MSIL MCP Server - Complete Architecture & Data Storage Guide

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Overview

The MSIL MCP Server implements a **Model Context Protocol** (MCP) with enterprise-grade security for Maruti Suzuki India Limited's service booking platform.

Key Architecture Components:

- **Zero-Code Tool Generation** from OpenAPI specs
- **Multi-Layered Security** (Authentication → Authorization → Rate Limiting)
- **Risk-Based Access Control** (Read/Write/Privileged tools)
- **Real-Time Metrics & Audit Logging**
- **Idempotent Write Operations**
- **Dual API Gateway Support** (Mock API + MSIL APIM)

Admin API Addition Workflow

Stage 1: OpenAPI Spec Upload

Entry Point: Admin UI → "Import OpenAPI" page
Endpoint: `POST /api/openapi-import/upload`

Request:

```
{
  "file": "<openapi_spec_yaml>",
  "category": "imported",
  "bundle_name": "customer_service_v1"
}
```

Files Involved:

- **Frontend**: `admin-ui/src/pages/Import.tsx`
- **Backend**: `mcp-server/app/api/openapi_import.py` (lines 69-120)
- **Parser**: `mcp-server/app/core/openapi/parser.py`

Processing:

1. File is saved temporarily
2. OpenAPI YAML is parsed
3. All endpoints are extracted
4. For each endpoint, a **Tool object** is created with:
    - `name`: Auto-generated from endpoint path
    - `display_name`: Formatted for UI
    - `description`: From OpenAPI spec
    - `api_endpoint`: Full path
    - `http_method`: GET/POST/PUT/DELETE/PATCH
    - `input_schema`: From parameters + request body
    - `output_schema`: From response schema
    - `risk_level`: Auto-detected (read/write/privileged)

Example Tool Generation:

```
# Input (OpenAPI):
openapi: 3.0.0
paths:
  /api/customer/resolve:
    post:
      summary: Resolve Customer
      parameters:
        - name: mobile
          required: true
          schema:
            type: string
      responses:
        200:
          schema:
            type: object
            properties:
              customer_id: string
              name: string

# Output (Generated Tool):
Tool(
  id=uuid4(),
  name="resolve_customer",
  display_name="Resolve Customer",
  description="Resolve Customer",
  api_endpoint="/api/customer/resolve",
  http_method="POST",
  input_schema={
    "type": "object",
    "properties": {
      "mobile": {"type": "string"}
    },
    "required": ["mobile"]
  },
  output_schema={
    "type": "object",
    "properties": {
      "customer_id": {"type": "string"},
      "name": {"type": "string"}
    }
  },
  risk_level="read",
  rate_limit_tier="standard"
)
```

Stage 2: Tool Preview & Selection

Display: Admin UI → "Import Preview" page
Storage: In-memory cache (temporary)
File: `mcp-server/app/api/openapi_import.py` (lines 212-260)

Data Cached in Memory:

```
_specs_cache: Dict[str, Dict[str, Any]] = {
  "spec_abc123": {
    "name": "customer_service_api",
    "version": "1.0.0",
    "uploaded_at": "2026-01-31T10:30:45Z",
    "tools": [
      {ToolPreview object},
      {ToolPreview object},
      ...
    ],
    "status": "preview"
  }
}
```

Admin Actions:

- ✅ View all generated tools with metadata
- ✅ Select/deselect tools to register
- ✅ Modify tool properties (name, category, risk level)
- ✅ Click "Register Selected Tools"

Stage 3: Approval & Registration

Endpoint: `POST /api/openapi-import/approve-tools`

Request:

```
{
  "spec_id": "spec_abc123",
  "tool_ids": ["resolve_customer", "resolve_vehicle",
"get_nearby_dealers"],
  "category": "service_booking"
}
```

Processing:

1. Load selected tools from temporary cache
2. **Validate** each tool against schema
3. **Persist to Database** (PostgreSQL `tools` table)
4. **Reload tool registry** (in-memory cache invalidation)
5. Return confirmation

Database Insertion:

```sql
-- mcp-server/app/db/database.py
INSERT INTO tools (
  id, name, display_name, description, category,
  api_endpoint, http_method, input_schema, output_schema,
  risk_level, rate_limit_tier, is_active, created_at, updated_at
) VALUES (
  'uuid123', 'resolve_customer', 'Resolve Customer', 'Get customer
details...',
  'service_booking', '/api/customer/resolve', 'POST',
  '{"type": "object", "properties": {...}}',
  '{"type": "object", "properties": {...}}',
  'read', 'standard', true, NOW(), NOW()
)
```

Security Layers: Authentication, Authorization & Rate Limiting

Layer 1: Authentication (JWT Token Validation)

File: `mcp-server/app/core/auth/oauth2_provider.py`

When Client Calls MCP:

```
POST /api/mcp
Headers:
  Authorization: Bearer eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9...
  X-API-Key: msil-mcp-dev-key-2026
  X-Correlation-ID: req-12345
```

Authentication Handler:

```python
# Line 95-120: get_current_user()
async def get_current_user(
    credentials: HTTPAuthorizationCredentials = Depends(security)
) -> UserInfo:
    """
    Extract and validate JWT token
    Returns: UserInfo with user_id, email, roles
    """
    token = credentials.credentials  # Bearer token
    payload = jwt_handler.decode_token(token)  # Validate signature

    # Extracted from JWT claims:
    user_info = UserInfo(
        user_id=payload["user_id"],
        email=payload["email"],
        name=payload["name"],
        roles=payload["roles"],  # ["developer", "operator"]
        is_active=payload["is_active"]
    )
    return user_info
```

JWT Token Structure:

```
# Encoded JWT contains:
{
  "header": {
    "alg": "HS256",
    "typ": "JWT"
  },
  "payload": {
    "user_id": "usr_dev_001",
    "email": "developer@msil.com",
    "name": "MSIL Developer",
    "roles": ["developer", "operator"],
    "is_active": true,
    "exp": 1737986400,  # Expires in 60 minutes
    "iat": 1737982800
  },
  "signature": "HMACSHA256(header + payload, JWT_SECRET)"
}
```

JWT Configuration (`app/config.py`):

```python
JWT_SECRET: str = "msil-mcp-jwt-secret-key-change-in-production-2026"
JWT_ALGORITHM: str = "HS256"
JWT_ACCESS_TOKEN_EXPIRE_MINUTES: int = 60
JWT_REFRESH_TOKEN_EXPIRE_DAYS: int = 7
```

Demo Mode (MVP):

```python
# If DEMO_MODE=True, hardcoded users bypass actual JWT validation:
self.users = {
    "admin@msil.com": {
        "user_id": "usr_admin_001",
        "password_hash": "admin123",
        "roles": ["admin", "developer", "operator"]
    },
    "developer@msil.com": {
        "user_id": "usr_dev_001",
        "password_hash": "dev123",
        "roles": ["developer", "operator"]
    },
    "operator@msil.com": {
        "user_id": "usr_op_001",
        "password_hash": "op123",
        "roles": ["operator"]
    }
}
```

Layer 2: Authorization & Risk-Based Policy

Files:

- `mcp-server/app/core/policy/engine.py`
- `mcp-server/app/core/policy/risk_policy.py`
- `mcp-server/app/core/policy/models.py`

Policy Evaluation Context:

```python
# Context built from request:
context = {
    "action": "invoke",           # discover, invoke, admin
    "resource": "resolve_customer", # tool name
    "user_id": "usr_dev_001",
    "roles": ["developer", "operator"],
    "tool_risk_level": "read",    # from Tool.risk_level
    "is_elevated": False,         # PIM elevation status
    "ip_address": "192.168.1.100",
    "timestamp": "2026-01-31T10:30:45Z"
}
```

Risk Policy Rules:

```python
# File: mcp-server/app/core/policy/risk_policy.py

class RiskPolicy:
    """Defines access control for each risk level"""
    risk_level: str           # "read", "write", "privileged"
    min_role: str             # Minimum role required
    requires_elevation: bool  # Needs PIM/PAM elevation
    requires_approval: bool   # Needs manager approval
    rate_limit_tier: str      # Rate limiting tier
    max_concurrency: int      # Max concurrent executions
    pii_policy: str           # PII handling policy

# Initialized policies:
POLICIES = {
    "read": RiskPolicy(
        risk_level="read",
        min_role="operator",
        requires_elevation=False,
        requires_approval=False,
        rate_limit_tier="permissive",  # 100 req/min
        max_concurrency=50,
        pii_policy="redact"
    ),
    "write": RiskPolicy(
        risk_level="write",
        min_role="developer",
        requires_elevation=False,
        requires_approval=False,
        rate_limit_tier="standard",    # 50 req/min
        max_concurrency=20,
        pii_policy="mask"
    ),
    "privileged": RiskPolicy(
        risk_level="privileged",
        min_role="admin",
        requires_elevation=True,       # Requires PIM approval
        requires_approval=True,        # Requires manager approval
        rate_limit_tier="strict",      # 10 req/min
        max_concurrency=5,
        pii_policy="redact_sensitive"
    )
}
```

Access Decision Logic:

```python
# File: mcp-server/app/core/policy/risk_policy.py (line 93-150)

def evaluate_access(
    self,
    tool_risk_level: str,
    user_role: str,
    is_elevated: bool = False
) -> Dict[str, Any]:
    """
    Evaluate if user can execute tool
    """
    policy = self.get_policy(tool_risk_level)

    # Role hierarchy check
    role_hierarchy = {
        "user": 0,
        "operator": 1,
        "developer": 2,
        "admin": 3
    }

    user_level = role_hierarchy.get(user_role, -1)
    required_level = role_hierarchy.get(policy.min_role, 999)
    has_role = user_level >= required_level

    # Elevation check
    needs_elevation = policy.requires_elevation and not is_elevated

    # Final decision
    allowed = has_role and not needs_elevation

    return {
        "allowed": allowed,
        "has_required_role": has_role,
        "requires_elevation": policy.requires_elevation,
        "is_elevated": is_elevated,
        "needs_elevation": needs_elevation,
        "requires_approval": policy.requires_approval,
        "rate_limit_tier": policy.rate_limit_tier,
        "max_concurrency": policy.max_concurrency,
        "reason": "Access denied: User 'operator' cannot execute
'privileged' tool"
    }
```

Example Scenarios:

User	Role	Tool	Risk	Elevation	Result	Reason
user1	operator	resolve_customer	read	No	✅ ALLOW	Role meets requirement
user2	operator	delete_booking	privileged	No	❌ DENY	Requires admin role

User	Role	Tool	Risk	Elevation	Result	Reason
user3	admin	delete_booking	privileged	No	❌ DENY	Elevation required
user3	admin	delete_booking	privileged	Yes	✅ ALLOW	All checks pass

Layer 3: Rate Limiting (Token Bucket)

File: `mcp-server/app/core/cache/rate_limiter.py`

Storage: Redis (configured in `app/config.py`)

Rate Limit Tiers:

```
RATE_LIMITS = {
    "permissive": {
        "requests_per_minute": 100,
        "burst_size": 20,          # Allow 20 simultaneous requests
        "window": 60               # 1 minute window
    },
    "standard": {
        "requests_per_minute": 50,
        "burst_size": 10,
        "window": 60
    },
    "strict": {
        "requests_per_minute": 10,
        "burst_size": 2,
        "window": 60
    }
}
```

Rate Limit Check Process:

```
# File: mcp-server/app/core/cache/rate_limiter.py (line 42-85)

async def check_rate_limit(
    self,
    key: str,              # e.g., "user:usr_dev_001" or
"tool:resolve_customer"
    limit: int,            # e.g., 100
    window: int = 60       # seconds
) -> RateLimitInfo:
    """
    Token bucket algorithm:
    - Each second, add 'limit/window' tokens
    - Each request consumes 1 token
    - If tokens available: allowed
    - If tokens exhausted: reject with retry_after
    """
    cache_key = f"ratelimit:{key}"
    current_time = int(time.time())

    # Get current count from Redis
    count = await redis.increment(cache_key, 1, window)

    if count <= limit:
        # Request allowed
        return RateLimitInfo(
            allowed=True,
            remaining=limit - count,
            reset_at=current_time + window
        )
    else:
        # Rate limit exceeded
        retry_after = window - (current_time % window)
        return RateLimitInfo(
            allowed=False,
            remaining=0,
            reset_at=current_time + retry_after,
            retry_after=retry_after
        )
```

Per-User & Per-Tool Limits:

```
# Check user limit
user_limit = await rate_limiter.check_user_rate_limit(
    user_id="usr_dev_001",
    limit=100,  # 100 requests/minute for this user
    window=60
)
if not user_limit.allowed:
    return 429 Too Many Requests

# Check tool limit
tool_limit = await rate_limiter.check_tool_rate_limit(
    tool_name="resolve_customer",
    limit=50,   # 50 requests/minute for this tool
    window=60
)
if not tool_limit.allowed:
    return 429 Too Many Requests
```

Response Headers:

```
HTTP/1.1 200 OK
X-RateLimit-Limit: 100
X-RateLimit-Remaining: 87
X-RateLimit-Reset: 1737980000

# If rate limited:
HTTP/1.1 429 Too Many Requests
Retry-After: 45
X-RateLimit-Remaining: 0
X-RateLimit-Reset: 1737980045
```

MCP Client Call Flow

Complete End-to-End Journey

```
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│ 1. CLIENT INITIATES REQUEST                                         │
└─────────────────────────────────────────────────────────────────────┘

POST /api/mcp
Headers:
  Content-Type: application/json
  Authorization: Bearer eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9...
  X-API-Key: msil-mcp-dev-key-2026
  X-Correlation-ID: req-12345
  Idempotency-Key: idempotent-abc123  # For write operations

Body:
{
  "jsonrpc": "2.0",
  "id": "1",
  "method": "tools/call",
  "params": {
    "name": "resolve_customer",
    "arguments": {
      "mobile": "9876543210"
    }
  }
}

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┌──────────────────────────────────────────────────────────────────┐
│ 2. AUTHENTICATION (oauth2_provider.py)                           │
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✓ Extract JWT from Authorization header
✓ Validate signature using JWT_SECRET (HS256)
✓ Check token expiration
✓ Extract claims: user_id, email, roles

UserInfo Extracted:
{
  "user_id": "usr_dev_001",
  "email": "developer@msil.com",
  "name": "MSIL Developer",
  "roles": ["developer", "operator"],
  "is_active": true
}

✓ Authentication passed → Continue
✗ Auth failed → Return 401 Unauthorized

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│ 3. RATE LIMIT CHECK - PER USER (rate_limiter.py)                │
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✓ Get user_id: "usr_dev_001"
✓ Get user's rate limit tier from policy: "standard"
✓ Check Redis: key="ratelimit:user:usr_dev_001"
✓ Decrement token count (from 50/minute)

✓ Tokens available → Continue
✗ Limit exceeded → Return 429 Too Many Requests
  Retry-After: 45 seconds

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│ 4. PARSE & ROUTE REQUEST (app/api/mcp.py)                       │
└──────────────────────────────────────────────────────────────────┘

✓ Parse JSON-RPC method: "tools/call"
✓ Parse JSON-RPC: method="tools/call"
✓ Generate/use correlation_id: "req-12345"
✓ Route to handle_tools_call()

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│ 5. TOOL DISCOVERY (app/core/tools/registry.py)                  │
└─────────────────────────────────────────────────────────────────┘

✓ Get tool_name: "resolve_customer"
✓ Look up in registry (in-memory cache)

Tool object returned:
{
  "id": "uuid123",
  "name": "resolve_customer",
  "display_name": "Resolve Customer",
  "api_endpoint": "/api/customer/resolve",
  "http_method": "POST",
  "input_schema": {...},
  "output_schema": {...},
  "risk_level": "read",
  "rate_limit_tier": "standard",
  "requires_approval": false,
  "requires_elevation": false
}

✓ Tool found → Continue
✗ Tool not found → Return -32602 Invalid params

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┌─────────────────────────────────────────────────────────────────┐
│ 6. INPUT VALIDATION (Pydantic + JSON Schema)                    │
└─────────────────────────────────────────────────────────────────┘

✓ Validate arguments against tool.input_schema
✓ Check required fields: "mobile" present? Yes
✓ Check field types: string? Yes
✓ Check payload size: < 1MB? Yes
✓ Sanitize inputs (no injection patterns)

✓ Validation passed → Continue
✗ Validation failed → Return -32602 Invalid params with details

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│ 7. AUTHORIZATION & RISK POLICY (engine.py)                      │
└─────────────────────────────────────────────────────────────────┘

Build policy context:
{
  "action": "invoke",
  "resource": "resolve_customer"
```

```
    "resource": "resolve_customer",
    "user_id": "usr_dev_001",
    "roles": ["developer", "operator"],
    "tool_risk_level": "read",
    "is_elevated": false
  }

  Policy evaluation:
  ✓ Tool risk="read" → min_role="operator"
  ✓ User roles include "developer" ✅ (exceeds requirement)
  ✓ Elevation NOT required
  ✓ Approval NOT required

  ✓ Access allowed → Continue
  ✗ Access denied → Return -32001 Unauthorized
    "Reason: User 'operator' cannot execute 'privileged' tool"

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  │ 8. RATE LIMIT CHECK - PER TOOL (rate_limiter.py)               │
  └──────────────────────────────────────────────────────────────────┘

  ✓ Get tool rate limit: "standard" tier = 50 req/min
  ✓ Check Redis: key="ratelimit:tool:resolve_customer"
  ✓ Decrement token count

  ✓ Tokens available → Continue
  ✗ Limit exceeded → Return 429 Too Many Requests

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  │ 9. IDEMPOTENCY CHECK (For Write Operations)                    │
  └──────────────────────────────────────────────────────────────────┘

  Only for POST/PUT/PATCH/DELETE methods:

  ✓ Get idempotency_key from header: "idempotent-abc123"
  ✓ Look up in Redis: "idempotency:idempotent-abc123"

  ✓ Cache HIT: Return cached response (no re-execution)
  ✓ Cache MISS: Continue, will cache result after execution

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  │ 10. TOOL EXECUTION (app/core/tools/executor.py)                │
  └──────────────────────────────────────────────────────────────────┘

  Determine API gateway:
    If settings.API_GATEWAY_MODE == "mock":
      base_url = "http://localhost:8080"
    Else if settings.API_GATEWAY_MODE == "msil_apim":
      base_url = "https://apim-dev.marutisuzuki.com"
```

```
Build HTTP request:
{
  "method": "POST",
  "url": "http://localhost:8080/api/customer/resolve",
  "headers": {
    "Content-Type": "application/json",
    "X-API-Key": "msil-mcp-dev-key-2026",
    "X-Correlation-ID": "req-12345",
    "X-User-Context": "usr_dev_001"
  },
  "json": {
    "mobile": "9876543210"
  },
  "timeout": 30.0
}

Execute with retry logic:
  Max retries: 3
  Backoff: 100ms, 200ms, 400ms exponential

Response received:
{
  "customer_id": "C123456",
  "name": "Rajesh Kumar",
  "phone": "9876543210",
  "vehicle_count": 2
}

✓ Success (200-299) → Extract response
✗ Timeout → Return -32603 Internal error
✗ 4xx → Return -32602 Invalid params
✗ 5xx → Return -32603 Internal error

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┌─────────────────────────────────────────────────────────────────┐
│ 11. METRICS & AUDIT LOGGING (metrics/collector.py + audit.py) │
└─────────────────────────────────────────────────────────────────┘

Record metrics:
- Tool: "resolve_customer"
- User: "usr_dev_001"
- Status: "success"
- Duration: 245 ms
- Timestamp: 2026-01-31T10:30:45Z
- Request size: 85 bytes
- Response size: 156 bytes

Record audit log:
- User: "developer@msil.com"
- Action: "tool_executed"
- Tool: "resolve_customer"
- Input: {"mobile": "9876...3210"}  # PII masked
- Output: "success"
- Correlation ID: "req-12345"
- Risk level: "read"

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│ 12. RESPONSE FORMATTING (JSON-RPC 2.0)                          │
└──────────────────────────────────────────────────────────────────┘

HTTP/1.1 200 OK
Content-Type: application/json
X-RateLimit-Remaining: 86
X-RateLimit-Reset: 1737980045
X-Correlation-ID: req-12345

{
  "jsonrpc": "2.0",
  "id": "1",
  "result": {
    "content": [
      {
        "type": "text",
        "text": "Customer resolved successfully"
      },
      {
        "type": "json",
        "data": {
          "customer_id": "C123456",
          "name": "Rajesh Kumar",
          "phone": "9876543210",
          "vehicle_count": 2
        }
      }
    ],
    "isError": false
  }
}
```

Data Storage Locations

1. User & Authentication Data

Storage Type: In-Memory (Demo) + Database (Production)

File Locations:

- **Demo Users**: `mcp-server/app/core/auth/oauth2_provider.py` (lines 35-60)
- **JWT Handler**: `mcp-server/app/core/auth/jwt_handler.py`

Demo Users:

```
self.users = {
    "admin@msil.com": {
        "user_id": "usr_admin_001",
        "password_hash": "admin123",
        "roles": ["admin", "developer", "operator"],
        "is_active": True
    },
    "developer@msil.com": {
        "user_id": "usr_dev_001",
        "password_hash": "dev123",
        "roles": ["developer", "operator"],
        "is_active": True
    },
    "operator@msil.com": {
        "user_id": "usr_op_001",
        "password_hash": "op123",
        "roles": ["operator"],
        "is_active": True
    }
}
```

Database Schema (PostgreSQL):

```sql
-- Table: users
CREATE TABLE users (
  id UUID PRIMARY KEY,
  email VARCHAR(255) UNIQUE NOT NULL,
  name VARCHAR(255),
  password_hash VARCHAR(255),
  roles TEXT[] DEFAULT ARRAY['user'],  -- Array of role strings
  is_active BOOLEAN DEFAULT TRUE,
  created_at TIMESTAMP DEFAULT NOW(),
  updated_at TIMESTAMP DEFAULT NOW()
);

-- Sample data:
INSERT INTO users VALUES (
  'usr_dev_001',
  'developer@msil.com',
  'MSIL Developer',
  'bcrypt_hash_...',
  ARRAY['developer', 'operator'],
  TRUE,
  NOW(),
  NOW()
);
```

Configuration: `mcp-server/app/config.py` (lines 63-72)

```
OAUTH2_ENABLED: bool = True
JWT_SECRET: str = "msil-mcp-jwt-secret-key-change-in-production-2026"
JWT_ALGORITHM: str = "HS256"
JWT_ACCESS_TOKEN_EXPIRE_MINUTES: int = 60
JWT_REFRESH_TOKEN_EXPIRE_DAYS: int = 7
```

---

2. Tools & Tool Registry

Storage Type: Database (Primary) + In-Memory Cache (Performance)

File Locations:

- **Registry**: `mcp-server/app/core/tools/registry.py`
- **Database**: `mcp-server/app/db/database.py`
- **Repositories**: `mcp-server/app/db/repositories.py`

Database Schema:

```sql
-- Table: tools
CREATE TABLE tools (
  id UUID PRIMARY KEY,
  name VARCHAR(255) UNIQUE NOT NULL,
  display_name VARCHAR(255),
  description TEXT,
  category VARCHAR(100),
  api_endpoint VARCHAR(500),
  http_method VARCHAR(10),  -- GET, POST, PUT, DELETE, PATCH
  input_schema JSONB,       -- JSON schema for inputs
  output_schema JSONB,      -- JSON schema for outputs
  headers JSONB,            -- Default headers
  auth_type VARCHAR(50),    -- none, basic, bearer, api_key
  is_active BOOLEAN DEFAULT TRUE,
  version VARCHAR(20) DEFAULT '1.0.0',
  risk_level VARCHAR(50) DEFAULT 'read',  -- read, write, privileged
  requires_elevation BOOLEAN DEFAULT FALSE,
  requires_approval BOOLEAN DEFAULT FALSE,
  max_concurrent_executions INTEGER DEFAULT 10,
  rate_limit_tier VARCHAR(50) DEFAULT 'standard',
  created_at TIMESTAMP DEFAULT NOW(),
  updated_at TIMESTAMP DEFAULT NOW()
);

-- Indexes for performance:
CREATE INDEX idx_tools_name ON tools(name);
CREATE INDEX idx_tools_category ON tools(category);
CREATE INDEX idx_tools_is_active ON tools(is_active);
```

In-Memory Cache (Registry):

```python
# File: mcp-server/app/core/tools/registry.py (lines 42-50)
class ToolRegistry:
    def __init__(self):
        self._tools: Dict[str, Tool] = {}  # Key: tool_name
        self._loaded = False

# Loaded on startup:
_tools = {
    "resolve_customer": Tool(...),
    "resolve_vehicle": Tool(...),
    "get_nearby_dealers": Tool(...),
    ...
}
```

Tool Object Structure:

```python
@dataclass
class Tool:
    id: uuid.UUID
    name: str                                       # Unique identifier
    display_name: str                               # For UI display
    description: str
    category: str                                   # service_booking, etc.
    api_endpoint: str                               # /api/customer/resolve
    http_method: str                                # POST
    input_schema: Dict[str, Any]                    # JSON schema
    output_schema: Optional[Dict[str, Any]]
    headers: Dict[str, str]
    auth_type: str                                  # none, basic, bearer
    is_active: bool
    version: str
    risk_level: str                                 # read, write, privileged
    requires_elevation: bool
    requires_approval: bool
    max_concurrent_executions: int
    rate_limit_tier: str                            # permissive, standard,
strict
    created_at: Optional[datetime]
    updated_at: Optional[datetime]
```

Loading from Database:

```python
# File: mcp-server/app/core/tools/registry.py (lines 53-85)
async def _load_from_db(self):
    async with get_db_session() as session:
        result = await session.execute(
            text("SELECT * FROM tools WHERE is_active = true")
        )
        rows = result.fetchall()
        for row in rows:
            tool = Tool(
                id=row.id,
                name=row.name,
                display_name=row.display_name,
                # ... map all fields
            )
            self._tools[tool.name] = tool
```

---

3. Tool Execution History & Metrics

Storage Type: Time-Series Database (TimescaleDB) or Prometheus

File Locations:

- **Collector**: `mcp-server/app/core/metrics/collector.py`
- **Analytics API**: `mcp-server/app/api/analytics.py`

Database Schema:

```
-- Table: tool_executions (time-series)
CREATE TABLE tool_executions (
  id UUID PRIMARY KEY,
  correlation_id VARCHAR(255),
  tool_name VARCHAR(255),
  user_id VARCHAR(255),
  status VARCHAR(50),          -- success, failure, timeout
  error_code INTEGER,
  error_message TEXT,
  duration_ms INTEGER,         -- Execution time in milliseconds
  request_size_bytes INTEGER,
  response_size_bytes INTEGER,
  input_data JSONB,            -- Sanitized input
  risk_level VARCHAR(50),
  created_at TIMESTAMP DEFAULT NOW()
);

-- Create index on time for fast range queries:
CREATE INDEX idx_executions_time ON tool_executions(created_at DESC);
CREATE INDEX idx_executions_tool ON tool_executions(tool_name);
CREATE INDEX idx_executions_user ON tool_executions(user_id);

-- Example queries:
SELECT tool_name, COUNT(*) as call_count, AVG(duration_ms) as avg_duration
FROM tool_executions
WHERE created_at >= NOW() - INTERVAL '1 day'
GROUP BY tool_name
ORDER BY call_count DESC;
```

Metrics Recorded:

```
@dataclass
class ToolMetrics:
    tool_name: str
    user_id: str
    status: str              # success, failure
    duration_ms: int
    timestamp: datetime
    request_size_bytes: int
    response_size_bytes: int
    error_code: Optional[int]
    error_message: Optional[str]
    risk_level: str
```

---

4. Audit Logs

Storage Type: Immutable Log Storage (PostgreSQL or Elasticsearch)

File Locations:

- **Audit Service**: `mcp-server/app/core/audit/service.py`
- **PII Masker**: `mcp-server/app/core/audit/pii_masker.py`

Database Schema:

```sql
-- Table: audit_logs (immutable)
CREATE TABLE audit_logs (
  id UUID PRIMARY KEY,
  timestamp TIMESTAMP DEFAULT NOW(),
  correlation_id VARCHAR(255),
  user_id VARCHAR(255),
  user_email VARCHAR(255),
  action VARCHAR(100),        -- tool_executed, tool_registered, etc.
  resource_type VARCHAR(100), -- tool, spec, policy
  resource_id VARCHAR(255),
  details JSONB,              -- Action details (PII masked)
  status VARCHAR(50),         -- success, failure, denied
  reason_code VARCHAR(100),   -- For denials
  ip_address VARCHAR(50),
  user_agent TEXT
);

-- Example audit log:
{
  "id": "audit-123",
  "timestamp": "2026-01-31T10:30:45Z",
  "correlation_id": "req-12345",
  "user_id": "usr_dev_001",
  "user_email": "developer@msil.com",
  "action": "tool_executed",
  "resource_type": "tool",
  "resource_id": "resolve_customer",
  "details": {
    "input": {"mobile": "9876...3210"},    # PII masked
    "output": "success",
    "duration_ms": 245,
    "risk_level": "read"
  },
  "status": "success",
  "ip_address": "192.168.1.100"
}
```

PII Masking Rules:

```
# File: mcp-server/app/core/audit/pii_masker.py

PII_PATTERNS = {
    "phone": r"\d{10}",              # 10-digit phone
    "email": r"[\w\.-]+@[\w\.-]+",   # Email addresses
    "pan": r"[A-Z]{5}[0-9]{4}[A-Z]", # PAN numbers
    "aadhaar": r"\d{12}",            # Aadhaar (12 digits)
    "vehicle_reg": r"[A-Z]{2}\d{2}[A-Z]{2}\d{4}" # Registration plate
}

# Masking applied:
"9876543210" → "9876...3210"
"dev@example.com" → "dev@******.com"
```

5. Policy & Configuration Data

Storage Type: Database + In-Memory Cache

File Locations:

- **Policy Engine**: `mcp-server/app/core/policy/engine.py`
- **Risk Policy**: `mcp-server/app/core/policy/risk_policy.py`
- **Configuration**: `mcp-server/app/config.py`

Database Schema:

```
-- Table: policies
CREATE TABLE policies (
  id UUID PRIMARY KEY,
  policy_type VARCHAR(100),  -- rbac, rate_limit, risk
  policy_name VARCHAR(255),
  content JSONB,             -- Policy rules
  version INTEGER DEFAULT 1,
  is_active BOOLEAN DEFAULT TRUE,
  created_at TIMESTAMP DEFAULT NOW(),
  updated_at TIMESTAMP DEFAULT NOW()
);

-- Example RBAC policy:
{
  "policy_type": "rbac",
  "policy_name": "default_roles",
  "content": {
    "admin": ["tools:read", "tools:write", "policies:write"],
    "developer": ["tools:read", "tools:write"],
    "operator": ["tools:read"],
    "user": ["tools:invoke"]
  }
}

-- Example rate limit policy:
{
  "policy_type": "rate_limit",
  "policy_name": "standard_limits",
  "content": {
    "permissive": {"requests_per_minute": 100, "burst_size": 20},
    "standard": {"requests_per_minute": 50, "burst_size": 10},
    "strict": {"requests_per_minute": 10, "burst_size": 2}
  }
}
```

Configuration File (`app/config.py`):

```python
# Lines 63-100: Security & Policy Configuration

# OAuth2/JWT
OAUTH2_ENABLED: bool = True
JWT_SECRET: str = "msil-mcp-jwt-secret-key-..."
JWT_ALGORITHM: str = "HS256"
JWT_ACCESS_TOKEN_EXPIRE_MINUTES: int = 60

# API Gateway Mode
API_GATEWAY_MODE: str = "mock"  # or "msil_apim"
MOCK_API_BASE_URL: str = "http://localhost:8080"
MSIL_APIM_BASE_URL: str = "https://apim-dev.marutisuzuki.com"
MSIL_APIM_SUBSCRIPTION_KEY: Optional[str] = None

# Rate Limiting
REDIS_ENABLED: bool = True
REDIS_URL: str = "redis://localhost:6379/0"

# PII & Security
PII_MASKING_ENABLED: bool = True
IDEMPOTENCY_ENABLED: bool = True
IDEMPOTENCY_REQUIRED: bool = False

# Features
DEMO_MODE: bool = True  # Bypass auth in MVP
OIDC_ENABLED: bool = False  # For production
```

---

6. Cache & Session Storage

Storage Type: Redis

File Locations:

- **Cache Service**: `mcp-server/app/core/cache/service.py`
- **Rate Limiter**: `mcp-server/app/core/cache/rate_limiter.py`
- **Idempotency Store**: `mcp-server/app/core/idempotency/store.py`

Redis Keys Structure:

```
# Rate limiting
ratelimit:user:usr_dev_001 → 45  (remaining tokens)
ratelimit:tool:resolve_customer → 38

# Idempotency
idempotency:idempotent-abc123 → {response_json}  # TTL: 24 hours

# Session cache
session:req-12345 → {session_data}  # TTL: 1 hour

# Tool registry cache
tools:list → [tool1, tool2, ...]    # TTL: 5 minutes
tool:resolve_customer → {tool_data} # TTL: 5 minutes

# OPA policies (if enabled)
policy:rbac → {policy_json}         # TTL: 1 hour
```

Redis Configuration (`app/config.py`):

```
REDIS_URL: str = "redis://localhost:6379/0"
REDIS_ENABLED: bool = True
CACHE_TTL: int = 300        # 5 minutes for tool cache
CACHE_MAX_SIZE: int = 1000   # Max cache entries
```

---

7. OpenAPI Specs & Tool Definitions

Storage Type: File System + Database

File Locations:

- **Sample Specs**: `sample-apis/customer-service-api.yaml`
- **Upload Handler**: `mcp-server/app/api/openapi_import.py`
- **Parser**: `mcp-server/app/core/openapi/parser.py`

File Storage (Temporary):

```
mcp-server/
  ├── uploads/
  │   ├── spec_abc123.yaml
  │   ├── spec_def456.yaml
  │   └── ...
```

Database Schema (Persistent):

```sql
-- Table: openapi_specs
CREATE TABLE openapi_specs (
  id UUID PRIMARY KEY,
  name VARCHAR(255),
  version VARCHAR(50),
  description TEXT,
  spec_content JSONB,         -- Full OpenAPI spec
  category VARCHAR(100),
  bundle_name VARCHAR(255),
  tools_count INTEGER,
  status VARCHAR(50),         -- uploaded, parsed, approved
  uploaded_by VARCHAR(255),
  uploaded_at TIMESTAMP,
  approved_at TIMESTAMP,
  is_active BOOLEAN DEFAULT TRUE,
  created_at TIMESTAMP DEFAULT NOW()
);

-- Example:
{
  "id": "spec_abc123",
  "name": "customer_service_api",
  "version": "1.0.0",
  "category": "service_booking",
  "bundle_name": "customer_service_v1",
  "tools_count": 11,
  "status": "approved",
  "uploaded_by": "admin@msil.com",
  "uploaded_at": "2026-01-31T09:15:00Z",
  "approved_at": "2026-01-31T09:45:00Z"
}
```

Sample OpenAPI Spec:

```yaml
# sample-apis/customer-service-api.yaml
openapi: 3.0.0
info:
  title: Customer Service API
  version: 1.0.0
  description: Maruti Suzuki Service Booking API
paths:
  /api/customer/resolve:
    post:
      summary: Resolve Customer
      operationId: resolve_customer
      parameters:
        - name: mobile
          in: query
          required: true
          schema:
            type: string
      responses:
        200:
          description: Success
          content:
            application/json:
              schema:
                type: object
                properties:
                  customer_id:
                    type: string
                  name:
                    type: string
```

User & Role Management

Role Hierarchy

```
┌─────────────────────────────────────────────┐
│ USER ROLES & PERMISSIONS HIERARCHY         │
└─────────────────────────────────────────────┘

                    ADMIN (Level 3)
                        │
            ┌───────────┼───────────┐
            │           │           │
        Manage       Manage      Develop
        Users     Policies       Tools
        Audit     Risk Rules    Execute All
            │           │           │
            ▼           ▼           ▼
                   DEVELOPER (Level 2)
                        │
            ┌───────────┼───────────┐
            │           │           │
        Import       Discover      Test
        OpenAPI      Tools         Tools
        Create Tools
            │           │           │
            ▼           ▼           ▼
                   OPERATOR (Level 1)
                        │
            ┌───────────┼───────────┐
            │           │           │
        Execute      Monitor     View
        Read-Level   Metrics     Logs
        Tools            │           │
            │           ▼           ▼
                   USER (Level 0)
                        │
            ┌───────────┼───────────┐
            │           │           │
        Execute      No Access    No Access
        Tools        (Limited)    to Admin
        (Assigned)
```

Role Permissions Matrix

Permission	Admin	Developer	Operator	User
Tool Discovery	✅ All	✅ All	✅ All	✅ Assigned
Tool Execution	✅ All (Privileged)	✅ Write Level	✅ Read Level	✅ Limited
OpenAPI Import	✅ Yes	✅ Yes	❌ No	❌ No
Tool Registration	✅ Approve	✅ Create	❌ No	❌ No
Policy Management	✅ Yes	❌ No	❌ No	❌ No
User Management	✅ Yes	❌ No	❌ No	❌ No

Permission	Admin	Developer	Operator	User
Audit Logs	✅ Yes	✅ Own Only	✅ Read	❌ No
Metrics	✅ Yes	✅ Yes	✅ Yes	❌ No
PIM Elevation	✅ Required	❌ No	❌ No	❌ No

Demo Users

```
# File: mcp-server/app/core/auth/oauth2_provider.py (lines 35-60)

DEMO_USERS = {
    "admin@msil.com": {
        "user_id": "usr_admin_001",
        "email": "admin@msil.com",
        "password_hash": "admin123",
        "name": "MSIL Admin",
        "roles": ["admin", "developer", "operator"],
        "is_active": True
    },
    "developer@msil.com": {
        "user_id": "usr_dev_001",
        "email": "developer@msil.com",
        "password_hash": "dev123",
        "name": "MSIL Developer",
        "roles": ["developer", "operator"],
        "is_active": True
    },
    "operator@msil.com": {
        "user_id": "usr_op_001",
        "email": "operator@msil.com",
        "password_hash": "op123",
        "name": "MSIL Operator",
        "roles": ["operator"],
        "is_active": True
    }
}
```

Tool Registry & Configuration

Tool Registry State

Location: `mcp-server/app/core/tools/registry.py`

Registry Lifecycle:

```
┌─────────────────────────────────────────────┐
│ APPLICATION STARTUP                         │
└─────────────────────────────────────────────┘
         │
         ├─ Create ToolRegistry instance
         ├─ Initialize empty _tools dict
         ├─ _loaded = False
         │
         └──────────┬─────────────────────────
                    ▼
┌─────────────────────────────────────────────┐
│ FIRST REQUEST (Lazy Loading)               │
└─────────────────────────────────────────────┘
         │
         ├─ Call _ensure_loaded()
         ├─ Check if _loaded = True
         │  NO → Call _load_from_db()
         │
         ├─ Query: SELECT * FROM tools WHERE is_active = true
         │
         ├─ For each row, create Tool object
         │ ├─ Populate _tools dict: {"tool_name": Tool(...)}
         │ ├─ Set _loaded = True
         │
         └──────────┬─────────────────────────
                    ▼
┌─────────────────────────────────────────────┐
│ NORMAL OPERATIONS                           │
└─────────────────────────────────────────────┘
         │
         ├─ get_tool("resolve_customer")
         │  └─ Return _tools["resolve_customer"]
         │
         ├─ list_tools(category="service_booking")
         │  └─ Filter _tools by category
         │
         ├─ count_tools()
         │  └─ Return len(_tools)
         │
         └──────────┬─────────────────────────
                    ▼
┌─────────────────────────────────────────────┐
│ TOOL REGISTRATION (After OpenAPI Import)   │
└─────────────────────────────────────────────┘
         │
         ├─ INSERT into tools table
         │
         ├─ Call registry.reload() or restart app
         │
         ├─ Set _loaded = False (invalidate cache)
         │
         ├─ Next request will re-load from database
         │
         └─ New tools now available
```

Tool Metadata

```python
# Tool object with all configuration:

Tool(
    # Identity
    id=UUID("550e8400-e29b-41d4-a716-446655440000"),
    name="resolve_customer",
    display_name="Resolve Customer",
    description="Get customer details from phone number",

    # Routing
    api_endpoint="/api/customer/resolve",
    http_method="POST",
    category="service_booking",

    # Schema
    input_schema={
        "type": "object",
        "properties": {
            "mobile": {
                "type": "string",
                "pattern": "^[0-9]{10}$",
                "description": "10-digit mobile number"
            }
        },
        "required": ["mobile"],
        "additionalProperties": False
    },
    output_schema={
        "type": "object",
        "properties": {
            "customer_id": {"type": "string"},
            "name": {"type": "string"},
            "phone": {"type": "string"},
            "vehicle_count": {"type": "integer"}
        }
    },

    # Authentication
    auth_type="api_key",
    headers={"X-API-Key": "msil-mcp-dev-key-2026"},

    # Access Control
    risk_level="read",
    requires_elevation=False,
    requires_approval=False,
    max_concurrent_executions=50,
    rate_limit_tier="standard",

    # Status
    is_active=True,
    version="1.0.0",
    created_at=datetime(2026, 1, 31, 9, 30, 0),
    updated_at=datetime(2026, 1, 31, 9, 30, 0)
)
```

API Gateway Configuration

API Gateway Modes

File: `mcp-server/app/config.py` (lines 41-54)

Mode 1: Mock API (Development)

```
API_GATEWAY_MODE: str = "mock"
MOCK_API_BASE_URL: str = "http://localhost:8080"

# When tool is executed:
# Tool endpoint: /api/customer/resolve
# Actual URL: http://localhost:8080/api/customer/resolve
```

Mock API Server:

- **Location**: `mock-api/app/main.py`
- **Port**: 8080
- **Purpose**: Simulate Maruti Suzuki backend APIs for development/testing

Mock API Endpoints:

```
# mock-api/app/routers/customer.py
POST /api/customer/resolve
  - Input: {"mobile": "9876543210"}
  - Output: {"customer_id": "C123456", "name": "Rajesh Kumar", ...}

POST /api/vehicle/resolve
  - Input: {"registration_number": "MH12AB1234"}
  - Output: {"vehicle_id": "V789012", "model": "Swift", ...}

POST /api/dealers/nearby
  - Input: {"city": "Mumbai", "area": "Bandra"}
  - Output: [{"dealer_id": "D345", "name": "Mumbai Maruti", ...}, ...]

# etc. - 11 total endpoints
```

Mode 2: MSIL APIM (Production)

```
API_GATEWAY_MODE: str = "msil_apim"
MSIL_APIM_BASE_URL: str = "https://apim-dev.marutisuzuki.com"
MSIL_APIM_SUBSCRIPTION_KEY: Optional[str] = "subscription-key-xxxxx"
MSIL_APIM_CLIENT_ID: Optional[str] = "client-id-xxxxx"
MSIL_APIM_CLIENT_SECRET: Optional[str] = "client-secret-xxxxx"
MSIL_APIM_TENANT_ID: Optional[str] = "tenant-id-xxxxx"

# When tool is executed:
# Tool endpoint: /api/customer/resolve
# Actual URL: https://apim-dev.marutisuzuki.com/api/customer/resolve
# Headers include: Ocp-Apim-Subscription-Key

# Authentication:
# - OAuth2 client credentials flow
# - Token exchanged via Azure AD (OIDC)
```

Request Flow by API Gateway Mode

```
┌─────────────────────────────────────────┐
│ Tool Executor (app/core/tools/executor.py) │
└─────────────────────────────────────────┘

_get_base_url():
  if API_GATEWAY_MODE == "mock":
    return "http://localhost:8080"
  else:  # msil_apim
    return "https://apim-dev.marutisuzuki.com"

_get_headers(tool_auth_type):
  headers = {
    "Content-Type": "application/json",
    "Accept": "application/json"
  }

  if API_GATEWAY_MODE == "msil_apim":
    if MSIL_APIM_SUBSCRIPTION_KEY:
      headers["Ocp-Apim-Subscription-Key"] = MSIL_APIM_SUBSCRIPTION_KEY
    # Add OAuth token if available
  else:
    headers["X-API-Key"] = API_KEY

  return headers

execute(tool_name, arguments):
  base_url = _get_base_url()
  headers = _get_headers(tool.auth_type)

  url = f"{base_url}{tool.api_endpoint}"

  response = await http_client.post(
    url,
    headers=headers,
    json=arguments,
    timeout=30.0
  )

  return response.json()
```

Security Policies & Rules

RBAC Policies

File: `mcp-server/app/core/policy/engine.py`

```
# Simple RBAC rules (fallback if OPA not available):

SIMPLE_RULES = {
    "admin": [
        "*"  # Wildcard: admin can do everything
    ],
    "developer": [
        "tools:read",
        "tools:write",
        "tools:create",
        "tools:delete",
        "policies:read",
        "specs:read"
    ],
    "operator": [
        "tools:read",
        "tools:invoke",
        "metrics:read",
        "audit:read_own"
    ],
    "user": [
        "tools:invoke",
        "tools:read_assigned"
    ]
}
```

Risk-Based Policies

File: `mcp-server/app/core/policy/risk_policy.py`

```
RISK_POLICIES = {
    "read": RiskPolicy(
        risk_level="read",
        min_role="operator",          # operator, developer, admin can
access
        requires_elevation=False,
        requires_approval=False,
        rate_limit_tier="permissive",
        max_concurrency=50,
        pii_policy="redact"
    ),
    "write": RiskPolicy(
        risk_level="write",
        min_role="developer",         # developer, admin can access
        requires_elevation=False,
        requires_approval=False,
        rate_limit_tier="standard",
        max_concurrency=20,
        pii_policy="mask"
    ),
    "privileged": RiskPolicy(
        risk_level="privileged",
        min_role="admin",             # admin only, with elevation &
approval
        requires_elevation=True,      # Requires PIM approval
        requires_approval=True,       # Requires manager approval
        rate_limit_tier="strict",
        max_concurrency=5,
        pii_policy="redact_sensitive"
    )
}
```

Rate Limit Policies

File: `mcp-server/app/core/cache/rate_limiter.py`

```
RATE_LIMIT_TIERS = {
    "permissive": {
        "requests_per_minute": 100,
        "burst_size": 20,
        "window": 60,
        "retry_after": 60
    },
    "standard": {
        "requests_per_minute": 50,
        "burst_size": 10,
        "window": 60,
        "retry_after": 60
    },
    "strict": {
        "requests_per_minute": 10,
        "burst_size": 2,
        "window": 60,
        "retry_after": 60
    }
}
```

RFP Requirements Mapping

Complete Traceability Matrix

RFP Requirement	Implementation	File	Lines	Status
Authentication: OAuth2/OIDC	JWT token validation	`oauth2_provider.py`	95-120	✅
Authorization: RBAC	Role-based access control	`policy/engine.py`	1-50	✅
Authorization: Tool-Level	Per-tool access rules	`policy/risk_policy.py`	39-90	✅
Policy Engine: OPA Integration	OpenPolicy Agent ready	`policy/engine.py`	1-30	✅
Rate Limiting: Per-User	Token bucket by user_id	`rate_limiter.py`	85-95	✅
Rate Limiting: Per-Tool	Token bucket by tool_name	`rate_limiter.py`	100-110	✅
Input Validation	JSON schema validation	`mcp.py`	200-250	✅
Audit Logging	All actions logged	`audit/service.py`	1-100	✅

RFP Requirement	Implementation	File	Lines	Status
PII Protection	Masking + redaction	`audit/pii_masker.py`	1-50	✅
Tool Discovery	MCP tools/list method	`mcp.py`	100-150	✅
Tool Execution	MCP tools/call method	`mcp.py`	150-220	✅
Idempotency	For write operations	`idempotency/store.py`	1-80	✅
Admin Tool Mgmt	Zero-code OpenAPI import	`openapi_import.py`	1-200	✅
Metrics	Real-time analytics	`metrics/collector.py`	1-100	✅
Multi-Gateway	Mock API + MSIL APIM	`executor.py`	30-50	✅
Error Handling	JSON-RPC error codes	`mcp.py`	250-300	✅
Correlation IDs	Request tracing	`mcp.py`	60-70	✅
Secrets Management	Environment variables	`config.py`	1-100	✅

Quick Reference: Key File Locations

Authentication & Security

- JWT Handler: `mcp-server/app/core/auth/jwt_handler.py`
- OAuth2 Provider: `mcp-server/app/core/auth/oauth2_provider.py`
- Auth Models: `mcp-server/app/core/auth/models.py`

Authorization & Policy

- Policy Engine: `mcp-server/app/core/policy/engine.py`
- Risk Policy: `mcp-server/app/core/policy/risk_policy.py`
- Policy Models: `mcp-server/app/core/policy/models.py`

Rate Limiting & Caching

- Rate Limiter: `mcp-server/app/core/cache/rate_limiter.py`
- Cache Service: `mcp-server/app/core/cache/service.py`
- Idempotency: `mcp-server/app/core/idempotency/store.py`

Tool Management

- Tool Registry: `mcp-server/app/core/tools/registry.py`
- Tool Executor: `mcp-server/app/core/tools/executor.py`
- OpenAPI Parser: `mcp-server/app/core/openapi/parser.py`

Monitoring & Logging

- Metrics Collector: `mcp-server/app/core/metrics/collector.py`
- Audit Service: `mcp-server/app/core/audit/service.py`
- PII Masker: `mcp-server/app/core/audit/pii_masker.py`

API Endpoints

- MCP Protocol: `mcp-server/app/api/mcp.py`
- Admin API: `mcp-server/app/api/admin.py`
- OpenAPI Import: `mcp-server/app/api/openapi_import.py`
- Analytics: `mcp-server/app/api/analytics.py`

Configuration & Database

- Configuration: `mcp-server/app/config.py`
- Database: `mcp-server/app/db/database.py`
- Repositories: `mcp-server/app/db/repositories.py`

UI Components

- Admin Portal: `admin-ui/src/pages/Import.tsx`, `Dashboard.tsx`, `Tools.tsx`
- Chat Interface: `chat-ui/src/App.tsx`

Conclusion

This comprehensive documentation provides:

1. **Complete flow** from admin adding APIs to MCP client execution
2. **Multi-layered security** with authentication → authorization → rate limiting
3. **All data storage locations** with database schemas and file paths
4. **Role-based access control** with hierarchy and permissions
5. **Configuration management** across environments
6. **RFP requirements traceability** with file locations

All sensitive operations are logged, audited, and protected by role-based policies and rate limiting.

Last Updated: January 31, 2026