Labels**:

- `location`: Frontend/SMSC name where subscribers are registered
- `ims_capable`: Whether the registrations are IMS capable (true/false)

**Use Case**: Monitor current subscriber distribution across frontends. Track IMS adoption. Identify load imbalances between frontends. Capacity planning for each SMSC instance.

**Alerting**: Set alerts for:

- Sudden drops in registrations for a location (may indicate frontend issues)
- Imbalanced distribution across frontends
- Total registrations approaching capacity limits

**Example Prometheus Queries**:

```
# Total active registrations
sum(sms_c_location_active_registrations_count)

# Active registrations by location
sum by (location) (sms_c_location_active_registrations_count)

# Active IMS-capable registrations by location
sum by (location)
(sms_c_location_active_registrations_count{ims_capable="true"})

# IMS adoption rate per location
sum by (location)
(sms_c_location_active_registrations_count{ims_capable="true"}) /
sum by (location) (sms_c_location_active_registrations_count) *
100

# Total IMS vs non-IMS registrations
sum by (ims_capable) (sms_c_location_active_registrations_count)

# Locations with most registrations
topk(10, sum by (location)
(sms_c_location_active_registrations_count))

# Registration distribution as percentage of total
sum by (location) (sms_c_location_active_registrations_count) /
sum(sms_c_location_active_registrations_count) * 100
```

---

# HTTP API Request Metrics

## phoenix_endpoint_stop_duration

**Type**: Distribution (Histogram)

**Description**: HTTP request processing duration in milliseconds, from request start to response completion.

**Labels**:

- `route`: API endpoint route (e.g., `/api/messages`, `/api/frontends`)

**Buckets**: 10ms, 50ms, 100ms, 250ms, 500ms, 1s, 2.5s, 5s

**Use Case**: Monitor API performance. Identify slow endpoints. Track response time SLAs.

**Alerting**: Set alerts for:

- P95 latency > 500ms for critical endpoints
- P99 latency > 1s for any endpoint
- Increasing latency trends

**Example Query**:

```
# P95 response time by endpoint
histogram_quantile(0.95,
  rate(phoenix_endpoint_stop_duration_bucket[5m]))

# Requests slower than 1 second
sum(rate(phoenix_endpoint_stop_duration_bucket{le="1000"}[5m]))
```

---

## phoenix_endpoint_stop_count

**Type**: Counter

**Description**: Total number of HTTP requests completed, categorized by route and HTTP status code.

**Labels**:

- `route`: API endpoint route
- `status`: HTTP status code (200, 201, 400, 404, 500, etc.)

**Use Case**: Monitor API request volume and success rates. Track error rates by endpoint.

**Alerting**: Set alerts for:

- Error rate > 5% for any endpoint
- 5xx errors on critical endpoints
- Sudden drops in request volume

**Example Query**:

```
# Request rate per endpoint
sum by (route) (rate(phoenix_endpoint_stop_count[5m]))

# Error rate by endpoint
sum by (route) (rate(phoenix_endpoint_stop_count{status=~"5.."}
[5m])) /
sum by (route) (rate(phoenix_endpoint_stop_count[5m]))

# Success rate
sum(rate(phoenix_endpoint_stop_count{status=~"2.."}[5m])) /
sum(rate(phoenix_endpoint_stop_count[5m]))
```

---

## phoenix_router_dispatch_exception_count

**Type**: Counter

**Description**: Total number of exceptions/errors raised during HTTP request processing.

**Labels**:

- `route`: API endpoint route where exception occurred
- `kind`: Type of exception (error, exit, throw)

**Use Case**: Track application errors. Identify problematic endpoints. Monitor system stability.

**Alerting**: Set alerts for any non-zero value on critical endpoints.

**Example Query**:

```
# Exception rate by endpoint
rate(phoenix_router_dispatch_exception_count[5m])

# Total exceptions in last hour
increase(phoenix_router_dispatch_exception_count[1h])
```

---

# Erlang VM Metrics

## vm_memory_total

**Type**: Gauge

**Description**: Total memory allocated by the Erlang VM in bytes.

**Use Case**: Monitor overall memory usage. Detect memory leaks. Plan capacity.

**Alerting**: Alert when memory usage > 80% of available system memory.

---

## vm_memory_processes

**Type**: Gauge

**Description**: Memory used by Erlang processes in bytes.

**Use Case**: Track process memory consumption. Most common source of memory growth.

**Alerting**: Alert on sustained high growth rate.

---

## vm_total_run_queue_lengths_total

**Type**: Gauge

**Description**: Total number of processes waiting to be scheduled across all CPU schedulers.

**Use Case**: Measure system load. High values indicate CPU saturation.

**Alerting**: Alert when consistently > 10 * number of CPU cores.

---

## vm_system_counts_process_count

**Type**: Gauge

**Description**: Current number of processes running in the VM.

**Use Case**: Monitor process creation patterns. Detect process leaks.

**Alerting**: Alert when approaching process limit (default 262,144).

---

# Metric Collection and Polling

The system automatically collects the following metrics every 10 seconds:

- Queue sizes and ages
- Mnesia table sizes
- ENUM cache statistics

All other metrics are event-driven and emitted when the corresponding action occurs.

# Common Monitoring Patterns

## Delivery Success Rate by Destination

Track the success rate of message delivery for each destination SMSC:

**Formula**: `(sms_c_delivery_succeeded_count) / (sms_c_delivery_queued_count)`

**Interpretation**: Should be > 95% for healthy destinations. Lower rates indicate delivery issues.

---

## End-to-End Message Latency

Monitor total time from message receipt to delivery:

**Metrics**:

- `sms_c_message_processing_stop_duration` (processing)
- `sms_c_delivery_time_delta_delta_ms` (delivery)

**Interpretation**: Sum represents total user-facing latency.

---

## ENUM Cache Effectiveness

Measure how well the ENUM cache is performing:

**Formula**: `(sms_c_enum_cache_hit_count) / (sms_c_enum_cache_hit_count + sms_c_enum_cache_miss_count)`

**Interpretation**: Should be > 80% after warm-up. Lower rates may indicate short TTL or high traffic variance.

---

## Route Utilization

Identify which routes handle the most traffic:

**Metric**: `sms_c_routing_route_matched_count` grouped by `route_id`

**Interpretation**: Use to identify hot routes for optimization and capacity planning.

---

## Queue Backlog Trend

Monitor if message queue is growing (backlog) or shrinking (catching up):

**Metrics**:

- `sms_c_queue_size_pending` (current pending)
- `sms_c_queue_oldest_message_age_seconds` (age trending)

**Interpretation**: Growing pending count + increasing age = backlog forming.

---

## Retry Rate

Understand how often delivery retries are required:

**Metric**: `sms_c_delivery_succeeded_attempt_count` histogram percentiles

**Interpretation**: If p95 > 1, most messages require retries. Indicates destination reliability issues.

---

# Recommended Alerts

| Alert | Condition | Severit |
|---|---|---|
| High Routing Failure Rate | `routing_failed_count` increase | Critical |
| Queue Backlog | `queue_size_pending` > threshold | Warning |
| Old Messages in Queue | `queue_oldest_message_age_seconds` > 300 | Critical |
| Delivery Failure Spike | `delivery_failed_count` spike | High |
| Dead Letter Events | `delivery_dead_letter_count` > 0 | High |
| ENUM Lookup Timeouts | `enum_lookup_stop_duration` p95 > 5000ms | Warning |
| Low Cache Hit Rate | ENUM cache hit rate < 0.7 | Warning |
| Frontend Disconnected | `frontend_status_count{status="disconnected"}` > 0 | High |
| Charging Failures | `charging_failed_count` > threshold | High |

| Alert | Condition | Severit |
| --- | --- | --- |
| Slow Message Processing | `message_processing_stop_duration` p95 > 1000ms | Warning |

---

# Dashboard Recommendations

## Operations Dashboard

**Purpose**: Real-time system health monitoring

**Panels**:

1. Message throughput (received/processed/delivered per minute)
2. Queue sizes (pending, failed, delivered)
3. Delivery success rate by destination
4. p95 processing and delivery latency
5. Active frontends status
6. Current alerts

---

## Performance Dashboard

**Purpose**: System performance analysis

**Panels**:

1. Message processing duration histogram
2. Routing duration histogram
3. ENUM lookup duration histogram
4. Charging duration histogram
5. Delivery attempts distribution
6. Cache hit rates

## Business Dashboard

**Purpose**: Traffic and usage analysis

**Panels**:

1. Messages by source SMSC
2. Messages by destination SMSC
3. Route utilization heatmap
4. Auto-reply and drop action counts
5. ENUM usage statistics
6. Charging volume by account

---

# Metric Retention

Recommended Prometheus retention settings:

- **Raw metrics**: 15 days
- **5-minute aggregates**: 90 days
- **1-hour aggregates**: 2 years

This provides detailed recent history while maintaining long-term trends for capacity planning.

---

# Troubleshooting with Metrics

## Scenario: Messages Not Being Delivered

**Investigation Steps**:

1. Check `sms_c_message_received_count` - Are messages being received?
2. Check `sms_c_routing_failed_count` - Are they being routed?

3. Check `sms_c_delivery_queued_count` - Are they being queued?
4. Check `sms_c_delivery_failed_count` - Are delivery attempts failing?
5. Check `dest_smsc` labels to identify problematic destination

---

## Scenario: Slow Message Processing

**Investigation Steps**:

1. Check `sms_c_message_processing_stop_duration` histogram - Overall processing time
2. Check `sms_c_routing_stop_duration` - Is routing slow?
3. Check `sms_c_enum_lookup_stop_duration` - Are ENUM lookups slow?
4. Check `sms_c_charging_succeeded_duration` - Is charging slow?
5. Identify bottleneck and investigate specific component

---

## Scenario: Growing Message Queue

**Investigation Steps**:

1. Check `sms_c_queue_size_pending` trend - Is it growing?
2. Check `sms_c_delivery_attempted_count` - Are delivery attempts happening?
3. Check `sms_c_delivery_failed_count` - Are they failing?
4. Check `sms_c_delivery_time_delta_delta_ms` - Is delivery taking too long?
5. Check `dest_smsc` labels to identify slow destinations

---

# Prometheus Query Examples

## Message Throughput

**Messages Received Per Second (5-minute average)**:

```
rate(sms_c_message_received_count[5m])
```

**Messages Received Per Minute (1-hour average)**:

```
rate(sms_c_message_received_count[1h]) * 60
```

**Total Messages Today**:

```
increase(sms_c_message_received_count[24h])
```

**Messages by Source Type**:

```
sum by (source_type) (rate(sms_c_message_received_count[5m]))
```

**Messages by Source SMSC**:

```
sum by (source_smsc) (rate(sms_c_message_received_count[5m]))
```

# Delivery Performance

**Delivery Success Rate (Percentage)**:

```
(rate(sms_c_delivery_succeeded_count[5m]) /
rate(sms_c_delivery_queued_count[5m])) * 100
```

**Delivery Failure Rate (Percentage)**:

```
(rate(sms_c_delivery_failed_count[5m]) /
rate(sms_c_delivery_queued_count[5m])) * 100
```

**Average Delivery Attempts (p95)**:

```
histogram_quantile(0.95,
sms_c_delivery_succeeded_attempt_count_bucket)
```

**Delivery Success by Destination**:

```
sum by (dest_smsc) (rate(sms_c_delivery_succeeded_count[5m]))
```

**Delivery Failure Reasons**:

```
sum by (reason) (rate(sms_c_delivery_failed_count[5m]))
```

**Time to Delivery (p95)**:

```
histogram_quantile(0.95,
sms_c_delivery_time_delta_delta_ms_bucket)
```

**Time to Delivery (p99)**:

```
histogram_quantile(0.99,
sms_c_delivery_time_delta_delta_ms_bucket)
```

# Queue Metrics

**Current Pending Messages**:

```
sms_c_queue_size_pending
```

**Failed Messages Awaiting Retry**:

```
sms_c_queue_size_failed
```

**Oldest Message Age (Minutes)**:

```
sms_c_queue_oldest_message_age_seconds / 60
```

**Queue Growth Rate (Messages/Hour)**:

```
rate(sms_c_queue_size_size[1h]) * 3600
```

**Messages Entering Queue**:

```
rate(sms_c_delivery_queued_count[5m])
```

**Messages Leaving Queue**:

```
rate(sms_c_delivery_succeeded_count[5m]) +
rate(sms_c_delivery_failed_count[5m])
```

**Queue Backlog (Entering - Leaving)**:

```
rate(sms_c_delivery_queued_count[5m]) -
(rate(sms_c_delivery_succeeded_count[5m]) +
rate(sms_c_delivery_failed_count[5m]))
```

# Routing Performance

**Routing Success Rate**:

```
(1 - (rate(sms_c_routing_failed_count[5m]) /
(rate(sms_c_routing_route_matched_count[5m]) +
rate(sms_c_routing_failed_count[5m])))) * 100
```

**Most Used Routes**:

```
topk(10, sum by (route_id, dest_smsc)
(rate(sms_c_routing_route_matched_count[1h])))
```

**Routing Latency (p50, p95, p99)**:

```
histogram_quantile(0.50, sms_c_routing_stop_duration_bucket)
histogram_quantile(0.95, sms_c_routing_stop_duration_bucket)
histogram_quantile(0.99, sms_c_routing_stop_duration_bucket)
```

**Routing Failures Per Minute**:

```
rate(sms_c_routing_failed_count[5m]) * 60
```

**Drop Actions Per Hour**:

```
increase(sms_c_routing_action_count{action="drop"}[1h])
```

**Auto-Reply Actions Per Hour**:

```
increase(sms_c_routing_action_count{action="auto_reply"}[1h])
```

# ENUM Performance

**ENUM Cache Hit Rate**:

```
rate(sms_c_enum_cache_hit_count[5m]) /
(rate(sms_c_enum_cache_hit_count[5m]) +
rate(sms_c_enum_cache_miss_count[5m]))
```

**ENUM Cache Hit Percentage**:

```
(rate(sms_c_enum_cache_hit_count[5m]) /
(rate(sms_c_enum_cache_hit_count[5m]) +
rate(sms_c_enum_cache_miss_count[5m]))) * 100
```

**ENUM Lookup Latency (p95)**:

```
histogram_quantile(0.95, sms_c_enum_lookup_stop_duration_bucket)
```

**ENUM Lookups Per Second (Cached vs Uncached)**:

```
# Cached (fast)
rate(sms_c_enum_cache_hit_count[5m])

# Uncached (requires DNS query)
rate(sms_c_enum_cache_miss_count[5m])
```

**Average NAPTR Records Returned**:

```
rate(sms_c_enum_naptr_records_record_count_sum[5m]) /
rate(sms_c_enum_naptr_records_record_count_count[5m])
```

**ENUM Cache Size**:

```
sms_c_enum_cache_size_size
```

# Processing Performance

**Message Processing Latency (p95)**:

```
histogram_quantile(0.95,
sms_c_message_processing_stop_duration_bucket)
```

**Message Processing Latency (p99)**:

```
histogram_quantile(0.99,
sms_c_message_processing_stop_duration_bucket)
```

**Processing Failures**:

```
rate(sms_c_message_processing_stop_duration_count{success="false"}
[5m])
```

**Validation Failure Rate**:

```
rate(sms_c_message_validated_count{valid="false"}[5m]) /
rate(sms_c_message_validated_count[5m])
```

# Charging Metrics

**Charging Success Rate**:

```
rate(sms_c_charging_succeeded_count[5m]) /
rate(sms_c_charging_requested_count[5m])
```

**Charging Failures Per Minute**:

```
rate(sms_c_charging_failed_count[5m]) * 60
```

**Charging Latency (p95)**:

```
histogram_quantile(0.95, sms_c_charging_succeeded_duration_bucket)
```

**Charging Volume by Account**:

```
sum by (account) (rate(sms_c_charging_requested_count[1h]))
```

# Frontend Health

**Active Frontends**:

```
sum(sms_c_frontend_status_count{status="connected"})
```

**Disconnected Frontends**:

```
sum(sms_c_frontend_status_count{status="disconnected"})
```

**Frontends by Name**:

```
sum by (frontend_name)
(sms_c_frontend_status_count{status="connected"})
```

## System Health

**Mnesia Table Sizes**:

```
sms_c_mnesia_table_size_record_count
```

**Route Count**:

```
sms_c_mnesia_table_size_record_count{table="sms_route"}
```

**Translation Rule Count**:

```
sms_c_mnesia_table_size_record_count{table="translation_rule"}
```

# Grafana Dashboard Examples

## Dashboard 1: Real-Time Operations

**Purpose**: Monitor current system activity and health.

**Panels**:

1. **Message Throughput (Graph)**

- Query: `rate(sms_c_message_received_count[5m])`
- Query: `rate(sms_c_delivery_succeeded_count[5m])`
- Unit: messages/second
- Legend: {{source_type}}

2. **Delivery Success Rate (Gauge)**
   - Query: `(rate(sms_c_delivery_succeeded_count[5m]) / rate(sms_c_delivery_queued_count[5m])) * 100`
   - Unit: percent (0-100)
   - Thresholds:
     - Red: < 90
     - Yellow: 90-95
     - Green: > 95

3. **Queue Depth (Graph)**
   - Query: `sms_c_queue_size_pending`
   - Query: `sms_c_queue_size_failed`
   - Unit: messages
   - Legend: {{queue_type}}

4. **Oldest Message Age (Stat)**
   - Query: `sms_c_queue_oldest_message_age_seconds / 60`
   - Unit: minutes
   - Thresholds:
     - Green: < 5
     - Yellow: 5-10
     - Red: > 10

5. **Active Frontends (Stat)**
   - Query: `sum(sms_c_frontend_status_count{status="connected"})`
   - Unit: count
   - Color: Blue

6. **Routing Failures (Graph)**

- Query: `rate(sms_c_routing_failed_count[5m]) * 60`
- Unit: failures/minute
- Alert threshold: > 0

# Dashboard 2: Performance Analysis

**Purpose**: Analyze system performance and identify bottlenecks.

**Panels**:

1. **End-to-End Latency (Graph)**
   - Query: `histogram_quantile(0.50, sms_c_message_processing_stop_duration_bucket)` (p50)
   - Query: `histogram_quantile(0.95, sms_c_message_processing_stop_duration_bucket)` (p95)
   - Query: `histogram_quantile(0.99, sms_c_message_processing_stop_duration_bucket)` (p99)
   - Unit: milliseconds
   - Legend: Percentile
2. **Component Latencies (Bar Gauge)**
   - Routing: `histogram_quantile(0.95, sms_c_routing_stop_duration_bucket)`
   - ENUM: `histogram_quantile(0.95, sms_c_enum_lookup_stop_duration_bucket)`
   - Charging: `histogram_quantile(0.95, sms_c_charging_succeeded_duration_bucket)`
   - Delivery: `histogram_quantile(0.95, sms_c_delivery_time_delta_delta_ms_bucket)`
   - Unit: milliseconds
   - Horizontal bars
3. **Delivery Attempts Distribution (Heatmap)**
   - Query: `sms_c_delivery_succeeded_attempt_count_bucket`

- Shows how many attempts are typically needed
- Color scale: Blue (1 attempt) to Red (many attempts)

4. **ENUM Cache Performance (Graph)**
   - Hit Rate: `rate(sms_c_enum_cache_hit_count[5m]) / (rate(sms_c_enum_cache_hit_count[5m]) + rate(sms_c_enum_cache_miss_count[5m]))`
   - Cache Size: `sms_c_enum_cache_size_size`
   - Dual Y-axis (rate vs size)

5. **Processing Success Rate (Gauge)**
   - Query: `(rate(sms_c_message_processing_stop_duration_count{success="true"}[5m]) / rate(sms_c_message_processing_stop_duration_count[5m])) * 100`
   - Unit: percent
   - Thresholds:
     - Red: < 95
     - Yellow: 95-99
     - Green: > 99

# Dashboard 3: Traffic Analysis

**Purpose**: Analyze message traffic patterns and routing distribution.

**Panels**:

1. **Messages by Source Type (Pie Chart)**
   - Query: `sum by (source_type) (increase(sms_c_message_received_count[1h]))`
   - Shows distribution: IMS vs CS vs SMPP

2. **Messages by Source SMSC (Bar Chart)**
   - Query: `sum by (source_smsc) (rate(sms_c_message_received_count[1h]))`

- Top 10 sources
- Horizontal bars

3. **Route Utilization (Table)**
   - Columns:
     - Route ID
     - Destination SMSC
     - Messages (1h): `sum by (route_id, dest_smsc) (increase(sms_c_routing_route_matched_count[1h]))`
     - Priority
     - Success Rate
   - Sorted by message count

4. **Delivery by Destination (Graph)**
   - Query: `sum by (dest_smsc) (rate(sms_c_delivery_succeeded_count[5m]))`
   - Unit: messages/second
   - Stacked area chart
   - Legend: {{dest_smsc}}

5. **Drop/Auto-Reply Actions (Stat)**
   - Dropped: `increase(sms_c_routing_action_count{action="drop"}[1h])`
   - Auto-Replied: `increase(sms_c_routing_action_count{action="auto_reply"}[1h])`
   - Side by side stats

6. **Hourly Traffic Pattern (Graph)**
   - Query: `rate(sms_c_message_received_count[1h]) * 3600`
   - Time range: Last 7 days
   - Shows daily patterns

# Dashboard 4: Capacity & Resources

**Purpose**: Monitor resource usage and capacity limits.

**Panels**:

1. **Queue Capacity (Graph)**
   - Current: `sms_c_queue_size_size`
   - Capacity line: Fixed value based on system limits
   - Shows utilization trend
2. **Database Table Growth (Graph)**
   - Messages: `sms_c_mnesia_table_size_record_count{table="sms_route"}`
   - Translations: `sms_c_mnesia_table_size_record_count{table="translation_rule"}`
   - Trend over last 30 days
3. **Message Backlog Trend (Graph)**
   - Query: `rate(sms_c_delivery_queued_count[5m]) - (rate(sms_c_delivery_succeeded_count[5m]) + rate(sms_c_delivery_failed_count[5m]))`
   - Positive = backlog growing
   - Negative = catching up
4. **Peak Traffic (Stat)**
   - Query: `max_over_time(rate(sms_c_message_received_count[5m])[24h:])`
   - Shows highest 5m rate in last 24h
   - Unit: messages/second
5. **Capacity Utilization (Gauge)**
   - Query: `(rate(sms_c_message_received_count[5m]) / MAX_CAPACITY) * 100`

- Replace MAX_CAPACITY with your system limit
- Unit: percent
- Thresholds:
  - Green: < 70
  - Yellow: 70-85
  - Red: > 85

# Dashboard 5: SLA Compliance

**Purpose**: Track SLA metrics and compliance.

**Panels**:

1. **SLA Compliance (Gauge)**
   - Delivery Success: `(rate(sms_c_delivery_succeeded_count[1h]) / rate(sms_c_delivery_queued_count[1h])) * 100`
   - Target line at 99%
   - Thresholds:
     - Red: < 95
     - Yellow: 95-99
     - Green: >= 99
2. **Messages Delivered Within SLA (Stat)**
   - Query: `count(sms_c_delivery_time_delta_delta_ms_bucket{le="5000"}) / count(sms_c_delivery_time_delta_delta_ms_bucket)`
   - Shows percentage delivered within 5 seconds
   - Unit: percent
3. **SLA Violations (Counter)**
   - Messages exceeding 5 minutes: `increase(sms_c_queue_oldest_message_age_seconds{} > 300)[24h:]`
   - Should be 0
4. **Uptime (Stat)**

- Query: `up{job="sms-c"}`
- Binary: 1 = up, 0 = down
- Shows current status

5. **Daily Success Rate Trend (Graph)**
   - Query: `avg_over_time((rate(sms_c_delivery_succeeded_count[1h]) / rate(sms_c_delivery_queued_count[1h]))[24h:1h])`
   - Time range: Last 30 days
   - SLA line at 99%

# Alert Rule Examples

## Critical Alerts

**Routing Failures**:

```
alert: RoutingFailuresDetected
expr: increase(sms_c_routing_failed_count[5m]) > 0
for: 2m
labels:
  severity: critical
annotations:
  summary: "{{ $value }} routing failures in last 5 minutes"
  description: "Messages cannot be routed. Check routing
configuration."
```

**Queue Backlog**:

```
alert: MessageQueueBacklog
expr: sms_c_queue_size_pending > 10000
for: 5m
labels:
  severity: critical
annotations:
  summary: "Message queue has {{ $value }} pending messages"
  description: "Queue is backing up. Check delivery performance."
```

**Old Messages in Queue**:

```
alert: OldMessagesInQueue
expr: sms_c_queue_oldest_message_age_seconds > 300
for: 2m
labels:
  severity: critical
annotations:
  summary: "Oldest message is {{ $value }} seconds old"
  description: "Messages not being delivered. Check frontends."
```

**All Frontends Disconnected**:

```
alert: NoActiveFrontends
expr: sum(sms_c_frontend_status_count{status="connected"}) == 0
for: 1m
labels:
  severity: critical
annotations:
  summary: "No frontends connected"
  description: "No delivery path available. Check frontend
connectivity."
```

**Dead Letter Queue Growing**:

```
alert: DeadLetterMessagesIncreasing
expr: rate(sms_c_delivery_dead_letter_count[10m]) > 0
for: 5m
labels:
  severity: critical
annotations:
  summary: "{{ $value }} messages moved to dead letter queue"
  description: "Messages are becoming undeliverable. Investigate
failures."
```

# Warning Alerts

**Low Delivery Success Rate**:

```
alert: LowDeliverySuccessRate
expr: (rate(sms_c_delivery_succeeded_count[10m]) /
rate(sms_c_delivery_queued_count[10m])) < 0.95
for: 10m
labels:
  severity: warning
annotations:
  summary: "Delivery success rate is {{ $value |
humanizePercentage }}"
  description: "Success rate below 95%. Investigate delivery
failures."
```

**High Retry Rate**:

```
alert: HighDeliveryRetryRate
expr: histogram_quantile(0.95,
sms_c_delivery_succeeded_attempt_count_bucket) > 2
for: 15m
labels:
  severity: warning
annotations:
  summary: "95th percentile delivery attempts: {{ $value }}"
  description: "Messages requiring multiple attempts. Check
destination reliability."
```

**Slow Message Processing**:

```
alert: SlowMessageProcessing
expr: histogram_quantile(0.95,
sms_c_message_processing_stop_duration_bucket) > 1000
for: 10m
labels:
  severity: warning
annotations:
  summary: "95th percentile processing time: {{ $value }}ms"
  description: "Message processing is slow. Check system
resources."
```

**ENUM Lookups Failing**:

```
alert: HighEnumFailureRate
expr: rate(sms_c_enum_lookup_stop_duration_count{success="false"}
[10m]) > 0.1
for: 10m
labels:
  severity: warning
annotations:
  summary: "ENUM lookup failure rate: {{ $value }}"
  description: "DNS lookups failing. Check DNS servers."
```

**Low ENUM Cache Hit Rate**:

```
alert: LowEnumCacheHitRate
expr: rate(sms_c_enum_cache_hit_count[10m]) /
(rate(sms_c_enum_cache_hit_count[10m]) +
rate(sms_c_enum_cache_miss_count[10m])) < 0.70
for: 30m
labels:
  severity: warning
annotations:
  summary: "ENUM cache hit rate: {{ $value | humanizePercentage
}}"
  description: "Low cache efficiency. May indicate unique number
traffic."
```

**Charging Failures**:

```
alert: ChargingFailuresDetected
expr: rate(sms_c_charging_failed_count[10m]) > 0.05
for: 10m
labels:
  severity: warning
annotations:
  summary: "Charging failure rate: {{ $value }}"
  description: "Charging system errors. Check OCS connectivity."
```

# Additional Notes

- All duration metrics use nanosecond precision internally but are converted to milliseconds for reporting
- Counter metrics are cumulative and should be used with `rate()` or `increase()` functions in Prometheus queries
- Gauge metrics represent instantaneous values at collection time
- Histogram metrics provide percentile calculations (p50, p95, p99) and can be used to create heatmaps
- All metrics include default labels added by Prometheus (instance, job, etc.)
- When creating dashboards, use appropriate time ranges: 5m for real-time, 1h for trends, 24h+ for capacity planning
- Set up recording rules in Prometheus for frequently-used complex queries to improve dashboard performance
- Use variable templating in Grafana for dynamic dashboards (select dest_smsc, source_smsc, etc.)

# SMS-C Number Translation Guide

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## Overview

The SMS-C Number Translation system provides flexible, regex-based transformation of phone numbers before routing. Translation rules can normalize numbers, add international prefixes, format numbers for specific gateways, and chain multiple transformations together. Rules are stored in Mnesia for persistence and can be modified at runtime without service interruption.

## Key Features

- **Prefix-based matching**: Match numbers by prefix before applying transformations
- **Regex-based transformation**: Powerful pattern matching and replacement with capture groups
- **Source SMSC filtering**: Apply different translations based on message origin
- **Priority-based evaluation**: Control rule order with configurable priorities (1-255)
- **Rule chaining**: Continue processing through multiple rules with loop prevention
- **Separate calling/called transforms**: Independent transformation for originating and destination numbers
- **Configuration file loading**: Load initial rules from `runtime.exs` on first startup
- **Runtime configuration**: Add, modify, or disable rules without restarting
- **Web UI**: Full CRUD interface for rule management

- **Simulation tool**: Test translation logic with step-by-step evaluation
- **Backup/Restore**: Export and import translation configurations
- **Pre-routing integration**: Translations applied before routing for consistent number formats

# Architecture

## Data Model

Each translation rule contains the following fields:

| Field | Type | Description | Required |
|---|---|---|---|
| `rule_id` | integer | Auto-incrementing unique identifier | Yes (auto) |
| `calling_prefix` | string/nil | Prefix match for calling number (nil = wildcard) | No |
| `called_prefix` | string/nil | Prefix match for called number (nil = wildcard) | No |
| `source_smsc` | string/nil | Source SMSC name (nil = wildcard) | No |
| `calling_match` | string/nil | Regex pattern to match calling number | No |
| `calling_replace` | string/nil | Replacement pattern for calling number | No |
| `called_match` | string/nil | Regex pattern to match called number | No |
| `called_replace` | string/nil | Replacement pattern for called number | No |
| `priority` | integer | Rule priority (1-255, lower = higher priority) | Yes |
| `description` | string | Human-readable description | No |
| `enabled` | boolean | Enable/disable rule | Yes |
| `continue` | boolean | Continue evaluating rules after match (default: false) | No |

**Note**: Rules are evaluated in priority order (lowest number first). Only enabled rules are evaluated.

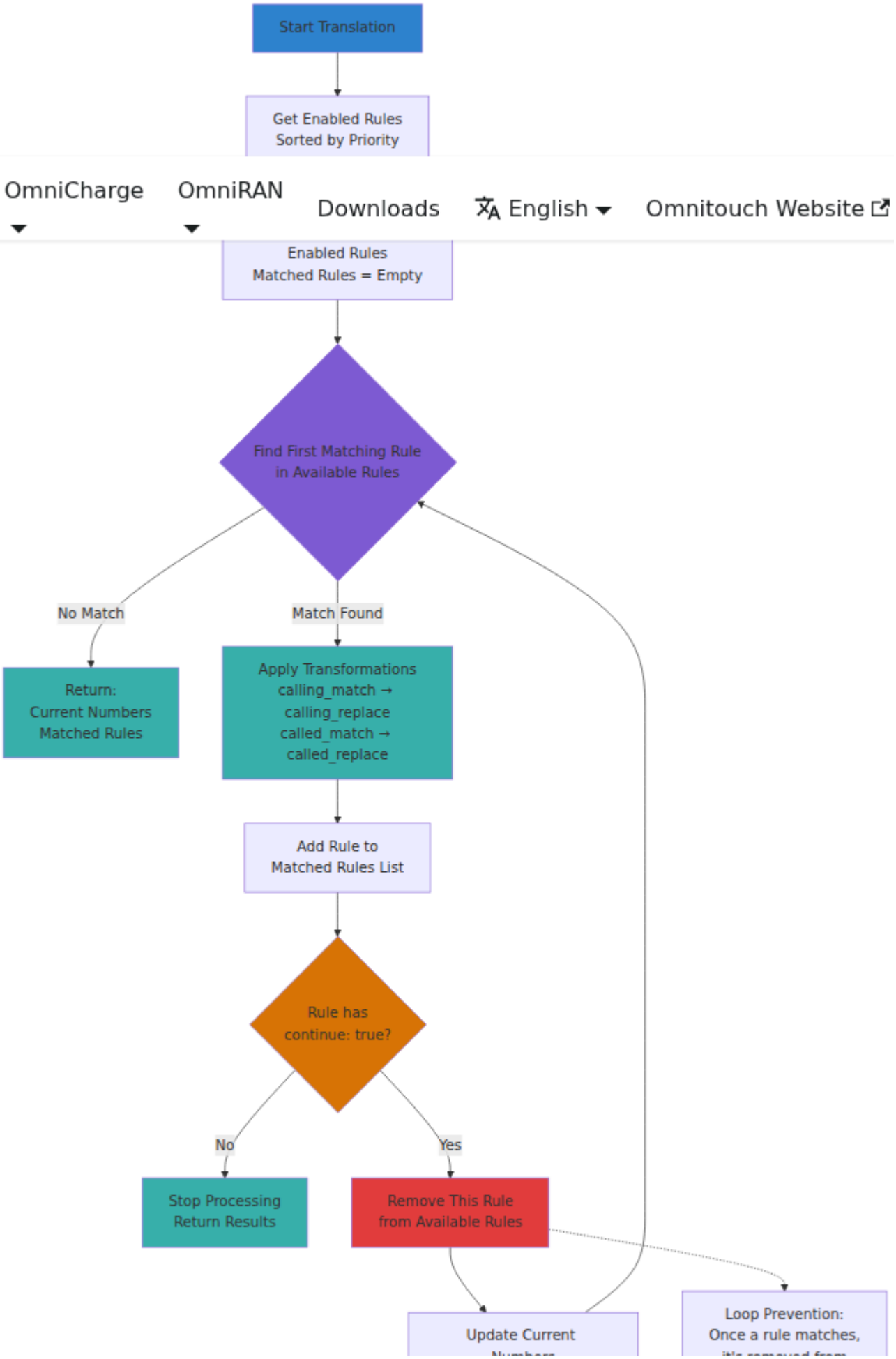
## Translation Algorithm

When translating numbers, the system:

1. **Retrieves enabled rules** sorted by priority (lowest first)
2. **Evaluates rules sequentially** against message parameters:
   - Match `calling_prefix` (if specified)
   - Match `called_prefix` (if specified)
   - Match `source_smsc` (if specified)
3. **Applies first matching rule**:
   - Transform calling number using `calling_match` and `calling_replace`
   - Transform called number using `called_match` and `called_replace`
4. **Checks continue flag**:
   - If `continue: false` → Stop processing, return result
   - If `continue: true` → Remove matched rule from available rules, continue with step 2 using **transformed numbers**
5. **Returns final numbers** and list of all applied rules

## Rule Chaining with Loop Prevention

The `continue` flag enables powerful rule chaining while preventing infinite loops:


Start Translation
Get Enabled Rules
Sorted by Priority
OmniCharge
OmniRAN
Downloads
English
Omnitouch Website
Enabled Rules
Matched Rules = Empty
Find First Matching Rule
in Available Rules
No Match
Match Found
Return:
Current Numbers
Matched Rules
Apply Transformations
calling_match →
calling_replace
called_match →
called_replace
Add Rule to
Matched Rules List
Rule has
continue: true?
No
Yes
Stop Processing
Return Results
Remove This Rule
from Available Rules
Update Current
Loop Prevention:
Once a rule matches,


## Wildcards

- `nil` or empty values act as wildcards that match any value
- A rule with no matching criteria is a catch-all rule
- A rule with no transformation patterns (nil match/replace) passes numbers through unchanged

## Example: Rule Chaining Scenario

Parse error on line 20: ...] style R1 fill:#38B2AC style R ----------^
Expecting 'SOLID_OPEN_ARROW', 'DOTTED_OPEN_ARROW', 'SOLID_ARROW', 'BIDIRECTIONAL_SOLID_ARROW', 'DOTTED_ARROW', 'BIDIRECTIONAL_DOTTED_ARROW', 'SOLID_CROSS', 'DOTTED_CROSS', 'SOLID_POINT', 'DOTTED_POINT', got 'TXT'

Try again

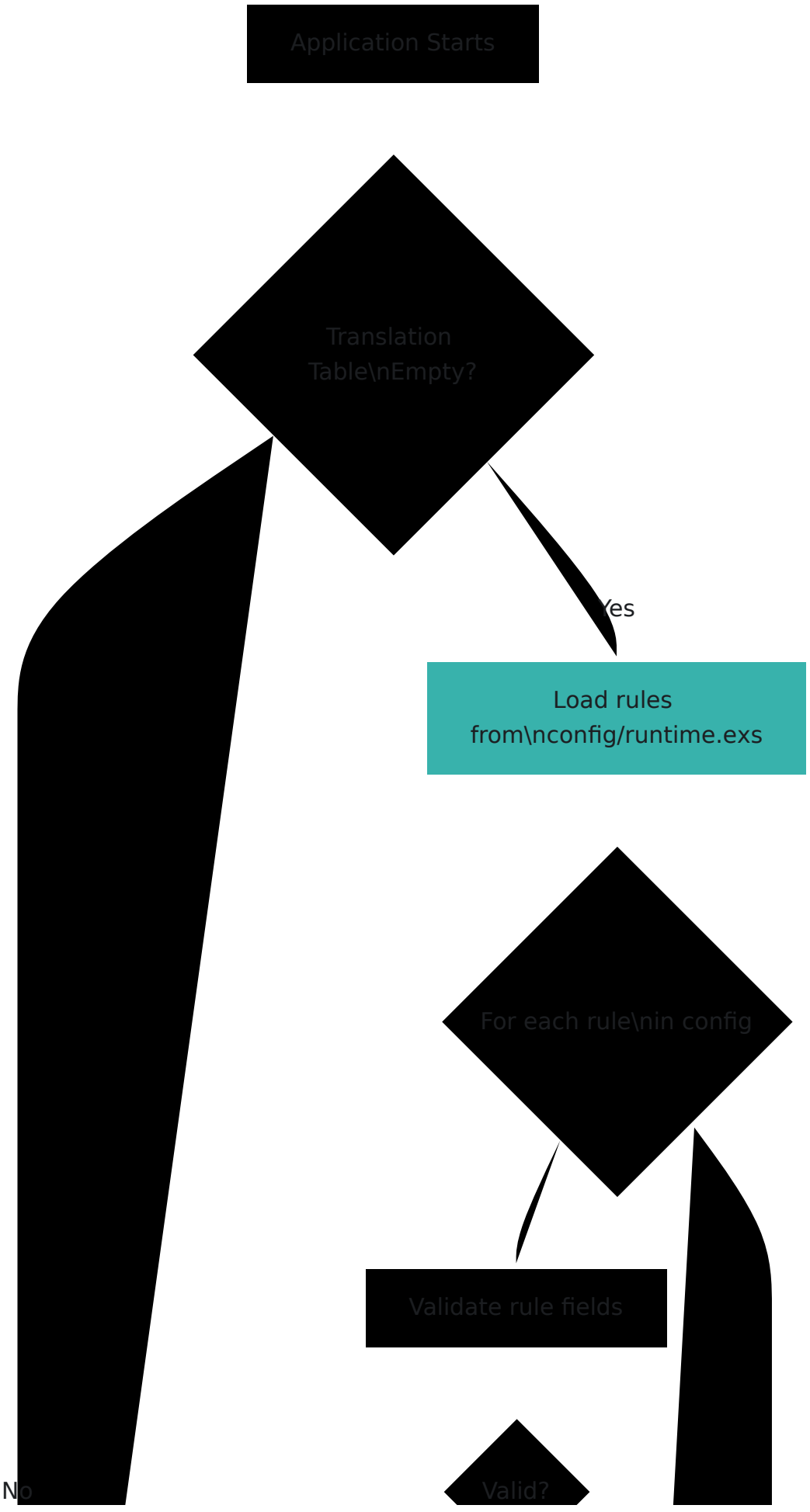
# Configuration

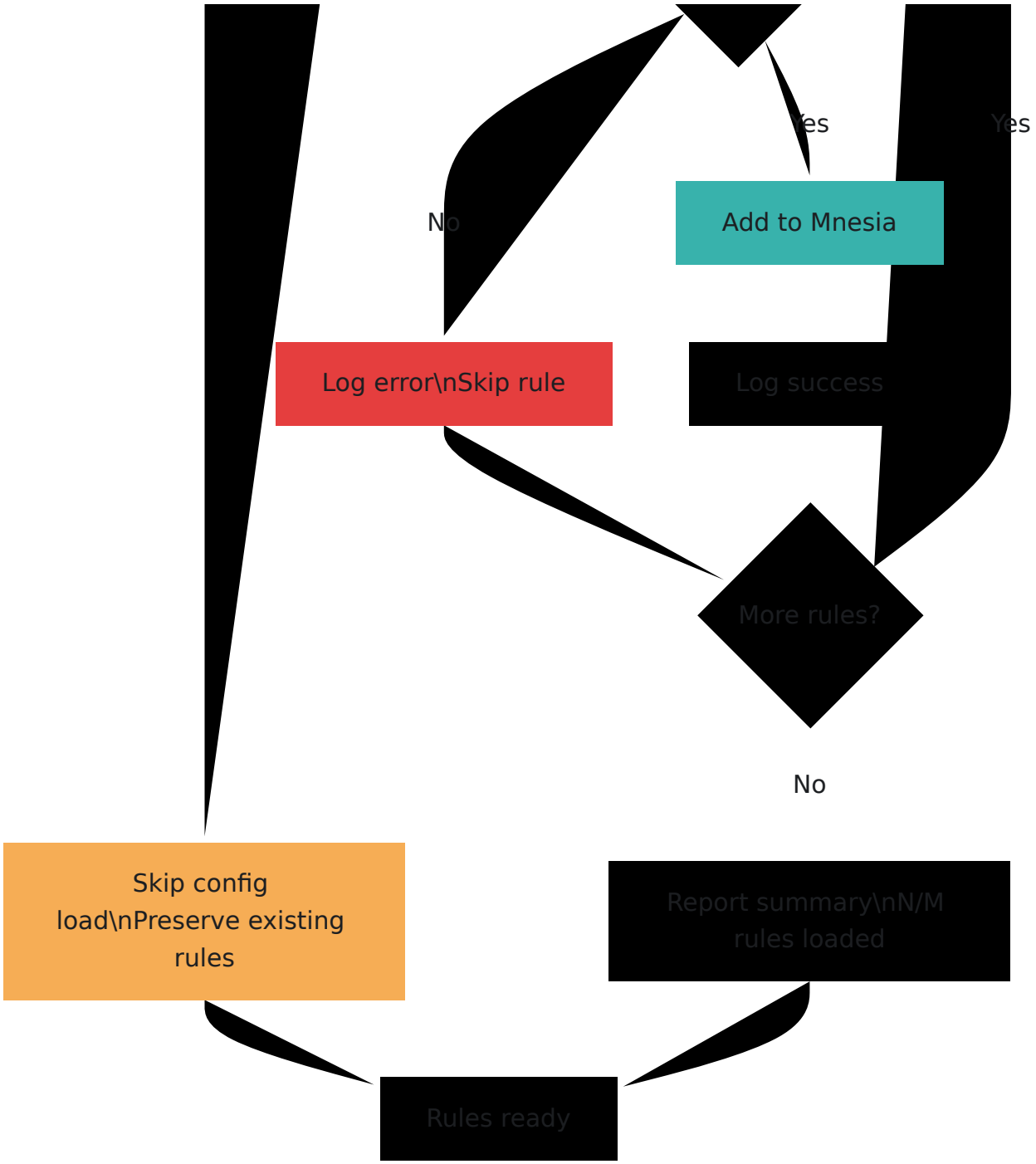
## Loading Rules from Configuration File

Translation rules can be defined in `config/runtime.exs` and will be automatically loaded on first startup.

**Important**: Rules from configuration are only loaded when the translation table is **empty** (first startup). This preserves rules added via the Web UI during runtime and prevents duplicates on restarts.

#### Configuration Loading Flow


Application Starts
Translation Table\nEmpty?
Yes
Load rules from\nconfig/runtime.exs
For each rule\nin config
Validate rule fields
Valid?
No



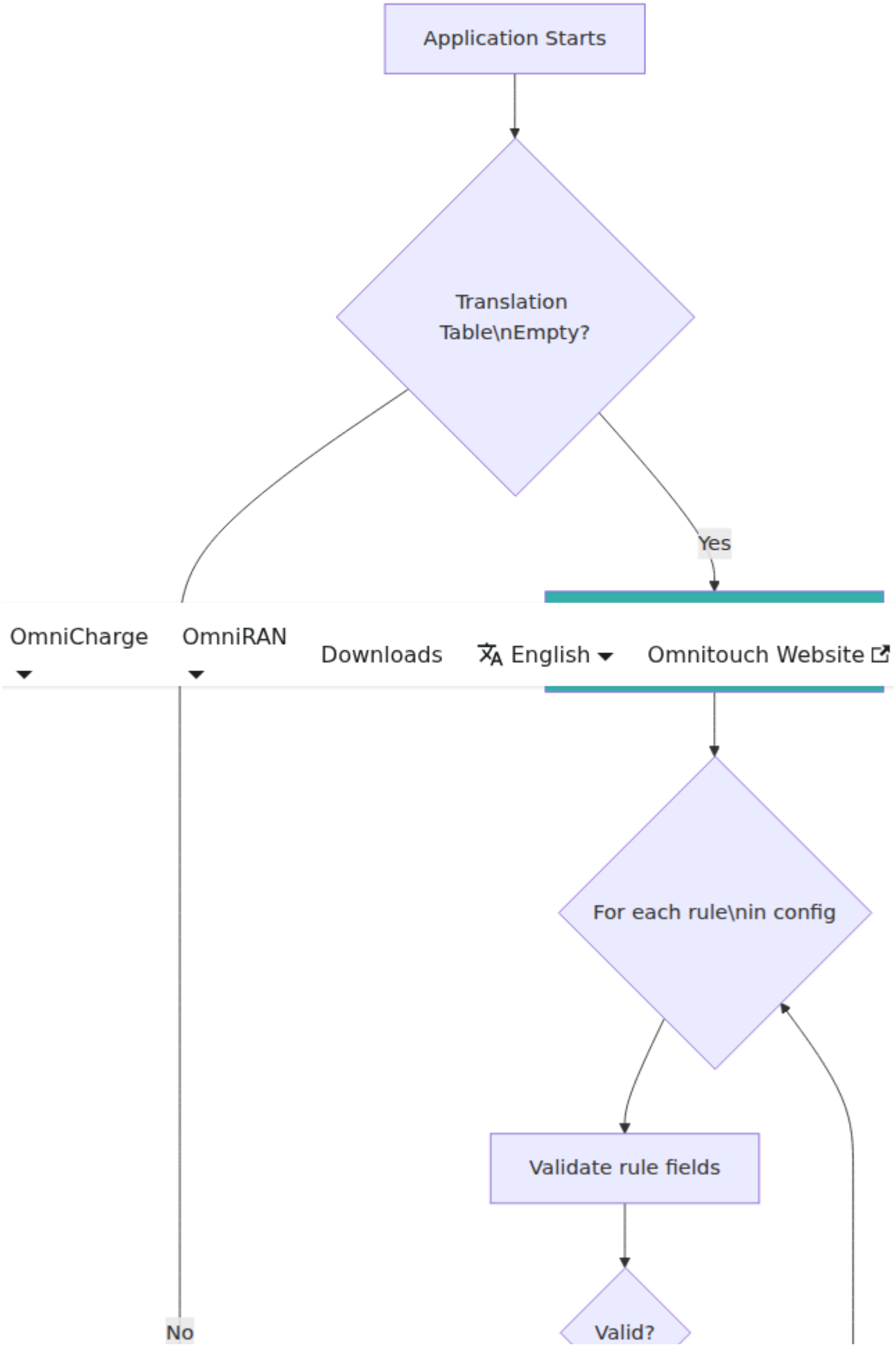

**Example Configuration**

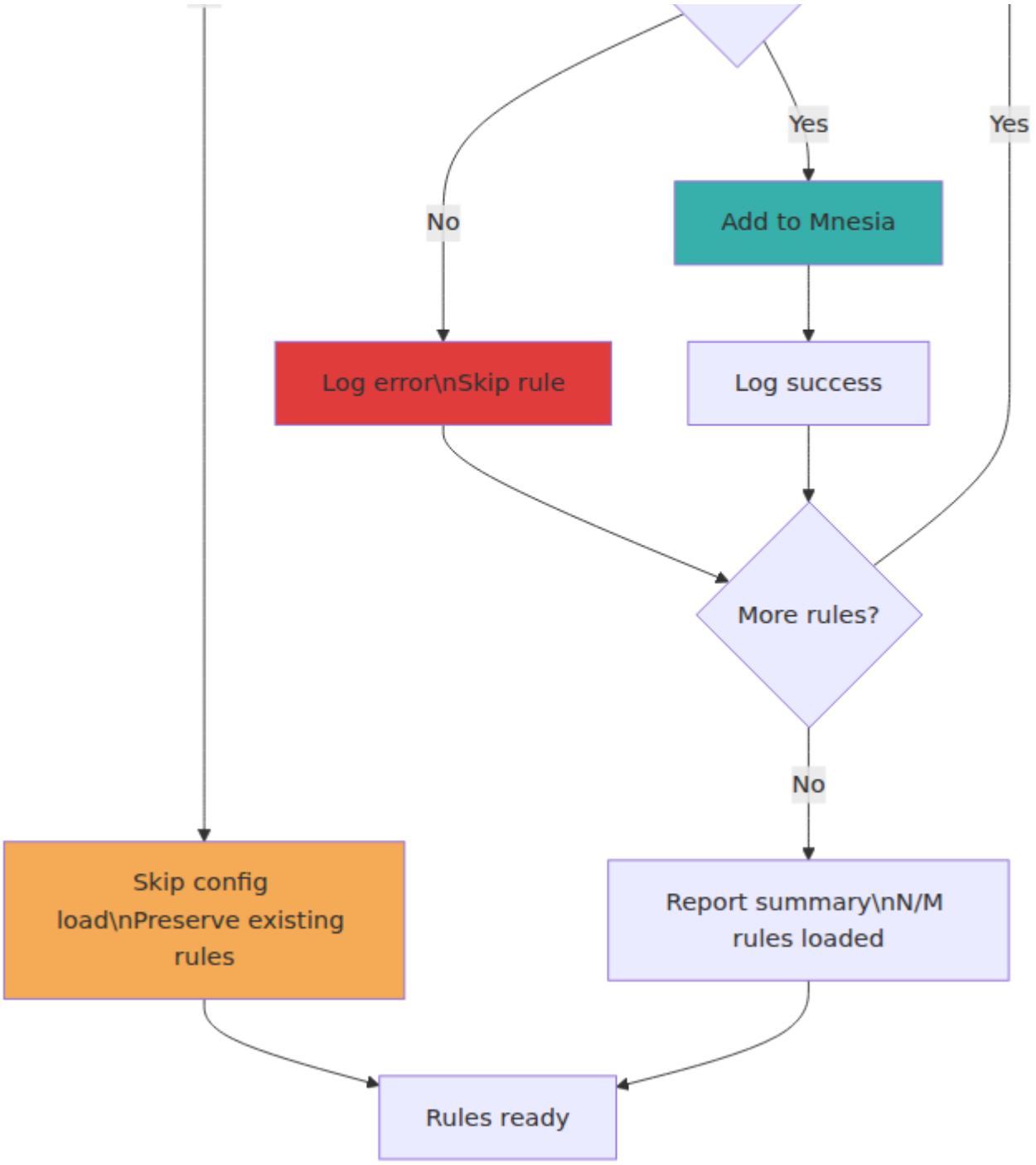
```
# config/runtime.exs
config :sms_c, :translation_rules, [
  # Add +1 to 10-digit US numbers
  %{
    calling_prefix: nil,
    called_prefix: nil,
    source_smsc: "us_domestic_smsc",
    calling_match: "^(\d{10})$",
    calling_replace: "+1\1",
    called_match: "^(\d{10})$",
    called_replace: "+1\1",
    priority: 10,
    description: "Add +1 to 10-digit US numbers from domestic
SMSC",
    enabled: true,
    continue: false
  },

  # Strip leading zeros from international format
  %{
    calling_prefix: "00",
    called_prefix: nil,
    source_smsc: nil,
    calling_match: "^00(.+)$",
    calling_replace: "+\1",
    called_match: nil,
    called_replace: nil,
    priority: 5,
    description: "Convert 00 international prefix to +",
    enabled: true,
    continue: true  # Continue to apply more formatting
  },

  # Format UK numbers for specific gateway
  %{
    calling_prefix: "+44",
    called_prefix: "+44",
    source_smsc: nil,
    calling_match: "^\+44(.*)$",
    calling_replace: "0044\1",
    called_match: "^\+44(.*)$",
    called_replace: "0044\1",
    priority: 20,
```

```
    description: "Format UK numbers for legacy gateway",
    enabled: true,
    continue: false
  }
]
```

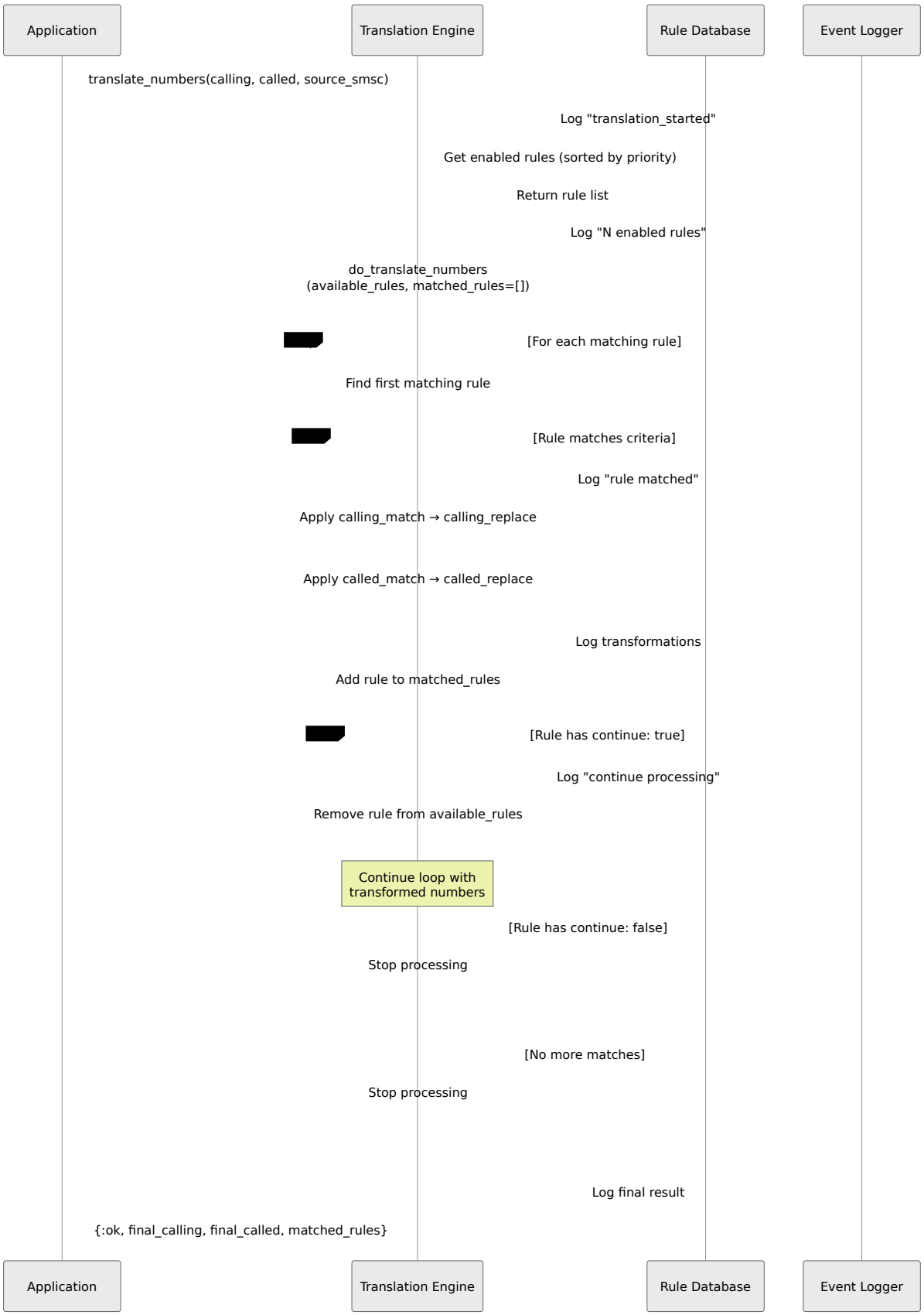
# Getting Started

## Initialization Flow


Application Starts
Translation Table\nEmpty?
Yes
OmniCharge
OmniRAN
Downloads
English
Omnitouch Website
For each rule\nin config
Validate rule fields
Valid?
No



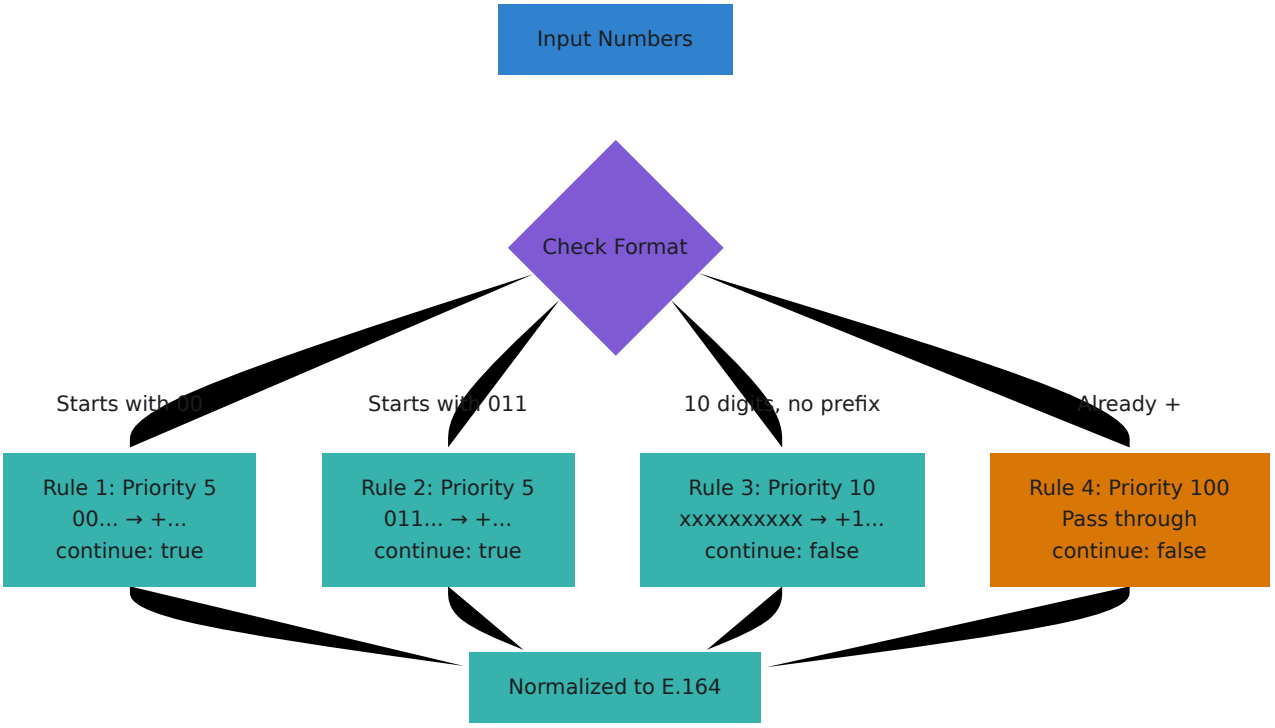

## Message Translation Flow


Application
Translation Engine
Rule Database
Event Logger
translate_numbers(calling, called, source_smsc)
Log "translation_started"
Get enabled rules (sorted by priority)
Return rule list
Log "N enabled rules"
do_translate_numbers
(available_rules, matched_rules=[])
[For each matching rule]
Find first matching rule
[Rule matches criteria]
Log "rule matched"
Apply calling_match → calling_replace
Apply called_match → called_replace
Log transformations
Add rule to matched_rules
[Rule has continue: true]
Log "continue processing"
Remove rule from available_rules
Continue loop with
transformed numbers
[Rule has continue: false]
Stop processing
[No more matches]
Stop processing
Log final result
{:ok, final_calling, final_called, matched_rules}
Application
Translation Engine
Rule Database
Event Logger

# Common Use Cases

## International Number Normalization

Normalize various international formats to E.164:




## Gateway-Specific Formatting

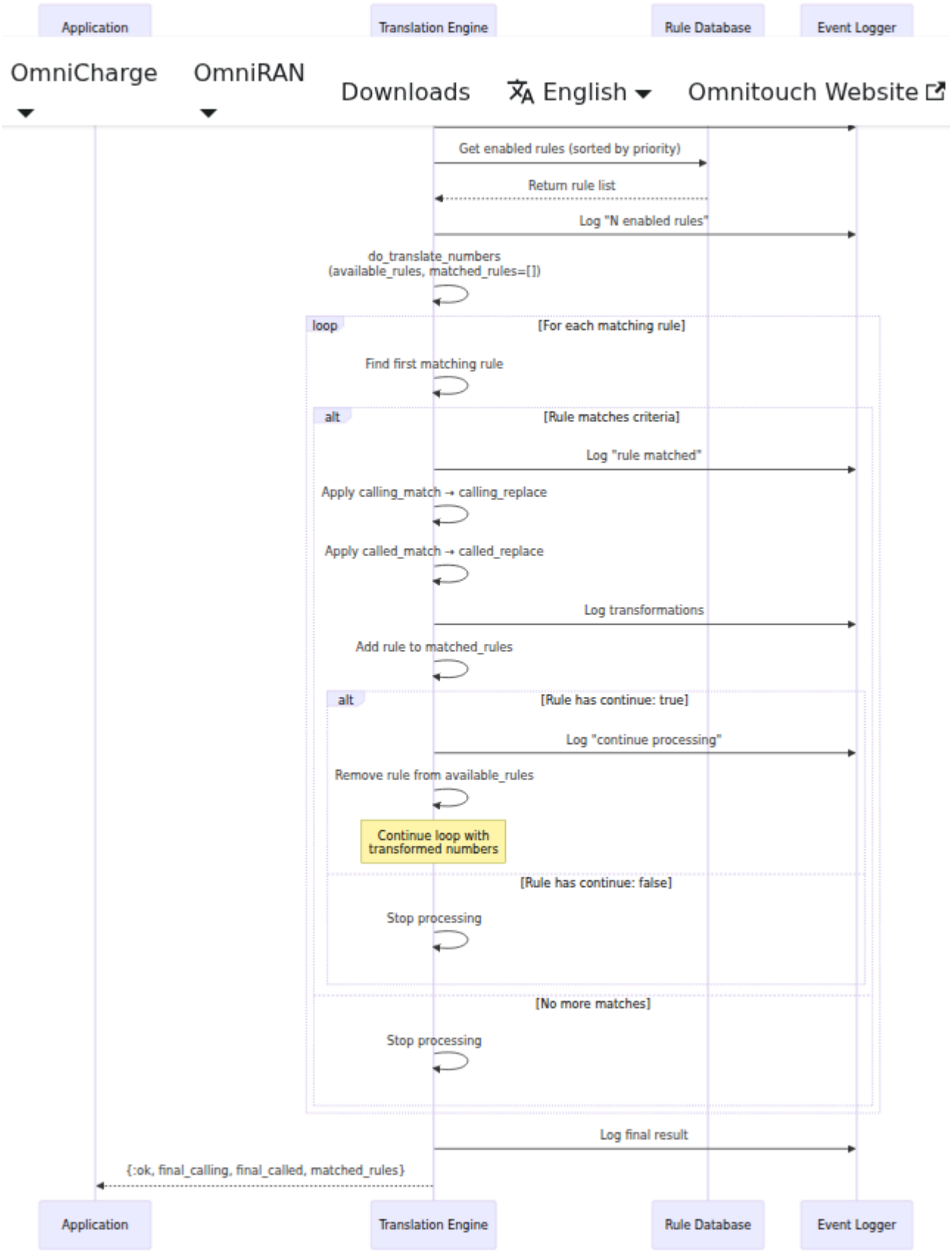
Chain rules to format numbers for specific gateway requirements:

Parse error on line 2: ...rt TD I[Input: "5551234567"] --> S1[ ----------^
Expecting 'SQE', 'DOUBLECIRCLEEND', 'PE', '-)', 'STADIUMEND', 'SUBROUTINEEND', 'PIPE', 'CYLINDEREND', 'DIAMOND_STOP', 'TAGEND', 'TRAPEND', 'INVTRAPEND', 'UNICODE_TEXT', 'TEXT', 'TAGSTART', got 'STR'

Try again

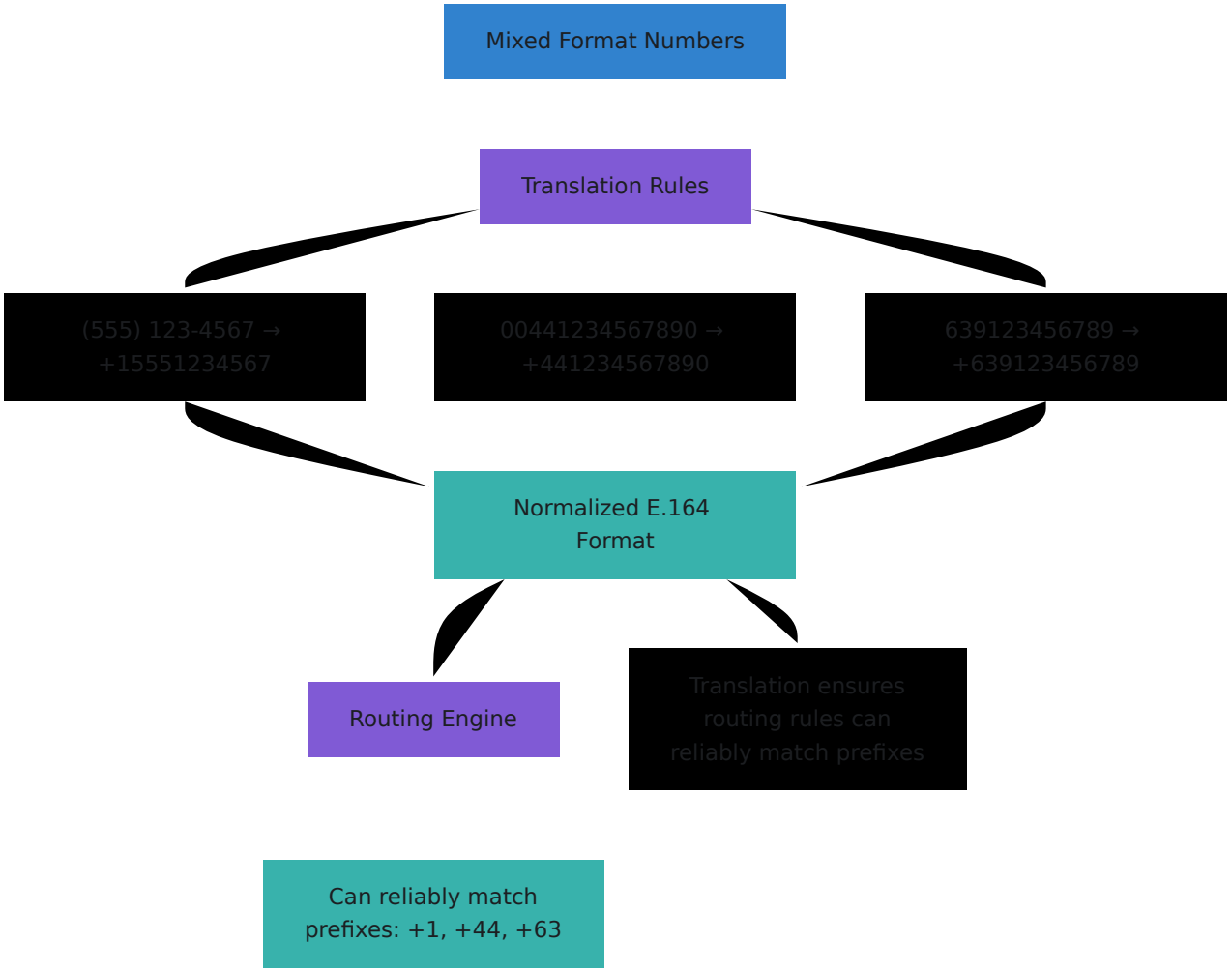
## SMSC-Specific Translations

Apply different translations based on message source:




## Prefix-Based Routing Preparation

Normalize numbers before routing to ensure consistent prefix matching:




## Number Portability Handling

Handle ported numbers that require prefix changes:

Parse error on line 18: ... style Input fill:#3182CE style R ----------^ Expecting 'SOLID_OPEN_ARROW', 'DOTTED_OPEN_ARROW', 'SOLID_ARROW', 'BIDIRECTIONAL_SOLID_ARROW', 'DOTTED_ARROW', 'BIDIRECTIONAL_DOTTED_ARROW', 'SOLID_CROSS', 'DOTTED_CROSS', 'SOLID_POINT', 'DOTTED_POINT', got 'TXT'

Try again

# Web Interface

## Translation Rule Management UI

Access the rule management interface at `/number_translation` (via navigation menu):

**Features:**

- View all rules in a sortable table by priority
- Add new rules with form validation
- Edit existing rules
- Enable/disable rules without deleting
- Delete rules with confirmation
- Visual indicator for rules with `continue: true`
- Import/Export rules as JSON

**Adding a Rule:**

1. Fill in matching criteria (optional):
   - Calling prefix (e.g., "+1", "44")
   - Called prefix (e.g., "+639", "1555")
   - Source SMSC (leave empty for any)
2. Define transformations (optional):
   - Calling number regex match and replace
   - Called number regex match and replace
3. Set priority (1-255, lower = higher priority)
4. Set status:
   - **Enabled**: Rule is active
   - **Continue Processing**: Continue evaluating more rules after this one
5. Add description
6. Click "Add Rule" or "Update Rule"

**Continue Processing Toggle:**

- **Stop** (default): Stop processing after this rule matches

- **Continue**: Apply this rule and continue evaluating remaining rules
- Rules with continue enabled show a blue "↓ Continue" badge in the table

**Editing a Rule:**

1. Click "Edit" next to the rule
2. Modify fields as needed
3. Click "Update Rule"

**Rule Table Indicators:**

- **Enabled/Disabled** badge shows rule status
- **↓ Continue** badge shows rules that will continue processing
- **Priority** badge shows evaluation order
- Regex patterns displayed in monospace font for clarity

# Translation Simulator

Access the simulator at `/translation_simulator` (via navigation menu):

**Features:**

- Test translation logic with actual numbers
- **Step-by-Step Transformation** showing each rule applied
- See before/after values for each transformation
- View which rules matched and why
- Load example scenarios for quick testing
- View test history (last 10 tests)

**Using the Simulator:**

1. Enter test parameters:
    - Calling number (from)
    - Called number (to)
    - Source SMSC (optional)
2. Click "Test Translation"
3. View comprehensive results:

- **Translation Result**: Final numbers after all transformations
- **Rules Applied**: Count and list of all rules that matched
- **Step-by-Step Transformations**: Detailed view of each rule:
  - Step number and rule information
  - Rule description
  - Before → After for both calling and called numbers
  - "↓ Continue" indicator for rules that continued processing
  - Transformations highlighted in green
  - Unchanged values marked as "passed through"

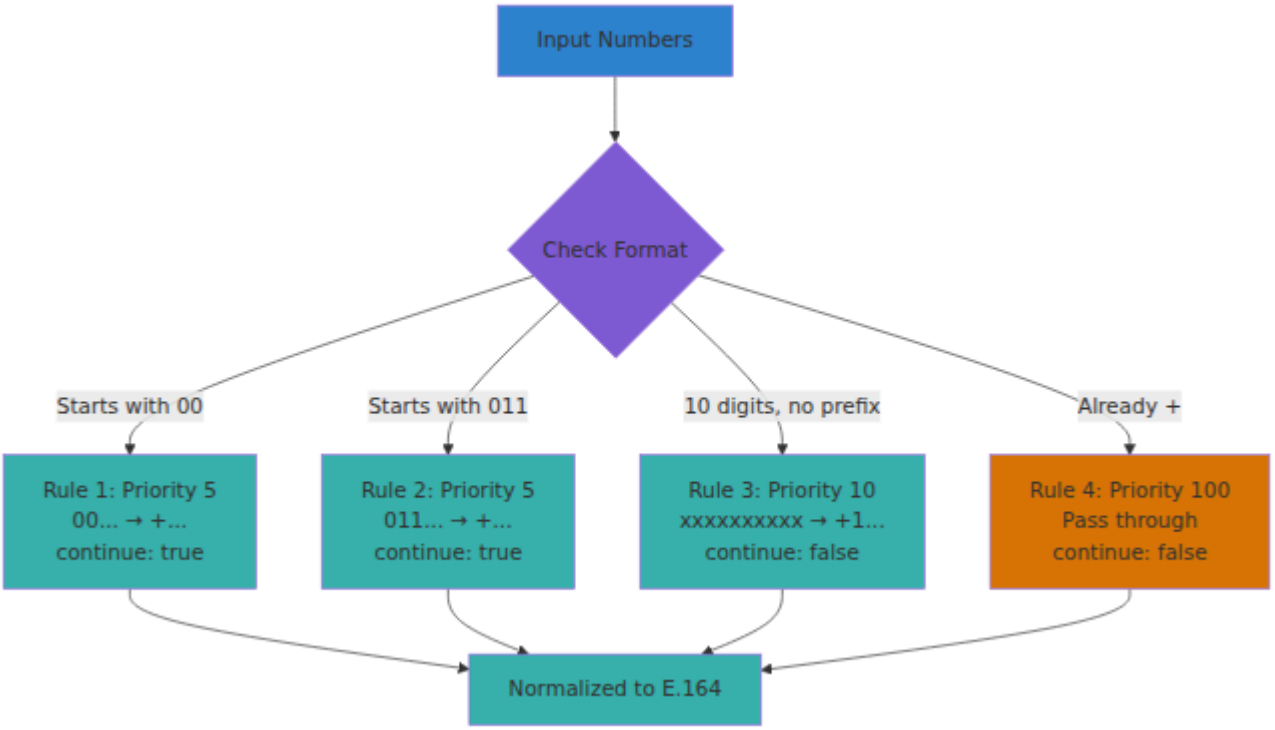
4. Load pre-configured examples using the example buttons
5. Review test history to compare different scenarios

**Example Output:**

```
Translation Result
═══════════════════════════════════════════════
Calling Number:  5551234567 → +1-555-123-4567
Called Number:   9078720155 → +1-907-872-0155
✓ Translated by 3 rule(s)

Step-by-Step Transformations
═══════════════════════════════════════════════
┌─ Step 1 ──────────────────────────────────────┐
│ Rule #1 (Priority 10)         ↓ Continue      │
│ Add country code to 10-digit numbers          │
│                                               │
│ Called: 9078720155 → +19078720155             │
└───────────────────────────────────────────────┘

┌─ Step 2 ──────────────────────────────────────┐
│ Rule #2 (Priority 20)         ↓ Continue      │
│ Format area code with dashes                  │
│                                               │
│ Called: +19078720155 → +1-907-8720155         │
└───────────────────────────────────────────────┘

┌─ Step 3 ──────────────────────────────────────┐
│ Rule #3 (Priority 30)                         │
│ Final formatting for gateway                  │
│                                               │
│ Called: +1-907-8720155 → +1-907-872-0155      │
└───────────────────────────────────────────────┘
```

# API Reference

## Core Operations Overview




## Translation Parameters

**translate_numbers** accepts the following parameters:

- `calling_number` (optional): Originating phone number
- `called_number` (optional): Destination phone number
- `source_smsc` (optional): Source SMSC identifier
- `message_id` (optional): For event logging

**Returns:**

- `{:ok, translated_calling, translated_called, [rules_applied]}` - Always successful
- Returns original numbers if no rules match
- Returns list of all rules that were applied (in order)

```
# Example usage
{:ok, new_calling, new_called, rules} =
  NumberTranslation.translate_numbers(
    calling_number: "5551234567",
    called_number: "9078720155",
    source_smsc: "domestic_gateway",
    message_id: "msg_123"
  )

# Check if any translation occurred
if rules != [] do
  Logger.info("Applied #{length(rules)} translation rules")
  Enum.each(rules, fn rule ->
    Logger.info("  - Rule ##{rule.rule_id}: #{rule.description}")
  end)
end
```

## Rule Management Operations

```
# Add a new rule
{:ok, rule} = NumberTranslation.add_rule(%{
  calling_prefix: nil,
  called_prefix: nil,
  source_smsc: "gateway1",
  calling_match: "^(\d{10})$",
  calling_replace: "+1\1",
  called_match: "^(\d{10})$",
  called_replace: "+1\1",
  priority: 10,
  description: "Add +1 to 10-digit numbers",
  enabled: true,
  continue: false
})

# Update a rule
{:ok, updated_rule} = NumberTranslation.update_rule(rule_id, %{
  enabled: false,
  description: "Disabled for testing"
})

# Delete a rule
:ok = NumberTranslation.delete_rule(rule_id)

# Get a specific rule
rule = NumberTranslation.get_rule(rule_id)

# List all rules
all_rules = NumberTranslation.list_rules()

# List only enabled rules (sorted by priority)
enabled_rules = NumberTranslation.list_enabled_rules()
```

## Import/Export Operations

```
# Export all rules
backup = NumberTranslation.export_rules()
# Returns: %{
#   version: "1.0",
#   exported_at: ~U[2024-01-15 10:30:00Z],
#   count: 5,
#   rules: [...]
# }

# Save to JSON file
json = Jason.encode!(backup, pretty: true)
File.write!("translation_rules_backup.json", json)

# Import rules (merge with existing)
{:ok, %{imported: 3, failed: 0}} =
  NumberTranslation.import_rules(backup, mode: :merge)

# Import rules (replace all existing)
{:ok, %{imported: 5, failed: 0}} =
  NumberTranslation.import_rules(backup, mode: :replace)
```

# Best Practices

## Rule Design

1. **Keep priorities organized**:
   - **1-10**: Critical normalization rules (add country codes, fix formats)
   - **11-50**: Gateway-specific formatting
   - **51-100**: Optional transformations
   - **101+**: Catch-all or debugging rules
2. **Use continue strategically**:
   - Enable `continue: true` for normalization rules that prepare numbers for further processing

- Disable `continue: false` for final formatting rules
- Avoid long chains (3-4 rules maximum) to maintain performance

3. **Document your rules**:
   - Always add clear descriptions
   - Include examples in the description (e.g., "5551234567 → +15551234567")
   - Document the purpose and expected input/output
4. **Test regex patterns**:
   - Test patterns with the simulator before deploying
   - Use capture groups (\1, \2) for flexible transformations
   - Escape special regex characters (dots, parentheses, etc.)

# Performance

1. **Minimize rule count**:
   - Combine similar rules where possible
   - Use prefix matching to reduce regex evaluations
   - Remove or disable unused rules
2. **Optimize regex patterns**:
   - Use prefix matching first (faster than regex)
   - Keep regex patterns simple
   - Avoid backtracking-heavy patterns
3. **Limit rule chaining**:
   - Long chains (5+ rules) can impact performance
   - Consider combining multiple steps into one rule if possible
   - Monitor translation latency with Telemetry metrics

# Operations

1. **Test before deploy**:
    - Use the simulator with real-world examples
    - Test edge cases (empty numbers, special characters)
    - Verify continue flag behavior
2. **Backup regularly**:
    - Export rules before making major changes
    - Version control your exports
    - Test imports in non-production first
3. **Monitor translations**:
    - Enable message_id logging for debugging
    - Check event logs for translation decisions
    - Monitor which rules are being applied
4. **Gradual rollout**:
    - Add new rules as disabled first
    - Test with simulator
    - Enable and monitor
    - Adjust as needed

# Regex Tips

1. **Common patterns**:
    - 10-digit US number: `^(\d{10})$`
    - International format: `^\+(\d+)$`
    - Remove leading zeros: `^0+(.+)$`
    - Add dashes: `^(\d{3})(\d{3})(\d{4})$` → `\1-\2-\3`
2. **Capture groups**:

- Use parentheses to capture: `^(\d{3})(\d{7})$`
- Reference in replace: `+1\1\2`
- Multiple captures: `^\+(\d{1,3})(\d+)$` → `00\1\2`

3. **Escape special characters**:
   - Literal dot: `\.`
   - Literal plus: `\+`
   - Literal parenthesis: `\(` or `\)`

# Troubleshooting

## Rule Not Matching

**Symptom**: Expected rule doesn't match, numbers pass through unchanged

**Possible causes:**

- Prefix doesn't match (check for exact prefix match)
- Source SMSC doesn't match
- Regex pattern doesn't match input format
- Rule is disabled
- Higher priority rule matched first (with continue: false)

**Solutions:**

1. Use simulator to see which rules are evaluated
2. Check rule status (enabled/disabled)
3. Verify prefix matching (case-sensitive)
4. Test regex pattern separately
5. Check priority order

## Wrong Transformation Applied

**Symptom**: Number transformed but result is incorrect

**Possible causes:**

- Regex pattern matches but replace pattern is wrong
- Multiple rules applying in unexpected order
- Capture group references incorrect (\1, \2, etc.)

**Solutions:**

1. Use simulator to see step-by-step transformations
2. Verify regex pattern captures correct groups
3. Check replace pattern syntax
4. Test regex in online regex tester
5. Review rule priority and continue flags

## Infinite Loop / Performance Degradation

**Symptom**: Translation takes very long or appears to hang

**Note**: This should not happen due to loop prevention, but if it does:

**Possible causes:**

- Bug in loop prevention logic
- Extremely long regex evaluation
- Very long rule chain

**Solutions:**

1. Check application logs for errors
2. Review rules with continue: true
3. Simplify regex patterns
4. Reduce number of chained rules
5. Report bug if loop prevention failed

## Unexpected Rule Chaining

**Symptom**: More rules applied than expected

**Possible causes:**

- Rules have continue: true when they shouldn't
- Priority ordering allows multiple matches
- Transformed number matches additional rules

**Solutions:**

1. Use simulator to see exact rule chain
2. Review continue flags on all rules
3. Adjust priorities to control order
4. Set continue: false on final rule

## Translation Not Applied Before Routing

**Symptom**: Router sees untranslated numbers

**Possible causes:**

- Translation not integrated in message flow
- Translation happening after routing
- Application code bypassing translation

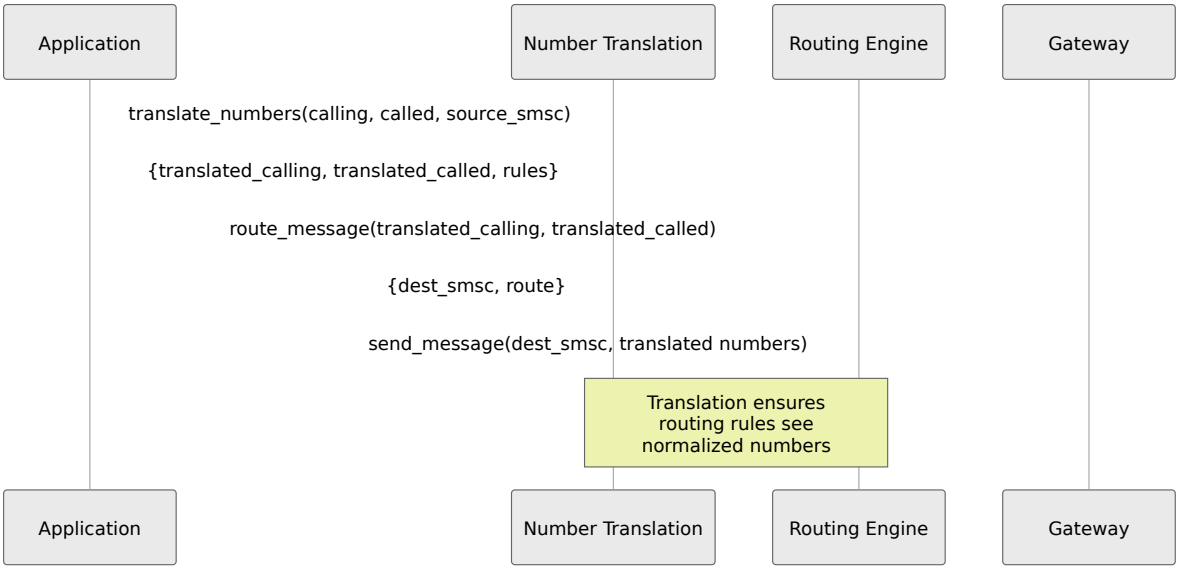
**Solutions:**

1. Verify application integration: translation should be called before routing
2. Check message processing pipeline
3. Review event logs for translation events
4. Ensure translate_numbers is called in correct order

# Advanced Topics

## Integration with Routing

Translation happens **before** routing to ensure consistent number formats:




# Event Logging

Translation decisions are logged via the EventLogger:

- `translation_started`: Translation begins
- `translation_candidates`: Number of enabled rules
- `translation_matched`: Rule matched and applied
- `translation_calling`: Calling number transformed
- `translation_called`: Called number transformed
- `translation_continue`: Rule has continue=true, continuing evaluation
- `translation_none`: No rules matched

Enable logging by passing `message_id` to `translate_numbers/1`.

# Telemetry Metrics

Monitor translation performance with Telemetry:

```
:telemetry.attach(
  "number-translation-handler",
  [:sms_c, :number_translation, :translate, :stop],
  fn _event_name, measurements, metadata, _config ->
    # measurements: %{duration: microseconds}
    # metadata: %{rules_applied: count, ...}
  end,
  nil
)
```

**Key metrics to monitor:**

- Translation duration (p50, p95, p99)
- Rules applied per message
- Rules matched vs not matched
- Continue flag usage

## Clustering

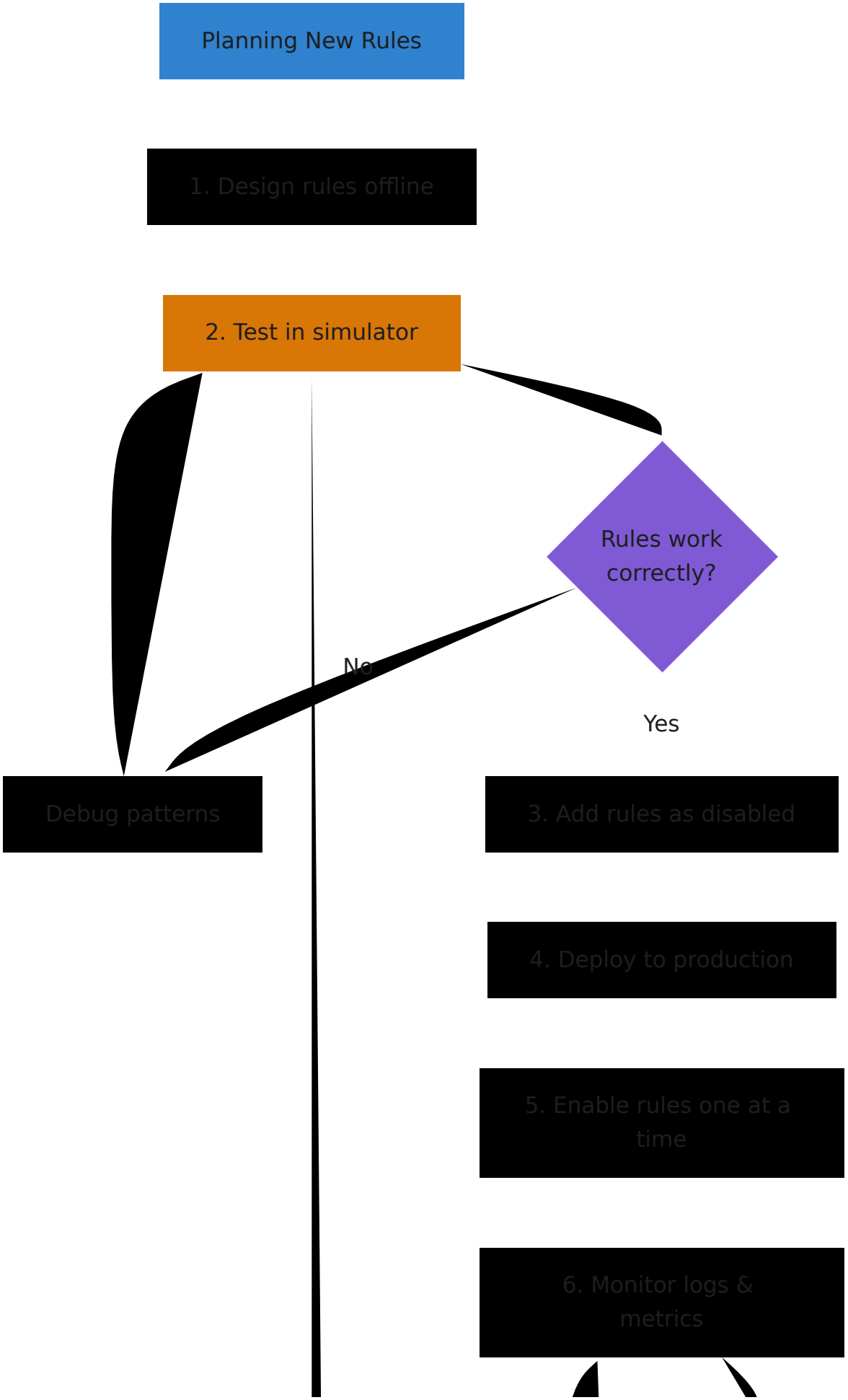
Mnesia tables are automatically distributed across clustered nodes. Translation rules are replicated for high availability.

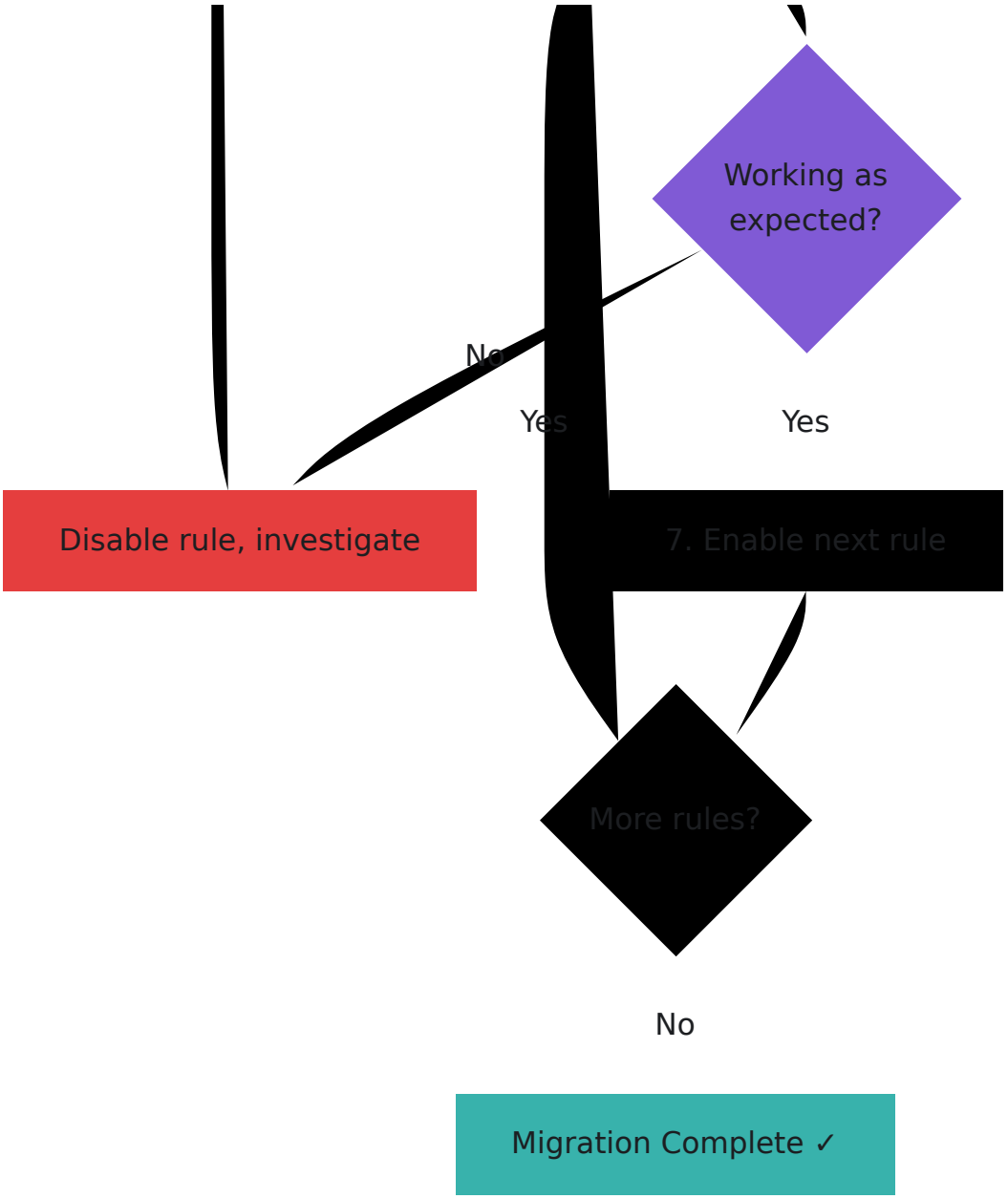
Parse error on line 25: ... style New fill:#3182CE style P ----------^ Expecting 'SOLID_OPEN_ARROW', 'DOTTED_OPEN_ARROW', 'SOLID_ARROW', 'BIDIRECTIONAL_SOLID_ARROW', 'DOTTED_ARROW', 'BIDIRECTIONAL_DOTTED_ARROW', 'SOLID_CROSS', 'DOTTED_CROSS', 'SOLID_POINT', 'DOTTED_POINT', got 'TXT'

Try again

## Migration Strategies

When deploying new translation rules:


Planning New Rules
1. Design rules offline
2. Test in simulator
Rules work correctly?
No
Yes
Debug patterns
3. Add rules as disabled
4. Deploy to production
5. Enable rules one at a time
6. Monitor logs & metrics




# Examples

## Example 1: US Number Normalization

**Requirement**: Convert various US number formats to E.164 (+1XXXXXXXXXX)

```
# Rule 1: 10-digit numbers (highest priority)
%{
  calling_match: "^(\d{10})$",
  calling_replace: "+1\1",
  called_match: "^(\d{10})$",
  called_replace: "+1\1",
  priority: 5,
  description: "Add +1 to bare 10-digit numbers",
  enabled: true,
  continue: false
}

# Rule 2: 1 + 10 digits (medium priority)
%{
  calling_match: "^1(\d{10})$",
  calling_replace: "+1\1",
  called_match: "^1(\d{10})$",
  called_replace: "+1\1",
  priority: 10,
  description: "Convert 1XXXXXXXXXX to +1XXXXXXXXXX",
  enabled: true,
  continue: false
}

# Test cases:
# "5551234567" → "+15551234567" (Rule 1)
# "15551234567" → "+15551234567" (Rule 2)
# "+15551234567" → "+15551234567" (No match, pass through)
```

## Example 2: International Prefix Conversion with Chaining

**Requirement**: Convert 00 prefix to +, then format for gateway

```
# Rule 1: Convert 00 to + (continues to next rule)
%{
  calling_match: "^00(.+)$",
  calling_replace: "+\1",
  called_match: "^00(.+)$",
  called_replace: "+\1",
  priority: 5,
  description: "Convert 00 international prefix to +",
  enabled: true,
  continue: true  # Continue to format
}

# Rule 2: Format for gateway (stops processing)
%{
  calling_match: "^\+(\d+)$",
  calling_replace: "00\1",
  called_match: "^\+(\d+)$",
  called_replace: "00\1",
  priority: 10,
  description: "Format + numbers as 00 for gateway",
  enabled: true,
  continue: false  # Stop after this
}

# Test case:
# Step 1: "00441234567890" → "+441234567890" (Rule 1, continue)
# Step 2: "+441234567890" → "00441234567890" (Rule 2, stop)
# Result: "00441234567890"
# Rules applied: [Rule 1, Rule 2]
```

## Example 3: SMSC-Specific Handling

**Requirement**: Apply different rules based on source SMSC

```
# Rule 1: Trusted SMSC - pass through (priority 5)
%{
  source_smsc: "trusted_gateway",
  calling_match: nil,  # No transformation
  calling_replace: nil,
  called_match: nil,
  called_replace: nil,
  priority: 5,
  description: "Pass through numbers from trusted gateway",
  enabled: true,
  continue: false
}

# Rule 2: Untrusted SMSC - normalize (priority 10)
%{
  source_smsc: "untrusted_gateway",
  calling_match: "^(.*)$",
  calling_replace: "+VALIDATE\1",
  called_match: "^(.*)$",
  called_replace: "+VALIDATE\1",
  priority: 10,
  description: "Add validation prefix for untrusted source",
  enabled: true,
  continue: false
}

# Rule 3: Catch-all for other SMSCs (priority 100)
%{
  source_smsc: nil,  # Wildcard
  calling_match: "^(\d{10})$",
  calling_replace: "+1\1",
  called_match: "^(\d{10})$",
  called_replace: "+1\1",
  priority: 100,
  description: "Default: Add +1 to 10-digit numbers",
  enabled: true,
  continue: false
}
```

# Example 4: Multi-Step Formatting Chain

**Requirement**: Normalize → Add country code → Format with dashes

```
# Rule 1: Strip leading zeros (continue)
%{
  calling_match: "^0+(.+)$",
  calling_replace: "\1",
  called_match: "^0+(.+)$",
  called_replace: "\1",
  priority: 5,
  description: "Strip leading zeros",
  enabled: true,
  continue: true
}

# Rule 2: Add country code if missing (continue)
%{
  calling_match: "^(\d{10})$",
  calling_replace: "+1\1",
  called_match: "^(\d{10})$",
  called_replace: "+1\1",
  priority: 10,
  description: "Add +1 to 10-digit numbers",
  enabled: true,
  continue: true
}

# Rule 3: Format with dashes (stop)
%{
  calling_match: "^\+1(\d{3})(\d{3})(\d{4})$",
  calling_replace: "+1-\1-\2-\3",
  called_match: "^\+1(\d{3})(\d{3})(\d{4})$",
  called_replace: "+1-\1-\2-\3",
  priority: 15,
  description: "Format as +1-XXX-XXX-XXXX",
  enabled: true,
  continue: false
}

# Test case:
# Input: "005551234567"
# Step 1: "005551234567" → "5551234567" (Rule 1, continue)
# Step 2: "5551234567" → "+15551234567" (Rule 2, continue)
# Step 3: "+15551234567" → "+1-555-123-4567" (Rule 3, stop)
```

```
# Result: "+1-555-123-4567"
# Rules applied: [Rule 1, Rule 2, Rule 3]
```

# Support

For issues or questions:

- Check the test suite at `test/sms_c/messaging/number_translation_test.exs` for examples
- Use the simulator to debug translation logic
- Review event logs for translation decisions
- Check Mnesia table contents: `:mnesia.table_info(:translation_rule, :size)`
- Monitor Telemetry metrics for performance issues

# SMS-C Operations Guide

**← Back to Documentation Index** | **Main README**

Daily operational procedures, monitoring, and maintenance tasks for SMS-C operations teams.

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# Daily Operations

## Morning Health Check

Perform these checks at the start of each day:

### 1. Check System Status

```
# API health check
curl https://api.example.com:8443/api/status

# Expected response:
# {"status":"ok","application":"OmniMessage","timestamp":"2025-10-
30T08:00:00Z"}
```

**2. Review Prometheus Metrics**

Access Prometheus dashboard and check:

- Message throughput (last 24 hours)
- Routing failure rate (should be < 1%)
- Queue backlog (should be < 1000 pending)
- Delivery success rate (should be > 95%)
- Frontend connection status (all expected frontends active)

**3. Check Message Queue**

Access Web UI: `https://sms-admin.example.com/message_queue`

Review:

- Total pending messages (should be low)
- Oldest message age (should be < 5 minutes)
- Messages with high delivery attempts (investigate if > 3)
- Dead letter messages (investigate any present)

**4. Review Frontend Status**

Access Web UI: `https://sms-admin.example.com/frontend_status`

Verify:

- All expected frontends are active
- No unexpired disconnections
- No frontend errors in last 24 hours

**5. Check Application Logs**

Access Web UI: `https://sms-admin.example.com/logs` or check log files

Look for:

- Error-level messages
- Routing failures
- Charging failures
- Database connection issues
- Cluster node problems

# Message Volume Monitoring

**Check Hourly Message Counts**:

Use Prometheus query:

```
# Messages received per hour
increase(sms_c_message_received_count[1h])

# Messages delivered per hour
increase(sms_c_delivery_succeeded_count[1h])

# Calculate delivery rate
rate(sms_c_delivery_succeeded_count[1h]) /
rate(sms_c_message_received_count[1h])
```

**Expected Patterns**:

- Business hours: Higher volume
- Nights/weekends: Lower volume
- Delivery rate: Should be > 95%

**Alert Conditions**:

- Sudden drop in messages ( > 50% decrease)
- Sudden spike in messages ( > 200% increase)

- Delivery rate drop below 90%

# Monitoring

## Key Metrics to Watch

### Message Processing Metrics

**Message Received Count** (`sms_c_message_received_count`):

- **What**: Total messages entering system
- **Alert**: Sudden drop or spike
- **Query**: `rate(sms_c_message_received_count[5m])`

**Message Processing Duration** (`sms_c_message_processing_stop_duration`):

- **What**: End-to-end processing time
- **Alert**: p95 > 1000ms
- **Query**: `histogram_quantile(0.95, sms_c_message_processing_stop_duration)`

### Routing Metrics

**Routing Failures** (`sms_c_routing_failed_count`):

- **What**: Messages that couldn't be routed
- **Alert**: Any failures ( > 0)
- **Query**: `increase(sms_c_routing_failed_count[5m])`

**Route Matched** (`sms_c_routing_route_matched_count`):

- **What**: Which routes are being used
- **Alert**: High-priority routes not matching
- **Query**: `sms_c_routing_route_matched_count`

### Delivery Metrics

**Delivery Success Rate**:

- **What**: Percentage of successful deliveries
- **Alert**: Rate < 95%
- **Query**: `rate(sms_c_delivery_succeeded_count[5m]) / rate(sms_c_delivery_queued_count[5m])`

**Delivery Attempts** (`sms_c_delivery_succeeded_attempt_count`):

- **What**: Retries needed for delivery
- **Alert**: p95 > 2 (too many retries)
- **Query**: `histogram_quantile(0.95, sms_c_delivery_succeeded_attempt_count)`

**Queue Metrics**

**Queue Size** (`sms_c_queue_size_size`):

- **What**: Total messages in queue
- **Alert**: Size > 10,000
- **Query**: `sms_c_queue_size_size`

**Oldest Message Age** (`sms_c_queue_oldest_message_age_seconds`):

- **What**: Age of oldest pending message
- **Alert**: Age > 300 seconds
- **Query**: `sms_c_queue_oldest_message_age_seconds`

# Dashboard Setup

**Operational Dashboard Panels**:

1. **Message Throughput** (Graph)
    - Messages received (5-minute rate)
    - Messages delivered (5-minute rate)
    - Time range: Last 24 hours
2. **Queue Status** (Single Stats)

- Current pending messages
- Oldest message age
- Failed message count

3. **Delivery Performance** (Graph)
   - Success rate over time
   - Failure rate over time
   - Time range: Last 24 hours
4. **Routing Status** (Table)
   - Route ID
   - Match count (last hour)
   - Destination SMSC
   - Priority
5. **Frontend Status** (Table)
   - Frontend name
   - Status (active/expired)
   - Last seen
   - Message count (last hour)
6. **System Health** (Single Stats)
   - API response time (p95)
   - Database query time (p95)
   - ENUM lookup time (p95)

# Alert Configuration

**Critical Alerts** (Immediate Response Required):

```yaml
# No route found - messages cannot be delivered
- alert: RoutingFailures
  expr: increase(sms_c_routing_failed_count[5m]) > 0
  severity: critical
  description: "{{ $value }} messages failed routing in last 5
minutes"

# Queue building up - processing falling behind
- alert: QueueBacklog
  expr: sms_c_queue_size_pending > 10000
  severity: critical
  description: "Queue has {{ $value }} pending messages"

# Messages aging - delivery stuck
- alert: OldMessagesInQueue
  expr: sms_c_queue_oldest_message_age_seconds > 300
  severity: critical
  description: "Oldest message is {{ $value }} seconds old"

# Frontend disconnected - no delivery path
- alert: FrontendDisconnected
  expr: sms_c_frontend_status_count{status="disconnected"} > 0
  severity: critical
  description: "{{ $value }} frontends disconnected"
```

**Warning Alerts** (Investigation Needed):

```yaml
# Delivery success rate dropping
- alert: LowDeliveryRate
  expr: rate(sms_c_delivery_succeeded_count[10m]) /
rate(sms_c_delivery_queued_count[10m]) < 0.90
  severity: warning
  description: "Delivery success rate is {{ $value }}"

# Too many delivery retries
- alert: HighRetryRate
  expr: histogram_quantile(0.95,
sms_c_delivery_succeeded_attempt_count) > 2
  severity: warning
  description: "95th percentile delivery attempts: {{ $value }}"

# ENUM lookups slow or failing
- alert: SlowEnumLookups
  expr: histogram_quantile(0.95, sms_c_enum_lookup_stop_duration)
> 5000
  severity: warning
  description: "ENUM lookups taking > 5 seconds"

# Low ENUM cache hit rate
- alert: LowEnumCacheHitRate
  expr: rate(sms_c_enum_cache_hit_count[10m]) /
(rate(sms_c_enum_cache_hit_count[10m]) +
rate(sms_c_enum_cache_miss_count[10m])) < 0.70
  severity: warning
  description: "ENUM cache hit rate: {{ $value }}"
```

# Message Tracking

## Find Specific Message

**By Message ID**:

1. **Web UI**: Navigate to `/message_queue`
2. Enter message ID in search box
3. View full details and event history

**Via API**:

```
curl https://api.example.com:8443/api/messages/12345
```

**By Phone Number**:

1. **Web UI**: Navigate to `/message_queue`
2. Enter phone number in search box
3. View all messages for that number

# Track Message Lifecycle

**View Event History**:

1. **Web UI**: Click on message in queue, view "Events" section
2. **API**: `GET /api/events/12345`

**Common Event Sequence**:

```
1. message_inserted - Message created
   ↓
2. number_translated - Numbers normalized (if configured)
   ↓
3. message_routed - Routing decision made
   ↓
4. charging_attempted - Charging check (if enabled)
   ↓
5. message_delivered - Successfully delivered
```

**Failed Delivery Sequence**:

```
1. message_inserted
   ↓
2. message_routed
   ↓
3. delivery_attempt_1 - First attempt failed
   ↓
4. delivery_attempt_2 - Second attempt failed (2min delay)
   ↓
5. delivery_attempt_3 - Third attempt failed (4min delay)
   ↓
6. message_dead_letter - Exceeded retry limit
```

## Check Delivery Status

**Pending Messages**:

- Status: "pending"
- deliver_after: Future timestamp
- delivery_attempts: 0 or low number

**Delivered Messages**:

- Status: "delivered"
- deliver_time: Timestamp of delivery
- dest_smsc: Frontend that delivered

**Failed Messages**:

- Status: "pending" with high delivery_attempts
- deadletter: true (if expired)
- Check event log for failure reasons

## Location-Based Message Routing

The SMS-C supports location-based message retrieval, allowing frontends to automatically receive messages destined for subscribers registered at their location.

**How It Works**:

When a frontend queries for pending messages using `get_messages_for_smsc(smsc_name)`, the system returns messages in two ways:

1. **Explicit Routing** - Messages where `dest_smsc` explicitly matches the frontend name
2. **Location-Based Routing** - Messages where:
   - `dest_smsc` is `null` (not explicitly routed)
   - `destination_msisdn` has an active location record
   - The location's `location` field matches the frontend name
   - The location has not expired

**Example Scenario**:

A subscriber with MSISDN `+447700900123` registers at frontend `uk_gateway`:

```
# Subscriber registers (creates location record)
POST /api/locations
{
  "msisdn": "+447700900123",
  "imsi": "234150123456789",
  "location": "uk_gateway",
  "expires": "2025-11-01T12:00:00Z"
}
```

When a message arrives for this subscriber without explicit routing:

```
# Message submitted without dest_smsc
POST /api/messages
{
  "source_msisdn": "+15551234567",
  "destination_msisdn": "+447700900123",
  "message_body": "Hello",
  "source_smsc": "api"
  # Note: dest_smsc is null
}
```

The `uk_gateway` frontend will automatically receive this message when it polls:

```
# Frontend polls for messages
GET /api/messages/queue?smsc=uk_gateway

# Returns the message even though dest_smsc is null
# because the destination subscriber is registered at uk_gateway
```

**Location Requirements**:

For location-based routing to work:

- The `locations` table must have an entry for the `destination_msisdn`
- The `location` field must match the querying SMSC name
- The `expires` timestamp must be in the future

**Monitoring Location-Based Routing**:

Check location records:

```
# Via API
GET /api/locations/{msisdn}

# Check if location is expired
# expires field should be > current time
```

**Common Issues**:

- **Message not delivered**: Check if location has expired
- **Wrong frontend**: Verify `location` field matches expected frontend name
- **Location not found**: Subscriber may need to re-register

# Manual Interventions

**Retry Failed Message**:

```
# Reset delivery_attempts and deliver_after
curl -X PATCH https://api.example.com:8443/api/messages/12345 \
  -H "Content-Type: application/json" \
  -d '{
    "delivery_attempts": 0,
    "deliver_after": "2025-10-30T12:00:00Z"
  }'
```

**Change Destination**:

```
# Route to different SMSC
curl -X PATCH https://api.example.com:8443/api/messages/12345 \
  -H "Content-Type: application/json" \
  -d '{
    "dest_smsc": "backup_gateway"
  }'
```

**Delete Stuck Message**:

```
curl -X DELETE https://api.example.com:8443/api/messages/12345
```

# Route Management

## View Current Routes

**Web UI**: Navigate to `/sms_routing`

**Via API**:

```
# List all routes
curl https://api.example.com:8443/api/routes
```

**Check Route Usage**:

Prometheus query:

```
# Messages routed by each route (last hour)
increase(sms_c_routing_route_matched_count[1h])
```

# Add New Route

**Web UI**:

1. Navigate to `/sms_routing`
2. Click "Add New Route"
3. Fill in fields:
   - **Calling Prefix**: Source number prefix (optional)
   - **Called Prefix**: Destination number prefix (required for geographic routing)
   - **Source SMSC**: Source system filter (optional)
   - **Dest SMSC**: Destination gateway (required unless auto-reply/drop)
   - **Priority**: Route priority (1-255, lower = higher priority)
   - **Weight**: Load balancing weight (1-100)
   - **Description**: Human-readable description
   - **Enabled**: Check to activate immediately
4. Click "Save Route"

**Example: Geographic Route**:

- Called Prefix: `+44`
- Dest SMSC: `uk_gateway`
- Priority: 50
- Weight: 100
- Description: "UK routing"

**Example: Load Balanced Route**:

Create two routes with same criteria but different weights:

Route 1:

- Called Prefix: `+44`

- Dest SMSC: `uk_primary`
- Priority: 50
- Weight: 70
- Description: "UK primary (70%)"

Route 2:

- Called Prefix: `+44`
- Dest SMSC: `uk_backup`
- Priority: 50
- Weight: 30
- Description: "UK backup (30%)"

# Test Routes

**Routing Simulator**:

1. Navigate to `/simulator`
2. Enter test parameters:
   - Calling Number: `+15551234567`
   - Called Number: `+447700900000`
   - Source SMSC: (optional)
   - Source Type: (optional)
3. Click "Simulate Routing"
4. Review results:
   - **Selected Route**: Which route was chosen
   - **All Matches**: Which routes matched criteria
   - **Evaluation**: Why each route matched or didn't match

**Test Before Production**:

- Test all new routes in simulator
- Verify correct route is selected
- Check priority ordering
- Validate weight distribution

## Modify Existing Route

**Web UI**:

1. Navigate to `/sms_routing`
2. Find route in list
3. Click "Edit"
4. Modify fields
5. Click "Save Route"

**Common Modifications**:

- **Disable Route**: Uncheck "Enabled" (temporary removal)
- **Adjust Weight**: Change load balance distribution
- **Change Priority**: Reorder route evaluation
- **Update Destination**: Switch to different SMSC

## Delete Route

**Web UI**:

1. Navigate to `/sms_routing`
2. Find route in list
3. Click "Delete"
4. Confirm deletion

**Warning**: Deleting routes is permanent. Consider disabling instead.

## Export/Import Routes

**Export Routes** (Backup):

1. Navigate to `/sms_routing`
2. Click "Export Routes"
3. Save JSON file

**Import Routes**:

1. Navigate to `/sms_routing`
2. Click "Import Routes"
3. Select JSON file
4. Choose import mode:
   - **Merge**: Add to existing routes
   - **Replace**: Delete all and import

**Use Cases**:

- Backup before major changes
- Copy routes between environments
- Disaster recovery
- Configuration versioning

# Frontend Management

## Monitor Frontend Connections

**Web UI**: Navigate to `/frontend_status`

**Check**:

- All expected frontends are "active"
- Last seen times are recent ( < 90 seconds)
- No unexpected expired frontends

**Via API**:

```
# Get active frontends
curl https://api.example.com:8443/api/frontends/active

# Get statistics
curl https://api.example.com:8443/api/frontends/stats
```

# Investigate Disconnections

**Frontend Expired**:

1. Check frontend logs for errors
2. Verify network connectivity to SMS-C
3. Confirm frontend is running
4. Check frontend registration logic (should re-register every 60s)

**Registration Not Showing**:

1. Verify frontend is calling POST `/api/frontends/register`
2. Check API logs for registration errors
3. Verify JSON payload format
4. Test registration manually with curl

**Example Manual Registration**:

```
curl -X POST https://api.example.com:8443/api/frontends/register \
  -H "Content-Type: application/json" \
  -d '{
    "frontend_name": "test_gateway",
    "frontend_type": "smpp",
    "ip_address": "10.0.1.50",
    "hostname": "gateway.example.com"
  }'
```

# View Frontend History

**Web UI**:

1. Navigate to `/frontend_status`
2. Find frontend in list
3. Click "History"
4. Review past registrations

**Via API**:

```
curl https://api.example.com:8443/api/frontends/history/uk_gateway
```

**Use Cases**:

- Investigate connection reliability
- Track frontend uptime patterns
- Identify configuration changes

# Number Translation Management

Number translation rules are managed via `config/runtime.exs`. Changes require application restart.

## View Active Translation Rules

Check configuration file:

```
cat config/runtime.exs | grep -A 20 "translation_rules:"
```

## Common Translation Tasks

**Add Country Code to Local Numbers**:

Edit `config/runtime.exs`:

```
%{
  calling_prefix: nil,
  called_prefix: nil,
  source_smsc: nil,
  calling_match: "^(\d{10})$",
  calling_replace: "+1\1",
  called_match: "^(\d{10})$",
  called_replace: "+1\1",
  priority: 100,
  description: "Add +1 to 10-digit US numbers",
  enabled: true
}
```

**Normalize International Format**:

```
%{
  calling_prefix: nil,
  called_prefix: nil,
  source_smsc: nil,
  calling_match: "^00(\d+)$",
  calling_replace: "+\1",
  called_match: "^00(\d+)$",
  called_replace: "+\1",
  priority: 10,
  description: "Convert 00 prefix to +",
  enabled: true
}
```

**Carrier-Specific Code Stripping**:

```
%{
  calling_prefix: nil,
  called_prefix: "101",
  source_smsc: "carrier_a",
  calling_match: nil,
  calling_replace: nil,
  called_match: "^101(\d+)$",
  called_replace: "\1",
  priority: 5,
  description: "Strip carrier code from carrier A",
  enabled: true
}
```

## Test Translation Rules

After configuration changes:

1. Restart application to load new rules
2. Submit test message with source/destination that should match
3. Check event log for `number_translated` event
4. Verify numbers were transformed correctly

## Disable Translation Rule

Set `enabled: false` in rule:

```
%{
  ...
  enabled: false
}
```

Restart application.

# System Maintenance

## Database Maintenance

**Check Database Size**:

Use your database management tools to monitor CDR storage size:

- **MySQL/MariaDB**: Query `information_schema.tables` for database size
- **PostgreSQL**: Use `pg_database_size()` function or `\l+` command in psql

**Cleanup Old CDR Records**:

CDR records should be archived and purged periodically based on your retention policy:

- Configure automatic archiving based on business requirements (typically 30-90 days in operational database)
- Archive older records to data warehouse or cold storage
- Delete archived records from operational database in batches to avoid lock contention

**Optimize Tables**:

Periodically optimize database tables to maintain performance:

- **MySQL/MariaDB**: Run `OPTIMIZE TABLE` command during low-traffic periods
- **PostgreSQL**: Run `VACUUM ANALYZE` regularly (or enable autovacuum)

**Run Weekly** during low-traffic period to maintain optimal performance.

## Mnesia Database Maintenance

**Check Mnesia Table Size**:

```
# In IEx console
:mnesia.table_info(:sms_route, :size)
:mnesia.table_info(:translation_rule, :size)
```

**Backup Mnesia Tables**:

```
# Export routes (Web UI)
# Navigate to /sms_routing
# Click "Export Routes"

# Or via Mnesia backup
:mnesia.backup("/var/backups/sms_c/mnesia_backup.bup")
```

**Restore Mnesia**:

```
# Via Web UI import
# Or restore backup:
:mnesia.restore("/var/backups/sms_c/mnesia_backup.bup", [])
```

# Log Rotation

Configure logrotate for application logs:

```
# /etc/logrotate.d/sms_c
/var/log/sms_c/*.log {
    daily
    rotate 30
    compress
    delaycompress
    notifempty
    create 0644 sms_user sms_group
    sharedscripts
    postrotate
        systemctl reload sms_c || true
    endscript
}
```

## Restart Application

**Graceful Restart** (zero downtime in cluster):

```
# Restart one node at a time
systemctl restart sms_c

# Wait for node to join cluster
# Repeat for each node
```

**Emergency Restart** (all nodes):

```
systemctl restart sms_c
```

**After Restart**:

- Verify all frontends reconnect
- Check Prometheus for metric continuity
- Monitor logs for errors
- Verify message processing resumes

# Backup and Recovery

## What to Backup

1. **Configuration Files**:
   - `config/runtime.exs`
   - `config/config.exs`
   - `config/prod.exs` (if exists)
2. **Routing Tables** (Mnesia):
   - Export via Web UI
   - Or Mnesia backup command

3. **SQL CDR Database**:
    - Daily full backup
    - Transaction log backups (continuous)
4. **TLS Certificates**:
    - `priv/cert/*.crt`
    - `priv/cert/*.key`

# Backup Procedures

**Daily Configuration Backup**:

```
#!/bin/bash
# /opt/sms_c/scripts/backup_config.sh

BACKUP_DIR="/var/backups/sms_c/$(date +%Y%m%d)"
mkdir -p $BACKUP_DIR

# Backup configuration
cp -r /opt/sms_c/config $BACKUP_DIR/

# Backup certificates
cp -r /opt/sms_c/priv/cert $BACKUP_DIR/

# Set permissions
chmod 600 $BACKUP_DIR/cert/*

echo "Configuration backup completed: $BACKUP_DIR"
```

**Database Backup**:

```
#!/bin/bash
# /opt/sms_c/scripts/backup_database.sh

BACKUP_DIR="/var/backups/sms_c/database"
DATE=$(date +%Y%m%d_%H%M%S)

mkdir -p $BACKUP_DIR

# Backup SQL CDR database
# MySQL/MariaDB: Use mysqldump with --single-transaction for
consistency
# PostgreSQL: Use pg_dump -F c for custom format

# Example structure (adapt to your database):
# - Use appropriate backup tool (mysqldump, pg_dump)
# - Enable transaction-safe backups for consistency
# - Compress output to save space
# - Configure retention period (e.g., 30 days)

# Remove old backups
find $BACKUP_DIR -name "sms_c_*.gz" -mtime +30 -delete

echo "Database backup completed: sms_c_${DATE}"
```

**Routing Table Backup**:

```
#!/bin/bash
# /opt/sms_c/scripts/backup_routes.sh

BACKUP_DIR="/var/backups/sms_c/routes"
DATE=$(date +%Y%m%d)

mkdir -p $BACKUP_DIR

# Export via API
curl https://api.example.com:8443/api/routes/export \
  > $BACKUP_DIR/routes_${DATE}.json

echo "Routes backup completed: routes_${DATE}.json"
```

**Schedule Backups** (crontab):

```
# Daily at 2 AM
0 2 * * * /opt/sms_c/scripts/backup_config.sh
0 2 * * * /opt/sms_c/scripts/backup_database.sh
0 2 * * * /opt/sms_c/scripts/backup_routes.sh
```

# Recovery Procedures

**Restore Configuration**:

```
# Stop application
systemctl stop sms_c

# Restore config files
cp -r /var/backups/sms_c/20251030/config/* /opt/sms_c/config/

# Restore certificates
cp -r /var/backups/sms_c/20251030/cert/* /opt/sms_c/priv/cert/

# Start application
systemctl start sms_c
```

**Restore SQL CDR Database**:

Use appropriate restore tools for your database:

- **MySQL/MariaDB**: Decompress and pipe to mysql client
- **PostgreSQL**: Use pg_restore with custom format dumps

**Important**: Stop the SMS-C application before restoring database to prevent data conflicts.

**Restore Routing Tables**:

1. Navigate to Web UI `/sms_routing`
2. Click "Import Routes"
3. Select backup JSON file
4. Choose "Replace" mode
5. Confirm import

# Capacity Planning

## Monitor Growth Trends

**Message Volume Trend**:

Prometheus query (30-day average):

```
avg_over_time(sms_c_message_received_count[30d])
```

**Database Growth Rate**:

```
-- Monthly data growth
SELECT
  DATE_FORMAT(inserted_at, '%Y-%m') AS month,
  COUNT(*) AS message_count,
  ROUND(SUM(LENGTH(message_body)) / 1024 / 1024, 2) AS data_mb
FROM message_queues
GROUP BY month
ORDER BY month DESC
LIMIT 12;
```

## Capacity Indicators

**CPU Usage**:

- **Normal**: < 50% average
- **High**: > 70% sustained
- **Critical**: > 90%

**Memory Usage**:

- **Normal**: < 70% of available
- **High**: > 80%
- **Critical**: > 90%

**Disk Usage**:

- **Normal**: < 60% full
- **High**: > 75%
- **Critical**: > 85%

**Queue Depth**:

- **Normal**: < 1000 pending
- **High**: > 5000 pending
- **Critical**: > 10,000 pending

# Scaling Recommendations

**When to Scale Vertically** (Upgrade Resources):

- CPU consistently > 70%
- Memory consistently > 80%
- Single-node bottleneck

**When to Scale Horizontally** (Add Nodes):

- CPU > 50% on all nodes
- Message volume > 5,000 msg/sec
- Geographic distribution needed
- High availability required

**Database Scaling**:

- Read replicas for reporting queries
- Connection pooling optimization
- Index optimization
- Partition large tables by date

# Incident Response

## Severity Levels

**Critical** (Immediate Response):

- No messages being delivered
- All frontends disconnected
- Database unavailable
- API completely down

**High** (Response within 1 hour):

- Delivery success rate < 80%
- Multiple frontends disconnected
- Routing failures > 10%
- Queue backlog growing

**Medium** (Response within 4 hours):

- Single frontend disconnected
- Delivery success rate 80-95%
- Slow message processing
- ENUM lookups failing

**Low** (Response within 24 hours):

- Minor performance degradation
- Single route issue
- Non-critical warning alerts

## Incident Checklist

**1. Assess Severity**:

- Check Prometheus alerts
- Review dashboard metrics

- Check message queue status
- Verify frontend connections

**2. Gather Information**:

- Recent configuration changes?
- Recent deployments?
- External dependencies status (OCS, DNS)?
- Error messages in logs?

**3. Immediate Actions**:

- Stop ongoing changes
- Roll back recent deployments if suspected cause
- Enable verbose logging if needed
- Notify stakeholders

**4. Investigation**:

- Review application logs
- Check system resource usage
- Examine database performance
- Test external dependencies

**5. Resolution**:

- Apply fix
- Test in simulator
- Deploy to production
- Monitor for improvement

**6. Post-Incident**:

- Document root cause
- Update monitoring/alerts
- Implement preventive measures
- Update runbooks

# Common Incidents

**High Queue Backlog**:

1. Check delivery success rate
2. Verify frontends are connected and polling
3. Check database performance
4. Review Prometheus for bottlenecks
5. Consider increasing batch size/interval

**Routing Failures**:

1. Review routing configuration
2. Test in routing simulator
3. Check for missing routes
4. Verify catch-all route exists
5. Check event logs for failure reasons

**Frontend Disconnections**:

1. Check frontend system status
2. Verify network connectivity
3. Review frontend logs
4. Test manual API registration
5. Check firewall rules

**Slow Message Processing**:

1. Check database query performance
2. Review batch worker configuration
3. Verify adequate resources (CPU/Memory)
4. Check for ENUM lookup delays
5. Review charging system performance

For detailed troubleshooting procedures, see the Troubleshooting Guide.

# Performance Tuning Guide

**← Back to Documentation Index** | **Main README**

This guide explains how to optimize SMS-C performance for different workload scenarios.

# Performance Overview

SMS-C delivers **1,750 messages/second** throughput using Mnesia for in-memory message storage with automatic SQL database archiving for CDR retention.

## Key Performance Metrics

Measured on Intel i7-8650U @ 1.90GHz (8 cores):

| Operation | Throughput | Latency (avg) | Improvement |
|---|---|---|---|
| Message Insert (with routing) | 1,750 msg/sec | 0.58ms | 21x faster than SQL |
| Message Insert (simple) | 1,750 msg/sec | 0.57ms | 21x faster than SQL |
| Get Messages for SMSC | 800 msg/sec | 1.25ms | In-memory query |
| Memory per Insert | 62 KB | - | 50% reduction |

**Capacity:** ~150 million messages per day on single node

# Table of Contents



# Message Storage Architecture

SMS-C uses a dual-storage architecture for optimal performance:

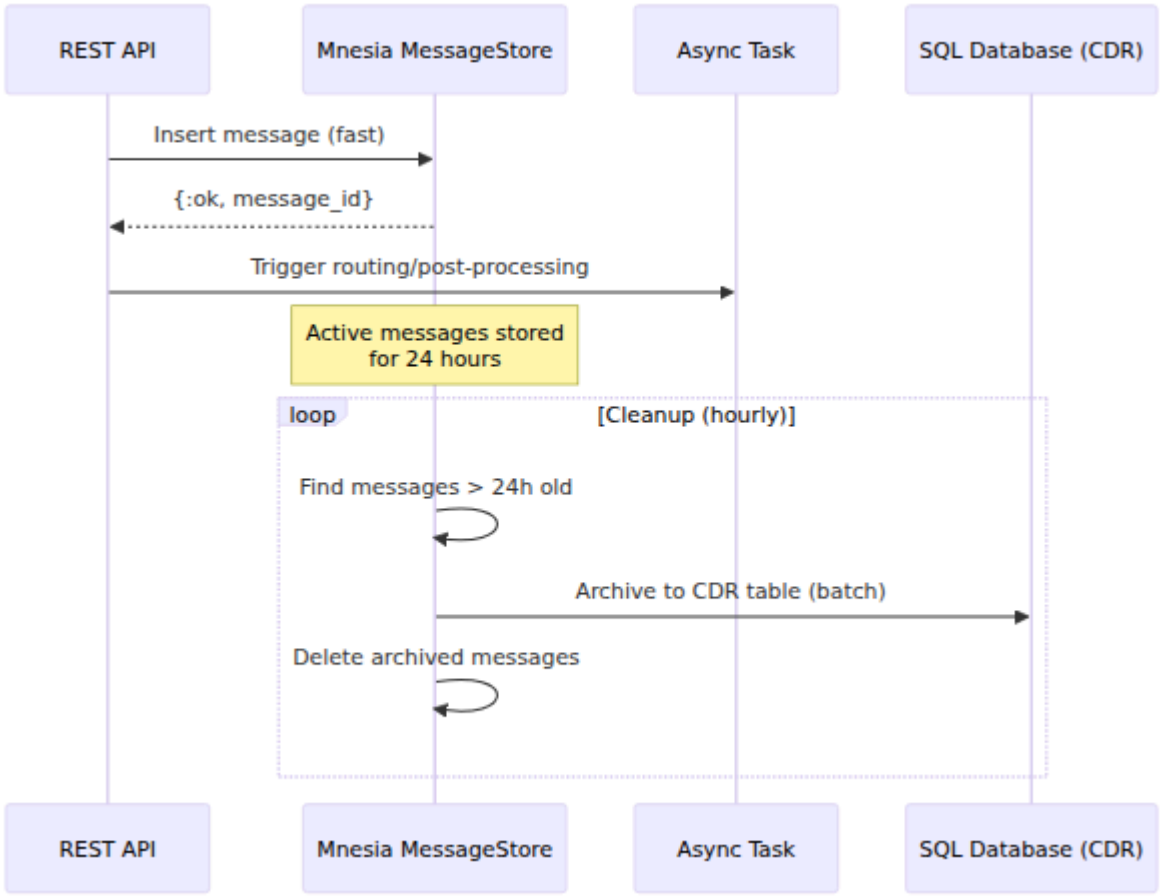
## Active Message Store (Mnesia)

- **Purpose**: Ultra-fast message insertion, routing, and delivery
- **Storage**: In-memory with disk persistence (disc_copies)
- **Performance**: 1,750 msg/sec insert throughput, 0.58ms latency
- **Retention**: Configurable (default: 24 hours)
- **Clustering**: Supports distributed Mnesia for horizontal scaling

## CDR Archive (SQL Database)

- **Purpose**: Long-term message history and reporting
- **Storage**: SQL database (MySQL/MariaDB or PostgreSQL) for durable archival
- **Performance**: Batched writes to minimize database load
- **Retention**: Permanent (or per data retention policy)
- **Queries**: Analytics, reporting, compliance

## Data Flow




# Mnesia Optimization

## Message Retention Configuration

```
# config/runtime.exs
config :sms_c,
  message_retention_hours: 24  # Default: 24 hours
```

**Tuning Guidelines:**

- **High volume (>1M msg/day)**: 12-24 hours retention
  - Minimizes Mnesia table size
  - Faster queries
  - More frequent archiving to MySQL

- **Medium volume (100K-1M msg/day)**: 24-48 hours retention
  - Good balance for most deployments
  - Adequate buffer for retry logic
- **Low volume (<100K msg/day)**: 48-168 hours retention
  - Longer message history in fast storage
  - Less frequent archiving

## Mnesia Table Indices

MessageStore automatically creates indices on:

- `status` - For filtering pending/delivered messages
- `dest_smsc` - For SMSC-specific queries
- `expires` - For expiration handling
- `destination_msisdn` - For subscriber queries
- `source_msisdn` - For subscriber queries

## Mnesia Disc Persistence

Messages are stored as `disc_copies` providing:

- □ In-memory performance
- □ Automatic disk persistence
- □ Crash recovery
- □ No data loss on restart

# CDR Archiving Configuration

The `BatchInsertWorker` handles CDR archiving to MySQL using batched writes:

```
# config/runtime.exs
config :sms_c,
  batch_insert_batch_size: 100,           # CDR batch size
  batch_insert_flush_interval_ms: 100     # Auto-flush interval
```

# CDR Tuning Guidelines

### High Volume Archiving

```
batch_insert_batch_size: 200
batch_insert_flush_interval_ms: 200
```

- Larger batches reduce MySQL load
- Higher latency for CDR writes (acceptable for archiving)

### Balanced (Recommended)

```
batch_insert_batch_size: 100
batch_insert_flush_interval_ms: 100
```

- Good balance for most deployments
- CDRs written within 100ms

### Real-time CDR Requirements

```
batch_insert_batch_size: 20
batch_insert_flush_interval_ms: 20
```

- Faster CDR writes for compliance
- More MySQL write operations

# Query Optimization

## Using Mnesia Indices Effectively

Queries that use indexed fields are fastest:

```
# Fast queries (use indices)
MessageStore.list(status: :pending)
MessageStore.list(dest_smsc: "gateway-1")
Messaging.get_messages_for_smsc("gateway-1")

# Slower queries (full table scan)
MessageStore.list(limit: :infinity)  # Returns all messages
```

## MySQL Connection Pool

For CDR queries and archiving, configure MySQL connection pool:

```
# config/runtime.exs
config :sms_c, SmsC.Repo,
  pool_size: 10  # Increase for heavy CDR reporting
```

**Guidelines:**

- Standard deployment: `pool_size: 10`
- Heavy CDR reporting: `pool_size: 20-30`
- Archiving only: `pool_size: 5`

# Benchmarking

## Running Benchmarks

The project includes Benchee-based benchmarks for performance testing:

```
# Raw SMS API benchmark (compares sync vs async)
mix run benchmarks/raw_sms_bench.exs

# General message API benchmark
mix run benchmarks/message_api_bench.exs
```

## Interpreting Results

Example output:

```
Name                                          ips        average
deviation         median         99th %
submit_message_raw_async (batch)        4.65 K        0.22 ms
±41.72%       0.184 ms        0.55 ms
submit_message_raw (sync)             0.0696 K       14.36 ms
±33.42%       12.57 ms       33.71 ms
```

**Key metrics:**

- **ips**: Iterations per second (higher is better)
- **average**: Average execution time (lower is better)
- **median**: Middle value, more representative than average for skewed distributions
- **99th %**: 99th percentile latency (important for SLA compliance)

## Performance Baseline

Expected performance on modern hardware (Intel i7-8650U, 8 cores):

| Metric | insert_message (Mnesia) | Previous (MySQL) |
|---|---|---|
| Throughput (with routing) | 1,750 msg/sec | 83 msg/sec |
| Throughput (simple) | 1,750 msg/sec | 89 msg/sec |
| Response Time (avg) | 0.58ms | 16ms |
| Response Time (p99) | <5ms | 30ms |
| Memory per operation | 62 KB | 121 KB |
| **Performance Gain** | **21x faster** | - |

**Key Improvements:**

- □ Removed duplicate number translation calls
- □ Async post-processing (routing, charging, events)
- □ Mnesia in-memory storage vs MySQL disk I/O
- □ 50% memory reduction

# Monitoring

## Runtime Statistics

Check batch worker statistics:

```
SmsC.Messaging.BatchInsertWorker.stats()
```

Returns:

```
%{
  total_enqueued: 10000,
  total_flushed: 9900,
  total_batches: 99,
  current_queue_size: 100,
  flush_errors: 0,
  last_flush_at: ~U[2025-10-22 12:34:56Z],
  last_flush_count: 100,
  last_flush_duration_ms: 45
}
```

## Key Metrics to Monitor

1. **Queue Size**: `current_queue_size` - Should be below `batch_size` most of the time
2. **Flush Duration**: `last_flush_duration_ms` - Should be < 100ms for batch_size=100
3. **Flush Errors**: `flush_errors` - Should be 0 or very low
4. **Throughput**: `total_flushed / uptime` - Should match expected load

## Alerts

Set up monitoring alerts for:

- Queue size consistently at max (indicates backpressure)
- Flush duration increasing (database performance degradation)
- Flush errors > 0 (database connectivity issues)
- Throughput below expected (performance degradation)

# Troubleshooting

## Symptom: Low Throughput

**Possible causes:**

1. Database connection pool exhausted: Increase `pool_size`

2. Slow database: Check query performance, add indexes
3. Network latency: Optimize network path to database
4. Batch size too small: Increase `batch_insert_batch_size`

## Symptom: High Latency

**Possible causes:**

1. Flush interval too high: Reduce `batch_insert_flush_interval_ms`
2. Batch size too high: Reduce `batch_insert_batch_size`
3. Database slow writes: Check disk I/O, optimize tables
4. Using async API when you need sync: Switch to synchronous endpoint

## Symptom: Memory Issues

**Possible causes:**

1. Queue backing up: Messages accumulating faster than flushing
2. Batch size too large: Reduce `batch_insert_batch_size`
3. Flush failures: Check `flush_errors` in stats
4. Need to restart worker: `Supervisor.terminate_child/2` and restart

# Best Practices

1. **Start with defaults** (100/100ms) and tune based on observed behavior
2. **Monitor in production** for at least 1 week before optimizing
3. **Test configuration changes** in staging with production-like load
4. **Use benchmarks** to validate configuration changes
5. **Document your tuning** decisions for future reference
6. **Set up alerts** before optimizing to catch regressions
7. **Consider time zones** - peak load varies by region

# Example Configurations

## Configuration: High-Volume Aggregator

```
# config/prod.exs
config :sms_c,
  batch_insert_batch_size: 200,
  batch_insert_flush_interval_ms: 200

config :sms_c, SmsC.Repo,
  pool_size: 50
```

## Configuration: Enterprise Real-Time Messaging

```
# config/prod.exs
config :sms_c,
  batch_insert_batch_size: 20,
  batch_insert_flush_interval_ms: 10

config :sms_c, SmsC.Repo,
  pool_size: 20
```

## Configuration: Development/Testing

```
# config/dev.exs
config :sms_c,
  batch_insert_batch_size: 10,
  batch_insert_flush_interval_ms: 50

config :sms_c, SmsC.Repo,
  pool_size: 5
```

# Further Reading

- Ecto Performance Guide

- Benchee Documentation
- Phoenix Under Pressure

# SMS-C Routing Guide

**← Back to Documentation Index** | **Main README**

## Overview

The SMS-C Routing system provides flexible, high-performance routing of SMS messages based on multiple criteria including number prefixes, SMSC identifiers, connection types, and more. Routes are stored in Mnesia for persistence and can be modified at runtime without service interruption.

## Key Features

- **Prefix-based routing**: Route based on calling/called number prefixes with longest-match-wins logic
- **SMSC-based routing**: Route based on source or destination SMSC
- **Type-based routing**: Route based on source connection type (IMS, Circuit Switched, SMPP)
- **Priority-based routing**: Control route selection order with configurable priorities
- **Weight-based load balancing**: Distribute traffic across multiple routes using weights
- **Auto-reply routing**: Automatically send replies back to message originators
- **Drop routing**: Discard messages matching specific criteria (spam filtering, etc.)
- **Charging control**: Configure charging behavior per route (Yes/No/Default)
- **Configuration file loading**: Load initial routes from `runtime.exs` on first startup
- **Runtime configuration**: Add, modify, or disable routes without restarting
- **Web UI**: Full CRUD interface for route management with frontend dropdown
- **Simulation tool**: Test routing logic before deployment

- **Backup/Restore**: Export and import routing configurations
- **ENUM support**: DNS-based number lookup (for future implementation)

# Architecture

## Data Model

Each route contains the following fields:

| Field | Type | Description | Required |
|---|---|---|---|
| `route_id` | integer | Auto-incrementing unique identifier | Yes (auto) |
| `calling_prefix` | string/nil | Prefix match for calling number (nil = wildcard) | No |
| `called_prefix` | string/nil | Prefix match for called number (nil = wildcard) | No |
| `source_smsc` | string/nil | Source SMSC name (nil = wildcard) | No |
| `dest_smsc` | string/nil | Destination SMSC name (required unless auto_reply or drop is true) | Conditional |
| `source_type` | atom/nil | Source type: `:ims`, `:circuit_switched`, `:smpp`, or nil | No |
| `enum_domain` | string/nil | DNS ENUM domain for lookup | No |
| `auto_reply` | boolean | If true, sends reply back to originator | No (default: false) |
| `auto_reply_message` | string/nil | Message text for auto-reply (required if auto_reply is true) | Conditional |
| `drop` | boolean | If true, discards message (spam filtering) | No (default: false) |

| Field | Type | Description | Required |
|---|---|---|---|
| `charged` | atom | Charging behavior: `:yes`, `:no`, or `:default` | No (default: `:default`) |
| `weight` | integer | Load balancing weight (1-100, default 100) | Yes |
| `priority` | integer | Route priority (1-255, lower = higher priority) | Yes |
| `description` | string | Human-readable description | No |
| `enabled` | boolean | Enable/disable route | Yes |

**Note**: A route must be one of three types:

1. **Normal routing**: `auto_reply=false`, `drop=false`, requires `dest_smsc`
2. **Auto-reply**: `auto_reply=true`, requires `auto_reply_message`
3. **Drop**: `drop=true`, discards the message

# Routing Algorithm

When routing a message, the system follows this priority order:

**PRIORITY 1: Location-Based Routing (Highest)**

1. **Check subscriber registration**: If the destination MSISDN is registered in the locations table
2. **Route directly to serving frontend**: Skip all routing rules and send directly to the frontend serving that subscriber
3. **This happens AFTER number translation** to ensure consistency with location registrations

**PRIORITY 2: Standard Routing Rules** (if no location registration found)

1. **Filters enabled routes** that match ALL specified criteria
2. **Sorts by specificity** (more specific routes first):
   - Longer called prefix = higher specificity (×100 points)
   - Longer calling prefix = medium specificity (×50 points)
   - Source SMSC specified = +25 points
   - ENUM result domain specified = +15 points
   - Source type specified = +10 points
   - ENUM domain specified = +5 points
3. **Groups by priority** (lower number = higher priority)
4. **Selects from highest priority group** using weighted random selection
5. **Executes route action**:
   - **Normal route**: Returns destination SMSC for message delivery
   - **Auto-reply route**: Sends reply back to originator asynchronously
   - **Drop route**: Discards message and logs event

## Wildcards

- `nil` or empty values act as wildcards that match any value
- A route with no criteria specified is a catch-all route

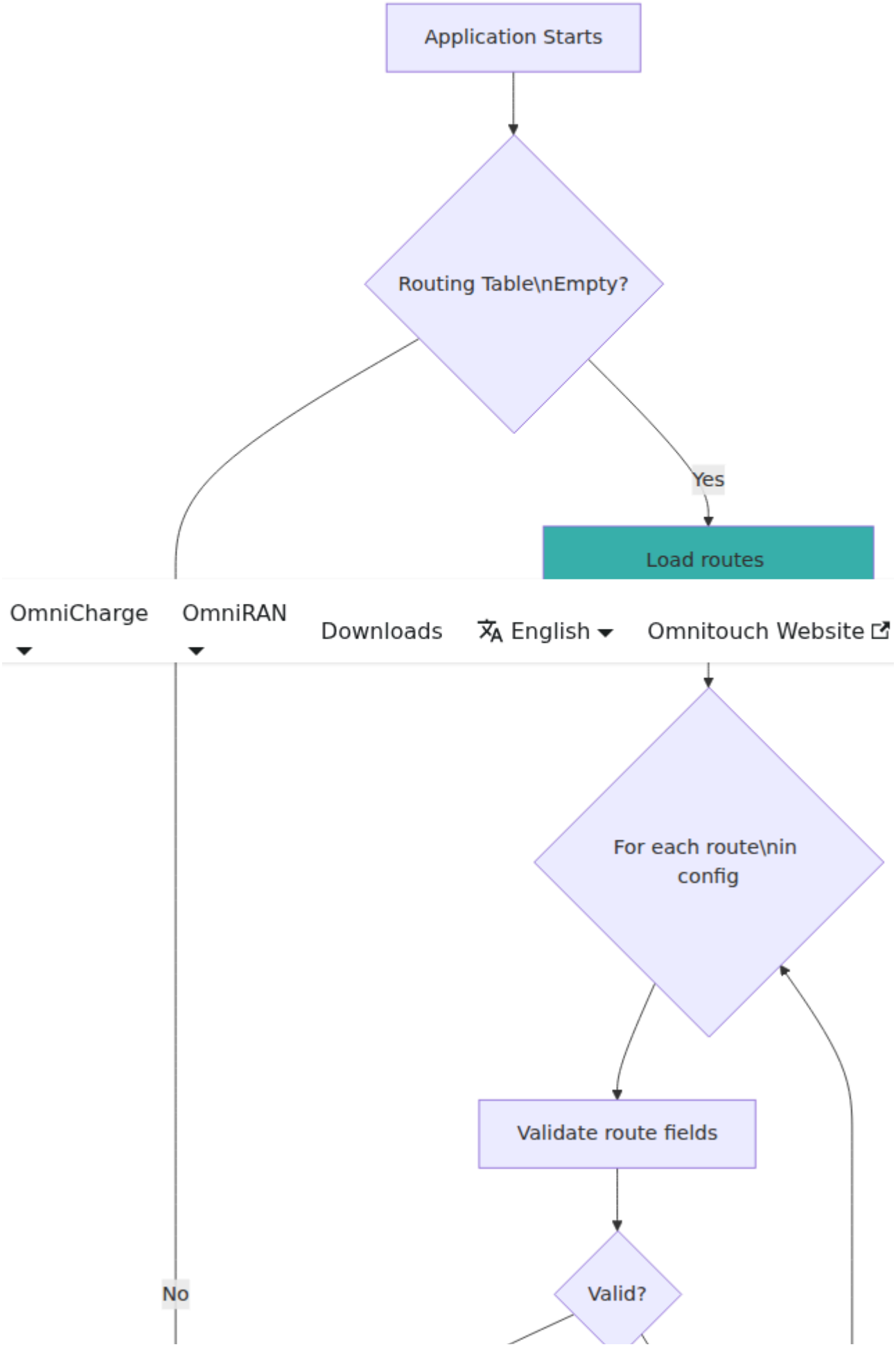
# Configuration

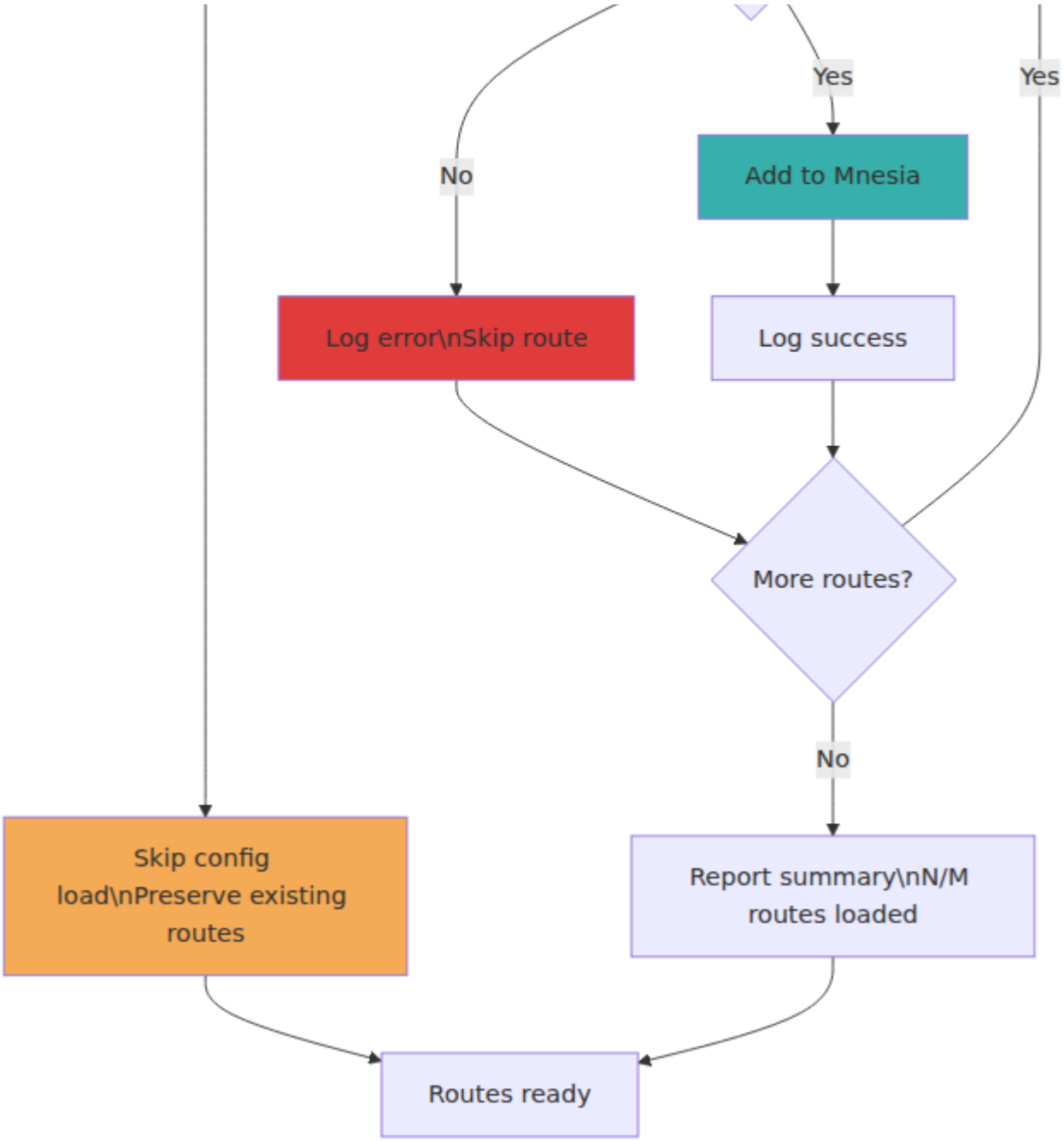
## Loading Routes from Configuration File

Routes can be defined in `config/runtime.exs` and will be automatically loaded on first startup. This is useful for defining baseline routing rules that should be present when the system first starts.

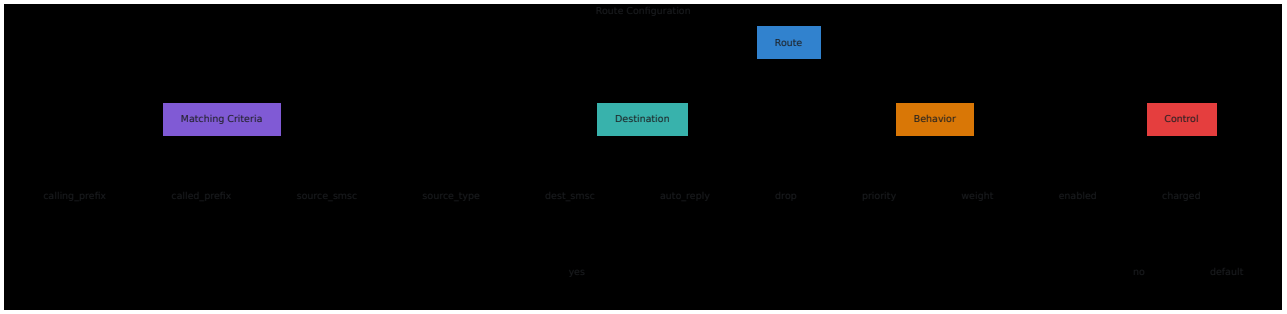
**Important**: Routes from configuration are only loaded when the routing table is **empty** (first startup). This preserves routes added via the Web UI during runtime and prevents duplicates on restarts.

#### Configuration Loading Flow


Application Starts
Routing Table\nEmpty?
Yes
Load routes
OmniCharge
OmniRAN
Downloads
English
Omnitouch Website
For each route\nin config
Validate route fields
Valid?
No




**Example Route Configuration Structure**

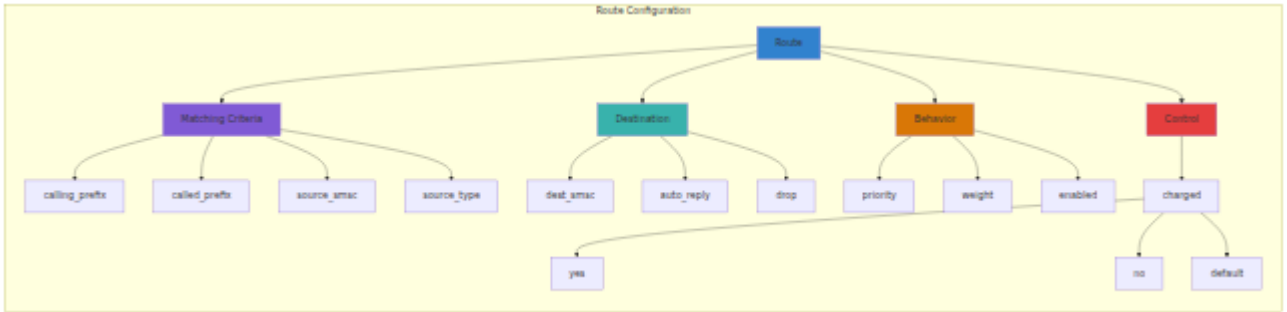



See `config/runtime.exs` and `config/sms_routes.example.exs` for complete examples including:

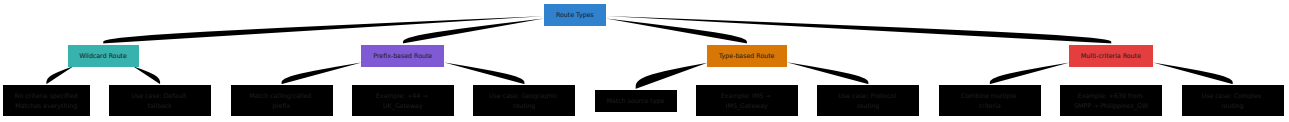
- Geographic routing
- Auto-reply routes
- Drop routes (spam filtering)
- Load-balanced routes
- Premium number routing with charging

# Getting Started

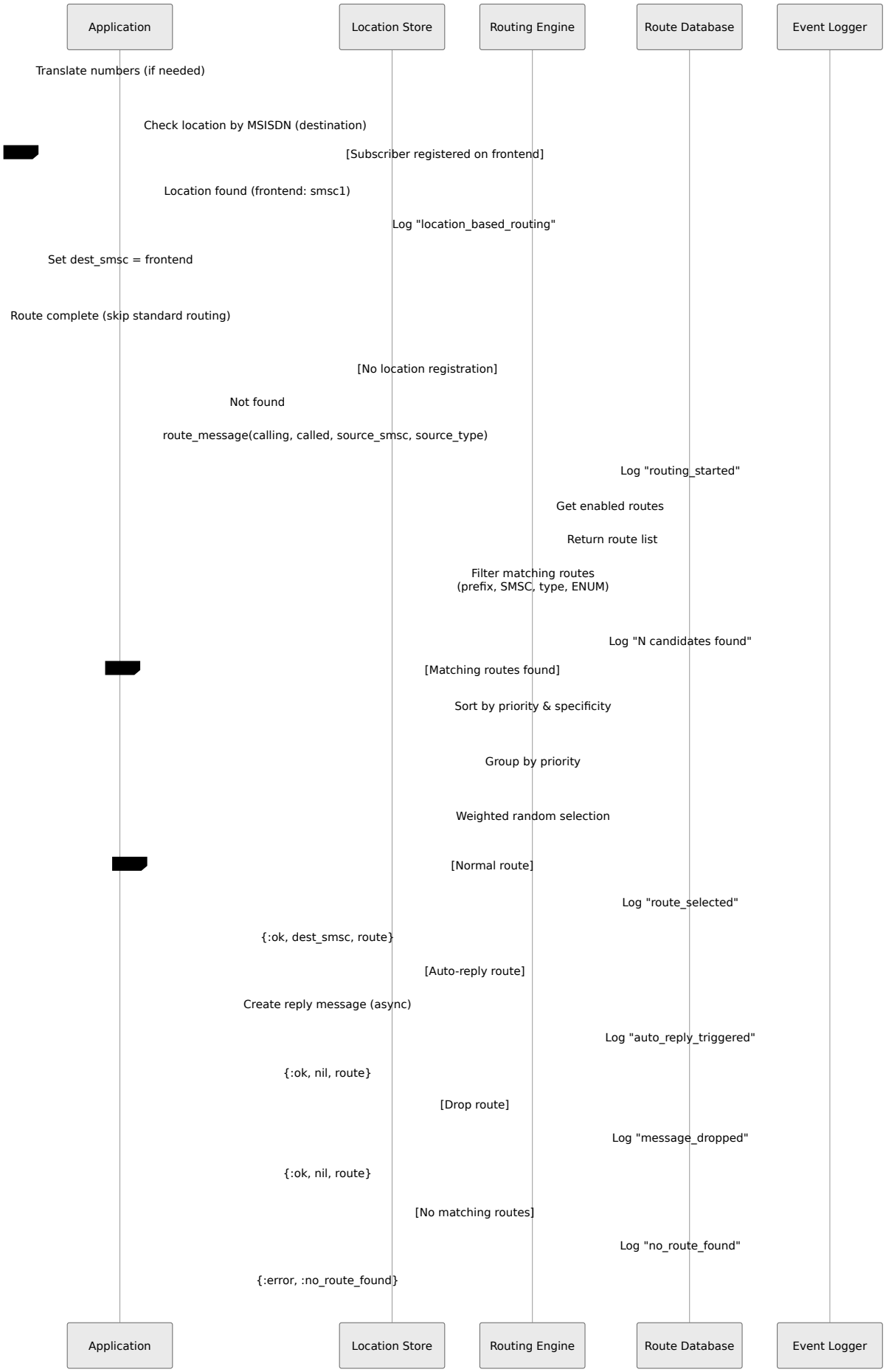
## Initialization Flow



# Route Types Overview



# Message Routing Flow


Application
Location Store
Routing Engine
Route Database
Event Logger
Translate numbers (if needed)
Check location by MSISDN (destination)
[Subscriber registered on frontend]
Location found (frontend: smsc1)
Log "location_based_routing"
Set dest_smsc = frontend
Route complete (skip standard routing)
[No location registration]
Not found
route_message(calling, called, source_smsc, source_type)
Log "routing_started"
Get enabled routes
Return route list
Filter matching routes
(prefix, SMSC, type, ENUM)
Log "N candidates found"
[Matching routes found]
Sort by priority & specificity
Group by priority
Weighted random selection
[Normal route]
Log "route_selected"
{:ok, dest_smsc, route}
[Auto-reply route]
Create reply message (async)
Log "auto_reply_triggered"
{:ok, nil, route}
[Drop route]
Log "message_dropped"
{:ok, nil, route}
[No matching routes]
Log "no_route_found"
{:error, :no_route_found}
Application
Location Store
Routing Engine
Route Database
Event Logger

# Common Use Cases

## Location-Based Routing (Highest Priority)

Route messages directly to the frontend serving a registered subscriber, bypassing all routing rules:

Parse error on line 4: ...ed<br/>on frontend "ims-core-1"| REG[Loc ----------^ Expecting 'SQE', 'DOUBLECIRCLEEND', 'PE', '-)', 'STADIUMEND', 'SUBROUTINEEND', 'PIPE', 'CYLINDEREND', 'DIAMOND_STOP', 'TAGEND', 'TRAPEND', 'INVTRAPEND', 'UNICODE_TEXT', 'TEXT', 'TAGSTART', got 'STR'

Try again

**How it works:**

1. Message arrives with destination number
2. Numbers are translated (if configured)
3. System checks if translated destination MSISDN is in the locations table
4. If registered, message routes directly to the frontend serving that subscriber
5. Standard routing rules are **completely skipped**
6. If not registered, normal routing rules apply

**Benefits:**

- **Guaranteed delivery** to the correct frontend for registered subscribers
- **Fastest routing** - no route table evaluation needed
- **Accurate routing** - subscriber location is the source of truth
- **Overrides all routing rules** - ensures subscriber reach-ability

**Use cases:**

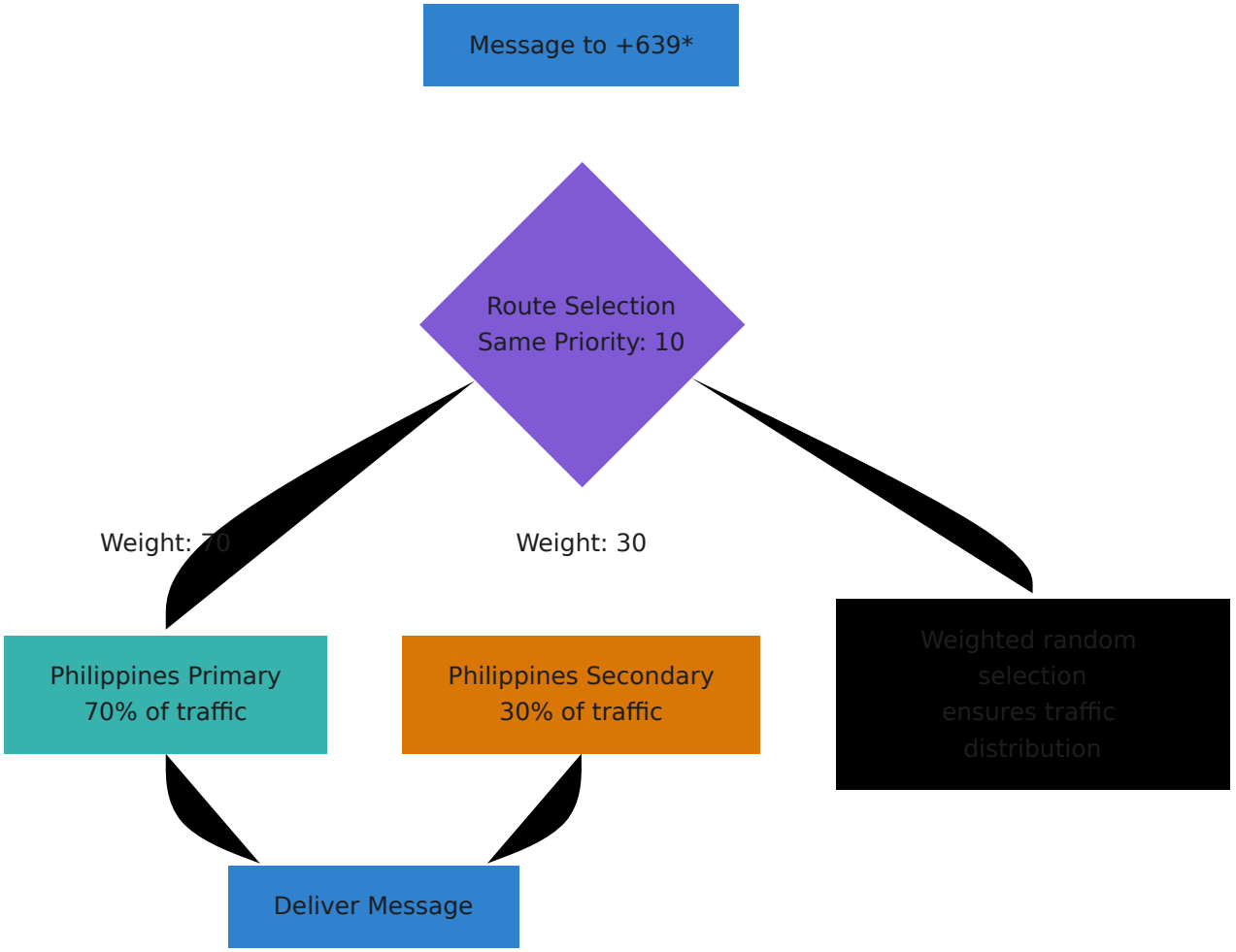
- IMS/VoLTE subscribers registered on specific IMS cores
- Mobile subscribers attached to specific MSCs
- SIP subscribers registered on specific application servers

## Geographic Routing

Route messages to regional SMSCs based on destination country:

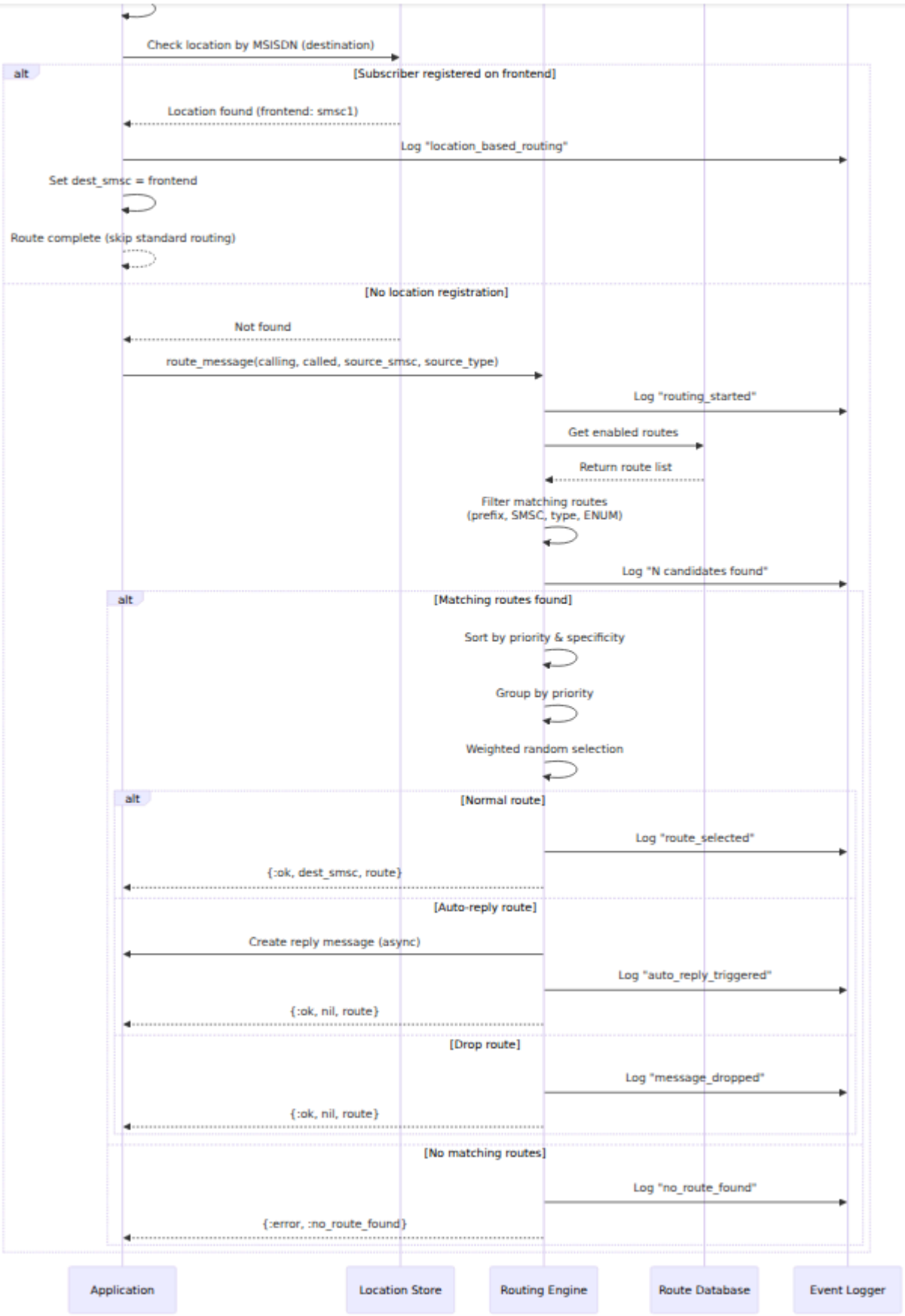
## Load Balancing

Distribute traffic across multiple SMSCs with weights:



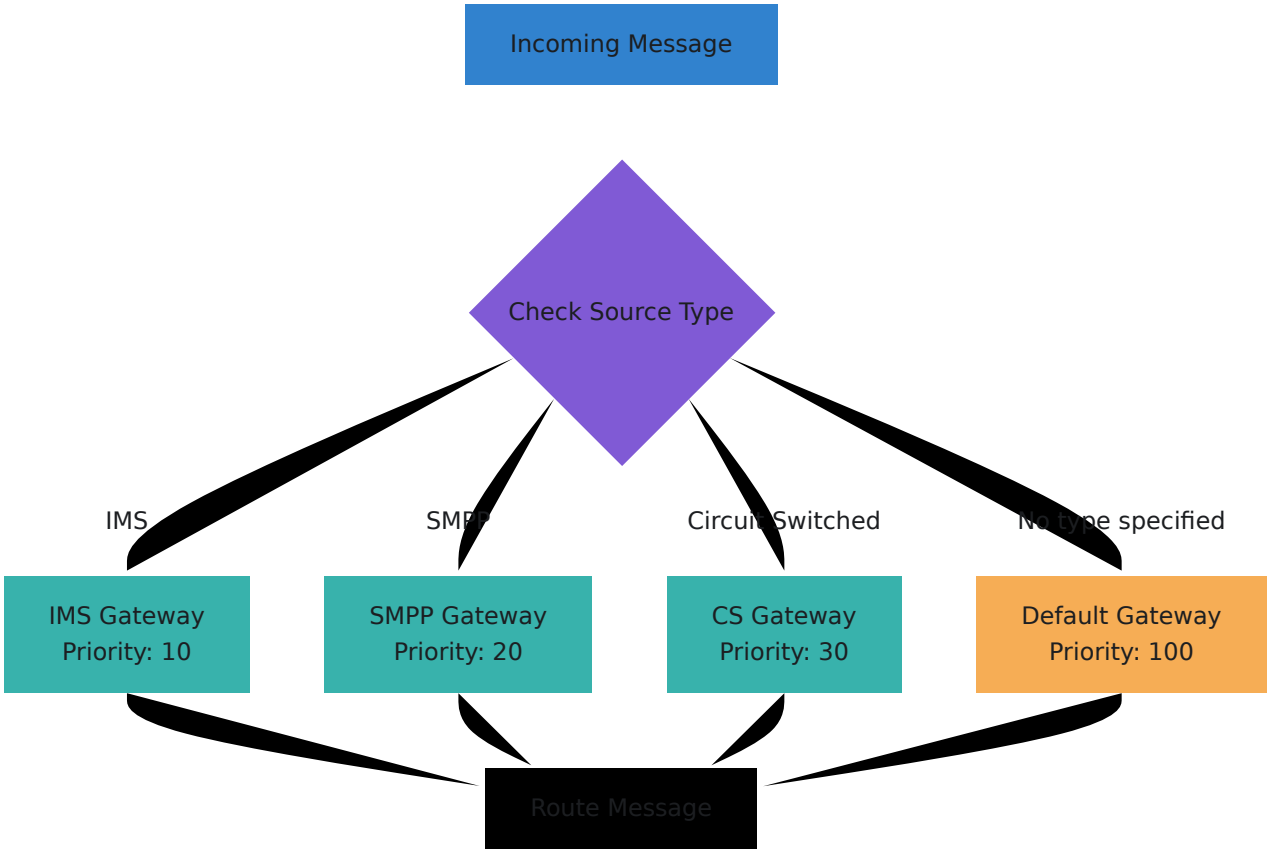

## Premium Number Routing

Route premium numbers to special handling with priority:


Check location by MSISDN (destination)
alt
[Subscriber registered on frontend]
Location found (frontend: smsc1)
Log "location_based_routing"
Set dest_smsc = frontend
Route complete (skip standard routing)
[No location registration]
Not found
route_message(calling, called, source_smsc, source_type)
Log "routing_started"
Get enabled routes
Return route list
Filter matching routes
(prefix, SMSC, type, ENUM)
Log "N candidates found"
alt
[Matching routes found]
Sort by priority & specificity
Group by priority
Weighted random selection
alt
[Normal route]
Log "route_selected"
{:ok, dest_smsc, route}
[Auto-reply route]
Create reply message (async)
Log "auto_reply_triggered"
{:ok, nil, route}
[Drop route]
Log "message_dropped"
{:ok, nil, route}
[No matching routes]
Log "no_route_found"
{:error, :no_route_found}
Application
Location Store
Routing Engine
Route Database
Event Logger

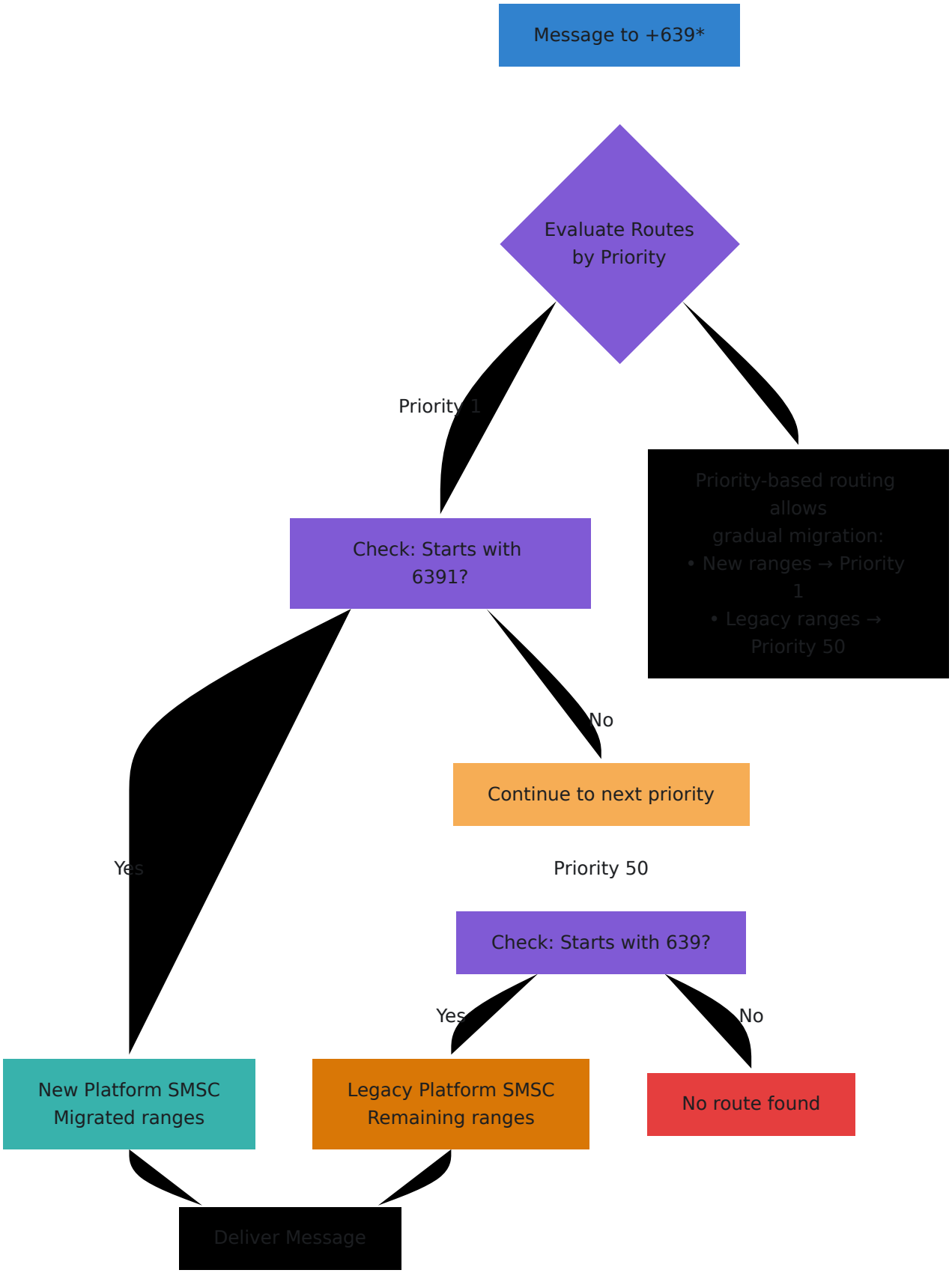
## Protocol-specific Routing

Route based on source connection type:



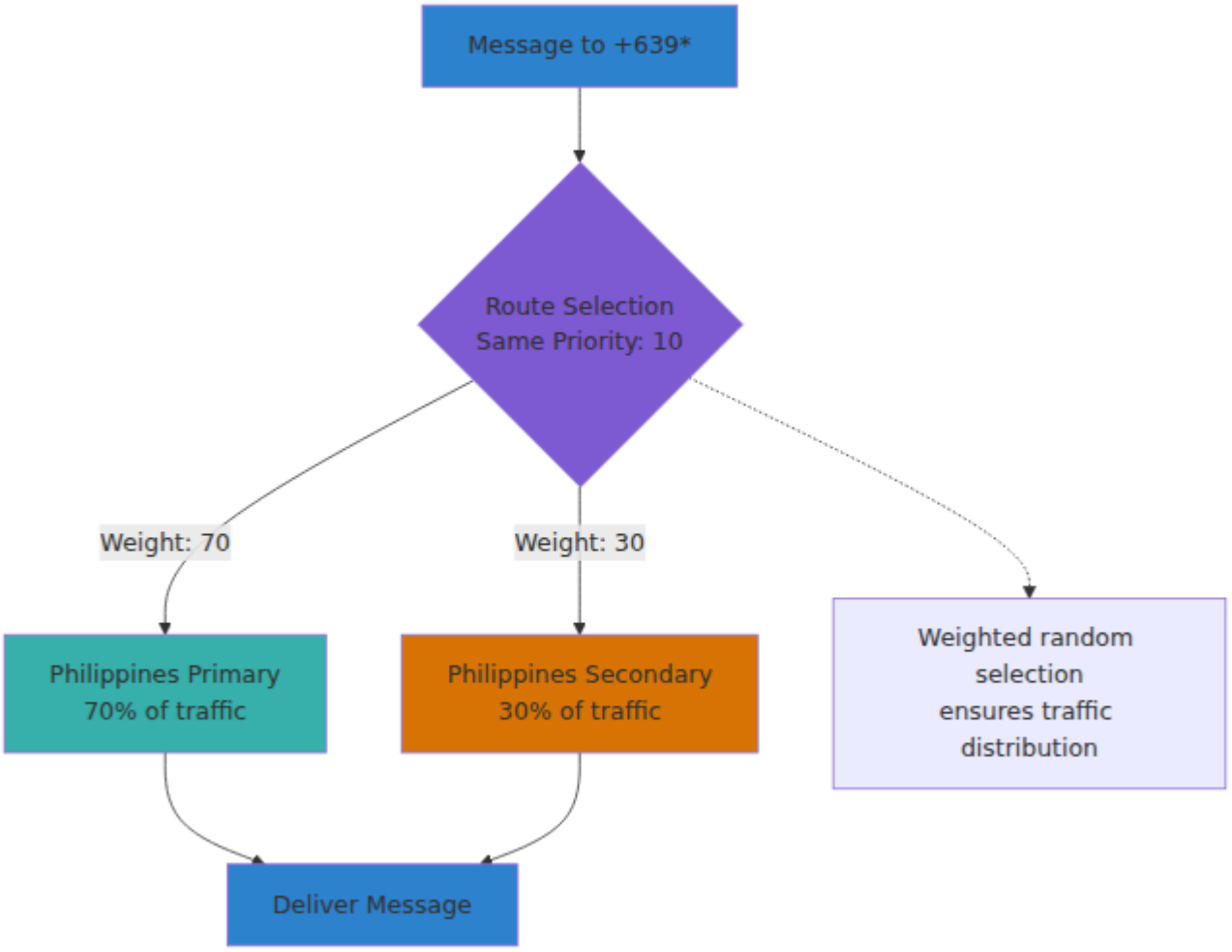

## Network Migration

During migration, route specific prefixes to new infrastructure:




## Complex Multi-criteria Routing

Combine multiple criteria for fine-grained control:




# Web Interface

## Route Management UI

Access the route management interface at `/sms_routing` (configure in your router):

**Features:**

- View all routes in a sortable table
- Add new routes with form validation
- Edit existing routes
- Enable/disable routes without deleting
- Delete routes with confirmation
- Real-time updates (5-second refresh)

**Adding a Route:**

1. Click "Add New Route"
2. Fill in the form fields (only destination SMSC is required)
3. Set weight (1-100, default 100) and priority (1-255, default 100)
4. Check "Enabled" to activate immediately
5. Click "Save Route"

**Editing a Route:**

1. Click "Edit" next to the route
2. Modify fields as needed
3. Click "Save Route"

**Disabling a Route:**

- Click "Disable" to temporarily deactivate without deleting
- Click "Enable" to reactivate

# Routing Simulator

Access the simulator at `/simulator` (via the navigation menu):

**Features:**

- Test routing logic with various parameters
- **Detailed field-by-field evaluation** showing why each route matched or didn't match
- See all routes evaluated in priority order
- Visual indicators for matched/selected routes
- Load example scenarios for quick testing
- View test history (last 10 tests)

**Using the Simulator:**

1. Enter test parameters:
    - Calling number (from)
    - Called number (to)

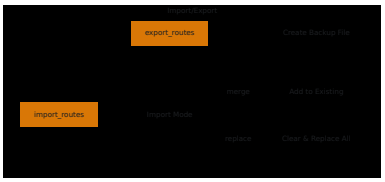
    - Source SMSC (optional)
    - Source type (Any/IMS/Circuit Switched/SMPP)
2. Click "Simulate Routing"
3. View comprehensive results:
    - **Routing Result**: Selected route and destination (or "No Route Found")
    - **Route Evaluation**: All routes with field-by-field analysis:
        - ✓ Green checkmark = Field matched
        - ✗ Red X = Field didn't match
        - Reason for each field's match/non-match
    - **Visual indicators**:
        - Green border + "SELECTED" badge = Route actually used
        - Purple border + "MATCHED" badge = Routes that matched but weren't selected
        - Gray border = Routes that didn't match
4. Load pre-configured examples using the example buttons
5. Review test history to compare different scenarios

**Example Evaluation Output:** For each route, you'll see why it matched or didn't:

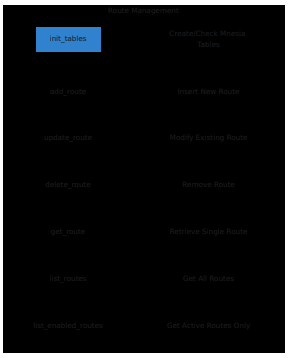
- **Calling prefix**: "Matches prefix '1234'" or "Does not start with '44'"
- **Called prefix**: "Wildcard (matches any)" or "Does not start with '639'"
- **Source SMSC**: "Matches 'smsc1'" or "Expected 'untrusted_smsc', got 'none'"
- **Source type**: "Wildcard (matches any)" or "Expected 'smpp', got 'IMS'"

# API Reference

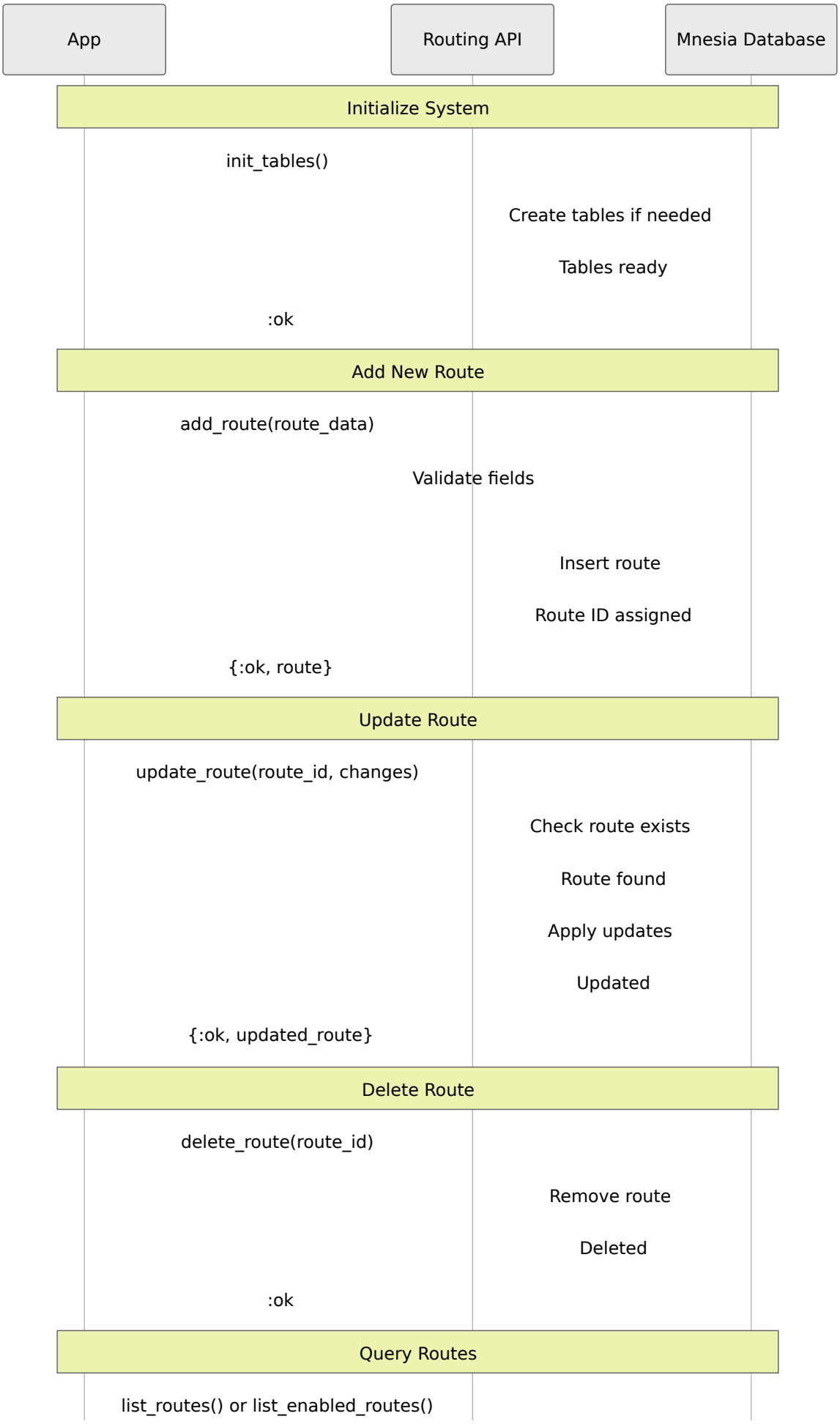
## Core Operations Overview

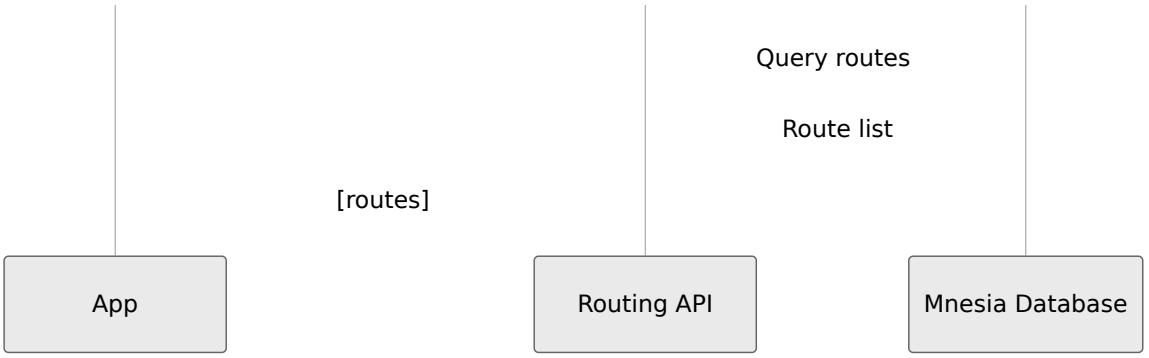






# Route Management Operations


App
Routing API
Mnesia Database
Initialize System
init_tables()
Create tables if needed
Tables ready
:ok
Add New Route
add_route(route_data)
Validate fields
Insert route
Route ID assigned
{:ok, route}
Update Route
update_route(route_id, changes)
Check route exists
Route found
Apply updates
Updated
{:ok, updated_route}
Delete Route
delete_route(route_id)
Remove route
Deleted
:ok
Query Routes
list_routes() or list_enabled_routes()



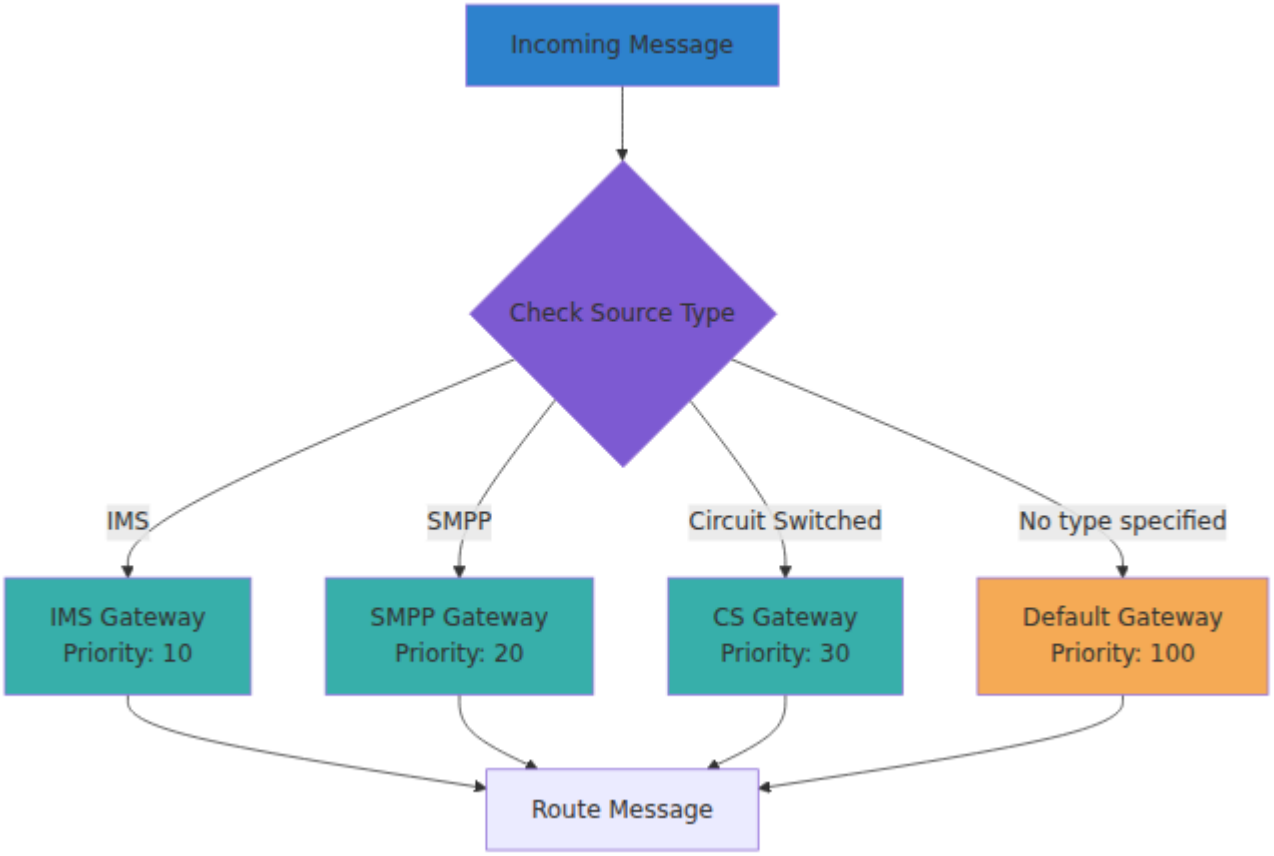

# Message Routing Parameters

**route_message** accepts the following parameters:

- `calling_number` (optional): Originating phone number
- `called_number` (optional): Destination phone number
- `source_smsc` (optional): Source SMSC identifier
- `source_type` (optional): Connection type (`:ims`, `:circuit_switched`, `:smpp`)
- `message_id` (optional): For event logging

**Returns:**

- `{:ok, dest_smsc, route}` - Route found and selected
- `{:error, :no_route_found}` - No matching route




## Import/Export Operations

# Best Practices

## Route Design

1. **Use priorities wisely**: Reserve low priorities (1-10) for critical routes
2. **Keep it simple**: Start with broad routes and add specific ones as needed
3. **Document routes**: Always add descriptions to routes
4. **Use catch-all**: Always have a default route with low priority

## Performance

1. **Minimize route count**: Combine similar routes where possible

2. **Use longest prefixes**: More specific prefixes reduce evaluation time
3. **Disable unused routes**: Don't delete routes you might need later; disable them

## Operations

1. **Test before deploy**: Use the simulator to verify routing logic
2. **Backup regularly**: Export routes before making major changes
3. **Monitor routing**: Check event logs for routing decisions
4. **Gradual rollout**: Use weights to gradually shift traffic to new routes

## Testing

1. **Write integration tests**: Test your specific routing scenarios
2. **Load test**: Verify routing performance under load
3. **Failover testing**: Ensure backup routes work when primaries fail

# Troubleshooting

## No Route Found

**Symptom**: `{:error, :no_route_found}` returned

**Possible causes:**

- No routes configured
- All matching routes are disabled
- Route criteria don't match message parameters
- Prefix doesn't match (check for typos)

**Solutions:**

1. Check that routes exist: `SmsRouting.list_enabled_routes()`
2. Use simulator to test routing with actual message parameters

3. Add a catch-all route for debugging: `add_route(%{dest_smsc: "debug_smsc", priority: 255})`
4. Check event logs for routing evaluation details

## Wrong Route Selected

**Symptom**: Message routed to unexpected destination

**Possible causes:**

- Priority misconfiguration
- Wildcard route has higher priority
- Specificity calculation favors different route
- Multiple routes with same criteria using weights

**Solutions:**

1. Use simulator to see all matching routes
2. Check priority values (lower = higher priority)
3. Verify specificity scores in simulator
4. Review weight distribution for load-balanced routes

## Performance Issues

**Symptom**: Routing is slow

**Possible causes:**

- Too many routes in database
- Complex route patterns
- Mnesia table not properly indexed

**Solutions:**

1. Consolidate similar routes
2. Remove disabled routes that are no longer needed
3. Ensure Mnesia indexes are created (automatic in `init_tables`)

4. Consider caching frequently-used routing decisions

# Advanced Topics

## ENUM/NAPTR Integration

ENUM (E.164 Number Mapping) provides DNS-based number lookup using NAPTR records. The SMS-C includes full ENUM support with caching, configurable DNS servers, and route matching based on ENUM lookup results.

#### What is ENUM?

ENUM maps E.164 phone numbers to DNS names using a simple transformation:

- **Phone Number**: +1-212-555-1234
- **ENUM Query**: 4.3.2.1.5.5.5.2.1.2.1.e164.arpa
- **DNS Record Type**: NAPTR (Naming Authority Pointer)
- **Result**: SIP URI, routing information, or other service data

#### Configuration

ENUM functionality is configured in `config/runtime.exs`:

#### Enable ENUM Lookups:

Set `enum_enabled: true` to enable ENUM lookups before routing. When enabled, the system will perform DNS ENUM lookups for incoming messages and use the results in routing decisions.

#### ENUM Domains:

List the ENUM domains to query in priority order. The system will try each domain until a successful lookup occurs.

Common ENUM domains:

- `e164.arpa` - Official IETF ENUM domain

- `e164.org` - Alternative ENUM registry
- Custom private ENUM domains

**DNS Servers:**

Configure specific DNS servers for ENUM queries. Format: `{ip_address, port}`

Leave empty or set to `[]` to use system default DNS servers.

Example custom DNS configuration:

- Google Public DNS: `{"8.8.8.8", 53}`, `{"8.8.4.4", 53}`
- Cloudflare DNS: `{"1.1.1.1", 53}`, `{"1.0.0.1", 53}`
- Custom ENUM DNS: `{"10.0.0.53", 53}`

**Timeout:**

Set the DNS query timeout in milliseconds (default: 5000ms). Increase for slow networks, decrease for faster failover.

**How ENUM Lookups Work**

Parse error on line 37: ... style Router fill:#3182CE style C ----------^ Expecting 'SOLID_OPEN_ARROW', 'DOTTED_OPEN_ARROW', 'SOLID_ARROW', 'BIDIRECTIONAL_SOLID_ARROW', 'DOTTED_ARROW', 'BIDIRECTIONAL_DOTTED_ARROW', 'SOLID_CROSS', 'DOTTED_CROSS', 'SOLID_POINT', 'DOTTED_POINT', got 'TXT'

Try again

**ENUM Caching**

The system caches ENUM lookup results for 15 minutes to improve performance and reduce DNS load.

**Cache Benefits:**

- Reduces DNS query load
- Improves routing latency

- Protects against DNS server failures (cached results remain available)

**Cache Statistics:**

- View cache size and status in the NAPTR Test page
- Monitor cache hit/miss rates via Prometheus metrics
- Clear cache manually if needed (configuration changes, testing, etc.)

**Cache Behavior:**

- Both successful and failed lookups are cached
- Failed lookups cached to avoid repeated queries for invalid numbers
- Cache automatically expires after 15 minutes
- Cache survives application restarts (stored in ETS)

**Using ENUM in Routes**

Routes can match on ENUM lookup results using the `enum_result_domain` field:

**Example Scenario:**

ENUM lookup for +1-555-0100 returns NAPTR record:

- Service: E2U+sip
- Replacement: sip:customer@voip-carrier.com
- **Result Domain**: voip-carrier.com

**Route Configuration:**

Create a route with `enum_result_domain: "voip-carrier.com"` to match messages where ENUM lookup returned this domain.

**Matching Logic:**

- If route has `enum_result_domain: nil` - matches all messages (wildcard)
- If route has `enum_result_domain: "specific.com"` - only matches if ENUM returned that domain
- Routes with matching ENUM domains receive higher specificity scores

**Priority Calculation:**

Routes with ENUM result domains receive +15 specificity points, prioritizing them over generic routes.

### Testing ENUM Lookups

Access the NAPTR Test page at `/naptr_test` (via navigation menu).

**Features:**

- Perform live ENUM lookups against configured DNS servers
- View detailed NAPTR record information
- See result domains extracted from NAPTR records
- Monitor cache statistics
- Clear cache for testing

**Test Workflow:**

1. Enter a phone number (with or without + prefix)
2. Specify ENUM domain (default: e164.arpa)
3. Click "Perform Lookup"
4. Review results:
    - NAPTR records found
    - Order and preference values
    - Service types (E2U+sip, E2U+tel, etc.)
    - Regular expressions
    - Replacement values
    - **Extracted result domains** (used for route matching)

**Current Configuration Display:**

- DNS servers being used (or "System Default")
- Timeout setting
- Cache size and status
- Clear cache button

**Understanding Results:**

Each NAPTR record contains:

- **Order**: Priority for processing (lower first)
- **Preference**: Within same order (lower first)
- **Flags**: Processing instructions (u=terminal, s=continue)
- **Service**: Service type (E2U+sip, E2U+tel, etc.)
- **Regexp**: Substitution expression
- **Replacement**: Alternative domain or address
- **Result Domain**: Extracted domain for route matching

**Common ENUM Use Cases**

**1. VoIP Peering**

Use ENUM to identify numbers hosted on SIP/VoIP networks and route directly to VoIP gateways:

- ENUM returns SIP URI: sip:number@voip-carrier.com
- Result domain: voip-carrier.com
- Route with `enum_result_domain: "voip-carrier.com"` selected
- Traffic sent to direct VoIP peering gateway

**2. Carrier Identification**

Identify the carrier serving a number and route accordingly:

- ENUM returns carrier information
- Result domain: carrier-a.com
- Route to carrier A's interconnect
- Optimize routing costs and quality

**3. Number Portability**

Handle ported numbers that moved between carriers:

- ENUM lookup returns current carrier
- Route to correct destination automatically
- No manual routing table updates needed

### 4. Least Cost Routing

Combine ENUM with multiple routes:

- ENUM identifies destination network
- Multiple routes for same domain with different costs
- Use priority and weights to prefer lower-cost routes

### 5. Emergency Services

Route emergency numbers (911, 112, etc.) to proper emergency services:

- ENUM lookup identifies local emergency gateway
- High-priority route ensures immediate routing
- No delay from normal route evaluation

**ENUM Routing Strategy**

**Recommended Configuration:**

1. **High Priority ENUM Routes (Priority 1-10)**
    - Routes that match specific ENUM result domains
    - Used for direct peering, VoIP routing
    - Highest specificity, selected first
2. **Medium Priority Prefix Routes (Priority 50-100)**
    - Standard prefix-based routing
    - Used when ENUM lookup fails or returns no records
    - Reliable fallback
3. **Low Priority Catch-All (Priority 200+)**
    - Default route for everything else
    - Ensures no message goes unrouted

**Example Route Hierarchy:**

- Priority 1: `enum_result_domain: "sip.carrier.com"` → Direct VoIP gateway

- Priority 10: `enum_result_domain: "tel.carrier.com"` → Carrier's PSTN gateway
- Priority 50: `called_prefix: "+1"` → North America default gateway
- Priority 100: `called_prefix: "+"` → International default gateway
- Priority 200: No criteria → Ultimate fallback

**Performance Considerations**

**DNS Query Latency:**

ENUM lookups add DNS query time to routing:

- **Cached**: < 1ms (fast)
- **Uncached**: 10-100ms (depends on DNS server)

**Recommendations:**

- Use geographically close DNS servers
- Configure appropriate timeout (5000ms default)
- Monitor cache hit rates (target > 80%)
- Consider warming cache for known numbers

**Scalability:**

The caching system handles high-volume scenarios:

- Cache is shared across all processes
- Read-concurrent ETS table for performance
- Automatic cache cleanup via TTL
- Scales to millions of cached entries

**Failure Handling:**

ENUM failures gracefully fall back to regular routing:

- DNS timeout → Fall through to next route
- No NAPTR records → Use prefix-based routes
- Invalid NAPTR format → Log error, continue routing

- DNS server unavailable → Use cached results or fallback

**Monitoring ENUM Operations**

Use Prometheus metrics to monitor ENUM performance:

- `sms_c_enum_lookup_stop_duration` - Lookup latency
- `sms_c_enum_cache_hit_count` - Cache hits
- `sms_c_enum_cache_miss_count` - Cache misses
- `sms_c_enum_cache_size_size` - Current cache size
- `sms_c_enum_naptr_records_record_count` - NAPTR records per lookup

**Key Metrics to Watch:**

- **Cache hit rate**: Should be > 70% after warm-up
- **Lookup duration p95**: Should be < 1000ms
- **Failed lookups**: Monitor for DNS issues

See `docs/METRICS.md` for complete metrics documentation.

**Troubleshooting ENUM**

**Issue: No NAPTR Records Found**

- Verify ENUM domain configuration
- Test DNS server connectivity
- Check if number is actually in ENUM registry
- Try alternative ENUM domain (e.g., e164.org)
- Use NAPTR Test page to diagnose

**Issue: Slow ENUM Lookups**

- Check DNS server latency
- Verify network connectivity
- Increase timeout if needed
- Consider using closer DNS servers
- Check cache hit rate

**Issue: Wrong Route Selected After ENUM**

- Verify `enum_result_domain` field in routes
- Use Route Simulator to test routing logic
- Check that result domain extraction is correct
- Review NAPTR record format in Test page

**Issue: ENUM Lookups Disabled**

- Verify `enum_enabled: true` in config/runtime.exs
- Check that `enum_domains` list is not empty
- Restart application after config changes
- Check application logs for ENUM initialization

**Security Considerations**

**DNS Cache Poisoning:**

- Use trusted DNS servers only
- Consider DNSSEC if available
- Validate NAPTR record formats
- Monitor for unexpected result domains

**Resource Exhaustion:**

- Cache limits prevent memory exhaustion
- Timeout prevents hanging on slow DNS
- Failed lookups cached to prevent retry storms

**Information Disclosure:**

- ENUM lookups reveal routing intentions to DNS servers
- Use private DNS servers for sensitive routing
- Consider VPN/encrypted DNS for privacy

# Event Logging

Routing decisions are logged via the EventLogger:

- `sms_routing_started`: Routing evaluation begins
- `sms_routing_candidates`: Number of enabled routes found
- `sms_routing_matches`: Number of matching routes
- `sms_routing_selected`: Selected route details
- `sms_routing_failed`: No route found

Enable logging by passing `message_id` to `route_message/1`.

### Clustering

Mnesia tables are automatically distributed across clustered nodes. Routes are replicated for high availability.

Parse error on line 25: ... style New fill:#3182CE style P ----------^
Expecting 'SOLID_OPEN_ARROW', 'DOTTED_OPEN_ARROW', 'SOLID_ARROW', 'BIDIRECTIONAL_SOLID_ARROW', 'DOTTED_ARROW', 'BIDIRECTIONAL_DOTTED_ARROW', 'SOLID_CROSS', 'DOTTED_CROSS', 'SOLID_POINT', 'DOTTED_POINT', got 'TXT'

Try again

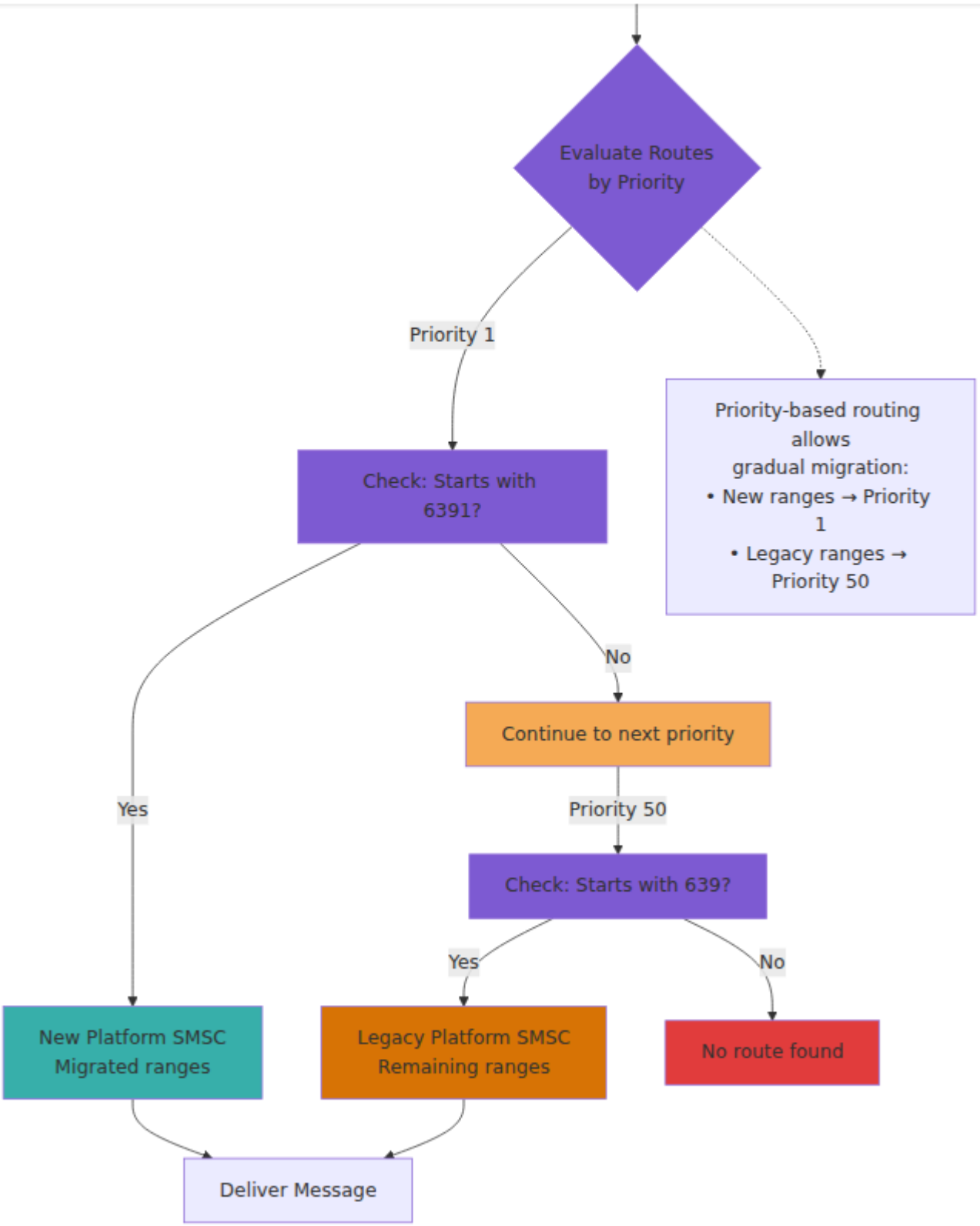
## Examples

See the test suite at `test/sms_c/messaging/sms_routing_test.exs` for comprehensive examples of:

- Prefix matching
- Priority-based routing
- Weight-based load balancing
- Multi-criteria routing
- Edge cases

## Migration from Old Routing

If migrating from the old config-based routing, follow this process:




# Migration Steps Detail

1. **Initialize Tables**

- Creates Mnesia routing tables
- Prepares system for new routing

2. **Analyze Old Routes**
   - **Regex patterns** → Prefix-based routes
   - **Canned responses** → Auto-reply routes
   - **Custom logic** → Multi-criteria routes
3. **Test Thoroughly**
   - Use the routing simulator
   - Verify all scenarios
   - Check edge cases
4. **Update Code**
   - Replace old routing calls
   - Use `route_message/1` API
   - Update error handling
5. **Deploy & Monitor**
   - Deploy new routing system
   - Monitor for issues
   - Keep old config as backup initially
6. **Clean Up**
   - Remove old routing configuration
   - Remove migration code
   - Update documentation

# Support

For issues or questions:

- Check the test suite for examples

- Use the simulator to debug routing logic
- Review event logs for routing decisions
- Check Mnesia table contents: `:mnesia.table_info(:sms_route, :size)`

# SMS-C Troubleshooting Guide

**← Back to Documentation Index** | **Main README**

Comprehensive guide for diagnosing and resolving common SMS-C issues.

## Table of Contents

# Diagnostic Tools

## Quick Health Check

```
# 1. Check API status
curl https://api.example.com:8443/api/status

# 2. Check Prometheus metrics endpoint
curl https://api.example.com:9568/metrics | grep sms_c

# 3. Check application logs
tail -f /var/log/sms_c/application.log

# 4. Check process status
systemctl status sms_c

# 5. Check SQL CDR database connectivity (MySQL/MariaDB)
mysql -u sms_user -p -h db.example.com -e "SELECT 1"

# For PostgreSQL:
# psql -U sms_user -h db.example.com -d sms_c_prod -c "SELECT 1"
```

## Log Analysis

**View Recent Errors**:

```
# Last 100 error-level log entries
tail -1000 /var/log/sms_c/application.log | grep "\[error\]"

# Search for specific error patterns
grep "routing_failed" /var/log/sms_c/application.log

# Find SQL database errors
grep -i "database\|sql\|ecto" /var/log/sms_c/application.log |
grep error
```

**Monitor Logs in Real-Time**:

```
# Follow logs with filter
tail -f /var/log/sms_c/application.log | grep -E "
(error|warning|critical)"
```

# Metric Queries

**Check Message Processing Rate**:

```
# Messages per second
rate(sms_c_message_received_count[5m])

# Delivery success rate
rate(sms_c_delivery_succeeded_count[5m]) /
rate(sms_c_delivery_queued_count[5m])
```

**Check Queue Status**:

```
# Current queue depth
sms_c_queue_size_pending

# Oldest message age (seconds)
sms_c_queue_oldest_message_age_seconds
```

**Check System Performance**:

```
# Message processing latency (p95)
histogram_quantile(0.95,
sms_c_message_processing_stop_duration_bucket)

# Routing latency (p95)
histogram_quantile(0.95, sms_c_routing_stop_duration_bucket)
```

# Message Delivery Issues

## Messages Not Being Delivered

**Symptoms**:

- Messages stuck in "pending" status
- High pending message count
- No delivery notifications

**Diagnostic Steps**:

1. **Check Frontend Connections**:

```
curl https://api.example.com:8443/api/frontends/active
```

Expected: List of active frontends Problem: Empty list or missing expected frontends

2. **Check Message Queue**:

Access Web UI: `/message_queue`

- Filter by status: "pending"
- Check `dest_smsc` value
- Verify `deliver_after` is not in future

3. **Check Routing**:

Access Web UI: `/simulator`

- Test with actual message parameters
- Verify route matches and destination is correct

4. **Check Frontend Polling**:

Review frontend system logs:

- Is frontend querying `/api/messages`?

- Is frontend sending `smsc` header correctly?

**Solutions**:

**No Frontends Connected**:

```
# Check frontend system status
systemctl status frontend_service

# Verify frontend can reach API
curl -k https://api.example.com:8443/api/status

# Manually register frontend
curl -X POST https://api.example.com:8443/api/frontends/register \
  -H "Content-Type: application/json" \
  -d '{
    "frontend_name": "test_gateway",
    "frontend_type": "smpp",
    "ip_address": "10.0.1.50"
  }'
```

**Messages Routed to Wrong SMSC**:

- Review routing configuration
- Check route priorities
- Test in routing simulator
- Verify frontend name matches `dest_smsc` in messages

**Messages Scheduled for Future**:

- Check `deliver_after` timestamp
- Reset if needed:

```
curl -X PATCH https://api.example.com:8443/api/messages/12345 \
  -H "Content-Type: application/json" \
  -d '{"deliver_after": "2025-10-30T12:00:00Z"}'
```

# Messages Failing with Retries

**Symptoms**:

- `delivery_attempts` counter increasing
- Messages with high attempt count ( > 3)
- Exponential backoff delays

**Diagnostic Steps**:

1. **Check Event Log**:

```
curl https://api.example.com:8443/api/events/12345
```

Look for:

- Delivery failure events
- Error descriptions
- Retry timestamps

2. **Check Frontend Logs**:

- Why is frontend failing to deliver?
- Network errors?
- Protocol errors?
- Downstream system unavailable?

**Solutions**:

**Temporary Network Issues**:

- Wait for retry (automatic)
- Monitor for successful delivery

**Persistent Failures**:

```
# Route to alternate gateway
curl -X PATCH https://api.example.com:8443/api/messages/12345 \
  -H "Content-Type: application/json" \
  -d '{"dest_smsc": "backup_gateway"}'

# Reset retry counter
curl -X PATCH https://api.example.com:8443/api/messages/12345 \
  -H "Content-Type: application/json" \
  -d '{"delivery_attempts": 0, "deliver_after": "2025-10-
30T12:00:00Z"}'
```

**Invalid Destination Number**:

- Verify number format
- Check number translation rules
- Delete message if truly invalid

# Dead Letter Messages

**Symptoms**:

- `deadletter: true` in message
- Messages past expiration time
- Status still "pending"

**Diagnostic Steps**:

1. **Find Dead Letter Messages**:

Access Web UI: `/message_queue`

- Filter by expired status
- Check expiration timestamps

2. **Check Why Expired**:

- Review event log
- Check delivery attempt history
- Verify routing was successful

**Solutions**:

**Extend Expiration**:

```
# Add 24 hours to expiration
curl -X PATCH https://api.example.com:8443/api/messages/12345 \
  -H "Content-Type: application/json" \
  -d '{"expires": "2025-10-31T12:00:00Z", "deadletter": false}'
```

# Routing Problems

## No Route Found

**Symptoms**:

- Error: `no_route_found`
- `sms_c_routing_failed_count` metric increasing
- Event log shows "routing_failed"

**Diagnostic Steps**:

1. **Check Routes Exist**:

Access Web UI: `/sms_routing`

- Verify routes are configured
- Check at least one route is enabled

2. **Test Routing**:

Access Web UI: `/simulator`

- Enter message parameters (calling number, called number, source SMSC)
- Review evaluation results
- Check why routes didn't match

3. **Check Route Criteria**:

- Prefix matches required?
- Source SMSC filter too restrictive?
- All routes disabled?

**Solutions**:

**No Routes Configured**:

Add catch-all route:

```
Calling Prefix: (empty)
Called Prefix: (empty)
Source SMSC: (empty)
Dest SMSC: default_gateway
Priority: 255
Weight: 100
Enabled: ✓
Description: Catch-all default route
```

**Routes Too Specific**:

Add broader route:

```
Called Prefix: +
Dest SMSC: international_gateway
Priority: 200
Weight: 100
Enabled: ✓
Description: International catch-all
```

**All Routes Disabled**:

- Enable appropriate routes via Web UI
- Check configuration didn't accidentally disable routes

# Wrong Route Selected

**Symptoms**:

- Messages routed to unexpected destination
- Wrong gateway receiving traffic
- Load balance not distributing as expected

**Diagnostic Steps**:

1. **Use Routing Simulator**:

Access Web UI: `/simulator`

- Test with actual message parameters
- Review "All Matches" section
- Check priority and specificity scores

2. **Check Route Priorities**:

- Lower number = higher priority
- Routes evaluated in priority order
- Within same priority, weights apply

3. **Check Route Specificity**:

Specificity scoring:

- Longer called prefix: +100 points per character
- Longer calling prefix: +50 points per character
- Source SMSC specified: +25 points
- Source type specified: +10 points
- ENUM domain specified: +15 points

**Solutions**:

**Adjust Priorities**:

Make specific route higher priority:

```
Premium Route:
  Called Prefix: +1555
  Priority: 10 (high priority)

General Route:
  Called Prefix: +1
  Priority: 50 (lower priority)
```

**Adjust Weights**:

Change load balance distribution:

```
Primary (70%):
  Weight: 70

Backup (30%):
  Weight: 30
```

**Add More Specific Route**:

Override general route for specific case:

```
Specific Route:
  Called Prefix: +15551234
  Dest SMSC: dedicated_gateway
  Priority: 1

General Route:
  Called Prefix: +1
  Dest SMSC: general_gateway
  Priority: 50
```

# Auto-Reply Not Working

**Symptoms**:

- Auto-reply route configured but not triggering
- No reply messages being sent

- Event log missing auto-reply event

**Diagnostic Steps**:

1. **Check Route Configuration**:

- `auto_reply: true`
- `auto_reply_message` contains text
- Route is enabled
- Route matches message criteria

2. **Test in Simulator**:

- Verify route is selected
- Check for "auto_reply" indication

3. **Check Event Log**:

```
curl https://api.example.com:8443/api/events/12345 | grep
auto_reply
```

**Solutions**:

**Route Not Matching**:

- Broaden criteria (remove filters)
- Check priority (should be higher than normal routes)
- Verify enabled status

**Message Not Set**:

Edit route, add message:

```
Auto-Reply: ✓
Auto-Reply Message: "Thank you for your message. We will respond
soon."
```

**Wrong Priority**:

Auto-reply routes should have high priority (low number):

```
Auto-Reply Route:
  Priority: 10

Normal Route:
  Priority: 50
```

# Performance Issues

## High Message Processing Latency

**Symptoms**:

- `sms_c_message_processing_stop_duration` p95 > 1000ms
- Slow API responses
- Queue building up

**Diagnostic Steps**:

1. **Check Component Latencies**:

```
# Routing latency
histogram_quantile(0.95, sms_c_routing_stop_duration_bucket)

# ENUM lookup latency
histogram_quantile(0.95, sms_c_enum_lookup_stop_duration_bucket)

# Charging latency
histogram_quantile(0.95, sms_c_charging_succeeded_duration_bucket)

# Delivery latency
histogram_quantile(0.95, sms_c_delivery_succeeded_duration_bucket)
```

2. **Check System Resources**:

```
# CPU usage
top -b -n 1 | grep sms_c

# Memory usage
ps aux | grep beam.smp


**Solutions**:

**Routing Slow** (Many routes):
- Reduce number of enabled routes
- Combine similar routes
- Optimize route criteria

**ENUM Lookups Slow**:
- Check DNS server latency
- Increase timeout
- Use faster/closer DNS servers
- Disable ENUM if not needed

**Charging Slow**:
- Check OCS performance
- Increase OCS timeout
- Disable charging if not needed
- Use async charging

**Database Slow**:
- Increase connection pool size
- Add indexes
- Optimize queries
- Upgrade database resources

**Configuration Changes**:

```elixir
# config/config.exs
# Increase batch size for throughput
config :sms_c,
  batch_insert_batch_size: 200,
  batch_insert_flush_interval_ms: 200

# Increase database pool
```
```

```
config :sms_c, SmsC.Repo,
  pool_size: 50
```

## Low Message Throughput

**Symptoms**:

- Processing < 100 msg/sec
- Using async API but still slow
- High API response times

**Diagnostic Steps**:

1. **Check Batch Worker**:

```
# In production console (iex)
SmsC.Messaging.BatchInsertWorker.stats()
```

Look for:

- `current_queue_size` near max
- `flush_errors` > 0
- `last_flush_duration_ms` very high

2. **Check Bottlenecks**:

```
# Database query time
ecto_pools_query_time

# Connection pool queue time
ecto_pools_queue_time
```

**Solutions**:

**Database Bottleneck**:

Increase pool size:

```
config :sms_c, SmsC.Repo,
  pool_size: 50  # Increase from 20
```

**Batch Configuration**:

Tune for throughput:

```
config :sms_c,
  batch_insert_batch_size: 200,  # Larger batches
  batch_insert_flush_interval_ms: 200  # Longer interval
```

**Use Async Endpoint**:

```
# High throughput: use /create_async
curl -X POST
https://api.example.com:8443/api/messages/create_async

# NOT: /api/messages (synchronous)
```

# Queue Backlog Growing

**Symptoms**:

- `sms_c_queue_size_pending` increasing
- Oldest message age increasing
- Processing can't keep up with incoming rate

**Diagnostic Steps**:

1. **Check Incoming vs Delivery Rate**:

```
# Incoming rate
rate(sms_c_message_received_count[5m])

# Delivery rate
rate(sms_c_delivery_succeeded_count[5m])
```

2. **Check Frontend Capacity**:

- Are frontends polling frequently enough?
- Are frontends processing messages fast enough?
- Any frontend errors?

3. **Check Delivery Success Rate**:

```
rate(sms_c_delivery_succeeded_count[5m]) /
rate(sms_c_delivery_attempted_count[5m])
```

**Solutions**:

**Frontends Not Polling**:

- Check frontend connectivity
- Verify polling interval (should be 5-10 seconds)
- Restart frontend services

**Frontends Too Slow**:

- Add more frontend instances
- Optimize frontend processing
- Increase frontend concurrency

**High Retry Rate**:

- Investigate delivery failures
- Fix downstream issues
- Route to alternate gateways

**Temporary Spike**:

- Wait for queue to drain
- Monitor until normal
- Consider capacity upgrades if recurring

# Database Problems

## Connection Failures

**Symptoms**:

- Error: "unable to connect to database"
- API returning 500 errors
- Application won't start

**Diagnostic Steps**:

1. **Check SQL CDR Database Status**:

```
# MySQL/MariaDB
systemctl status mysql

# PostgreSQL
systemctl status postgresql

# Test connectivity (MySQL/MariaDB)
mysql -u sms_user -p -h db.example.com -e "SELECT 1"

# Test connectivity (PostgreSQL)
psql -U sms_user -h db.example.com -d sms_c_prod -c "SELECT 1"
```

2. **Check Network**:

```
# Ping database host
ping db.example.com

# Check port connectivity (MySQL/MariaDB: 3306, PostgreSQL: 5432)
telnet db.example.com 3306
# or
telnet db.example.com 5432
```

3. **Check Credentials**:

```
# Verify environment variables
echo $DB_USERNAME
echo $DB_HOSTNAME
echo $DB_PORT

# Try manual connection with same credentials (MySQL/MariaDB)
mysql -u $DB_USERNAME -p$DB_PASSWORD -h $DB_HOSTNAME

# For PostgreSQL:
# psql -U $DB_USERNAME -h $DB_HOSTNAME -d sms_c_prod
```

**Solutions**:

**Database Down**:

```
# Start database (MySQL/MariaDB)
systemctl start mysql

# Start database (PostgreSQL)
systemctl start postgresql
```

**Wrong Credentials**:

Update configuration:

```
export DB_USERNAME=correct_user
export DB_PASSWORD=correct_password

# Restart application
systemctl restart sms_c
```

**Network Issue**:

- Check firewall rules
- Verify security groups (cloud)
- Check VPN/network connectivity

**Connection Pool Exhausted**:

Increase pool size:

```
config :sms_c, SmsC.Repo,
  pool_size: 50  # Increase from current value
```

## Slow Queries

**Symptoms**:

- Database query time high
- API responses slow
- Connection pool queue building up

**Diagnostic Steps**:

1. **Check Slow Query Log**:

```
-- MySQL/MariaDB: Enable slow query log
SET GLOBAL slow_query_log = 'ON';
SET GLOBAL long_query_time = 1;  -- Log queries > 1 second

-- View slow queries (MySQL/MariaDB)
SELECT * FROM mysql.slow_log ORDER BY query_time DESC LIMIT 10;

-- PostgreSQL: Enable slow query log in postgresql.conf
-- log_min_duration_statement = 1000  # milliseconds
-- Then check PostgreSQL logs
```

2. **Check Missing Indexes**:

```
-- Check table indexes
SHOW INDEX FROM message_queues;

-- Expected indexes:
-- - source_smsc
-- - dest_smsc
-- - send_time
-- - inserted_at
```

3. **Check Table Stats**:

```
-- Table sizes (MySQL/MariaDB)
SELECT
  table_name,
  table_rows,
  ROUND(data_length / 1024 / 1024, 2) AS data_mb,
  ROUND(index_length / 1024 / 1024, 2) AS index_mb
FROM information_schema.tables
WHERE table_schema = 'sms_c_prod';

-- Table sizes (PostgreSQL)
-- SELECT schemaname, tablename,
--
pg_size_pretty(pg_total_relation_size(schemaname||'.'||tablename))
AS size
-- FROM pg_tables WHERE schemaname = 'public';
```

**Solutions**:

**Missing Indexes**:

```
CREATE INDEX idx_message_queues_source_smsc ON
message_queues(source_smsc);
CREATE INDEX idx_message_queues_dest_smsc ON
message_queues(dest_smsc);
CREATE INDEX idx_message_queues_send_time ON
message_queues(send_time);
CREATE INDEX idx_message_queues_status ON message_queues(status);
```

**Table Fragmentation**:

```
-- MySQL/MariaDB
OPTIMIZE TABLE message_queues;
OPTIMIZE TABLE frontend_registrations;

-- PostgreSQL
-- VACUUM ANALYZE message_queues;
-- VACUUM ANALYZE frontend_registrations;
```

**Too Much Data**:

Clean up old records:

```
-- Delete delivered messages older than 30 days
DELETE FROM message_queues
WHERE status = 'delivered'
AND deliver_time < DATE_SUB(NOW(), INTERVAL 30 DAY)
LIMIT 10000;
```

## Disk Space Full

**Symptoms**:

- Error: "Disk full"
- Cannot write to database
- Application crashes

**Diagnostic Steps**:

1. **Check Disk Usage**:

```
df -h

# Check SQL database directory (MySQL/MariaDB)
du -sh /var/lib/mysql

# Check SQL database directory (PostgreSQL)
du -sh /var/lib/postgresql
```

2. **Find Large Files**:

```
# Find largest files (MySQL/MariaDB)
find /var/lib/mysql -type f -exec du -h &amp;#123;&amp;#125; + | sort -rh
| head -20

# Find largest files (PostgreSQL)
find /var/lib/postgresql -type f -exec du -h &amp;#123;&amp;#125; + | sort
-rh | head -20

# Check log files
du -sh /var/log/sms_c/*
```

**Solutions**:

**Clean Old Data**:

```
-- Delete old messages
DELETE FROM message_queues
WHERE inserted_at < DATE_SUB(NOW(), INTERVAL 90 DAY)
LIMIT 100000;
```

**Rotate Logs**:

```
# Force logrotate
logrotate -f /etc/logrotate.d/sms_c

# Clear old log files
find /var/log/sms_c -name "*.log.*" -mtime +30 -delete
```

**Expand Disk**:

- Resize volume (cloud)
- Add new disk and extend volume
- Move data to larger disk

# Frontend Connection Issues

## Frontend Not Showing as Active

**Symptoms**:

- Frontend status shows "expired"
- Frontend not in active list
- Messages not being delivered to frontend

**Diagnostic Steps**:

1. **Check Registration**:

```
curl https://api.example.com:8443/api/frontends/active | grep
frontend_name
```

2. **Check Frontend Logs**:

- Is frontend calling `/api/frontends/register`?
- Any API errors?
- Registration frequency (should be every 60s)

3. **Check API Logs**:

```
grep "frontend.*register" /var/log/sms_c/application.log | tail
-20
```

**Solutions**:

**Frontend Not Registering**:

Test manual registration:

```
curl -X POST https://api.example.com:8443/api/frontends/register \
  -H "Content-Type: application/json" \
  -d '&amp;#123;
    "frontend_name": "uk_gateway",
    "frontend_type": "smpp",
    "ip_address": "10.0.1.50"
  &amp;#125;'
```

If successful, problem is in frontend code/configuration.

**Registration Timing Out**:

Frontends expire after 90 seconds. Ensure registration every 60 seconds:

```
# Frontend should call register every 60 seconds
while True:
    register_with_smsc()
    time.sleep(60)
```

**Network Issues**:

- Check firewall between frontend and API
- Verify DNS resolution
- Test with curl from frontend server

## Frontend Repeatedly Connecting/Disconnecting

**Symptoms**:

- Frontend status flipping between active/expired
- High registration count in history
- Unstable connection

**Diagnostic Steps**:

1. **Check Frontend Health**:

- Is frontend process stable?
- Any crashes or restarts?
- Resource issues (CPU/memory)?

2. **Check Network Stability**:

```
# Check packet loss
ping -c 100 api.example.com

# Check connection resets
netstat -s | grep -i reset
```

3. **Check Registration Timing**:

- Too frequent? (every few seconds)
- Too infrequent? ( > 90 seconds)

**Solutions**:

**Frontend Unstable**:

- Fix frontend application issues
- Increase frontend resources
- Check frontend logs for errors

**Network Issues**:

- Check for intermittent connectivity
- Review firewall logs
- Check load balancer health checks

**Wrong Registration Interval**:

Correct interval:

```
REGISTRATION_INTERVAL = 60  # seconds
```

# Charging/Billing Issues

## Charging Failures

**Symptoms**:

- `sms_c_charging_failed_count` increasing
- Event log shows "charging_failed"
- Messages marked as `charge_failed: true`

**Diagnostic Steps**:

1. **Check OCS Connectivity**:

```
# Test OCS API
curl -X POST http://ocs.example.com:2080/jsonrpc \
  -H "Content-Type: application/json" \
  -d '&amp;#123;
    "method": "SessionSv1.Ping",
    "params": [],
    "id": 1
  &amp;#125;'
```

Expected: `{"result":"Pong"}`

2. **Check OCS Logs**:

```
tail -f /var/log/ocs/ocs.log
```

3. **Check Configuration**:

```
# Verify OCS URL
grep ocs_url config/runtime.exs
```

**Solutions**:

**OCS Unavailable**:

```
# Check OCS status
systemctl status ocs

# Start if needed
systemctl start ocs
```

**Configuration Error**:

Update configuration:

```
config :sms_c,
  ocs_url: "http://correct-host:2080/jsonrpc",
  ocs_tenant: "correct_tenant"
```

**Disable Charging Temporarily**:

```
config :sms_c,
  default_charging_enabled: false
```

Restart application.

**Account Issues**:

- Check account exists in OCS
- Verify account has balance
- Check rating plans are configured

# Charging Too Slow

**Symptoms**:

- `sms_c_charging_succeeded_duration` p95 > 500ms
- Message processing slow when charging enabled
- Fast when charging disabled

**Diagnostic Steps**:

1. **Check Charging Latency**:

```
histogram_quantile(0.95, sms_c_charging_succeeded_duration_bucket)
```

2. **Check OCS Performance**:

```
# OCS response time
curl -w "%&#123;time_total&#125;\n" -X POST
http://ocs.example.com:2080/jsonrpc \
  -H "Content-Type: application/json" \
  -d '&#123;"method":"SessionSv1.Ping","params":[],"id":1&#125;'
```

3. **Check Network Latency**:

```
# Ping OCS host
ping -c 10 ocs.example.com
```

**Solutions**:

**OCS Slow**:

- Optimize OCS configuration
- Add OCS resources
- Use faster rating engine

**Network Latency**:

- Deploy OCS closer to SMS-C
- Use direct network path
- Avoid VPN/tunnels if possible

**Timeout Too Low**:

Increase timeout:

```
config :sms_c,
  ocs_timeout: 5000  # 5 seconds
```

# ENUM Lookup Problems

## ENUM Lookups Failing

**Symptoms**:

- `sms_c_enum_lookup_stop_duration` showing failures
- Event log shows ENUM errors
- Routes with `enum_result_domain` not matching

**Diagnostic Steps**:

1. **Check ENUM Configuration**:

```
grep -A 10 "enum_" config/runtime.exs
```

2. **Test DNS Connectivity**:

```
# Test DNS server
dig @8.8.8.8 e164.arpa

# Test ENUM query
# For +15551234567:
dig @8.8.8.8 NAPTR 7.6.5.4.3.2.1.5.5.5.1.e164.arpa
```

3. **Check DNS Server**:

```
# Is custom DNS reachable?
ping 10.0.1.53

# Test port
nc -zv 10.0.1.53 53
```

**Solutions**:

**DNS Server Unreachable**:

Use alternate DNS:

```
config :sms_c,
  enum_dns_servers: [
    &#123;"8.8.8.8", 53&#125;,  # Google Public DNS
    &#123;"1.1.1.1", 53&#125;   # Cloudflare DNS
  ]
```

**ENUM Domain Wrong**:

Update domain:

```
config :sms_c,
  enum_domains: ["e164.arpa"]  # Use standard domain
```

**Timeout Too Short**:

Increase timeout:

```
config :sms_c,
  enum_timeout: 10000  # 10 seconds
```

**Disable ENUM** (if not needed):

```
config :sms_c,
  enum_enabled: false
```

# ENUM Cache Issues

**Symptoms**:

- Low cache hit rate (< 70%)
- Cache size growing unbounded
- Memory usage high

**Diagnostic Steps**:

1. **Check Cache Stats**:

```
# Cache hit rate
rate(sms_c_enum_cache_hit_count[5m]) /
(rate(sms_c_enum_cache_hit_count[5m]) +
rate(sms_c_enum_cache_miss_count[5m]))

# Cache size
sms_c_enum_cache_size_size
```

2. **Check Traffic Pattern**:

- Are numbers repeating?
- Cache TTL appropriate?

**Solutions**:

**Low Hit Rate** (Expected):

- Traffic to unique numbers (normal)
- Monitor but don't alarm if < 70%

**Cache Growing**:

Clear cache via NAPTR Test page or restart application.

**High Memory Usage**:

- Expected with large cache
- Monitor overall system memory
- Consider TTL adjustment

# Cluster Issues

## Node Can't Join Cluster

**Symptoms**:

- Single node running
- Cluster queries returning only local results
- Erlang distribution errors

**Diagnostic Steps**:

1. **Check Node Names**:

```
# In IEx console
Node.self()
# Expected: :sms@node1.example.com

Node.list()
# Expected: List of other nodes
```

2. **Check Erlang Cookie**:

```
# Check cookie file
cat ~/.erlang.cookie

# Verify same on all nodes
```

3. **Check Network**:

```
# Can nodes reach each other?
ping node2.example.com

# Check ports
nc -zv node2.example.com 4369
nc -zv node2.example.com 9100-9200
```

**Solutions**:

**Cookie Mismatch**:

Set same cookie on all nodes:

```
export ERLANG_COOKIE=same_secret_value_here

# Or update ~/.erlang.cookie
echo "same_secret_value_here" > ~/.erlang.cookie
chmod 400 ~/.erlang.cookie
```

**Firewall Blocking**:

Open required ports:

```
# EPMD
iptables -A INPUT -p tcp --dport 4369 -j ACCEPT

# Erlang distribution
iptables -A INPUT -p tcp --dport 9100:9200 -j ACCEPT
```

**DNS Issues**:

Use IP addresses instead of hostnames:

```
config :sms_c,
  cluster_nodes: [
    :"sms@10.0.1.10",
    :"sms@10.0.1.11"
  ]
```

# Cluster Split Brain

**Symptoms**:

- Nodes running but disconnected
- Different data on different nodes
- Mnesia inconsistencies

**Diagnostic Steps**:

1. **Check Node Connectivity**:

```
# On each node (IEx)
Node.list()
```

2. **Check Mnesia**:

```
:mnesia.system_info(:running_db_nodes)
```

**Solutions**:

**Reconnect Nodes**:

```
# Stop all nodes
systemctl stop sms_c

# Start one node first
systemctl start sms_c  # On node1

# Wait for it to fully start, then start others
systemctl start sms_c  # On node2
systemctl start sms_c  # On node3
```

**Mnesia Inconsistency**:

- Export routes from correct node
- Stop all nodes
- Delete Mnesia directory
- Start nodes
- Import routes

# API Problems

## API Not Responding

**Symptoms**:

- Connection timeout

- Connection refused
- No response

**Diagnostic Steps**:

1. **Check API Process**:

```
# Is application running?
systemctl status sms_c

# Check listening ports
netstat -tlnp | grep 8443
```

2. **Check Firewall**:

```
# Check iptables
iptables -L -n | grep 8443

# Test local connectivity
curl -k https://localhost:8443/api/status
```

3. **Check TLS Configuration**:

```
# Check certificate exists
ls -l priv/cert/server.crt priv/cert/server.key

# Check certificate validity
openssl x509 -in priv/cert/server.crt -noout -dates
```

**Solutions**:

**Application Not Running**:

```
systemctl start sms_c
```

**Firewall Blocking**:

```
# Allow API port
iptables -A INPUT -p tcp --dport 8443 -j ACCEPT
```

**Certificate Issues**:

Generate new certificate (see Configuration Guide).

**Wrong Port**:

Check configuration:

```
grep "port:" config/runtime.exs
```

# API Returning 500 Errors

**Symptoms**:

- Internal Server Error
- 500 status code
- Error in logs

**Diagnostic Steps**:

1. **Check Application Logs**:

```
tail -100 /var/log/sms_c/application.log | grep "\[error\]"
```

2. **Check Database**:

```
mysql -u sms_user -p -e "SELECT 1"
```

3. **Check Resources**:

```
# Memory
free -h

# CPU
top -b -n 1

# Disk
df -h
```

**Solutions**:

**Database Unavailable**:

- Start database
- Fix connection configuration

**Out of Memory**:

- Restart application
- Increase system memory
- Check for memory leaks

**Application Error**:

- Check specific error in logs
- Fix configuration issue
- Restart application

# Web UI Issues

## Can't Access Web UI

**Symptoms**:

- Connection timeout
- 404 Not Found
- Page won't load

**Diagnostic Steps**:

1. **Check Application Status**:

```
systemctl status sms_c
```

2. **Check Port**:

```
netstat -tlnp | grep 80
```

3. **Check URL**:

- Correct hostname?
- Correct port?
- HTTP vs HTTPS?

**Solutions**:

**Wrong Port**:

Check configuration:

```
grep "control_panel" config/runtime.exs
```

Access on correct port (default: 80 or 4000).

**Application Not Running**:

```
systemctl start sms_c
```

**Firewall**:

```
iptables -A INPUT -p tcp --dport 80 -j ACCEPT
```

# LiveView Not Updating

**Symptoms**:

- Page loads but doesn't update
- Data is stale
- WebSocket errors in browser console

**Diagnostic Steps**:

1. **Check Browser Console**:

- Open Developer Tools (F12)
- Look for WebSocket errors
- Check network tab for failed requests

2. **Check Proxy Configuration**:

If using reverse proxy, ensure WebSocket support:

```
location /live &amp;#123;
    proxy_http_version 1.1;
    proxy_set_header Upgrade $http_upgrade;
    proxy_set_header Connection "upgrade";
&amp;#125;
```

**Solutions**:

**WebSocket Blocked**:

- Configure proxy for WebSocket
- Check firewall
- Check browser extensions

**Refresh Page**:

- Hard refresh (Ctrl+F5)
- Clear browser cache

# System Resource Issues

## High CPU Usage

**Symptoms**:

- CPU consistently > 80%
- System slow
- Application unresponsive

**Diagnostic Steps**:

1. **Check Process**:

```
top -b -n 1 | grep beam.smp
```

2. **Check Metrics**:

```
# Message processing rate
rate(sms_c_message_received_count[5m])

# Routing operations
rate(sms_c_routing_route_matched_count[5m])
```

**Solutions**:

**High Traffic**:

- Scale horizontally (add nodes)
- Scale vertically (add CPU)

**Inefficient Routing**:

- Reduce number of routes
- Optimize route criteria

**Too Many ENUM Lookups**:

- Check cache hit rate
- Consider disabling if not needed

## High Memory Usage

**Symptoms**:

- Memory usage > 90%
- Application crashes
- Out of memory errors

**Diagnostic Steps**:

1. **Check Memory**:

```
free -h

ps aux | grep beam.smp
```

2. **Check Cache Sizes**:

```
sms_c_enum_cache_size_size
```

**Solutions**:

**ENUM Cache Too Large**:

- Clear cache
- Reduce TTL
- Disable ENUM if not needed

**Batch Queue Growing**:

```
# Check worker stats (IEx)
SmsC.Messaging.BatchInsertWorker.stats()
```

If queue is large, flush manually or restart.

**Add Memory**:

- Scale vertically
- Add swap (temporary)

**Memory Leak**:

- Restart application
- Report issue for investigation

---

For additional assistance, consult:

- Operations Guide - Daily procedures
- Configuration Guide - Configuration options
- Metrics Guide - Monitoring setup
- Application logs - `/var/log/sms_c/application.log`