

Ecommerce application

Microservices and Containerization based assignment



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COUSE: SCALABLE SERVICES

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#### **Github URL:** <https://github.com/vissharm/ecommerce-app/tree/feature/submodules> **Demo:** <https://drive.google.com/file/d/1nrV_Jwk2QDcnzVpjbdjJCRxSF97TYh4R/view?usp=drive_link>

*Thanks.  
THE ASSIGNMENT HAS BEEN POSSIBLE DUE TO THE effort you put in covering modern technologies and the use cases for applicatons of these technologies.*

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# **Assignment objective**

**Microservices-Based Application Development**

1. Develop a **microservices-based application** with at least **four microservices**. Each microservice should be maintained in a separate **code repository** to enable independent development, deployment, and testing.
2. Choose an appropriate **database** and apply a suitable **database design pattern** for these services.
3. Implement an efficient **communication mechanism** between the microservices, ensuring **low coupling** to maintain flexibility and scalability.

**Exploring Deployment Tools**

1. Deploy each microservice in an **individual Docker container**.
2. Set up a **Minikube cluster** on your local machine, explore its various functionalities, and attempt to deploy your application on it.

#### **Github URL:** <https://github.com/vissharm/ecommerce-app/tree/feature/submodules> **Demo:** <https://drive.google.com/file/d/1nrV_Jwk2QDcnzVpjbdjJCRxSF97TYh4R/view?usp=drive_link>

###### Application domain selected for assignment

A modern **basic e-commerce platform** built using microservices architecture. The application demonstrates enterprise-level patterns with Node.js-based services, React frontend, and event-driven communication. It features real-time order processing, inventory management, and user notifications through WebSocket integration.

## Key highlights:

* Microservices architecture with API Gateway pattern
* Event-driven design using Kafka for service communication
* Real-time updates via Socket.IO
* Containerized deployment with Docker and Kubernetes support
* Shared library approach for code reusability
* Comprehensive development and deployment options

The platform supports essential e-commerce operations including user management, product catalog, shopping cart, order processing, and real-time notifications. Built with scalability in mind, it utilizes MongoDB for data persistence, Redis for caching, and includes monitoring capabilities.

## **Technologies Stack**

### Backend

* **Node.js** - Runtime environment
* **Express.js** - Web framework
* **MongoDB** - Primary database
* **Kafka** - Message broker for event-driven architecture
* **JWT** - Authentication and authorization
* **Socket.IO** - Real-time notifications

### Frontend

* **React.js** - UI library
* **Redux** - State management
* **Material-UI** - Component library
* **Axios** - HTTP client

### DevOps & Infrastructure

* **Docker** - Containerization
* **Kubernetes** / Minikube- Container orchestration

# **Development phases**

I have done the development in four phases or steps.

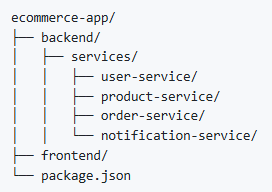
## **Phase 1: Local Development (Monolithic Repository)**

* Created master branch with all services in a single repository
* Basic project structure setup
* Local development with Express server

### Key achievements:

* + Basic service functionality
  + Local inter-service communication
  + Frontend-backend integration
  + Basic authentication flow
  + Database connectivity

### Directory structure



## **Phase 2: Microservices Architecture (Multi-Repository)**

* Split services into separate repositories
* Added repositories as submodules to main project
* Updated local development workflow

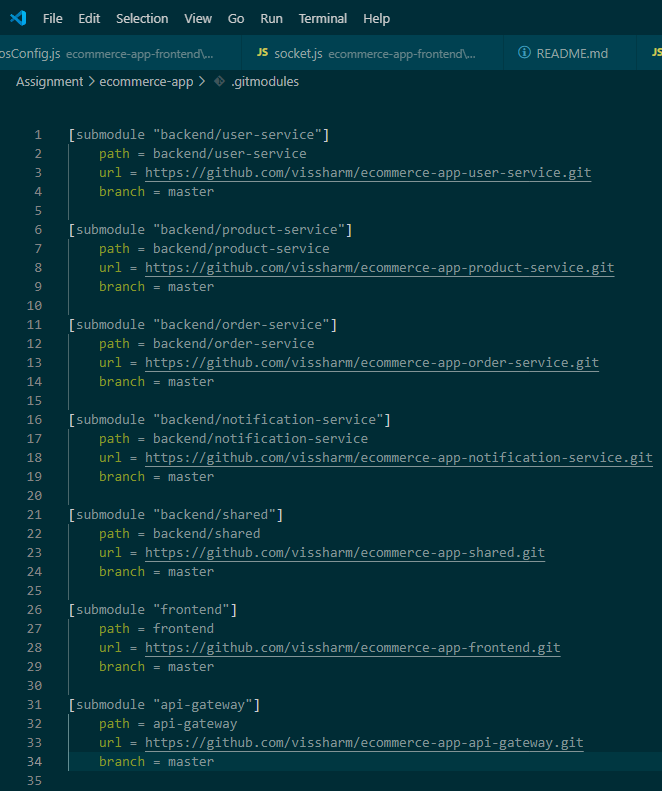
### Key changes:

* + Created separate repositories for each service
  + Implemented shared library
  + Updated service communication
  + Modified development scripts
  + Each service accesses its own database
  + Teams can do parallel development on submodules and test the api’s via postman locally

### Submodules setup

1. "**backend/user-service**" = "https://github.com/vissharm/ecommerce-app-user-service.git"
2. "**backend/product-service**" = "https://github.com/vissharm/ecommerce-app-product-service.git"
3. "**backend/order-service**" = "https://github.com/vissharm/ecommerce-app-order-service.git"
4. "**backend/notification-service**" = "https://github.com/vissharm/ecommerce-app-notification-service.git"
5. "**backend/shared**" = "https://github.com/vissharm/ecommerce-app-shared.git"
6. "**frontend**" = "https://github.com/vissharm/ecommerce-app-frontend.git"
7. "**api-gateway**" = <https://github.com/vissharm/ecommerce-app-api-gateway.git>
8. All these git sub-modules are referred to in **ecommerce-app** main root repository. **Repository**: [ecommerce-app/submodules](https://github.com/vissharm/ecommerce-app/tree/feature/submodules)

**Note:** .gitmodules file added in the root repository which cotains all the linked repositories information and allow user to setup and work on whole application also via ecommerce-app repository.



**# Initialize and update ecommerce-app with all git modules**

git submodule init

git submodule update --recursive –remote

## **Phase 3: Docker Containerization**

I used docker-compose to begin with easy containerization and deployment.

* Implemented Docker deployment
* Created docker-compose configuration
* Resolved container networking issues

### Key implementations:

* + Service Dockerfiles
  + Multi-stage builds
  + Shared library container

## **Phase 4: Minikube cluster deployment**

* Implemented Kubernetes manifests
* Created deployment automation scripts
* Configured service discovery

### Key implementations:

* + Kubernetes manifests for all services
  + Health check endpoints
  + Resource limits and requests
  + Automated deployment scripts

# **Service Details**

**API Gateway**

* Route management
* Request validation
* Authentication & Authorization
* Metrics/Logging

**User Service**

* User management
* Authentication
* Profile management

**Product Service**

* Product catalog management
* Inventory management

**Order Service**

* Order processing
* Order status management

**Notification Service**

* Push notifications
* Real-time updates

**Frontend Service**

* React-based user interface
* State management
* Material-UI components
* Responsive design
* Client-side routing
* Form validation
* Real-time updates via WebSocket

**Shared Library**

* Common utilities and models
* Versioned package (1.0.0)
* Used by all services
* Built as npm package
* Mounted in Kubernetes deployments

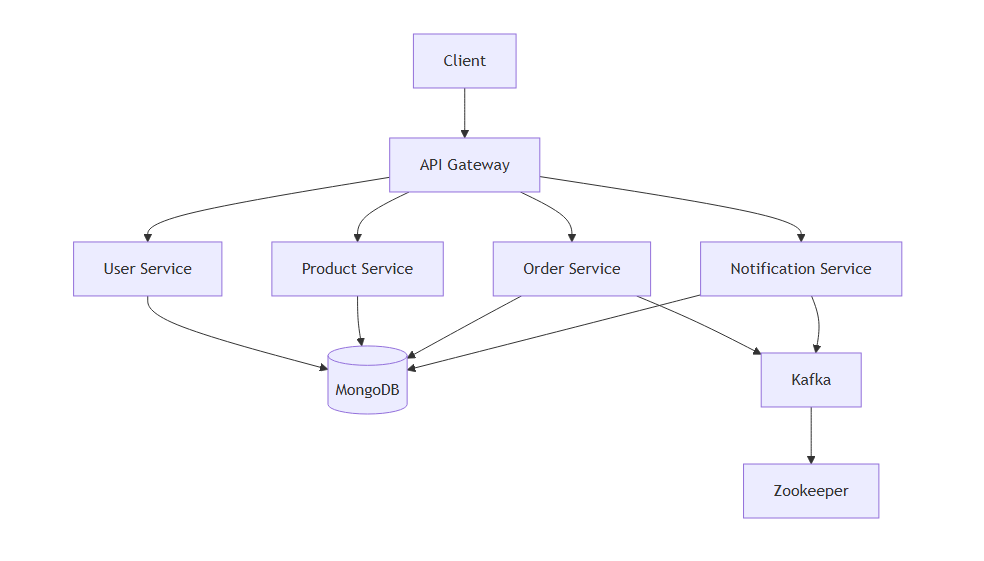
## Required Software Versions

* Node.js >= 14.x
* npm >= 6.x
* Docker >= 20.10.x
* Kubernetes >= 1.19.x
* Minikube >= 1.25.x
* Git >= 2.x
* MongoDB >= 4.4.x
* Apache Kafka >= 3.6.x
* Apache Zookeeper >= 3.7.x

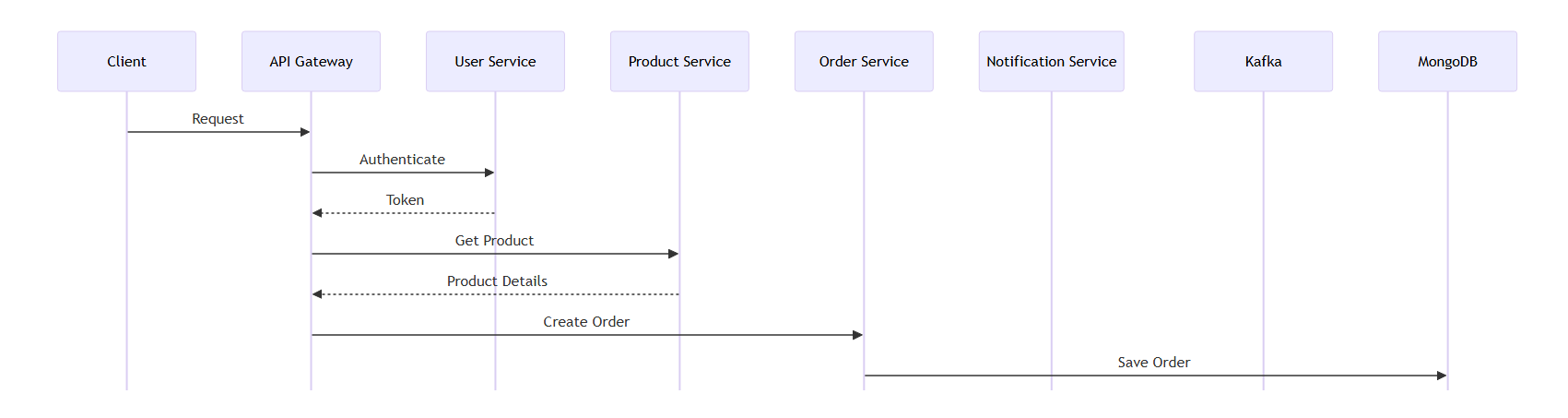
## Framework Versions

* Express.js >= 4.17.x
* React.js >= 17.0.x
* Material-UI >= 4.11.x
* Socket.IO >= 4.8.x
* JWT >= 8.5.x

# **System Architecture**



# **Data Flow diagram**



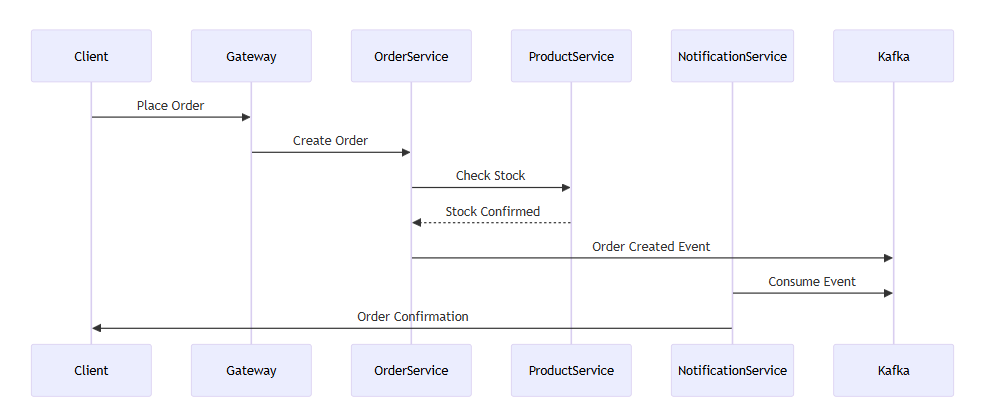
# **Architecture Documentation**

## **System Components**

1. **API Gateway**
   * Rate limiting: 100 requests/minute
   * JWT validation
   * Request routing
   * Load balancing
   * Response caching
   * Error handling
2. **Service Communication**
   * Synchronous: REST APIs
   * Asynchronous: Kafka events
   * WebSocket: Real-time updates
3. **Data Storage**
   * MongoDB: Primary database
   * Redis: Caching layer
   * Kafka: Event store

## **Event Flow Patterns**

### Order Processing Flow

  
  
Not explaining other flow like inventory/ stock update as I will covereing lot of things as part of demo video too. It will make the document lengthier.

## **Security Architecture**

1. **Authentication Flow**
   * JWT-based authentication
   * Token refresh mechanism
   * API key validation for service-to-service communication
2. **Data Security**
   * Password encryption
   * Audit logging (api-gateway and other services)

# **Repository Setup**

1. Clone the main repository:

git clone https://github.com/vissharm/ecommerce-app.git

1. Run the setup script to initialize and update all submodules:

# For Windows PowerShell

.\scripts\setup.ps1

**Note** - It internally calls .\scripts\**initialized\_database.js,** which configures the mongodb database connection and creates all the required database tables.

**Or using npm from the root ecommerce-app folder. This command added in the package.json scripts section and calls setup.ps1**

npm run start

This setup script will:

* Initialize git repository if not already initialized
* Set up all submodules with correct branches
* Update submodules to latest versions
* Install root level dependencies specified in package.json files
* Build and link shared library
* Install dependencies for all services as per respective package.json files
* Set up MongoDB

1. Manual submodule management (if needed):

# Initialize submodules

git submodule init

# Update submodules

git submodule update --init --recursive

# Pull latest changes for all submodules

git submodule update --remote –merge

#### Commands added in root package.json for ease.



# **Deployment Options**

I started with local development using console, then moved to docker-compose container deployment and then deployment with minikube cluster or Kubernetes as per phases I mentioned earlier.

## 1. Local Development (Without Containers)

* Services run directly on host
* MongoDB runs in Docker
* Hot reloading enabled
* Shared library linked locally

### NPM Commands added in root package.json for local development

# Initialize all submodules and build the complete monorepo

npm run initialize:monorepo\_dev\_with\_db\_initialization

# Initialize only the database

npm run initialize:db

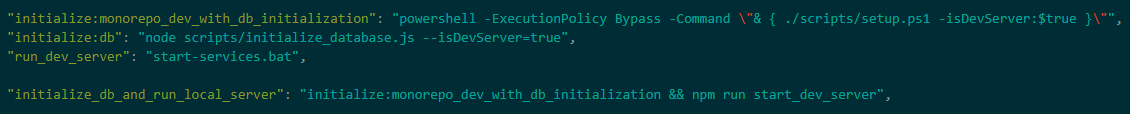
# Start the local development server using command prompt

npm run run\_dev\_server

# Single command to initialize everything and run local development server

npm run initialize\_db\_and\_run\_local\_server

#### Commands added in root package.json for ease.



### Actual scripts created and called by above commands are mentioned below.

1. Install dependencies and setup:

# Run the setup script

.\scripts\setup.ps1

# Or use npm command

npm run setup

1. Start all services:

# Using start-services.bat – runs development server for all services

.\start-services.bat

### Key points for start-services.bat:

* Ensure Zookeeper and Kafka are running first
* Opens separate terminal windows for each service
* Links shared library automatically
* Builds and starts frontend application

## 2. Docker Compose Deployment

* All services in containers
* Development-specific configurations
* Volume mounts for hot reloading
* Docker Compose override support

### NPM Commands added in root package.json for local development

# Deploy and run application using docker-compose

npm run docker-compose:run

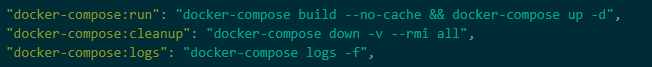
# Cleanup docker-compose created/initialized resources

npm run docker-compose:cleanup

# View logs for troubleshooting

npm run docker-compose:logs

#### Commands added in root package.json for ease.



### Additional docker commands

# View logs for specific service

docker-compose logs -f [service-name]

# Stop all services

docker-compose down

# Stop and remove volumes

docker-compose down -v

# Check service status

docker-compose ps

# Restart specific service

docker-compose restart [service-name]

## 3. **Minikube(Kubernetes) Deployment**

* Local Kubernetes development with minikube cluster
* Service discovery enabled
* ConfigMap for environment variables
* Ingress controller for routing

### NPM Commands added in root package.json for local development

# Deploy and run application using kubernetes/minikube

npm run k8s\_deploy\_with\_cleanup

# Quick deploy without cleaning up resources and rebuilding images

npm run k8s\_deploy:fast\_without\_cleanup

# Run below command to expose the api-gateway port to access the application - https://localhost:<port\_returned\_by\_below\_command>

# This is only needed if above scripts not emitting the port in the end. In windows, sometime it is needed to expose the port and access app.

minikube service api-gateway -n ecommerce –url

#### Commands added in root package.json for ease.



### Deploy services:

# Deploy all services

kubectl apply -f k8s/

# Deploy specific service

kubectl apply -f k8s/[service-name].yaml

### Check deployment status:

# View all pods in ecommerce namespace

kubectl get pods -n ecommerce

# View all services

kubectl get svc -n ecommerce

# View all deployments

kubectl get deployments -n ecommerce

### Get application URL:

# Get API Gateway URL to access the application in browser

minikube service api-gateway -n ecommerce –url

### Pod management:

# Get pod logs

kubectl logs [pod-name] -n ecommerce

# Get pod details

kubectl describe pod [pod-name] -n ecommerce

# Execute command in pod

kubectl exec -it [pod-name] -n ecommerce -- /bin/sh

# Delete pod (will recreate)

kubectl delete pod [pod-name] -n ecommerce

# Rollout restart

kubectl rollout restart deployment [deployment-name] -n ecommerce

### Debugging:

# Check pod events

kubectl get events -n ecommerce --sort-by='.lastTimestamp'

# Check init container logs

kubectl logs [pod-name] -c [init-container-name] -n ecommerce

# Port forward service - if face access issue

kubectl port-forward service/[service-name] [local-port]:[service-port] -n ecommerce

# **Service URLs**

Local/Docker:

* Frontend**: http://localhost:3000**
* API Gateway: **http://localhost:3000**
* User Service: **http://localhost:3001**
* Order Service: **http://localhost:3002**
* Notification Service: **http://localhost:3003**
* Product Service: [**http://localhost:3004**](http://localhost:3004)

# **API Documentation**

**Note:** Very few api’s are not implemented as it was not necessary as per scope and objective of assignment.

### Authentication Endpoints

POST /auth/login

POST /auth/register

POST /auth/refresh-token

GET /auth/verify-email/:token

POST /auth/forgot-password

POST /auth/reset-password

### User Service (Port: 3001)

GET /users # List users (Admin only)

GET /users/:id # Get user details

PUT /users/:id # Update user

DELETE /users/:id # Delete user

GET /users/profile # Get own profile

PUT /users/profile # Update own profile

GET /users/:id/addresses # Get user addresses

POST /users/addresses # Add address

PUT /users/addresses/:id # Update address

DELETE /users/addresses/:id # Delete address

### Product Service (Port: 3004)

GET /products # List products

GET /products/:id # Get product details

POST /products # Create product (Admin)

PUT /products/:id # Update product (Admin)

DELETE /products/:id # Delete product (Admin)

GET /products/categories # List categories

POST /products/categories # Create category (Admin)

PUT /products/categories/:id # Update category (Admin)

DELETE /products/categories/:id # Delete category (Admin)

POST /products/:id/reviews # Add product review

GET /products/:id/reviews # Get product reviews

DELETE /products/reviews/:id # Delete review (Admin/Owner)

### Order Service (Port: 3002)

GET /orders # List orders

GET /orders/:id # Get order details

POST /orders # Create order

PUT /orders/:id/status # Update order status

DELETE /orders/:id # Cancel order

GET /orders/cart # Get cart

POST /orders/cart # Add to cart

PUT /orders/cart/:id # Update cart item

DELETE /orders/cart/:id # Remove from cart

POST /orders/checkout # Checkout process

GET /orders/history # Order history

### Notification Service (Port: 3003)

WebSocket: /socket.io # Real-time notifications

GET /notifications # List notifications

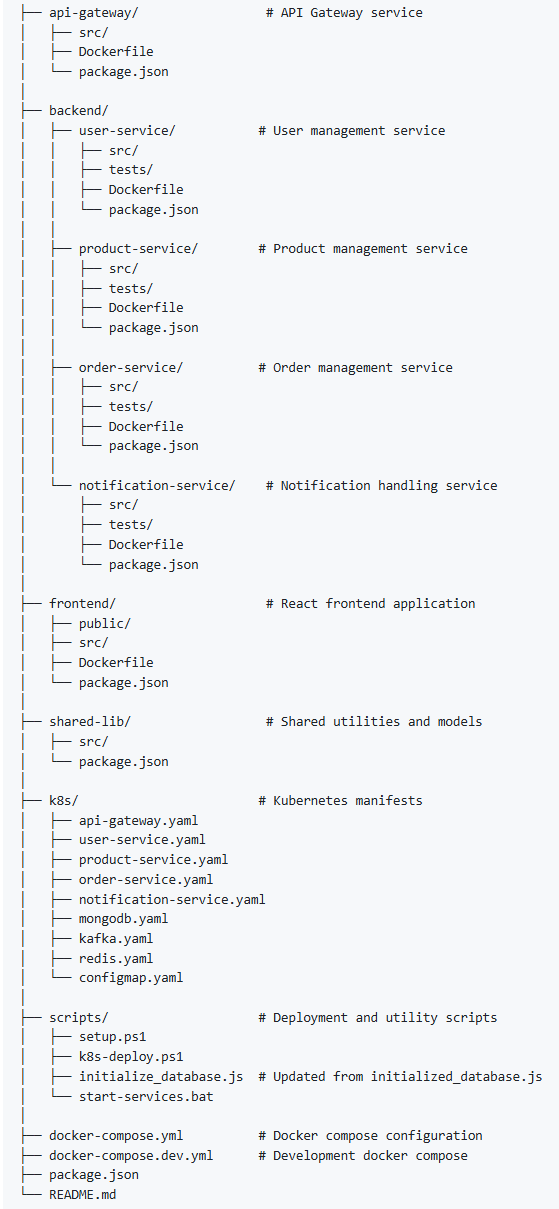
PUT /notifications/:id # Mark as read

DELETE /notifications/:id # Delete notification

POST /notifications/subscribe # Subscribe to notifications

POST /notifications/unsubscribe # Unsubscribe from notifications

# **Directory structure**



# Deployment Script (k8s-deploy.ps1)

### Purpose

The script automates the deployment of the e-commerce application to a Minikube cluster. It handles environment setup, service deployment, and health checks.

#### Key Functions

##### 1. Environment Setup

Test-KubernetesConnection

* Verifies Minikube status
* Starts Minikube if not running
* Ensures correct Kubernetes context
* Validates cluster connectivity

##### 2. Deployment Process

Main deployment flow

* Cleans up existing deployments (optional)
* Configures Docker to use Minikube daemon
* Creates namespace and applies ConfigMaps
* Builds and deploys services in order:
  + Shared library
  + Core services (user, product, order, notification)
  + API Gateway

##### 3. Infrastructure Components

* MongoDB (with initialization)
* Kafka
* Zookeeper

###### Service deployments

* user-service
* product-service
* order-service
* notification-service
* api-gateway

###### Usage Options

**Full deployment with cleanup:** ./scripts/k8s-deploy.ps1

**Deploy without cleanup (faster):** ./scripts/k8s-deploy.ps1 -SkipCleanup

#### Key Features

* Automated environment setup
* Health checks and readiness probes
* Error handling and recovery
* Pod status monitoring
* Database initialization
* Service dependency management

#### Monitoring and Debugging

* Pod status checks
* Service connectivity tests
* Detailed error logging
* Debug commands for troubleshooting

# Setup Script (setup.ps1)

### Purpose

Initial project setup script that prepares the development environment by cloning and initializing submodules in the main ecommerce-app repository. It takes care of installing dependencies, making builds and initializing database with table creation and dummy data.

### Key Operations

#### 1. Dependencies Installation

* Root level npm packages
* Shared library setup and linking
* Service-specific dependencies
* Frontend dependencies

#### 2. API Gateway Setup

* Install dependencies
* Link shared library
* Configure routes

#### 3. Database Initialization

* Calls initialize\_database.js
* Sets up initial data
* Configures development environment

#### Usage

**Full setup:** .\scripts\setup.ps1

**Through npm:** npm run setup

# Database Initialization Script (initialize\_database.js)

### Purpose

Sets up the MongoDB databases with initial data for development and testing.

### Data Initialization

1. User Service Data

2. Product Service Data

### Features

- Safe collection dropping

- Schema validation

- Connection management

- Error handling

### Usage

**Direct execution:** node scripts/initialize\_database.js

**With development server flag:** node scripts/initialize\_database.js --isDevServer=true

# Service Starter Script (start-services.bat)

### Purpose

Windows batch script that launches all required services in separate terminal windows for local development.

### Service Launch Order

#### 1. Infrastructure Services

* Zookeeper (Port: 2181)
* Kafka (Port: 9092)

#### 2. Microservices

* User Service (Port: 3001)
* Product Service (Port: 3004)
* Order Service (Port: 3002)
* Notification Service (Port: 3003)

#### 3. Frontend & Gateway

* Frontend Application (Port: 3000)
* API Gateway (Port: 8080)

### Features

* Parallel service execution
* Dependency management
* Shared library linking
* Development hot-reloading
* Terminal window organization

### Usage

**Start all services:** .\start-services.bat

##### Services are launched in separate Windows Terminal tabs

# Each service shows its own logs

# Terminal Window Layout

[Services Info] [Zookeeper] [Kafka] [Order Service]

[User Service] [Product Service] [Notification Service]

[Frontend] [API Gateway]

##### Service Dependencies

* Zookeeper must start before Kafka
* Kafka must be ready before microservices
* All services must be up before API Gateway
* Frontend builds after services start

##### These scripts work together to provide:

* Consistent development environment setup
* Automated dependency management
* Initial data population
* Service orchestration
* Development workflow automation

The combination ensures developers can quickly set up and start working with the full application stack in a development environment.

# **MongoDB compass screenshot**

