Securaa Playbook Service - Low Level Design Document

Document Information

- **Service Name**: Securaa Playbook Service
- **Version**: 1.0
- **Date**: September 11, 2025
- **Author**: Development Team
- **Related Documents**: High Level Design

Table of Contents

1. Overview

The Low Level Design document provides detailed implementation specifications for the Securaa Playbook Service, including class structures, method signatures, algorithm implementations, and detailed interaction patterns.

1.1 Scope

This document covers: - Detailed class and method specifications - Database schema with indexes and constraints - Complete API specifications with validation rules - Concurrency patterns and thread safety mechanisms - Performance optimization techniques - Error handling and recovery strategies

2. Detailed Component Design

2.1 Core Package Structure

```
securaa_services/securaa_playbook/
├── main.go                     // Application entry point
├── app.go                      // Application initialization
├── controllers/                // HTTP request handlers
│   ├── playbookcontroller.go
│   ├── listController.go
│   ├── caseController.go
│   ├── supportcontroller.go
│   └── processController.go
├── executionControllers/       // Execution orchestration
│   ├── playbookExecutionController.go
│   ├── runTaskController.go
│   ├── conditionController.go
│   └── subPlaybookController.go
├── models/                     // Data models
│   ├── playbook.go
│   ├── case.go
│   ├── task.go
│   └── Response.go
├── executionModels/           // Execution-specific models
│   ├── playbook.go
│   ├── Tasks.go
│   └── incidents.go
├── services/                  // Business logic
│   ├── genericTaskService.go
│   ├── processService.go
│   └── filterNTransformService.go
├── utils/                     // Utility functions
│   ├── filterConditionUtils.go
│   ├── matchConditionUtils.go
│   └── executionUtils.go
├── handlers/                  // Error and response handlers
│   ├── errorHandler.go
│   └── taskResponse.go
├── constants/                 // Application constants
│   └── constants.go
└── cacheControllers/         // Cache management
    └── cacheController.go
```

2.2 Main Application Structure

2.2.1 App Structure

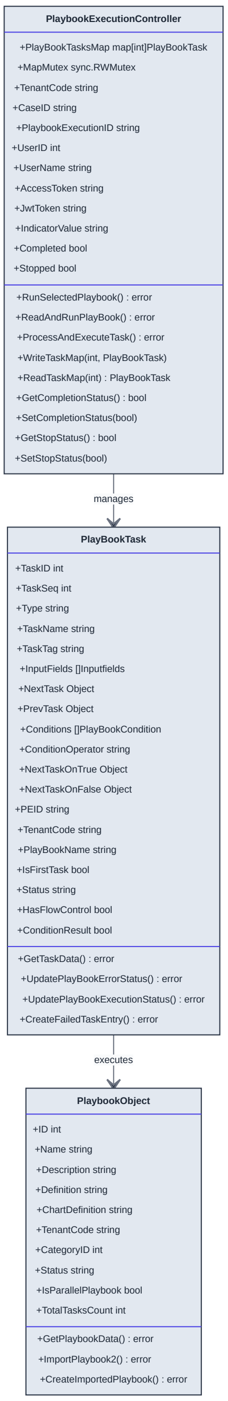
```
type App struct {
    Router            *mux.Router                    // HTTP router
    AccessTokenHashMap map[string]int64              // Session management
    DBSession         map[string]common.SessionStruct // Database sessions
    ConfigObject      config.ConfigStruct            // Configuration
    BuildType         string                         // Enterprise/MSSP
    LicenseType       string                         // License information
    RequestResponseLog bool                          // Logging flag
    DockerNodeID      string                         // Docker node identifier
}
```

2.2.2 Initialization Flow

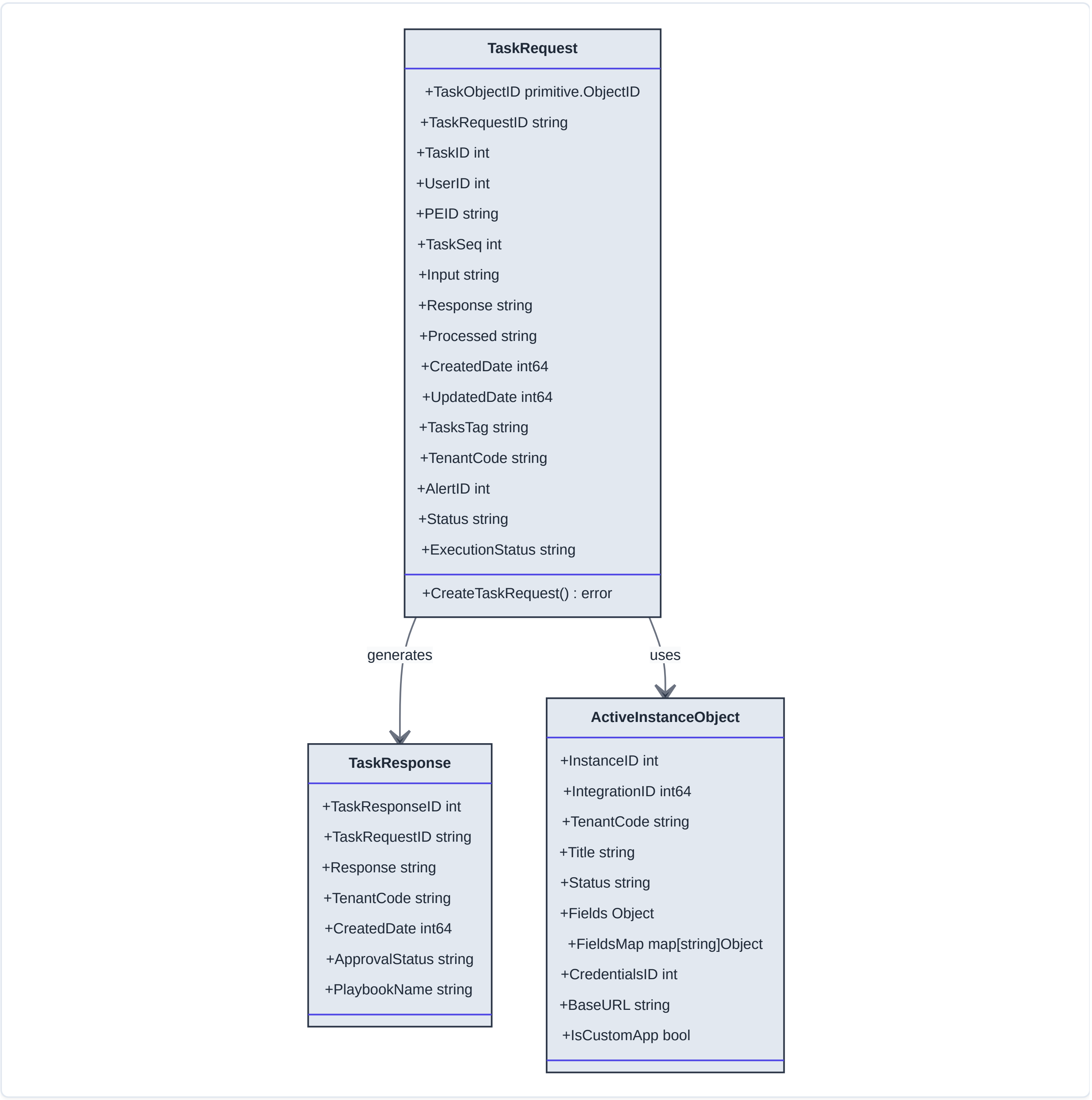
```
func (a *App) Initialize() {
    // 1. Load configuration
    a.ConfigObject = utils.InitConfig()

    // 2. Initialize database sessions
    a.InitMongoSession(a.ConfigObject)

    // 3. Initialize access token map
    a.AccessTokenHashMap = make(map[string]int64)

    // 4. Setup HTTP router
    a.Router = mux.NewRouter()
    a.initializeRoutes()

    // 5. Initialize Docker client
    cli, err := client.NewEnvClient()
    a.DockerNodeID, err = docker.GetNodeID(cli)

    // 6. Start background services
    go cache.CacheHealthCheck("test")
    go counter.SetMaxActiveTasksUtilsCount(cli, a.ConfigObject, false)

    // 7. Update playbook status on startup
    err = controllers.UpdatePlaybookStatus(a.ConfigObject)
}
```

3. Class Diagrams

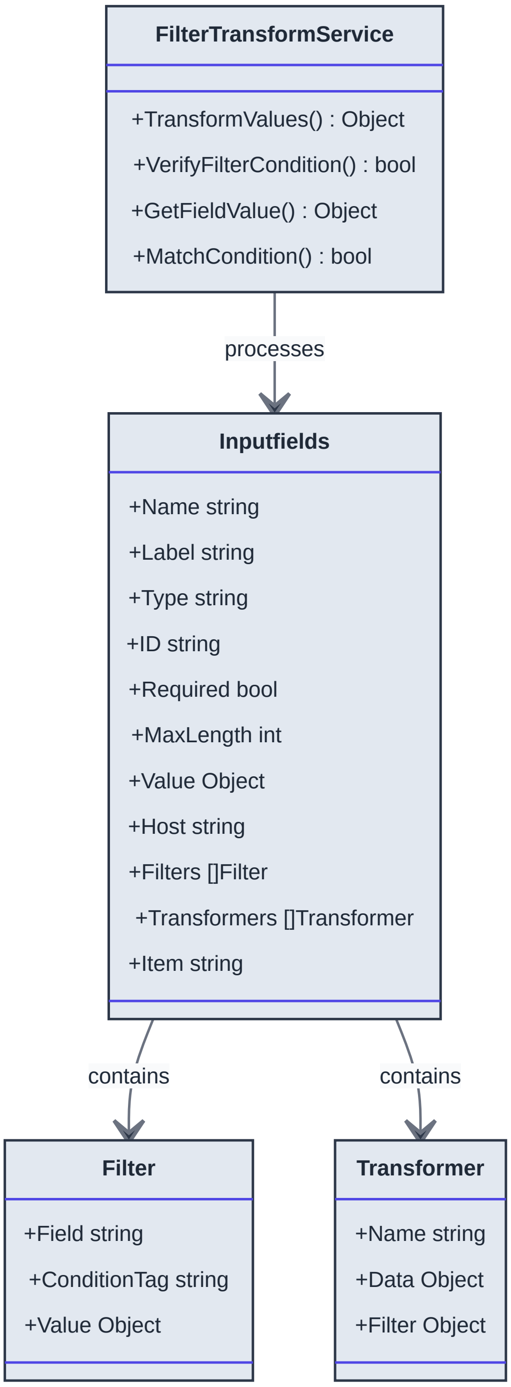
3.1 Playbook Execution Model



3.2 Task Execution Model

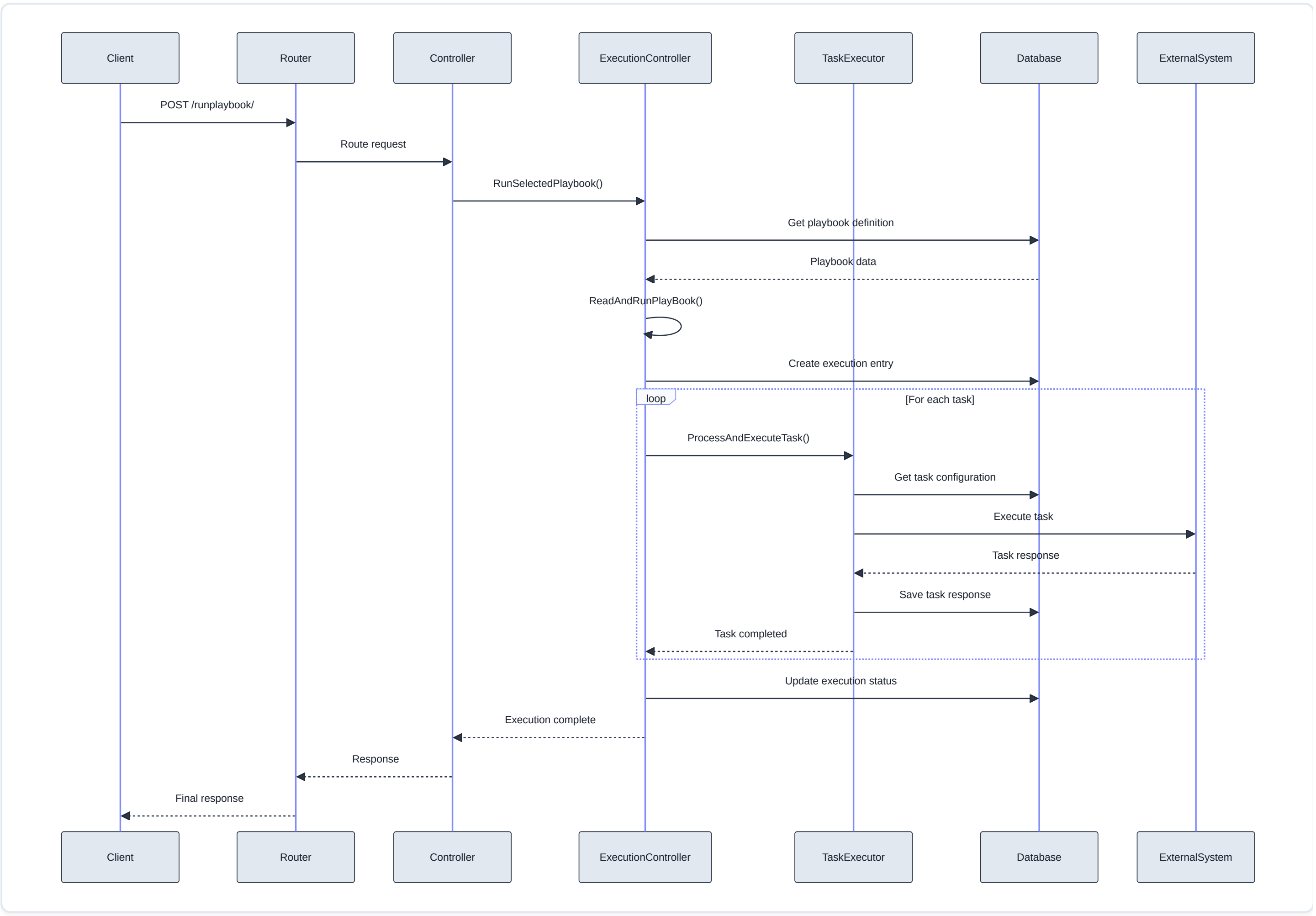


3.3 Filter & Transform Model

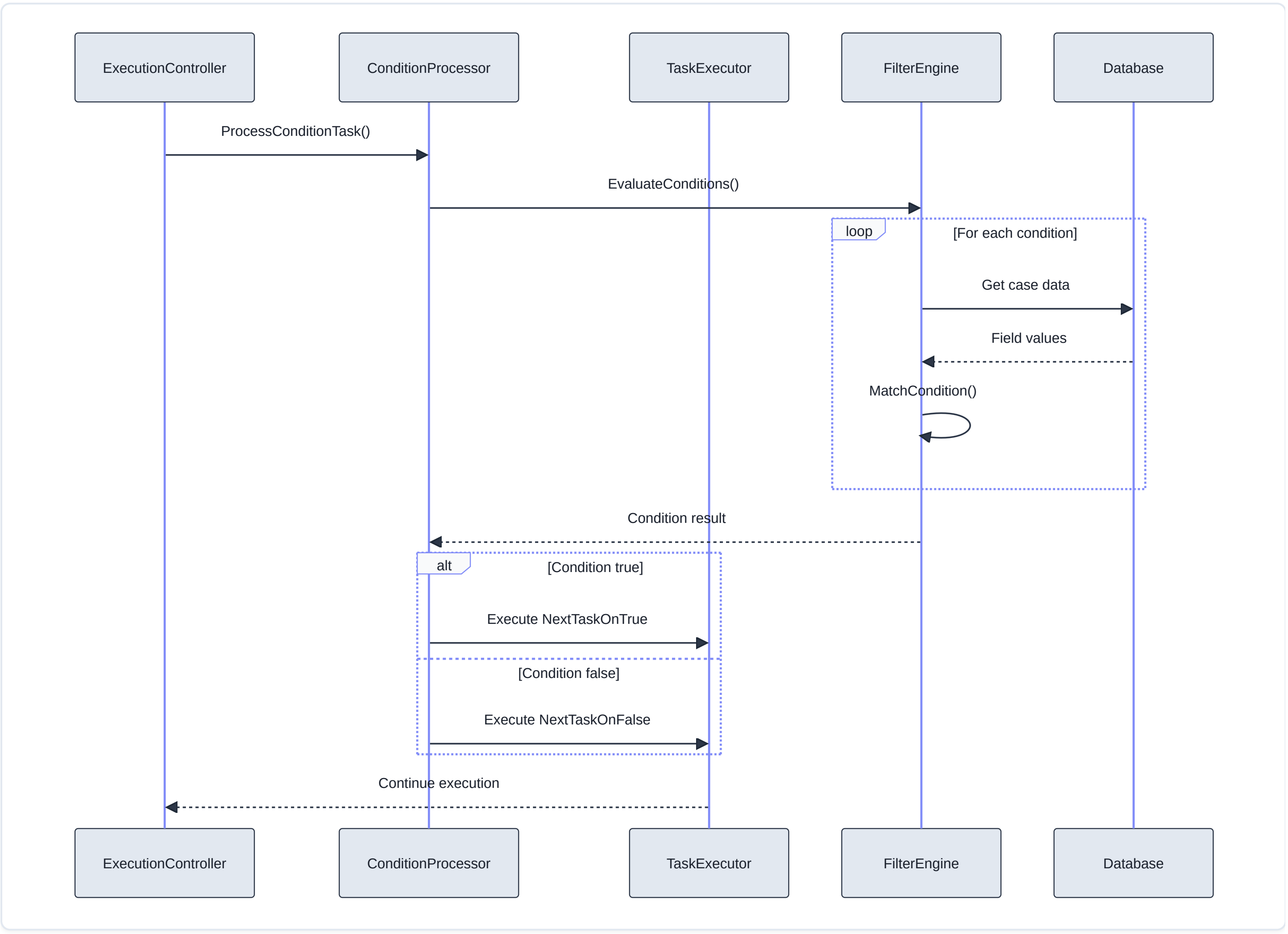

FilterTransformService
+TransformValues() : Object
+VerifyFilterCondition() : bool
+GetFieldValue() : Object
+MatchCondition() : bool
processes
Inputfields
+Name string
+Label string
+Type string
+ID string
+Required bool
+MaxLength int
+Value Object
+Host string
+Filters []Filter
+Transformers []Transformer
+Item string
contains
contains
Filter
+Field string
+ConditionTag string
+Value Object
Transformer
+Name string
+Data Object
+Filter Object

4. Sequence Diagrams

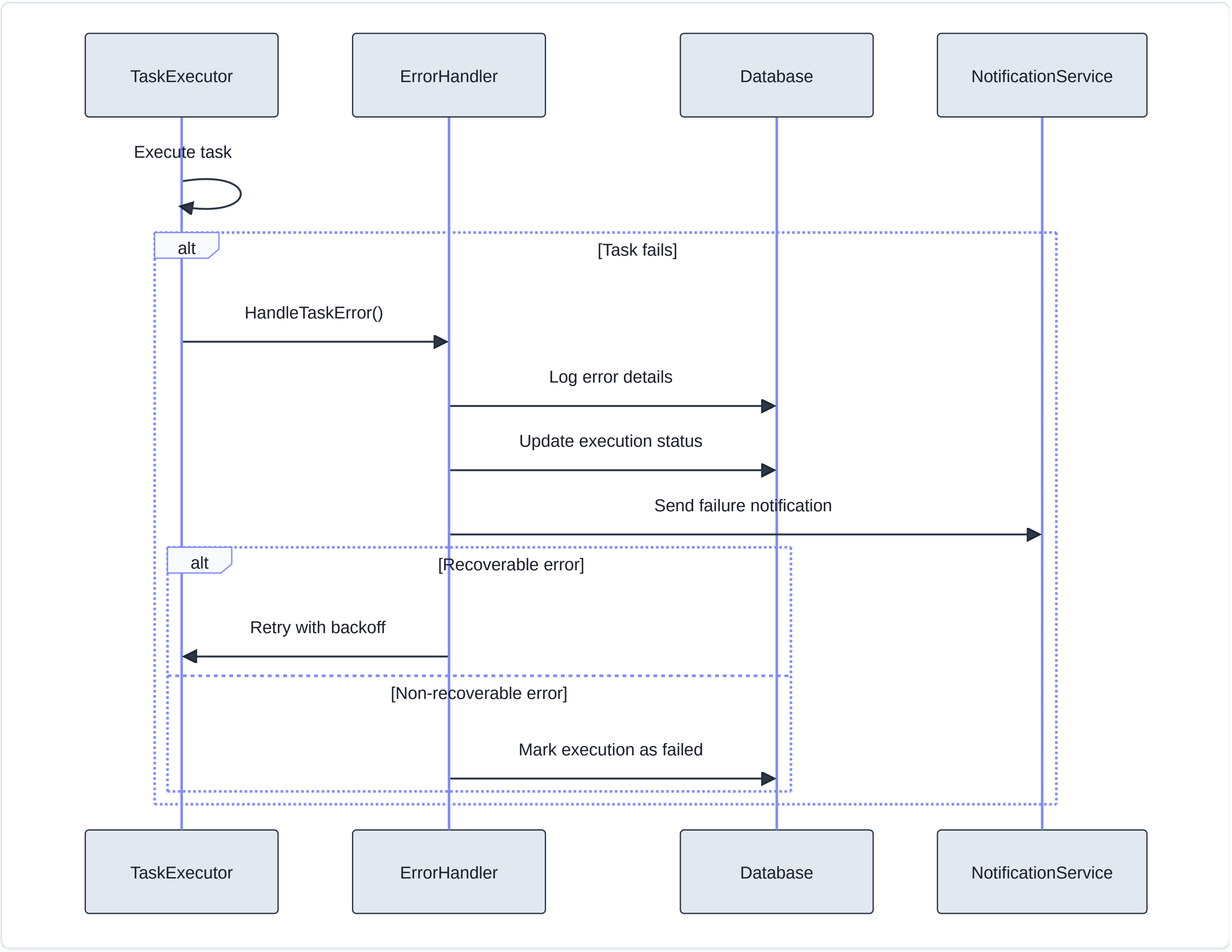
4.1 Playbook Execution Flow



4.2 Task Execution with Conditions



4.3 Error Handling Flow



5. Database Schema

5.1 MongoDB Collections Schema

5.1.1 Playbook Collection

```
{
  "_id": ObjectId,
  "id": 1001,                           // Auto-increment ID
  "name": "Malware Response Playbook",   // Unique per tenant
  "description": "Automated malware response workflow",
  "version": "1.0.0",
  "definition": "...",                   // JSON string of task definitions
  "chart_definition": "...",             // Visual representation
  "tenant_code": "tenant123",
  "category_id": 5,
  "status": "active",                    // active, draft, archived
  "created_date": 1694443200000,
  "updated_date": 1694443200000,
  "user_id": 1001,
  "group_id": 100,
  "type": "case",                        // case, indicator
  "filename": "1001_tenant123.json",
  "commit_id": "abc123",
  "list_names": ["suspicious_ips", "malware_domains"],
  "all_nodes_connected": "yes",
  "custom_utils_added": false,
  "custom_utils_names": [],
  "vertical_pb": false,
  "is_parallel_playbook": true,
  "total_tasks_count": 15,
  "total_utils_count": 3,
  "shard_bucket": 1                      // For sharding
}
// Indexes
db.playbook_collection.createIndex({"tenant_code": 1, "name": 1}, {unique: true})
db.playbook_collection.createIndex({"tenant_code": 1, "status": 1})
db.playbook_collection.createIndex({"category_id": 1, "status": 1})
db.playbook_collection.createIndex({"shard_bucket": 1})
```

5.1.2 Playbook Execution Collection

```
{
  "_id": ObjectId,
  "id": "pb_exec_123456",                // Execution ID
  "parent_playbook_execution_id": "pb_exec_123455",
  "pid": 1001,                           // Playbook ID
  "uid": 2001,                           // User ID
  "request_data": "...",                 // Original request
  "tenant_code": "tenant123",
  "alert_id": 50001,                     // Case/Incident ID
  "is_evidence": "n",
  "created_date": 1694443200000,
  "status": "active",
  "execution_status": "inprogress",      // inprogress, completed, failed, stopped
  "execution_completion_time": 1694443500000,
  "execution_error_msg": "",
  "execution_error_path": "",
  "username": "security_analyst",
  "indicator": "192.168.1.100",
  "playbook_stopped_manually": false,
  "stop_playbook_data": {
    "sub_playbook_execution_id": "pb_exec_sub_001"
  },
  "last_executed_task_seq": 5,
  "total_tasks_count": 15,
  "total_utils_count": 3,
  "playbook_name": "Malware Response",
  "playbook_runtime": 45000,             // milliseconds
  "source": "ui",                        // ui, api, scheduled
  "node_id": "docker_node_1",
  "shard_bucket": 1
}
// Indexes
db.playbook_execution_collection.createIndex({"tenant_code": 1, "alert_id": 1})
db.playbook_execution_collection.createIndex({"execution_status": 1, "created_date": -1})
db.playbook_execution_collection.createIndex({"uid": 1, "created_date": -1})
db.playbook_execution_collection.createIndex({"shard_bucket": 1})
```

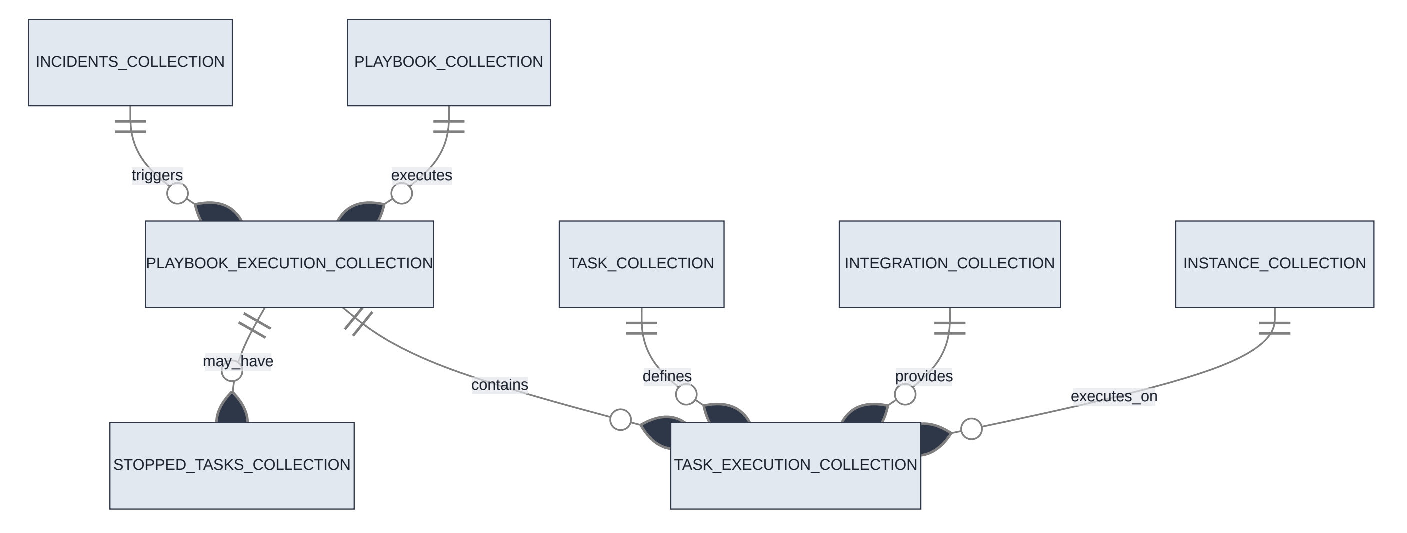
5.1.3 Task Execution Collection

```
{
  "_id": ObjectId,
  "task_request_id": "task_req_789012",
  "description": "Block malicious IP",
  "logo_path": "lib/logo/firewall.png",
  "tenant_code": "tenant123",
  "name": "Block IP Address",
  "app_name": "Palo Alto Firewall",
  "task_id": 301,
  "user_id": 2001,
  "username": "security_analyst",
  "input": "...",                        // Serialized input data
  "processed": "y",                      // y, n
  "created_date": 1694443200000,
  "updated_date": 1694443300000,
  "tasks_tag": "palo_alto_block_ip",
  "rest_url": "https://firewall.api/block",
  "method": "POST",
  "alert_id": 50001,
  "integration_id": 15,
  "instance_id": 150,
  "task_handler": "palo_alto",
  "response": "...",                     // Serialized response
  "is_demo": false,
  "peid": "pb_exec_123456",              // Playbook execution ID
  "task_peid": "",                       // Sub-playbook execution ID
  "task_seq": 3,
  "is_condition": "n",
  "task_condition": "",
  "condition_operator": "",
  "is_evidence": "n",
  "status": "completed",                 // not_started, inprogress, completed, failed
  "playbook_id": "1001",
  "instance_name": "Production Firewall",
  "indicator_type": "ip",
  "task_response_time_stamp": 1694443300000,
  "reputation": "malicious",
  "category": "network_security",
  "function_name": "block_ip_address",
  "filename": "palo_alto_tasks.py",
  "credentials_required": true,
  "task_operator_id": "op_001",
  "indicator": "192.168.1.100",
  "case_description": "Malware infection detected",
  "type": "integration",
  "command": "",
  "generic": false,
  "headers": {
    "Content-Type": "application/json",
    "Authorization": "Bearer token123"
  },
  "content_type": "application/json",
  "request_body": "...",
  "request_type": "POST",
  "task_type": "blocking",
  "custom_task_name": "",
  "playbook_name": "Malware Response",
  "node_id": "docker_node_1",
  "iterate_task": false,
  "iteration_config": "",
  "execution_status": "completed",
  "shard_bucket": 1
}
// Indexes
db.task_execution_collection.createIndex({"peid": 1, "task_seq": 1})
db.task_execution_collection.createIndex({"tenant_code": 1, "alert_id": 1})
db.task_execution_collection.createIndex({"processed": 1, "created_date": 1})
db.task_execution_collection.createIndex({"shard_bucket": 1})
```

5.1.4 Stopped Tasks Collection

```
{
  "_id": ObjectId,
  "case_id": "50001",
  "peid": "pb_exec_123456",
  "task_seq": 5,
  "routine": "MAIN",                    // MAIN, SUB
  "task_name": "Block IP Address",
  "status": "stopped"                   // stopped, resumed
}
// Indexes
db.stopped_tasks_collection.createIndex({"peid": 1, "case_id": 1, "status": 1})
```

5.2 Data Relationships



6. API Specifications

6.1 Playbook Management APIs

6.1.1 Create Playbook

```
POST /createplaybook/
Content-Type: application/json
Authorization: Bearer {jwt_token}

Request Body:
{
  "name": "Malware Response Playbook",
  "description": "Automated response to malware incidents",
  "definition": "...",                    // JSON string
  "chart_definition": "...",              // Visual representation
  "category_id": 5,
  "type": "case",
  "tenant_code": "tenant123",
  "user_id": 1001,
  "version": "1.0.0",
  "is_parallel_playbook": true,
  "total_tasks_count": 15,
  "total_utils_count": 3
}

Response:
{
  "success": true,
  "data": {
    "playbook_id": 1001,
    "filename": "1001_tenant123.json",
    "commit_id": "abc123"
  },
  "error": "",
  "displayMessage": "Playbook created successfully",
  "time": 1694443200000
}
Validation Rules:
- name: Required, max 255 chars, unique per tenant
- description: Optional, max 1000 chars
- definition: Required, valid JSON
- category_id: Required, must exist
- type: Required, enum [case, indicator]
- tenant_code: Required, valid tenant
- user_id: Required, valid user
```

6.1.2 Run Playbook

```
POST /runplaybook/
Content-Type: application/json
Authorization: Bearer {jwt_token}

Request Body:
{
  "tenantcode": "tenant123",
  "playbook_name": "Malware Response Playbook",
  "case_id": "50001",
  "is_bot": "false",
  "uid": "1001",
  "username": "security_analyst",
  "type": "case",
  "indicator": "192.168.1.100",
  "playbook_execution_id": "",           // For resume
  "resume_playbook": "false"
}
Response:
{
  "success": true,
  "data": {
    "playbook_execution_id": "pb_exec_123456",
    "status": "inprogress",
    "total_tasks": 15,
    "estimated_duration": 300000         // milliseconds
  },
  "error": "",
  "displayMessage": "Playbook execution started",
  "time": 1694443200000
}

Validation Rules:
- tenantcode: Required, valid tenant
- playbook_name: Required, must exist and be active
- case_id: Required for type=case
- uid: Required, valid user
- type: Required, enum [case, indicator]
- indicator: Required for type=indicator
```

6.2 Task Management APIs

6.2.1 Run Single Task

```
POST /runtask/
Content-Type: application/json
Authorization: Bearer {jwt_token}

Request Body:
{
  "task_id": 301,
  "tenant_code": "tenant123",
  "case_id": 50001,
  "user_id": 1001,
  "input_fields": [
    {
      "name": "ip_address",
      "value": "192.168.1.100",
      "type": "string"
    }
  ],
  "instance_id": 150,
  "is_demo": false
}
Response:
{
  "success": true,
  "data": {
    "task_request_id": "task_req_789012",
    "status": "inprogress"
  },
  "error": "",
  "displayMessage": "Task execution started",
  "time": 1694443200000
}
```

6.3 Error Response Format

```
{
  "success": false,
  "data": null,
  "error": "Invalid playbook configuration",
  "displayMessage": "The playbook contains invalid task definitions",
  "errorPath": "ExecutionController.ProcessAndExecuteTask",
  "status": "failed",
  "time": 1694443200000
}
```

7. Algorithm Specifications

7.1 Parallel Task Execution Algorithm

```go
func (executionController *PlaybookExecutionController) executeParallelTasks(
    tasks []executionModels.PlayBookTask,
    dockerNodeID string,
    mongodbSession mongo_driver.MongoClientWrapper,
    coreMongodbSession mongo_driver.MongoClientWrapper,
    configObject config.ConfigStruct,
    dbSession map[string]common.SessionStruct,
) error {

    var wg sync.WaitGroup
    var mutex sync.Mutex
    errorChan := make(chan error, len(tasks))
    panicChan := make(chan interface{}, len(tasks))
    ctx, cancel := context.WithCancel(context.Background())
    defer cancel()

    // Create stop lookup channel
    stopLookup := make(chan bool, 1)
    var lookupWg sync.WaitGroup
    lookupWg.Add(1)

    // Start stop lookup goroutine
    go func() {
        defer lookupWg.Done()
        ticker := time.NewTicker(2 * time.Second)
        defer ticker.Stop()

        for {
            select {
            case <-stopLookup:
                return
            case <-ticker.C:
                // Check if playbook should be stopped
                if executionController.checkStopCondition() {
                    cancel()
                    return
                }
            }
        }
    }()

    // Execute tasks in parallel
    for i, task := range tasks {
        wg.Add(1)
        go func(taskIndex int, t executionModels.PlayBookTask) {
            defer wg.Done()
            defer func() {
                if r := recover(); r != nil {
                    panicChan <- r
                }
            }()

            select {
            case <-ctx.Done():
                // Context cancelled, stop execution
                return
            default:
                // Execute task
                err := executionController.ProcessAndExecuteTask(
                    t.TaskSeq,
                    dockerNodeID,
                    mongodbSession,
                    coreMongodbSession,
                    configObject,
                    dbSession,
                    &wg,
                    "PARALLEL",
                    ctx,
                    panicChan,
                )

                if err != nil {
                    mutex.Lock()
                    select {
                    case errorChan <- err:
                    default:
                    }
                    mutex.Unlock()

                    if t.StopOnError {
                        cancel() // Stop all parallel tasks
                    }
                }
            }
        }(i, task)
    }

    // Wait for all tasks to complete
    wg.Wait()

    // Stop the lookup goroutine
    close(stopLookup)
    lookupWg.Wait()

    // Check for errors
    close(errorChan)
    for err := range errorChan {
        if err != nil {
            return err
        }
    }

    // Check for panics
    close(panicChan)
    for panic := range panicChan {
        if panic != nil {
            return fmt.Errorf("panic in task execution: %v", panic)
        }
    }

    return nil
}
```

7.2 Condition Evaluation Algorithm

```go
func (cc *ConditionController) evaluateConditions(
    conditions []executionModels.PlayBookCondition,
    conditionOperator string,
    alertData models.RunPlayBookRequest2,
    executedConditions []executionModels.ExecutedConditionStatus,
) (bool, error) {

    if len(conditions) == 0 {
        return true, nil
    }

    var results []bool

    for _, condition := range conditions {
        result, err := cc.evaluateSingleCondition(
            condition,
            alertData,
            executedConditions,
        )
        if err != nil {
            return false, err
        }
        results = append(results, result)
    }

    // Apply logical operator
    switch strings.ToLower(conditionOperator) {
    case "and":
        return cc.applyAndOperator(results), nil
    case "or":
        return cc.applyOrOperator(results), nil
    default:
        return false, fmt.Errorf("unsupported condition operator: %s", conditionOperator)
    }
}

func (cc *ConditionController) evaluateSingleCondition(
    condition executionModels.PlayBookCondition,
    alertData models.RunPlayBookRequest2,
    executedConditions []executionModels.ExecutedConditionStatus,
) (bool, error) {
    // Get field value from case data or previous task response
    var fieldValue interface{}
    var err error
    if condition.ConditionKeyValue != nil {
        // Static value condition
        fieldValue = condition.ConditionKeyValue
    } else if condition.TaskName != "" {
        // Previous task response condition
        fieldValue, err = cc.getPreviousTaskResponse(
            condition.TaskName,
            condition.ConditionKey,
            executedConditions,
        )
        if err != nil {
            return false, err
        }
    } else {
        // Case field condition
        fieldValue = utils.GetFieldValue(alertData, condition.ConditionKey)
    }

    // Evaluate condition
    return utils.MatchCondition(
        fieldValue,
        condition.ConditionType,
        condition.ConditionValue,
    )
}

func (cc *ConditionController) applyAndOperator(results []bool) bool {
    for _, result := range results {
        if !result {
            return false
        }
    }
    return true
}
func (cc *ConditionController) applyOrOperator(results []bool) bool {
    for _, result := range results {
        if result {
            return true
        }
    }
    return false
}
```

7.3 Cache Management Algorithm

```
type CacheManager struct {
    redisClient   *redis.Client
    localCache    *sync.Map
    ttlMap        *sync.Map
    mutex         sync.RWMutex
    cleanupTicker *time.Ticker
}

func (cm *CacheManager) Get(key string) (interface{}, bool) {
    cm.mutex.RLock()
    defer cm.mutex.RUnlock()
    // Check local cache first
    if value, exists := cm.localCache.Load(key); exists {
        // Check TTL
        if ttl, ok := cm.ttlMap.Load(key); ok {
            if time.Now().Unix() > ttl.(int64) {
                cm.localCache.Delete(key)
                cm.ttlMap.Delete(key)
                return nil, false
            }
            return value, true
        }
    }

    // Fall back to Redis
    result, err := cm.redisClient.Get(key).Result()
    if err != nil {
        return nil, false
    }

    // Parse and cache locally
    var value interface{}
    json.Unmarshal([]byte(result), &value)
    cm.localCache.Store(key, value)

    return value, true
}

func (cm *CacheManager) Set(key string, value interface{}, ttl time.Duration) error {
    cm.mutex.Lock()
    defer cm.mutex.Unlock()
    // Store in local cache
    cm.localCache.Store(key, value)
    if ttl > 0 {
        expiryTime := time.Now().Add(ttl).Unix()
        cm.ttlMap.Store(key, expiryTime)
    }
    // Store in Redis
    data, err := json.Marshal(value)
    if err != nil {
        return err
    }

    return cm.redisClient.Set(key, data, ttl).Err()
}

func (cm *CacheManager) startCleanupRoutine() {
    cm.cleanupTicker = time.NewTicker(5 * time.Minute)

    go func() {
        for range cm.cleanupTicker.C {
            now := time.Now().Unix()
            cm.ttlMap.Range(func(key, value interface{}) bool {
                if now > value.(int64) {
                    cm.localCache.Delete(key)
                    cm.ttlMap.Delete(key)
                }
                return true
            })
        }
    }()
}
```

8. Configuration Management

8.1 Configuration Structure

```
type ConfigStruct struct {
    DatabaseConfig    DatabaseConfig    `json:"database"`
    RedisConfig       RedisConfig       `json:"redis"`
    DockerConfig      DockerConfig      `json:"docker"`
    SecurityConfig    SecurityConfig    `json:"security"`
    LoggingConfig     LoggingConfig     `json:"logging"`
    IntegrationConfig IntegrationConfig `json:"integration"`
}

type DatabaseConfig struct {
    MongoURI        string `json:"mongo_uri"`
    DatabaseName    string `json:"database_name"`
    MaxPoolSize     int    `json:"max_pool_size"`
    MinPoolSize     int    `json:"min_pool_size"`
    MaxIdleTime     int    `json:"max_idle_time"`
    ConnectTimeout  int    `json:"connect_timeout"`
    ShardBucketCount int   `json:"shard_bucket_count"`
}

type RedisConfig struct {
    Host            string `json:"host"`
    Port            int    `json:"port"`
    Password        string `json:"password"`
    Database        int    `json:"database"`
    MaxRetries      int    `json:"max_retries"`
    PoolSize        int    `json:"pool_size"`
    IdleTimeout     int    `json:"idle_timeout"`
}
type SecurityConfig struct {
    JWTSecret           string `json:"jwt_secret"`
    SessionTimeout      int    `json:"session_timeout"`
    MaxLoginAttempts    int    `json:"max_login_attempts"`
    PasswordComplexity  bool   `json:"password_complexity"`
    EncryptionKey       string `json:"encryption_key"`
}
```

8.2 Environment-Based Configuration

```go
func LoadConfiguration() ConfigStruct {
    var config ConfigStruct

    // Load from environment variables
    config.DatabaseConfig.MongoURI = getEnvOrDefault("MONGO_URI", "mongodb://localhost:27017")
    config.DatabaseConfig.DatabaseName = getEnvOrDefault("DB_NAME", "securaa_playbook")
    config.DatabaseConfig.MaxPoolSize = getEnvIntOrDefault("DB_MAX_POOL_SIZE", 100)

    config.RedisConfig.Host = getEnvOrDefault("REDIS_HOST", "localhost")
    config.RedisConfig.Port = getEnvIntOrDefault("REDIS_PORT", 6379)
    config.RedisConfig.Password = getEnvOrDefault("REDIS_PASSWORD", "")

    config.SecurityConfig.JWTSecret = getEnvOrDefault("JWT_SECRET", "")
    config.SecurityConfig.SessionTimeout = getEnvIntOrDefault("SESSION_TIMEOUT", 3600)

    // Load from config file if exists
    if configFile := os.Getenv("CONFIG_FILE"); configFile != "" {
        loadFromFile(&config, configFile)
    }

    // Validate configuration
    if err := validateConfig(config); err != nil {
        log.Fatal("Invalid configuration:", err)
    }

    return config
}

func validateConfig(config ConfigStruct) error {
    if config.DatabaseConfig.MongoURI == "" {
        return errors.New("mongo_uri is required")
    }

    if config.SecurityConfig.JWTSecret == "" {
        return errors.New("jwt_secret is required")
    }

    if config.DatabaseConfig.MaxPoolSize <= 0 {
        return errors.New("max_pool_size must be positive")
    }

    return nil
}
```

9. Error Handling Implementation

9.1 Error Types and Hierarchy

```
type ErrorType string

const (
    ValidationError    ErrorType = "VALIDATION_ERROR"
    DatabaseError      ErrorType = "DATABASE_ERROR"
    IntegrationError   ErrorType = "INTEGRATION_ERROR"
    AuthenticationError ErrorType = "AUTHENTICATION_ERROR"
    AuthorizationError ErrorType = "AUTHORIZATION_ERROR"
    BusinessLogicError ErrorType = "BUSINESS_LOGIC_ERROR"
    SystemError        ErrorType = "SYSTEM_ERROR"
    NetworkError       ErrorType = "NETWORK_ERROR"
)

type ServiceError struct {
    Type        ErrorType `json:"type"`
    Code        string    `json:"code"`
    Message     string    `json:"message"`
    Details     string    `json:"details"`
    Timestamp   int64     `json:"timestamp"`
    RequestID   string    `json:"request_id"`
    UserID      int       `json:"user_id"`
    TenantCode  string    `json:"tenant_code"`
    StackTrace  string    `json:"stack_trace,omitempty"`
    Cause       error     `json:"-"`
}

func (e *ServiceError) Error() string {
    return fmt.Sprintf("[%s] %s: %s", e.Type, e.Code, e.Message)
}

func NewServiceError(errorType ErrorType, code string, message string) *ServiceError {
    return &ServiceError{
        Type:      errorType,
        Code:      code,
        Message:   message,
        Timestamp: time.Now().UnixMilli(),
    }
}
```

9.2 Error Handler Implementation

```go
func HandleError(err error, context string) models.Response {
    var response models.Response
    response.Success = false
    response.Time = time.Now().UnixMilli()

    if serviceErr, ok := err.(*ServiceError); ok {
        response.Error = serviceErr.Message
        response.ErrorPath = context
        response.Status = string(serviceErr.Type)

        // Log structured error
        logger.Error("Service Error",
            "type", serviceErr.Type,
            "code", serviceErr.Code,
            "message", serviceErr.Message,
            "context", context,
            "timestamp", serviceErr.Timestamp,
        )

        // Determine appropriate HTTP status
        switch serviceErr.Type {
        case ValidationError:
            response.DisplayMessage = "Invalid input provided"
        case AuthenticationError:
            response.DisplayMessage = "Authentication required"
        case AuthorizationError:
            response.DisplayMessage = "Access denied"
        case DatabaseError:
            response.DisplayMessage = "Data operation failed"
        case IntegrationError:
            response.DisplayMessage = "External service unavailable"
        default:
            response.DisplayMessage = "An unexpected error occurred"
        }
    } else {
        // Handle generic errors
        response.Error = err.Error()
        response.ErrorPath = context
        response.Status = "error"
        response.DisplayMessage = "An unexpected error occurred"

        logger.Error("Unhandled Error",
            "error", err.Error(),
            "context", context,
        )
    }

    return response
}
```

9.3 Retry Mechanism

```go
type RetryConfig struct {
    MaxAttempts   int           `json:"max_attempts"`
    InitialDelay  time.Duration `json:"initial_delay"`
    MaxDelay      time.Duration `json:"max_delay"`
    BackoffFactor float64       `json:"backoff_factor"`
    RetryableErrors []ErrorType `json:"retryable_errors"`
}

func RetryWithBackoff(
    operation func() error,
    config RetryConfig,
) error {
    var lastErr error
    delay := config.InitialDelay

    for attempt := 1; attempt <= config.MaxAttempts; attempt++ {
        err := operation()
        if err == nil {
            return nil
        }

        lastErr = err

        // Check if error is retryable
        if serviceErr, ok := err.(*ServiceError); ok {
            retryable := false
            for _, retryableType := range config.RetryableErrors {
                if serviceErr.Type == retryableType {
                    retryable = true
                    break
                }
            }
            if !retryable {
                return err
            }
        }

        if attempt < config.MaxAttempts {
            logger.Warn("Operation failed, retrying",
                "attempt", attempt,
                "max_attempts", config.MaxAttempts,
                "delay", delay,
                "error", err.Error(),
            )

            time.Sleep(delay)

            // Calculate next delay with exponential backoff
            delay = time.Duration(float64(delay) * config.BackoffFactor)
            if delay > config.MaxDelay {
                delay = config.MaxDelay
            }
        }
    }

    return fmt.Errorf("operation failed after %d attempts: %w",
        config.MaxAttempts, lastErr)
}
```

10. Concurrency & Thread Safety

10.1 Task Map Thread Safety

```go
type ThreadSafeTaskMap struct {
    tasks map[int]executionModels.PlayBookTask
    mutex sync.RWMutex
}

func NewThreadSafeTaskMap() *ThreadSafeTaskMap {
    return &ThreadSafeTaskMap{
        tasks: make(map[int]executionModels.PlayBookTask),
    }
}

func (tsm *ThreadSafeTaskMap) Set(taskSeq int, task executionModels.PlayBookTask) {
    tsm.mutex.Lock()
    defer tsm.mutex.Unlock()
    tsm.tasks[taskSeq] = task
}

func (tsm *ThreadSafeTaskMap) Get(taskSeq int) (executionModels.PlayBookTask, bool) {
    tsm.mutex.RLock()
    defer tsm.mutex.RUnlock()
    task, exists := tsm.tasks[taskSeq]
    return task, exists
}

func (tsm *ThreadSafeTaskMap) GetAll() map[int]executionModels.PlayBookTask {
    tsm.mutex.RLock()
    defer tsm.mutex.RUnlock()

    // Create a copy to avoid external modifications
    copy := make(map[int]executionModels.PlayBookTask)
    for k, v := range tsm.tasks {
        copy[k] = v
    }
    return copy
}

func (tsm *ThreadSafeTaskMap) Delete(taskSeq int) {
    tsm.mutex.Lock()
    defer tsm.mutex.Unlock()
    delete(tsm.tasks, taskSeq)
}
```

10.2 Channel-Based Communication

```go
type TaskChannel struct {
    taskQueue    chan executionModels.PlayBookTask
    resultQueue  chan TaskResult
    errorQueue   chan error
    stopSignal   chan struct{}
    workerCount  int
    wg           sync.WaitGroup
}

type TaskResult struct {
    TaskSeq  int
    Success  bool
    Response string
    Error    error
}

func NewTaskChannel(bufferSize, workerCount int) *TaskChannel {
    return &TaskChannel{
        taskQueue:   make(chan executionModels.PlayBookTask, bufferSize),
        resultQueue: make(chan TaskResult, bufferSize),
        errorQueue:  make(chan error, bufferSize),
        stopSignal:  make(chan struct{}),
        workerCount: workerCount,
    }
}

func (tc *TaskChannel) Start() {
    for i := 0; i < tc.workerCount; i++ {
        tc.wg.Add(1)
        go tc.worker(i)
    }
}

func (tc *TaskChannel) worker(workerID int) {
    defer tc.wg.Done()

    for {
        select {
        case task := <-tc.taskQueue:
            result := tc.executeTask(task)
            tc.resultQueue <- result

        case <-tc.stopSignal:
            logger.Info("Worker stopping", "worker_id", workerID)
            return
        }
    }
}

func (tc *TaskChannel) SubmitTask(task executionModels.PlayBookTask) {
    select {
    case tc.taskQueue <- task:
        // Task submitted successfully
    case <-time.After(5 * time.Second):
        logger.Error("Task submission timeout", "task_seq", task.TaskSeq)
    }
}

func (tc *TaskChannel) Stop() {
    close(tc.stopSignal)
    tc.wg.Wait()
    close(tc.taskQueue)
    close(tc.resultQueue)
    close(tc.errorQueue)
}
```

10.3 Context-Based Cancellation

```go
func (executionController *PlaybookExecutionController) ProcessWithContext(
    ctx context.Context,
    task executionModels.PlayBookTask,
) error {

    // Create a derived context with timeout
    taskCtx, cancel := context.WithTimeout(ctx, 5*time.Minute)
    defer cancel()

    // Create result channel
    resultChan := make(chan error, 1)

    // Execute task in goroutine
    go func() {
        defer func() {
            if r := recover(); r != nil {
                resultChan <- fmt.Errorf("task panicked: %v", r)
            }
        }()

        err := executionController.executeTaskInternal(taskCtx, task)
        resultChan <- err
    }()

    // Wait for completion or cancellation
    select {
    case err := <-resultChan:
        return err

    case <-taskCtx.Done():
        if taskCtx.Err() == context.DeadlineExceeded {
            return NewServiceError(SystemError, "TASK_TIMEOUT",
                fmt.Sprintf("Task %d timed out", task.TaskSeq))
        }
        return NewServiceError(SystemError, "TASK_CANCELLED",
            fmt.Sprintf("Task %d was cancelled", task.TaskSeq))
    }
}
```

11. Performance Optimizations

11.1 Connection Pool Management

```go
type ConnectionPoolManager struct {
    mongoPool   *mongo.Client
    redisPool   *redis.Client
    httpPool    *http.Client
    config      PoolConfig
}

type PoolConfig struct {
    MongoMaxPoolSize    int
    MongoMinPoolSize    int
    MongoMaxIdleTime    time.Duration
    RedisPoolSize       int
    RedisIdleTimeout    time.Duration
    HTTPMaxIdleConns    int
    HTTPIdleConnTimeout time.Duration
}

func NewConnectionPoolManager(config PoolConfig) *ConnectionPoolManager {
    // Configure MongoDB connection pool
    mongoOpts := options.Client().
        SetMaxPoolSize(uint64(config.MongoMaxPoolSize)).
        SetMinPoolSize(uint64(config.MongoMinPoolSize)).
        SetMaxConnIdleTime(config.MongoMaxIdleTime)

    mongoClient, _ := mongo.Connect(context.Background(), mongoOpts)

    // Configure Redis connection pool
    redisClient := redis.NewClient(&redis.Options{
        PoolSize:    config.RedisPoolSize,
        IdleTimeout: config.RedisIdleTimeout,
    })

    // Configure HTTP client pool
    httpClient := &http.Client{
        Transport: &http.Transport{
            MaxIdleConns:        config.HTTPMaxIdleConns,
            IdleConnTimeout:     config.HTTPIdleConnTimeout,
            TLSHandshakeTimeout: 10 * time.Second,
        },
        Timeout: 30 * time.Second,
    }

    return &ConnectionPoolManager{
        mongoPool: mongoClient,
        redisPool: redisClient,
        httpPool:  httpClient,
        config:    config,
    }
}
```

11.2 Batch Operations

```
func (service *TaskService) BatchUpdateTaskStatus(
    updates []TaskStatusUpdate,
) error {
    const batchSize = 1000

    for i := 0; i < len(updates); i += batchSize {
        end := i + batchSize
        if end > len(updates) {
            end = len(updates)
        }

        batch := updates[i:end]
        if err := service.processBatch(batch); err != nil {
            return err
        }
    }

    return nil
}

func (service *TaskService) processBatch(batch []TaskStatusUpdate) error {
    // Build bulk write operations
    var operations []mongo.WriteModel

    for _, update := range batch {
        filter := bson.M{"task_request_id": update.TaskRequestID}
        updateDoc := bson.M{
            "$set": bson.M{
                "status":         update.Status,
                "response":       update.Response,
                "updated_date":   time.Now().UnixMilli(),
            },
        }

        operation := mongo.NewUpdateOneModel().
            SetFilter(filter).
            SetUpdate(updateDoc)

        operations = append(operations, operation)
    }

    // Execute bulk write
    opts := options.BulkWrite().SetOrdered(false)
    _, err := service.collection.BulkWrite(
        context.Background(),
        operations,
        opts,
    )

    return err
}
```

11.3 Memory Management

```go
type ObjectPool struct {
    pool sync.Pool
}

func NewObjectPool(factory func() interface{}) *ObjectPool {
    return &ObjectPool{
        pool: sync.Pool{
            New: factory,
        },
    }
}

func (op *ObjectPool) Get() interface{} {
    return op.pool.Get()
}

func (op *ObjectPool) Put(obj interface{}) {
    op.pool.Put(obj)
}

// Example usage for task requests
var taskRequestPool = NewObjectPool(func() interface{} {
    return &models.TaskRequest{}
})

func ProcessTaskRequest(data []byte) error {
    // Get object from pool
    req := taskRequestPool.Get().(*models.TaskRequest)
    defer taskRequestPool.Put(req)

    // Reset object state
    *req = models.TaskRequest{}

    // Process request
    if err := json.Unmarshal(data, req); err != nil {
        return err
    }

    // ... process request

    return nil
}
```

12. Testing Strategy

12.1 Unit Testing Structure

```go
// Test file: controllers/playbookcontroller_test.go
package controllers

import (
    "testing"
    "github.com/stretchr/testify/assert"
    "github.com/stretchr/testify/mock"
)

type MockMongoSession struct {
    mock.Mock
}

func (m *MockMongoSession) FindSingleDocument(filter, opts, result interface{}) error {
    args := m.Called(filter, opts, result)
    return args.Error(0)
}

func TestPlaybookController_RunSelectedPlaybook(t *testing.T) {
    // Arrange
    mockSession := new(MockMongoSession)
    controller := NewPlaybookController()

    expectedPlaybook := models.PlaybookObject{
        ID:   1001,
        Name: "Test Playbook",
        Definition: `[{"task_seq": 1, "type": "start"}]`,
    }

    mockSession.On("FindSingleDocument",
        mock.Anything, mock.Anything, mock.Anything).
        Return(nil).
        Run(func(args mock.Arguments) {
            result := args.Get(2).(*models.PlaybookObject)
            *result = expectedPlaybook
        })

    // Act
    result, err := controller.RunSelectedPlaybook(
        "test_tenant",
        "Test Playbook",
        "12345",
        mockSession,
    )

    // Assert
    assert.NoError(t, err)
    assert.NotEmpty(t, result.PlaybookExecutionID)
    mockSession.AssertExpectations(t)
}

func TestPlaybookExecutionController_ParallelExecution(t *testing.T) {
    // Test parallel task execution
    controller := &PlaybookExecutionController{
        PlayBookTasksMap: make(map[int]executionModels.PlayBookTask),
    }

    // Create test tasks
    tasks := []executionModels.PlayBookTask{
        {TaskSeq: 1, TaskName: "Task 1", Type: "integration"},
        {TaskSeq: 2, TaskName: "Task 2", Type: "integration"},
        {TaskSeq: 3, TaskName: "Task 3", Type: "integration"},
    }

    // Execute parallel tasks
    err := controller.executeParallelTasks(tasks, mockSession)

    assert.NoError(t, err)
    assert.Equal(t, 3, len(controller.PlayBookTasksMap))
}
```

12.2 Integration Testing

```go
// Test file: integration/playbook_execution_test.go
package integration

import (
    "testing"
    "context"
    "time"
)

func TestPlaybookExecutionEndToEnd(t *testing.T) {
    // Setup test environment
    testDB := setupTestDatabase(t)
    defer cleanupTestDatabase(testDB)

    testRedis := setupTestRedis(t)
    defer cleanupTestRedis(testRedis)

    // Create test playbook
    playbook := createTestPlaybook(t, testDB)

    // Create test case
    testCase := createTestCase(t, testDB)

    // Execute playbook
    executionID, err := executePlaybook(
        playbook.Name,
        testCase.ID,
        testDB,
        testRedis,
    )

    assert.NoError(t, err)
    assert.NotEmpty(t, executionID)

    // Wait for completion
    timeout := time.After(30 * time.Second)
    ticker := time.Tick(1 * time.Second)

    for {
        select {
        case <-timeout:
            t.Fatal("Playbook execution timeout")
        case <-ticker:
            status := getExecutionStatus(executionID, testDB)
            if status == "completed" {
                return
            }
            if status == "failed" {
                t.Fatal("Playbook execution failed")
            }
        }
    }
}
```

12.3 Performance Testing

```go
// Test file: performance/load_test.go
package performance

import (
    "testing"
    "sync"
    "time"
)

func BenchmarkParallelPlaybookExecution(b *testing.B) {
    controller := setupPlaybookController()

    b.ResetTimer()
    b.RunParallel(func(pb *testing.PB) {
        for pb.Next() {
            _, err := controller.RunSelectedPlaybook(
                "test_tenant",
                "Load Test Playbook",
                generateRandomCaseID(),
                mockSession,
            )
            if err != nil {
                b.Error(err)
            }
        }
    })
}

func TestConcurrentPlaybookExecution(t *testing.T) {
    const numGoroutines = 100
    const numExecutions = 10

    var wg sync.WaitGroup
    controller := setupPlaybookController()

    for i := 0; i < numGoroutines; i++ {
        wg.Add(1)
        go func(routineID int) {
            defer wg.Done()

            for j := 0; j < numExecutions; j++ {
                _, err := controller.RunSelectedPlaybook(
                    fmt.Sprintf("tenant_%d", routineID),
                    "Concurrent Test Playbook",
                    fmt.Sprintf("case_%d_%d", routineID, j),
                    mockSession,
                )

                if err != nil {
                    t.Errorf("Execution failed: %v", err)
                }
            }
        }(i)
    }

    wg.Wait()
}
```

Conclusion

This Low Level Design document provides comprehensive implementation details for the Securaa Playbook Service, including:

- **Detailed component specifications** with class diagrams and method signatures
- **Complete database schema** with indexing strategies
- **API specifications** with validation rules and error handling
- **Algorithm implementations** for critical operations
- **Concurrency patterns** and thread safety mechanisms
- **Performance optimizations** and resource management

- **Testing strategies** for quality assurance

This document serves as the technical blueprint for implementing, maintaining, and extending the Securaa Playbook Service at the code level.