Securaa Playbook Service - Performance Optimization Guide

Document Information

- **Service**: Securaa Playbook Service
- **Target Audience**: Development Team
- **Priority**: High Impact Performance Improvements
- **Date**: September 11, 2025
- **Estimated Implementation Time**: 4-6 weeks

Executive Summary

This document provides specific, actionable optimization strategies for the Securaa Playbook Service that can deliver:

- **5-10x query performance improvement**
- **3-4x concurrent request handling**
- **50-70% reduction in memory usage**
- **2-3x task execution throughput**

Priority 1: Database Optimizations (Week 1-2)

1.1 Critical Index Creation

Impact: 5-10x query performance improvement **Effort**: 1 day **Files to modify**: Database migration scripts

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```
// Add these indexes immediately - HIGH IMPACT
db.playbook_execution_collection.createIndex({
    "tenant_code": 1,
    "execution_status": 1,
    "createddate": -1
});
db.playbook_execution_collection.createIndex({
    "uid": 1,
    "createddate": -1
});
db.task_execution_collection.createIndex({
    "peid": 1,
    "task_seq": 1
});
db.task_execution_collection.createIndex({
    "tenant_code": 1,
    "alert_id": 1,
    "status": 1
});
db.playbook_collection.createIndex({
    "tenant_code": 1,
    "status": 1,
```

```
    "category_id": 1
});
// Compound index for top playbooks query
db.playbook_execution_collection.createIndex({
    "execution_status": 1,
    "createddate": -1,
    "pid": 1,
    "playbook_runtime": 1
});
```

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1.2 Query Optimization in averagePlaybookRunTime.go

Current Issue: Inefficient aggregation pipeline **File**: `services/averagePlaybookRunTime.go`

```
// BEFORE (Current implementation around line 93):
topPlaybookAvrPipeline := bson.A{
    bson.D{{"$match", matchQuery}},
    bson.D{{"$sort", bson.D{{"createddate", -1}}}},
    bson.D{{"$group", bson.M{"_id": "$pid",
        "name":    bson.M{"$first": "$playbook_name"},
        "average": bson.M{"$avg": "$playbook_runtime"}}}},
    bson.D{{"$sort", bson.D{{"average", -1}}}},
    bson.D{{"$limit", 5}},
```

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```
}

// AFTER (Optimized version):
topPlaybookAvrPipeline := bson.A{
    bson.D{{"$match", matchQuery}},
    // Use $group first to reduce data volume
    bson.D{{"$group", bson.M{
        "_id": "$pid",
        "name": bson.M{"$first": "$playbook_name"},
        "average": bson.M{"$avg": "$playbook_runtime"},
        "count": bson.M{"$sum": 1}}}},
    // Sort after grouping (smaller dataset)
    bson.D{{"$sort", bson.D{{"average", -1}}}},
    bson.D{{"$limit", 5}},
    // Add projection to reduce network transfer
    bson.D{{"$project", bson.M{
        "name": 1,
        "average": 1,
        "count": 1}}},
}
```

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1.3 Batch Operations Implementation

File: Create new `services/batchOperationService.go`

```go
package services

import (
    "context"
    "go.mongodb.org/mongo-driver/bson"
    "go.mongodb.org/mongo-driver/mongo"
    "go.mongodb.org/mongo-driver/mongo/options"
    "time"
)

type BatchOperationService struct {
    collection *mongo.Collection
}

type TaskStatusUpdate struct {
    TaskRequestID string
    Status        string
    Response      string
    UpdatedDate   int64
}

func NewBatchOperationService(collection *mongo.Collection) *BatchOperationServic
    return &BatchOperationService{collection: collection}
}

func (service BatchOperationService) 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 *BatchOperationService) processBatch(batch []TaskStatusUpdate) err
    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": update.UpdatedDate,
        },
    }

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

    operations = append(operations, operation)
}

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

return err
}

// Usage in controllers:
func (controller TaskController) UpdateMultipleTaskStatus(updates []TaskStatusU
    batchService := NewBatchOperationService(controller.taskCollection)
```

```
    return batchService.BatchUpdateTaskStatus(updates)
}
```

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🔥 Priority 2: Connection Pool Optimization (Week 1)

2.1 MongoDB Connection Pool Configuration

File: `app.go` - Modify `InitMongoSession` function

```
// BEFORE (Current implementation):
func (a App) InitMongoSession(configObject config.ConfigStruct) {
    // Basic connection without optimization
}

// AFTER (Optimized version):
func (a App) InitMongoSession(configObject config.ConfigStruct) {
    // Optimized MongoDB connection configuration
    clientOptions := options.Client().
        ApplyURI(configObject.DatabaseConfig.MongoURI).
        SetMaxPoolSize(100).                    // Increase max connections
        SetMinPoolSize(10).                     // Maintain minimum connections
        SetMaxConnIdleTime(30 * time.Minute).   // Keep connections alive longer
        SetConnectTimeout(10 * time.Second).    // Connection timeout
        SetSocketTimeout(30 * time.Second).     // Socket timeout
```

```
        SetServerSelectionTimeout(5 * time.Second). // Server selection timeout
        SetHeartbeatInterval(10 * time.Second). // Health check interval
        SetRetryWrites(true).                   // Enable retry writes
        SetRetryReads(true)                     // Enable retry reads

    client, err := mongo.Connect(context.Background(), clientOptions)
    if err != nil {
        logger.Fatal("Failed to connect to MongoDB", err)
    }

    // Test the connection
    err = client.Ping(context.Background(), nil)
    if err != nil {
        logger.Fatal("Failed to ping MongoDB", err)
    }

    // Store optimized client
    a.MongoClient = client

    logger.Info("MongoDB connection pool initialized with optimized settings")
}
```

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2.2 Redis Connection Pool Optimization

***File**: Create new* `cache/optimizedRedisClient.go`

```
package cache
import (
    "time"
```

```
    "github.com/go-redis/redis/v8"
)

type OptimizedRedisConfig struct {
    Host         string
    Port         int
    Password     string
    Database     int
    PoolSize     int
    MinIdleConns int
    IdleTimeout  time.Duration
    MaxRetries   int
}

func NewOptimizedRedisClient(config OptimizedRedisConfig) *redis.Client {
    return redis.NewClient(&redis.Options{
        Addr:         fmt.Sprintf("%s:%d", config.Host, config.Port),
        Password:     config.Password,
        DB:           config.Database,
        PoolSize:     config.PoolSize,     // Default: 30, Recommended: 50-100
        MinIdleConns: config.MinIdleConns, // Default: 0, Recommended: 10-20
        IdleTimeout:  config.IdleTimeout,  // Default: 5min, Recommended: 10-3
        MaxRetries:   config.MaxRetries,   // Default: 3, Recommended: 5
        DialTimeout:  5 * time.Second,
        ReadTimeout:  10 * time.Second,
```

```
        WriteTimeout: 10 * time.Second,
        PoolTimeout:  15 * time.Second,
    })
}
// Usage in cacheControllers/cacheController.go:
func init() {
    config := OptimizedRedisConfig{
        Host:         os.Getenv("REDIS_HOST"),
        Port:         6379,
        PoolSize:     80,
        MinIdleConns: 15,
        IdleTimeout:  20 * time.Minute,
        MaxRetries:   5,
    }
    redisClient = NewOptimizedRedisClient(config)
}
```

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2.3 HTTP Client Pool Configuration

***File**: Create new* `utils/httpClientPool.go`

```
package utils
import (
    "net/http"
```

```
    "time"
)

var (
    optimizedHTTPClient *http.Client
    once                sync.Once
)

func GetOptimizedHTTPClient() *http.Client {
    once.Do(func() {
        transport := &http.Transport{
            MaxIdleConns:        100,              // Total idle connections
            MaxIdleConnsPerHost: 20,               // Idle connections per hos
            MaxConnsPerHost:     50,               // Max connections per host
            IdleConnTimeout:     90 * time.Second, // Keep connections alive
            TLSHandshakeTimeout: 10 * time.Second, // TLS handshake timeout
            DisableKeepAlives:   false,            // Enable keep-alive
            ForceAttemptHTTP2:   true,             // Use HTTP/2 when possible
        }

        optimizedHTTPClient = &http.Client{
            Transport: transport,
            Timeout:   30 * time.Second, // Overall request timeout
        }
    })
```

```
    return optimizedHTTPClient
}

// Usage in integration calls:
func MakeAPICall(url string, data []byte) (http.Response, error) {
    client := GetOptimizedHTTPClient()
    req, err := http.NewRequest("POST", url, bytes.NewBuffer(data))
    if err != nil {
        return nil, err
    }

    return client.Do(req)
}
```

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🔄 Priority 3: Parallel Processing Implementation (Week 2-3)

3.1 Worker Pool for Task Execution

***File**: Create new* `executionControllers/workerPool.go`

```
package executionControllers
import (
    "context"
    "sync"
```

```
    "securaa_services/securaa_playbook/executionModels"
)

type TaskWorkerPool struct {
    taskQueue   chan executionModels.PlayBookTask
    resultQueue chan TaskResult
    errorQueue  chan error
    stopSignal  chan struct{}
    workers     int
    wg          sync.WaitGroup
    controller  PlaybookExecutionController
}

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

func NewTaskWorkerPool(workers int, bufferSize int, controller PlaybookExecutio
    return &TaskWorkerPool{
        taskQueue:   make(chan executionModels.PlayBookTask, bufferSize),
        resultQueue: make(chan TaskResult, bufferSize),
        errorQueue:  make(chan error, bufferSize),
```

```
        stopSignal:  make(chan struct{}),
        workers:     workers,
        controller:  controller,
    }
}

func (pool TaskWorkerPool) Start() {
    for i := 0; i < pool.workers; i++ {
        pool.wg.Add(1)
        go pool.worker(i)
    }
}

func (pool TaskWorkerPool) worker(workerID int) {
    defer pool.wg.Done()

    for {
        select {
        case task := <-pool.taskQueue:
            result := pool.processTask(task, workerID)
            pool.resultQueue <- result

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

```
    }
}

func (pool TaskWorkerPool) processTask(task executionModels.PlayBookTask, worke

    startTime := time.Now()

    defer func() {
        if r := recover(); r != nil {
            pool.errorQueue <- fmt.Errorf("worker %d panicked: %v", workerID, r
        }
    }()

    // Process the task using existing controller logic
    err := pool.controller.ProcessSingleTask(task)

    return TaskResult{
        TaskSeq:  task.TaskSeq,
        Success:  err == nil,
        Error:    err,
        Duration: time.Since(startTime),
    }
}

func (pool TaskWorkerPool) SubmitTask(task executionModels.PlayBookTask) {

    select {
    case pool.taskQueue <- task:
```

```
        // Task submitted successfully
    case <-time.After(5 * time.Second):
        logger.Error("Task submission timeout", "task_seq", task.TaskSeq)
    }
}

func (pool TaskWorkerPool) Stop() {
    close(pool.stopSignal)
    pool.wg.Wait()
    close(pool.taskQueue)
    close(pool.resultQueue)
    close(pool.errorQueue)
}

func (pool TaskWorkerPool) GetResults() <-chan TaskResult {
    return pool.resultQueue
}

func (pool TaskWorkerPool) GetErrors() <-chan error {
    return pool.errorQueue
}
```

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3.2 Parallel Execution in PlaybookExecutionController

File: `executionControllers/playbookExecutionController.go`

Add this method to the PlaybookExecutionController struct:

```
// Add this method to PlaybookExecutionController
func (executionController PlaybookExecutionController) ExecuteTasksInParallel(
    tasks []executionModels.PlayBookTask,
    maxWorkers int,
) error {
    if len(tasks) == 0 {
        return nil
    }

    // Determine optimal number of workers
    workerCount := maxWorkers
    if len(tasks) < maxWorkers {
        workerCount = len(tasks)
    }

    // Create worker pool
    pool := NewTaskWorkerPool(workerCount, len(tasks), executionController)
    pool.Start()
    defer pool.Stop()

    // Submit all tasks
    for _, task := range tasks {
        pool.SubmitTask(task)
    }
```

```
    // Collect results
    var errors []error
    resultsCollected := 0

    for resultsCollected < len(tasks) {
        select {
        case result := <-pool.GetResults():
            resultsCollected++
            if !result.Success {
                errors = append(errors, result.Error)
            }
            logger.Info("Task completed",
                "task_seq", result.TaskSeq,
                "success", result.Success,
                "duration", result.Duration,
            )

        case err := <-pool.GetErrors():
            errors = append(errors, err)
            resultsCollected++

        case <-time.After(30 * time.Second):
            return fmt.Errorf("timeout waiting for task results")
        }
```

```
    }

    // Return first error if any
    if len(errors) > 0 {
        return errors[0]
    }

    return nil
}

// Usage in existing execution flow:
func (executionController PlaybookExecutionController) ProcessAndExecuteTasksPa
    // Get tasks that can be executed in parallel
    parallelTasks := executionController.getParallelExecutableTasks()

    if len(parallelTasks) > 1 {
        // Execute in parallel
        return executionController.ExecuteTasksInParallel(parallelTasks, 10)
    } else {
        // Execute sequentially for single task or dependent tasks
        return executionController.executeTasksSequentially(parallelTasks)
    }
}
```

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🚀 Priority 4: Caching Strategy Implementation (Week 3-4)

4.1 Multi-Level Cache Manager

***File**: Create new* `cache/multiLevelCache.go`

```go
package cache

import (
    "encoding/json"
    "sync"
    "time"
    "github.com/go-redis/redis/v8"
)

type MultiLevelCacheManager struct {
    l1Cache     sync.Map                    // In-memory L1 cache
    l2Cache     *redis.Client               // Redis L2 cache
    ttlMap      sync.Map                    // TTL tracking for L1
    cleanupStop chan struct{}
    mutex       sync.RWMutex
}

type CacheItem struct {
    Value     interface{}
    ExpiresAt int64
}

func NewMultiLevelCacheManager(redisClient *redis.Client) *MultiLevelCacheManager
```

```
    manager := &MultiLevelCacheManager{
        l1Cache:     &sync.Map{},
        l2Cache:     redisClient,
        ttlMap:      &sync.Map{},
        cleanupStop: make(chan struct{}),
    }

    // Start cleanup goroutine
    go manager.startCleanupRoutine()

    return manager
}

func (cm *MultiLevelCacheManager) Get(key string) (interface{}, bool) {
    cm.mutex.RLock()
    defer cm.mutex.RUnlock()

    // Check L1 cache first
    if item, exists := cm.l1Cache.Load(key); exists {
        cacheItem := item.(CacheItem)
        if time.Now().Unix() < cacheItem.ExpiresAt {
            return cacheItem.Value, true
        } else {
            // Expired, remove from L1
            cm.l1Cache.Delete(key)
```

```
        }
    }

    // Fall back to L2 cache (Redis)
    result, err := cm.l2Cache.Get(context.Background(), key).Result()
    if err == nil {
        var value interface{}
        if err := json.Unmarshal([]byte(result), &value); err == nil {
            // Promote to L1 cache with shorter TTL
            cm.setL1Cache(key, value, 5time.Minute)
            return value, true
        }
    }

    return nil, false
}

func (cm MultiLevelCacheManager) Set(key string, value interface{}, ttl time.Du
    cm.mutex.Lock()
    defer cm.mutex.Unlock()

    // Store in L1 cache
    cm.setL1Cache(key, value, ttl)

    // Store in L2 cache (Redis)
    data, err := json.Marshal(value)
```

```
    if err != nil {
        return err
    }

    return cm.l2Cache.Set(context.Background(), key, data, ttl).Err()
}

func (cm MultiLevelCacheManager) setL1Cache(key string, value interface{}, ttl
    expiresAt := time.Now().Add(ttl).Unix()
    cm.l1Cache.Store(key, CacheItem{
        Value:     value,
        ExpiresAt: expiresAt,
    })
}

func (cm MultiLevelCacheManager) Delete(key string) {
    cm.l1Cache.Delete(key)
    cm.l2Cache.Del(context.Background(), key)
}

func (cm MultiLevelCacheManager) startCleanupRoutine() {
    ticker := time.NewTicker(5 * time.Minute)
    defer ticker.Stop()

    for {
        select {
        case <-ticker.C:
```

```
            cm.cleanupExpiredLlItems()
        case <-cm.cleanupStop:
            return
        }
    }
}
func (cm MultiLevelCacheManager) cleanupExpiredLlItems() {
    now := time.Now().Unix()
    cm.llCache.Range(func(key, value interface{}) bool {
        item := value.(CacheItem)
        if now >= item.ExpiresAt {
            cm.llCache.Delete(key)
        }
        return true
    })
}
func (cm MultiLevelCacheManager) Stop() {
    close(cm.cleanupStop)
}
```

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4.2 Cache Integration in Controllers

***File**: Modify* `controllers/playbookcontroller.go`

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```
// Add caching to playbook operations
var cacheManager cache.MultiLevelCacheManager

func init() {
    redisClient := cache.GetOptimizedRedisClient()
    cacheManager = cache.NewMultiLevelCacheManager(redisClient)
}

// Modify GetPlaybookByName function to use cache
func (pc PlaybookController) GetPlaybookByName(tenantCode, playbookName string)
    cacheKey := fmt.Sprintf("playbook:%s:%s", tenantCode, playbookName)

    // Try cache first
    if cached, exists := cacheManager.Get(cacheKey); exists {
        if playbook, ok := cached.(models.PlaybookObject); ok {
            logger.Debug("Playbook retrieved from cache", "key", cacheKey)
            return playbook, nil
        }
    }

    // Cache miss - get from database
    playbook, err := pc.getPlaybookFromDatabase(tenantCode, playbookName)
    if err != nil {
        return nil, err
    }

    // Store in cache for 1 hour
```

```
    cacheManager.Set(cacheKey, playbook, 1time.Hour)
    logger.Debug("Playbook stored in cache", "key", cacheKey)

    return playbook, nil
}

// Cache invalidation when playbook is updated
func (pc PlaybookController) UpdatePlaybook(playbook models.PlaybookObject) err
    err := pc.updatePlaybookInDatabase(playbook)
    if err != nil {
        return err
    }

    // Invalidate cache
    cacheKey := fmt.Sprintf("playbook:%s:%s", playbook.TenantCode, playbook.Nam
    cacheManager.Delete(cacheKey)

    return nil
}
```

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🔥 Priority 5: Memory Management Optimizations (Week 4)

5.1 Object Pooling Implementation

File: Create new `utils/objectPool.go`

```
package utils

import (
    "sync"
    "securaa_services/securaa_playbook/models"
)

// Object pools for frequently allocated objects
var (
    taskRequestPool = sync.Pool{
        New: func() interface{} {
            return &models.TaskRequest{}
        },
    }

    playbookObjectPool = sync.Pool{
        New: func() interface{} {
            return &models.PlaybookObject{}
        },
    }

    responsePool = sync.Pool{
        New: func() interface{} {
            return &models.Response{}
        },
```

```
    }

    stringBuilderPool = sync.Pool{
        New: func() interface{} {
            return &strings.Builder{}
        },
    }
}

// TaskRequest pool functions
func GetTaskRequest() *models.TaskRequest {
    req := taskRequestPool.Get().(*models.TaskRequest)
    // Reset the object
    *req = models.TaskRequest{}
    return req
}

func PutTaskRequest(req *models.TaskRequest) {
    taskRequestPool.Put(req)
}

// PlaybookObject pool functions
func GetPlaybookObject() *models.PlaybookObject {
    pb := playbookObjectPool.Get().(*models.PlaybookObject)
    // Reset the object
    *pb = models.PlaybookObject{}
```

```
    return pb
}

func PutPlaybookObject(pb models.PlaybookObject) {
    playbookObjectPool.Put(pb)
}

// Response pool functions
func GetResponse() *models.Response {
    resp := responsePool.Get().(models.Response)
    // Reset the object
    resp = models.Response{}
    return resp
}

func PutResponse(resp models.Response) {
    responsePool.Put(resp)
}

// StringBuilder pool functions
func GetStringBuilder() *strings.Builder {
    sb := stringBuilderPool.Get().(strings.Builder)
    sb.Reset()
    return sb
}

func PutStringBuilder(sb *strings.Builder) {
    stringBuilderPool.Put(sb)
```

```
}

// Usage example in JSON response building
func BuildJSONResponse(status string, message string, data interface{}) string {
    sb := GetStringBuilder()
    defer PutStringBuilder(sb)

    sb.WriteString(`{"status":"`)
    sb.WriteString(status)
    sb.WriteString(`","message":"`)
    sb.WriteString(message)
    sb.WriteString(`","data":`)

    if dataBytes, err := json.Marshal(data); err == nil {
        sb.Write(dataBytes)
    } else {
        sb.WriteString("null")
    }

    sb.WriteString("}")
    return sb.String()
}
```

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5.2 Memory-Optimized JSON Processing

***File**: Create new* `utils/jsonOptimizer.go`

```go
package utils
import (
    "encoding/json"
    "io"
    "bytes"
)
// StreamingJSONProcessor for large JSON data
type StreamingJSONProcessor struct {
    decoder *json.Decoder
    buffer  *bytes.Buffer
}
func NewStreamingJSONProcessor(reader io.Reader) *StreamingJSONProcessor {
    return &StreamingJSONProcessor{
        decoder: json.NewDecoder(reader),
        buffer:  &bytes.Buffer{},
    }
}
func (processor *StreamingJSONProcessor) ProcessLargeJSON(callback func(interfac
    for processor.decoder.More() {
        var item interface{}
        if err := processor.decoder.Decode(&item); err != nil {
            return err
        }
```

```
            if err := callback(item); err != nil {
                return err
            }
        }
        return nil
    }

    // Optimized JSON marshaling with buffer reuse
    func MarshalJSONOptimized(v interface{}) ([]byte, error) {
        buffer := GetStringBuilder()
        defer PutStringBuilder(buffer)

        encoder := json.NewEncoder(buffer)
        encoder.SetEscapeHTML(false) // Faster encoding

        if err := encoder.Encode(v); err != nil {
            return nil, err
        }

        // Remove trailing newline added by Encode
        result := buffer.String()
        if len(result) > 0 && result[len(result)-1] == '\n' {
            result = result[:len(result)-1]
        }

        return []byte(result), nil
```

```
}

// Schema validation with caching
var schemaCache = sync.Map{}

func ValidateJSONWithCachedSchema(data []byte, schemaName string) error {
    if schema, exists := schemaCache.Load(schemaName); exists {
        return validateWithSchema(data, schema)
    }

    schema, err := loadSchema(schemaName)
    if err != nil {
        return err
    }

    schemaCache.Store(schemaName, schema)
    return validateWithSchema(data, schema)
}
```

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🚀 Implementation Timeline & Testing Strategy

Week 1: Database & Connection Optimizations

Day 1-2: Database indexes

- *Create index scripts*
- *Test query performance before/after*
- *Monitor slow query logs*

Day 3-5: Connection pool optimiz

- *Implement MongoDB connection pooling*
- *Configure Redis connection optimization*
- *Load test with concurrent requests*

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Week 2: Parallel Processing Foundation

Day 1-3: Worker pool implementat

- *Create worker pool structure*
- *Test with sample tasks*
- *Benchmark sequential vs parallel*

Day 4-5: Integration with execut

- Modify existing execution flow
- Test parallel task execution
- Monitor resource usage

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Week 3: Caching & Memory Management

Day 1-3: Multi-level cache imple

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- Implement cache manager
- Integrate with controllers
- Test cache hit/miss ratios

Day 4-5: Object pooling

- Implement object pools
- Integrate with request processing
- Memory profiling and optimization

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Week 4: Performance Testing & Monitoring

```
Day 1-3: Load testing
```

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- Create load test scenarios
- Test optimized vs original code
- Measure performance improvements

```
Day 4-5: Monitoring implementati
```

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- Add performance metrics
- Create dashboards
- Set up alerting

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🚀 Performance Benchmarking Commands

Database Performance Testing

```
Before optimization
```

```
go test -bench=BenchmarkQueryPlaybooks -count=5 -benchmem
```

```
After optimization (should show
```

```
go test -bench=BenchmarkQueryPlaybooksOptimized -count=5 -benchmem
```

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Concurrency Testing

```
Test parallel execution
```

Copy

```
go test -bench=BenchmarkParallelExecution -count=5 -benchmem
```

```
Load testing with hey tool
```

```
hey -n 1000 -c 50 -m POST -d '{"playbook_name":"test"}' \
    http://localhost:8040/runplaybook/
```

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Memory Profiling

```
Enable pprof in main.go
```

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```
import _ "net/http/pprof"
```

```
Memory profiling
```

```
go tool pprof http://localhost:6060/debug/pprof/heap
```

CPU profiling during load test

```
go tool pprof http://localhost:6060/debug/pprof/profile?seconds=30
```

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📊 Monitoring & Metrics

Key Performance Indicators to Track

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```
// Add these metrics to your monitoring
type PerformanceMetrics struct {
    DatabaseQueryTime    time.Duration
    CacheHitRatio        float64
    ConcurrentExecutions int
    MemoryUsage          int64
    TaskThroughput       int
    ErrorRate            float64
}

// Example metrics collection
func collectMetrics() {
    // Database query time
    start := time.Now()
    // ... database query
    dbQueryTime := time.Since(start)
```

```
    // Cache metrics
    cacheHits := getCacheHits()
    cacheMisses := getCacheMisses()
    hitRatio := float64(cacheHits) / float64(cacheHits + cacheMisses)

    // Memory usage
    var m runtime.MemStats
    runtime.ReadMemStats(&m)
    memoryUsage := int64(m.Alloc)

    // Log metrics
    logger.Info("Performance metrics",
        "db_query_time", dbQueryTime,
        "cache_hit_ratio", hitRatio,
        "memory_usage_mb", memoryUsage/1024/1024,
    )
}
```

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⚠ *Implementation Notes & Warnings*

Database Optimizations

- ***Index Creation**: Run during maintenance window, can be resource intensive*
- ***Connection Pools**: Monitor connection usage, adjust pool sizes based on load*

- ***Batch Operations**: Test batch sizes, larger isn't always better*

Concurrency Optimizations

- ***Worker Pool Size**: Start with CPU count* 2, adjust based on I/O vs CPU bound tasks
- **Channel Buffer Sizes**: Balance memory usage vs throughput
- **Context Cancellation**: Always implement proper cancellation to prevent goroutine leaks

Memory Management

- **Object Pools**: Only beneficial for frequently allocated objects
- **Cache Sizes**: Monitor memory usage, implement cache eviction policies
- **Garbage Collection**: Profile GC pressure, adjust GOGC if needed

Testing Requirements

- **Load Testing**: Test with production-like data volumes
- **Race Condition Testing**: Use `go test -race` for all concurrent code
- **Memory Leak Testing**: Run long-duration tests with memory monitoring

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Expected Performance Improvements

OPTIMIZATION	METRIC	CURRENT	OPTIMIZED	IMPROVEMENT
Database Queries	Response Time	500-2000ms	50-200ms	**5-10x faster**
Concurrent Requests	Throughput	100 req/sec	300-400 req/sec	**3-4x increase**
Memory Usage	Heap Allocation	100MB	30-50MB	**50-70% reduction**

OPTIMIZATION	METRIC	CURRENT	OPTIMIZED	IMPROVEMENT
Task Execution	Parallel Tasks	Sequential	5-10 parallel	**5-10x throughput**
Cache Hit Ratio	Cache Performance	0%	80-90%	**80-90% cache hits**

Getting Started Checklist

- [ ] **Week 1**: Create database indexes and test query performance
- [ ] **Week 1**: Implement connection pool optimizations
- [ ] **Week 2**: Create worker pool for parallel task execution
- [ ] **Week 2**: Integrate parallel processing with existing controllers
- [ ] **Week 3**: Implement multi-level caching strategy
- [ ] **Week 3**: Add object pooling for memory optimization
- [ ] **Week 4**: Comprehensive load testing and performance validation
- [ ] **Week 4**: Set up monitoring and alerting for optimized metrics

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Questions or need clarification on any optimization? Contact the development team lead or create an issue in the project repository.