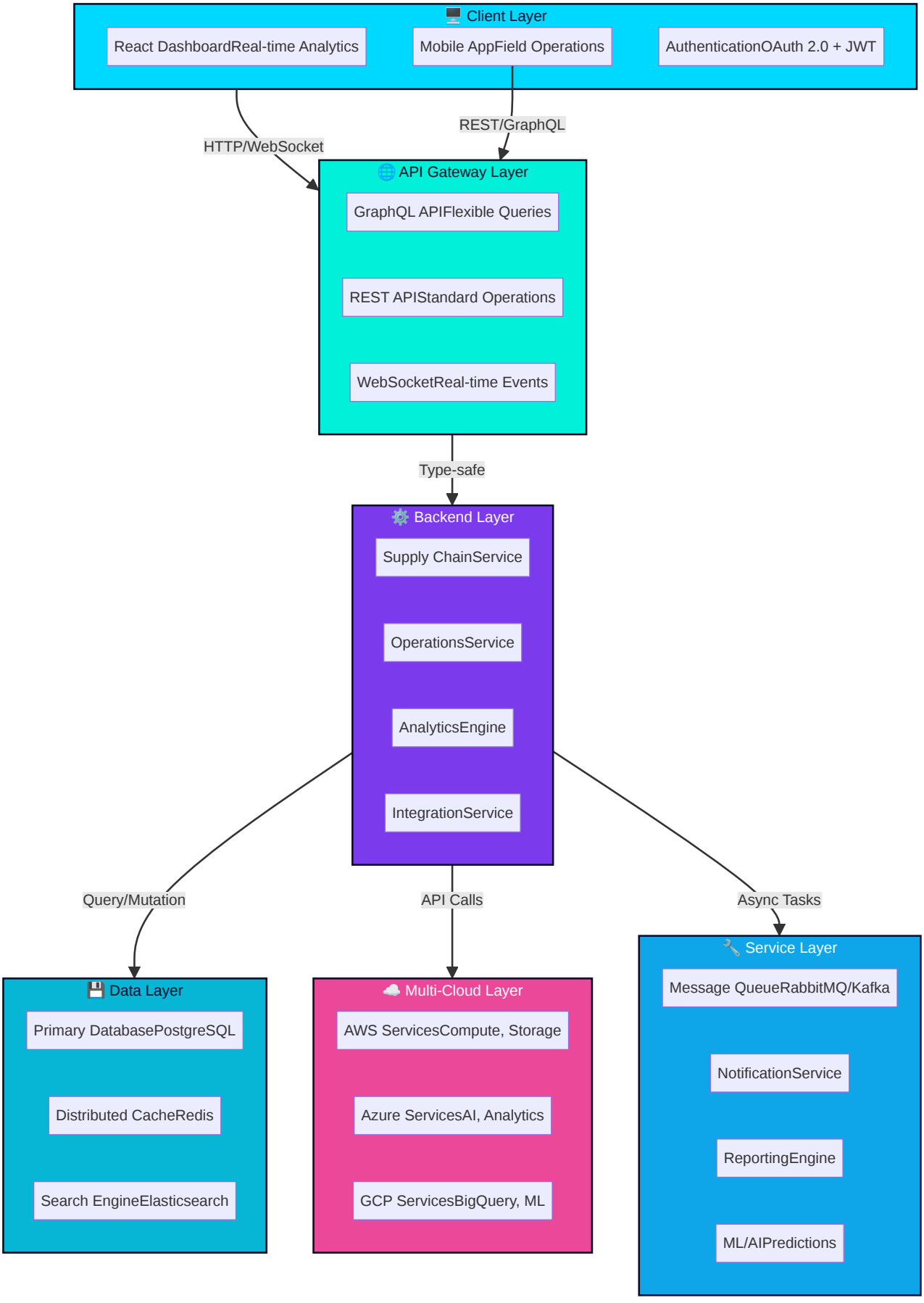
IMSOP - System Architecture

Overview

IMSOP (Intelligent Multi-Cloud Supply Chain & Operations Platform) is an enterprise-grade supply chain management and operations platform. It provides comprehensive visibility, control, and optimization across multi-cloud environments and supply chain networks.

System Architecture Diagram


🖥️ Client Layer
React DashboardReal-time Analytics
Mobile AppField Operations
AuthenticationOAuth 2.0 + JWT
HTTP/WebSocket
REST/GraphQL
🌐 API Gateway Layer
GraphQL APIFlexible Queries
REST APIStandard Operations
WebSocketReal-time Events
Type-safe
⚙️ Backend Layer
Supply ChainService
OperationsService
AnalyticsEngine
IntegrationService
Query/Mutation
API Calls
Async Tasks
💾 Data Layer
Primary DatabasePostgreSQL
Distributed CacheRedis
Search EngineElasticsearch
☁️ Multi-Cloud Layer
AWS ServicesCompute, Storage
Azure ServicesAI, Analytics
GCP ServicesBigQuery, ML
🔧 Service Layer
Message QueueRabbitMQ/Kafka
NotificationService
ReportingEngine
ML/AIPredictions

Component Details

Client Layer

- **React Dashboard**: Comprehensive supply chain analytics and management
- **Mobile App**: Field operations and real-time updates
- **Authentication**: OAuth 2.0 with JWT tokens

API Gateway Layer

- **GraphQL API**: Flexible query language for complex data requirements
- **REST API**: Standard CRUD operations and integrations
- **WebSocket**: Real-time event streaming and notifications

Backend Layer

- **Supply Chain Service**: Procurement, inventory, logistics management
- **Operations Service**: Workflow automation, task management
- **Analytics Engine**: Predictive analytics and business intelligence
- **Integration Service**: Third-party API integrations and data sync

Data Layer

- **PostgreSQL Database**: Primary data storage with ACID compliance
- **Redis Cache**: High-performance caching layer
- **Elasticsearch**: Full-text search and log aggregation

Multi-Cloud Layer

- **AWS Services**: EC2, S3, Lambda, RDS
- **Azure Services**: Cognitive Services, Machine Learning
- **GCP Services**: BigQuery, Dataflow, AI Platform

Service Layer

- **Message Queue**: Asynchronous task processing
- **Notification Service**: Email, SMS, push notifications
- **Reporting Engine**: PDF generation, scheduled reports
- **ML/AI**: Demand forecasting, anomaly detection

Data Flow

Supply Chain Order Flow

```
Order Creation → Validation → Inventory Check
                    ↓
              Queue Processing
                    ↓
        Supplier Notification → Fulfillment
                    ↓
              Shipment Tracking
                    ↓
        Delivery & Analytics Update
```

Real-time Analytics Flow

```
Data Sources → Collection → Processing
                                ↓
                          Cache Update
                                ↓
                          Dashboard Update
                                ↓
                          Alert Generation
```

Multi-Cloud Integration Flow

```
Local Request → Cloud Router → Cloud Selection
                                    ↓
                              Cloud API Call
                                    ↓
                              Result Aggregation
                                    ↓
                              Response to Client
```

Technology Stack

Layer	Technology	Purpose
Frontend	React 19 + TypeScript	UI Framework
Frontend	GraphQL Client	Data fetching
Frontend	Tailwind CSS	Styling
Backend	Node.js	Runtime
Backend	Express.js	Web Framework
Backend	GraphQL	API Layer
Database	PostgreSQL	Primary DB
Cache	Redis	Performance
Search	Elasticsearch	Full-text search
Cloud	AWS/Azure/GCP	Infrastructure
Queue	RabbitMQ/Kafka	Message Queue
Auth	OAuth 2.0 + JWT	Authentication

Key Features

1. Supply Chain Management

- Procurement automation
- Inventory optimization
- Supplier management
- Purchase order tracking

2. Operations Management

- Workflow automation
- Task management
- Resource allocation
- Performance tracking

3. Analytics & Insights

- Real-time dashboards
- Predictive analytics
- Anomaly detection
- Custom reports

4. Multi-Cloud Support

- AWS integration
- Azure integration
- GCP integration
- Hybrid cloud management

5. Integration Capabilities

- ERP system integration

- Third-party API support
- Data synchronization
- Webhook support

Security Architecture

Authentication

- OAuth 2.0 for third-party integrations
- JWT for API authentication
- Multi-factor authentication support
- Session management

Authorization

- Role-based access control (RBAC)
- Attribute-based access control (ABAC)
- Resource-level permissions
- Audit logging

Data Protection

- End-to-end encryption
- Database encryption at rest
- TLS/SSL in transit
- Data anonymization

Scalability Considerations

Horizontal Scaling

- Stateless microservices

- Load balancing
- Database replication
- Cache distribution

Performance Optimization

- Query optimization
- Caching strategies
- Batch processing
- Asynchronous operations

Monitoring & Observability

- Centralized logging
- Application performance monitoring
- Error tracking
- Health checks

Deployment Architecture

SOLID Principles Implementation

Single Responsibility

- Each service handles one domain
- Clear separation of concerns
- Focused business logic

Open/Closed

- Extensible through plugins
- New integrations without modification
- Interface-based design

Liskov Substitution

- Consistent service interfaces
- Predictable behavior
- Type-safe operations

Interface Segregation

- Minimal required dependencies
- Focused service contracts
- Specific API endpoints

Dependency Inversion

- Services depend on abstractions
- Dependency injection pattern
- Plugin architecture

Performance Metrics

- **API Response Time**: < 200ms (p95)
- **GraphQL Query Time**: < 500ms (p95)
- **Real-time Event Latency**: < 100ms
- **Dashboard Load Time**: < 2s
- **Database Query Time**: < 50ms (p95)
- **Cache Hit Rate**: > 85%
- **System Availability**: > 99.9%

Future Enhancements

1. **Advanced Analytics**
    - Machine learning models
    - Predictive maintenance
    - Demand forecasting
2. **Blockchain Integration**
    - Supply chain transparency
    - Smart contracts
    - Immutable audit trail
3. **IoT Integration**
    - Real-time tracking
    - Sensor data collection
    - Automated alerts
4. **Advanced Automation**
    - RPA integration
    - Workflow optimization
    - Intelligent routing
5. **Sustainability**
    - Carbon footprint tracking
    - Green logistics optimization
    - ESG reporting