Document Clustering System with Docker

Technical Mathematics for Big Data

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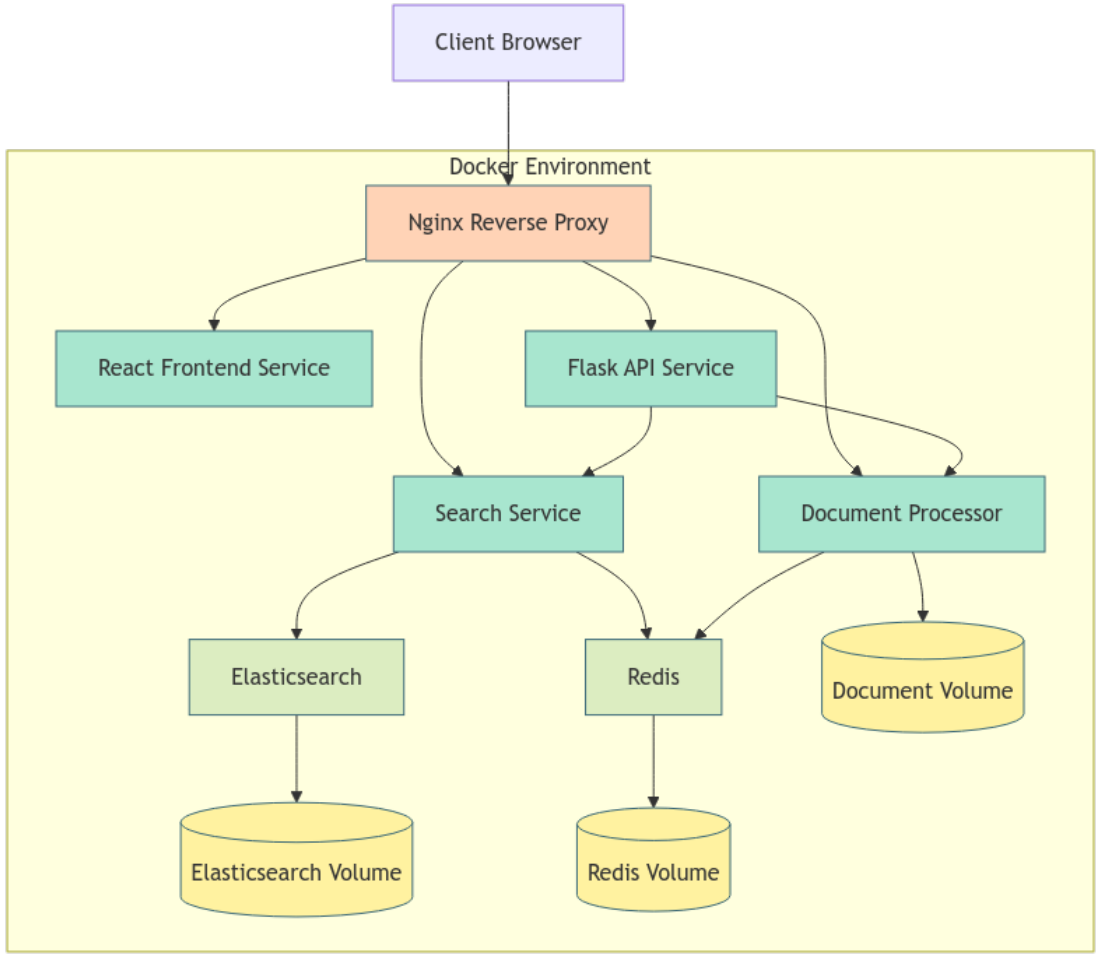
Project Overview

- Document Clustering System built with microservices
- Containerized solution using Docker technology

- React-based UI
- Flask microservices
- Elasticsearch engine
- Document analysis system



Docker Setup and Operations

Docker Compose Config

```
services:
  nginx:
    image: nginx:alpine
    ports:
      - "4321:80"
  frontend:
    build: ./frontend
    expose:
      - "3000"
  api:
    build: ./api
    expose:
      - "8000"
  document-processor: (...)
```

Common Commands

```
# Build and start
docker-compose up --build

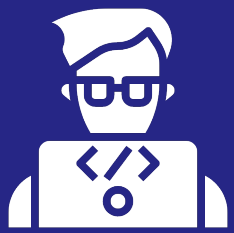
# Stop services
docker-compose down

# View logs
docker-compose logs -f

# Rebuild specific service
docker-compose build svc-name

# Show running containers
docker-compose ps
```

Docker Benefits



For Development

- **Consistent Environment**
  no "works on my machine"
- **Isolated Deps**
  no version conflicts
- **Rapid Dev Cycle**
  fast startup, easy rollbacks

For Performance

- **Resource Efficiency**
  lightweight architecture
- **Scalability**
  horizontal scaling
- **Maintenance**
  simple updates, min downtime

For Security

- **Vulnerability Management**
  image scanning, regular updates
- **Instance Isolation**
  for processes and networks
- **Security Features**
  access & resource limits

Core Components of Docker

Docker Client & Server (Engine): The client sends commands to the server (Docker Engine), which builds, runs, and manages containers.
Docker Images: A Docker image is a blueprint for creating containers, built using a Dockerfile.
Docker Containers: A Docker container is a running instance of a Docker image, providing isolated environments for applications.
Docker Registries: A Docker registry stores and distributes Docker images. Examples include Docker Hub and private registries.

Using Docker for Clustering

structure

```
clustering-project/
 app/   # Source code for both document and image clustering
    document_clustering/    # Document clustering code
       main.py           # Entry point for document clustering
       clustering.py  # Core clustering logic (e.g., K-means)
       utils.py      # Text preprocessing (tokenization, etc)
       requirements.txt    # Document clustering dependencies
    image_clustering/       # Image clustering code
       main.py           # Entry point for image clustering
       clustering.py  # Core clustering logic (e.g., DBSCAN)
       utils.py        # Image preprocessing (resizing, CNN)
       requirements.txt  # Image clustering dependencies (tens
 data/                        # Stores input and output files
    documents/                # Raw text documents
    images/                   # Raw image files
```

Using Docker for Clustering

```
   processed/  # Processed output (clusters, visualizations)
Dockerfile   # Configuration for containerization
docker-compose.yml  # Multi-container setup for both clusteri
README.md                    # Project documentation
requirements.txt   # Common dependencies (e.g.,numpy,pandas)
```

- **'app/'**: Contains source code for both tasks:
  - **'document clustering/'**: Includes Python scripts like `main.py`, `clustering.py` (e.g., K-means), and `utils.py` (text preprocessing). Dependencies include `scikit-learn`, `nltk`, and `spaCy`.
  - **'image clustering/'**: Includes scripts like `main.py`, `clustering.py`, and `utils.py` (image preprocessing). Dependencies include `opencv`, `PIL`, and `tensorflow`.
- **'data/'**: Stores input and output data:
  - **'documents/'**, **'images/'** (raw files) and **'processed/'** (output from clustering).

Dockerfile Components for Document and Image Clustering

- **Base Image**:
  `FROM python:3.8-slim`
  A lightweight Python image to start from for both document and image clustering.
- **Working Directory**:
  `WORKDIR /app`
  Defines the working directory inside the container.
- **Copy Application Files**:
  `COPY . /app`
  Copies project files (document_clustering/ or image_clustering/) into the container.
- **Install Dependencies**:
  `RUN pip install -r requirements.txt`

Dockerfile Components for Document and Image Clustering

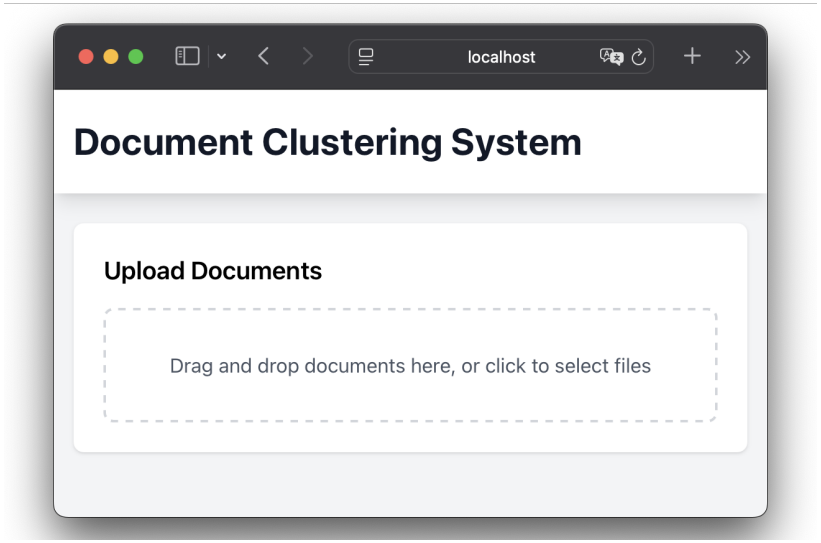
Installs necessary dependencies for the respective clustering task (e.g., `scikit-learn` for document clustering or `opencv`, `tensorflow` for image clustering).

- **Expose Ports (Optional)**:
  `EXPOSE 8000`
  If exposing a web app or API, define the port to be accessed outside the container.
- **Run the Application**:
  Document Clustering: `CMD ["python", "document_clustering/main.py"]`
  Image Clustering: `CMD ["python", "image_clustering/main.py"]`
  Executes the clustering application when the container starts.

Project Implementation and System Features

- **Multi-stage builds**
  - Optimized image sizes
  - Reduced attack surface
- **Docker Compose**
  - Service orchestration
  - Environment configuration
  - Network management
- **Volume Management**
  - Persistent data storage
  - Efficient data sharing

		Name	Tag	Image ID
☐	●	redis	alpine	1bf97f21f01b
☐	●	docker.elastic.co/elasticsearch/elasticsearch	7.17.9	59b37f77bd8b
☐	●	nginx	alpine	814a8e88df97
☐	●	docker-project-search	latest	4f5fbb64e1de
☐	●	docker-project-document-processor	latest	d8329a9c19bc
☐	●	docker-project-api	latest	1806fbbc4c1a



- **Single Port Access**
  - All services through one port
  - Nginx reverse proxy
- **Monitoring**
  - Health checks
  - Automated recovery
- **Data Management**
  - Elasticsearch integration
  - Redis caching

Performance Optimization with Parallelization

Parallel Document Processing

- Use `ThreadPoolExecutor` to process multiple documents in parallel:
  - OCR: Split documents into pages for concurrent processing.
  - Translations: Batch requests for multiple documents.
- Redis caches embeddings to avoid reprocessing.

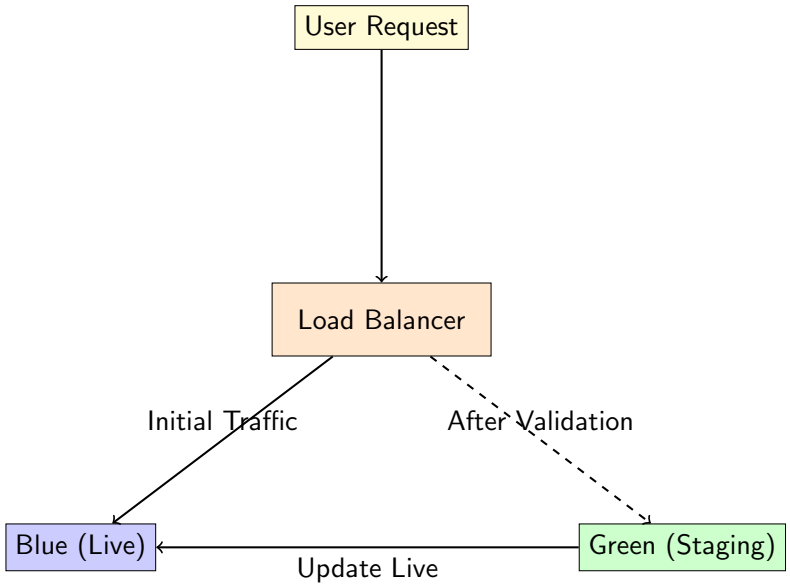
Future Enhancements

- Implement `Celery` + Redis for distributed task queues.
- Add more workers to scale up parallel computations.

Example Code:

- ```
  with ThreadPoolExecutor(max_workers=4) as executor:
  executor.map(process_document, docs)
  ```
  ```

Cloud Deployment & Blue-Green Strategy



Blue-Green Deployment Benefits:

- Two environments (Blue = Live, Green = Staging).
- Zero-downtime upgrades.
- Easy rollback in case of failure.

Cloud Platforms:

- **AWS ECS/EKS**: Orchestrates Docker containers.
- **Azure AKS**: Managed Kubernetes clusters.
- **DigitalOcean App Platform**: Simplified cloud deployments.

Next Steps:

- Test load balancer configuration with two API containers locally using Nginx.

Migration to Kubernetes

Why Kubernetes?

- Supports self-healing, auto-scaling, and automated rollouts.
- Handles complex deployments with better orchestration.

Migration Plan

- Convert `docker-compose.yml` to Kubernetes manifests: `kubectl apply -f deployment.yml`
- Use Helm charts for templating reusable manifests.

Key Components:

- **Pods:** Smallest deployable unit containing containers.
- **Deployments:** Manage replica sets of pods.
- **Services:** Expose pods to external requests.

Conclusion

Thank You

Document Clustering System
Docker-based Microservices Architecture

Questions?