

NMICPS Backend Application - Functional Report

Executive Summary

The NMICPS (National Mission on Interdisciplinary Cyber-Physical Systems) Backend Application is a comprehensive RESTful API system designed to manage technology innovation hubs across India. The application provides multi-role authentication, performance target management, hub administration, and comprehensive reporting capabilities.

1. System Overview

1.1 Application Purpose

- **Primary Function:** Management platform for technology innovation hubs under NMICPS
- **Target Users:** Hub administrators, super administrators, moderators, and system administrators
- **Geographic Scope:** Pan-India technology innovation hubs
- **Data Management:** Performance targets, user management, hub information, and reporting

1.2 Core Business Functions

- Hub registration and management
 - Performance target setting and tracking
 - Multi-level user authentication and authorization
 - Excel report generation and export
 - File upload and document management
 - Real-time data aggregation and analytics
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2. Functional Architecture

2.1 User Management System

2.1.1 User Roles and Permissions

Role	Access Level	Capabilities	Data Scope
Root	System Level	Full system access, create superadmin	All data
Superadmin	Platform Level	Manage all hubs, users, targets	All hubs
Admin	Hub Level	Manage own hub, users, data	Single hub
Moderator	Limited Hub	View and edit hub data	Single hub

2.1.2 Authentication Functions

- **Login System:** Multi-role authentication with JWT tokens
- **Password Management:** Secure hashing with bcrypt

- **Session Management:** HTTP-only cookies with secure settings
- **Password Reset:** Role-based password reset functionality

2.2 Hub Management System

2.2.1 Hub Registration

- **Hub Creation:** Superadmin/root can create new technology innovation hubs
- **Hub Information:** Institute name, hub name, technology vertical, URL, address
- **Logo Upload:** File upload capability for hub branding
- **Contact Management:** Project director and CEO information

2.2.2 Hub Operations

- **Hub Listing:** View all registered hubs
- **Hub Details:** Individual hub information retrieval
- **Hub Updates:** Modify hub information and contact details
- **Hub Search:** Find hubs by various criteria

2.3 Performance Target Management

2.3.1 Target Setting

- **Target Creation:** Superadmin can set performance targets
- **Bulk Operations:** Update multiple targets simultaneously
- **Year-wise Planning:** Targets organized by fiscal years
- **Category-wise Organization:** Targets categorized by technology domains

2.3.2 Target Tracking

- **Achievement Monitoring:** Track achieved vs set targets
- **Progress Reporting:** Real-time progress updates
- **Validation:** Invalid target tracking and reporting
- **Historical Data:** Year-over-year performance comparison

2.3.3 Reporting Functions

- **Excel Export:** Generate detailed Excel reports
- **Aggregated Reports:** System-wide performance summaries
- **Hub-specific Reports:** Individual hub performance data
- **Category-wise Reports:** Technology domain specific reports

2.4 Technology Development Tracking

2.4.1 Technology Products

- **Product Registration:** Track technology products and prototypes
- **TRL Levels:** Technology Readiness Level tracking
- **Commercialization:** Transfer status and value tracking

- **Project Management:** Project timelines and values

2.4.2 Research Activities

- **Publication Tracking:** Research publication management
- **IPR Activities:** Intellectual Property Rights tracking
- **CPS Research:** Cyber-Physical Systems research base
- **Technology Count:** Number of technologies developed

2.5 Entrepreneurship Development

2.5.1 Startup Ecosystem

- **TBI Management:** Technology Business Incubator tracking
- **Startup Creation:** Startup and spin-off company tracking
- **GCC Activities:** Global Capability Center operations
- **Prayas Program:** Innovation program tracking

2.5.2 Job Creation

- **Employment Tracking:** Direct and indirect job creation
- **Skill Development:** Training and skill development programs
- **Fellowship Programs:** Research fellowship management

2.6 Human Resources Management

2.6.1 Faculty and Staff

- **Faculty Chair:** Distinguished faculty chair positions
- **Skill Development:** Training program management
- **International Collaboration:** Global partnership tracking
- **Resource Management:** TIH resource utilization

2.7 Document Management

2.7.1 File Operations

- **Document Upload:** Multi-format document storage
- **File Organization:** Role-based file organization
- **Document Retrieval:** Secure document access
- **File Deletion:** Authorized file removal

3. API Functional Specifications

3.1 Authentication APIs

3.1.1 User Authentication

```
POST /auth/login
```

Function: Authenticate users across all roles **Input:** Email, password, role **Output:** JWT token, user information
Security: bcrypt password verification

3.1.2 User Registration

```
POST /auth/register/admin  
POST /auth/register/moderator
```

Function: Create new hub users **Input:** User details, hub information **Output:** Created user with token
Authorization: Role-based access control

3.1.3 Password Management

```
PATCH /auth/change-password  
POST /auth/resetPassword
```

Function: Password change and reset **Input:** Old/new passwords or reset credentials **Output:** Success confirmation **Security:** Role-based password policies

3.2 Hub Management APIs

3.2.1 Hub Operations

```
POST /hub/createHub  
GET /hub/get  
GET /hub/getAll
```

Function: Hub CRUD operations **Input:** Hub details, file uploads **Output:** Hub information **Features:** Logo upload, contact management

3.3 Performance Target APIs

3.3.1 Target Management

```
POST /target/admin/create  
PATCH /target/admin/update/:hub_id/:sub_category_id/:year_id  
PUT /target/bulk-update
```

Function: Performance target operations **Input:** Target values, year, category, hub **Output:** Updated target information **Features:** Bulk operations, validation

3.3.2 Reporting APIs

```
GET /target/download/:hubId/:categoryId
GET /target/admin/aggregated
```

Function: Report generation and export **Input:** Hub ID, category ID **Output:** Excel files, aggregated data **Features:** Excel generation, data aggregation

3.4 Target management APIs

GET /data/target/:category_id POST /data/target/create PATCH /data/target/update/:year_id/:hub_id/:sub_category_id PUT /data/target/bulk-update GET /data/target/aggregated GET /data/target/download/:hubId/:categoryId

```
**Function**: Comprehensive target management operations
**Input**: Target values, year, category, hub
**Output**: Target information, Excel reports, aggregated data
**Features**: CRUD operations, bulk updates, Excel generation, data aggregation

## 4. Data Management Functions

### 4.1 Database Operations

- **CRUD Operations**: Complete data lifecycle management
- **Data Validation**: Input validation and sanitization
- **Data Relationships**: Complex relational data management
- **Soft Deletes**: Data preservation with logical deletion

### 4.2 File Management

- **Upload Processing**: Multi-format file handling
- **Storage Organization**: Role-based file organization
- **Security Validation**: File type and size validation
- **Access Control**: Role-based file access

### 4.3 Data Export

- **Excel Generation**: Dynamic Excel report creation
- **Data Formatting**: Structured data presentation
- **Report Customization**: Hub and category-specific reports
- **Bulk Export**: Large dataset handling

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5. Security Functions

5.1 Authentication Security

- **JWT Tokens**: Secure token-based authentication
- **Password Hashing**: bcrypt with salt rounds
- **Session Management**: Secure cookie handling
- **Token Expiration**: Configurable token lifetimes

5.2 Authorization Functions

- **Role-based Access**: Granular permission system
- **Hub Isolation**: Data isolation between hubs
- **API Protection**: Route-level authorization
- **Resource Control**: User-specific data access

5.3 Data Security

- **Input Validation**: Comprehensive input sanitization
- **SQL Injection Prevention**: Parameterized queries
- **File Upload Security**: Type and size validation
- **Error Handling**: Secure error message handling

6. Reporting and Analytics

6.1 Performance Reporting

- **Target Achievement**: Set vs achieved target comparison
- **Progress Tracking**: Real-time progress monitoring
- **Trend Analysis**: Year-over-year performance trends
- **Hub Comparison**: Cross-hub performance analysis

6.2 Excel Report Generation

- **Dynamic Reports**: Real-time data compilation
- **Formatting**: Professional Excel formatting
- **Multiple Sheets**: Categorized data presentation
- **Charts and Graphs**: Visual data representation

6.3 Data Aggregation

- **System-wide Totals**: Overall performance metrics
- **Category-wise Aggregation**: Technology domain summaries
- **Year-wise Analysis**: Temporal performance analysis
- **Hub-specific Reports**: Individual hub performance

7. System Integration

7.1 Database Integration

- **PostgreSQL**: Primary database system
- **Sequelize ORM**: Object-relational mapping
- **Connection Pooling**: Optimized database connections
- **Migration System**: Version-controlled schema changes

7.2 File System Integration

- **Multer**: File upload handling
- **Storage Management**: Organized file storage
- **Path Management**: Dynamic file path handling
- **Cleanup Operations**: Automated file maintenance

7.3 External Integrations

- **Excel Processing**: ExcelJS for report generation
- **Monitoring**: Sentry for error tracking
- **Logging**: Winston for comprehensive logging

8. Performance and Scalability

8.1 Performance Optimization

- **Database Indexing**: Optimized query performance
- **Connection Pooling**: Efficient database connections
- **Caching Strategy**: Future caching implementation
- **Query Optimization**: Efficient data retrieval

8.2 Scalability Features

- **Modular Architecture**: Scalable code structure
- **Horizontal Scaling**: Multi-instance deployment ready
- **Load Balancing**: Future load balancer integration
- **Database Scaling**: Read/write separation capability

9. Error Handling and Logging

9.1 Error Management

- **HTTP Status Codes**: Standard REST error responses
- **Validation Errors**: Comprehensive input validation
- **Database Errors**: Graceful database error handling
- **File Operation Errors**: Secure file error handling

9.2 Logging System

- **Request Logging**: All API request tracking
- **Error Logging**: Detailed error information
- **Performance Logging**: Response time monitoring
- **Security Logging**: Authentication and authorization events

10. Deployment and Operations

10.1 Environment Management

- **Development Environment**: Local development setup
- **Production Environment**: Production deployment configuration
- **Environment Variables**: Secure configuration management
- **Process Management**: PM2 for production deployment

10.2 Monitoring and Maintenance

- **Health Checks**: System health monitoring
- **Performance Monitoring**: Response time tracking
- **Error Tracking**: Sentry integration for error monitoring
- **Log Management**: Centralized log collection

12. Conclusion

The NMICPS Backend Application provides a robust, scalable, and secure platform for managing technology innovation hubs across India. With comprehensive user management, performance tracking, and reporting capabilities, the system effectively supports the mission's objectives of fostering technology innovation and development.

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