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

```
// 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
```

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```
});

// 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`

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```
// 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}},

}

// 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`

```
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)
BatchOperationService {

    return &BatchOperationService{collection: collection}

}

func (service BatchOperationService) BatchUpdateTaskStatus(

    updates []TaskStatusUpdate,

) error {
```

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```
    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) error {
    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
[]TaskStatusUpdate) error {
```

```
    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)
```

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```
    }

    // 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`*

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```
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: 10-30min
        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 host

            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

}
```

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```
func NewTaskWorkerPool(workers int, bufferSize int, controller
PlaybookExecutionController) TaskWorkerPool {

    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,
workerID int) TaskResult {
    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)
```

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```
    }

    // 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)
ProcessAndExecuteTasksParallel() error {
    // 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`

```
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.Duration) error {
    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 time.Duration) {

    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.cleanupExpiredL1Items()

        case <-cm.cleanupStop:
```

```
            return
        }
    }
}
func (cm MultiLevelCacheManager) cleanupExpiredL1Items() {
    now := time.Now().Unix()
    cm.l1Cache.Range(func(key, value interface{}) bool {
        item := value.(CacheItem)
        if now >= item.ExpiresAt {
            cm.l1Cache.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`

```
// 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) (models.PlaybookObject, error) {

    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

    }
```

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```
    // 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) error {
    err := pc.updatePlaybookInDatabase(playbook)
    if err != nil {
        return err
    }

    // Invalidate cache
    cacheKey := fmt.Sprintf("playbook:%s:%s", playbook.TenantCode,
playbook.Name)
    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`

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```
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`*

```
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(interface{}) error) error {

    for processor.decoder.More() {

        var item interface{}

        if err := processor.decoder.Decode(&item); err != nil {

            return err
```

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```
        }

        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

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```
# Day 1-2: Database indexes

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

# Day 3-5: Connection pool optimization

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

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Week 2: Parallel Processing Foundation

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Day 1-3: Worker pool implementation

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

Day 4-5: Integration with execution controller

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

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Week 3: Caching & Memory Management

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Day 1-3: Multi-level cache implementation

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

Day 4-5: Object pooling

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

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Week 4: Performance Testing & Monitoring

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Day 1-3: Load testing

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

Day 4-5: Monitoring implementation

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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 5-10x improvement)
go test -bench=BenchmarkQueryPlaybooksOptimized -count=5 -benchmem
```

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Concurrency Testing

```
# Test parallel execution
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

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```
# Enable pprof in main.go

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**
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.