how does this assosiation happen is it written inside the container or what and where are these containers stored where are these images stored

The association between a Docker image and a container happens through the container creation process. Here's how it works:

##### **Association Process**

1. ****Image as a Template****: When you create a container, you specify an image as the template. This image contains the necessary filesystem and application dependencies required to run the container.
2. ****Container Creation****: Docker uses the specified image to create a container. During this process, Docker allocates a writable layer on top of the image's read-only layers. This writable layer is unique to the container and allows it to make changes to its filesystem without affecting the original image.
3. ****Metadata****: Docker maintains metadata about the container, including which image it was created from. This metadata is stored in Docker's internal storage system and is used to manage the lifecycle of containers and their association with images.

##### **Storage Locations**

* ****Images****: Docker images are stored in a directory on the host machine, typically under /var/lib/docker/ on Linux systems. This directory contains subdirectories for different storage drivers (like overlay2, btrfs, etc.), and the images are stored according to the storage driver's format. For example, with the overlay2 driver, image layers are stored in /var/lib/docker/overlay2/.
* ****Containers****: Containers are also stored under /var/lib/docker/, in a subdirectory specific to containers. This directory contains the container's writable layer, configuration, and metadata. The exact path and structure can vary depending on the storage driver in use.

##### **Storage Drivers**

The storage driver in use determines how images and containers are stored on disk. Common storage drivers include:

* ****overlay2****: The default and preferred storage driver for most Linux distributions.
* ****btrfs****: Allows for advanced features like snapshots but requires a Btrfs filesystem.
* ****windowsfilter****: Used on Windows systems.

Each storage driver has its own way of managing the filesystem layers and metadata, which affects how images and containers are stored and accessed.

For more detailed information, you can refer to the [Docker storage documentation⁠](https://docs.docker.com/storage/).

ok when you have a docker file and use docker build it creates the image accordingly ok but each time you do a docker build does it create a new image

Yes, each time you run docker build, Docker creates a new image based on the instructions in your Dockerfile. Here's what happens during the build process:

1. ****Dockerfile Instructions****: Docker reads the instructions in your Dockerfile and executes them step by step. Each instruction results in a new layer being added to the image.
2. ****Image Layers****: Docker uses a layered filesystem, where each instruction in the Dockerfile creates a new layer. These layers are cached, so if you rebuild the image without changes to certain layers, Docker can reuse the cached layers to speed up the build process.
3. ****New Image ID****: Every time you build an image, Docker assigns it a new unique image ID, even if the content of the image is identical to a previously built image. This is because the build process results in a new image object in Docker's storage.
4. ****Tagging****: You can tag the newly built image with a name and version (e.g., myapp:latest) using the -t option with docker build. This makes it easier to reference and manage the image.
5. ****Cache Usage****: If you make changes to the Dockerfile or the files it depends on, Docker will rebuild the affected layers and any subsequent layers. If no changes are detected, Docker will use the cached layers to avoid unnecessary work.

In summary, each docker build command results in a new image, but Docker's caching mechanism helps optimize the process by reusing unchanged layers. This is why subsequent builds can be much faster if there are no changes to the Dockerfile or the build context. For more details, you can refer to the [Docker build documentation⁠](https://docs.docker.com/engine/reference/commandline/build/).

ok done now in a project you have a docker file ok and we have an image and now how do we create a container from that image can you show me all these things step by step

Certainly! Here's a step-by-step guide on how to create a Docker container from an image using a Dockerfile:

##### **Step 1: Create a Dockerfile**

First, you need a Dockerfile that defines the environment and application you want to run. Here's a simple example of a Dockerfile for a Node.js application:

# Use an official Node.js runtime as a parent image

FROM node:14

# Set the working directory in the container

WORKDIR /usr/src/app

# Copy the current directory contents into the container at /usr/src/app

COPY . .

# Install any needed packages specified in package.json

RUN npm install

# Make port 8080 available to the world outside this container

EXPOSE 8080

# Run app.js when the container launches

CMD ["node", "app.js"]

##### **Step 2: Build the Docker Image**

Navigate to the directory containing your Dockerfile and run the following command to build the image:

docker build -t my-node-app .

* -t my-node-app: Tags the image with the name my-node-app.
* .: Specifies the current directory as the build context.

##### **Step 3: Verify the Image**

After building, you can verify that the image was created successfully by listing all images:

docker images

You should see my-node-app listed among the images.

##### **Step 4: Run a Container from the Image**

Now, create and start a container from the image using the docker run command:

docker run -d -p 8080:8080 --name my-running-app my-node-app

* -d: Runs the container in detached mode (in the background).
* -p 8080:8080: Maps port 8080 on your host to port 8080 in the container.
* --name my-running-app: Names the container my-running-app.
* my-node-app: Specifies the image to use.

##### **Step 5: Verify the Running Container**

To check if your container is running, use:

docker ps

This command lists all running containers. You should see my-running-app in the list.

##### **Step 6: Access the Application**

If your application is a web server, you can access it by navigating to http://localhost:8080 in your web browser.

##### **Step 7: Stop and Remove the Container**

When you're done, you can stop and remove the container:

docker stop my-running-app

docker rm my-running-app

This sequence of steps will help you build an image from a Dockerfile and run a container from that image. For more detailed information, you can refer to the [Docker documentation⁠](https://docs.docker.com/get-started/).

ok now once this is done I have never done any change to the app or dockerfile but the container stopped I come up after few days how do I run the container again show me a good practice step by step

If your container has stopped and you want to start it again without making any changes to the application or Dockerfile, you can follow these steps. This is a common scenario, and Docker provides straightforward commands to manage stopped containers.

##### **Step 1: List All Containers**

First, check the status of your containers to see which ones are stopped. Use the following command:

docker ps -a

This command lists all containers, including those that are stopped. Look for your container by name or ID.

##### **Step 2: Start the Stopped Container**

If you find your container in the stopped state, you can start it again using the docker start command. For example, if your container is named my-running-app, you would run:

docker start my-running-app

This command will start the container with all its previous state intact.

##### **Step 3: Verify the Container is Running**

After starting the container, verify that it is running:

docker ps

This command lists only the running containers. Ensure that my-running-app is listed.

##### **Step 4: Access the Application**

If your application is a web server, you can access it again at http://localhost:8080 (or whatever port you mapped) to ensure it's functioning as expected.

##### **Good Practices**

* ****Use Container Names****: Always use meaningful names for your containers. This makes it easier to manage them with commands like docker start, docker stop, etc.
* ****Check Logs****: If a container stops unexpectedly, check the logs to diagnose the issue. Use docker logs my-running-app to view the logs.
* ****Resource Management****: Ensure your host machine has enough resources (CPU, memory) to run the container, as resource constraints can cause containers to stop.
* ****Automate Restarts****: Consider using Docker's restart policies to automatically restart containers in case of failure. You can set this when you run the container initially:

docker run -d -p 8080:8080 --name my-running-app --restart unless-stopped my-node-app

The --restart unless-stopped policy restarts the container unless you explicitly stop it.

By following these steps and practices, you can efficiently manage and restart your Docker containers. For more details, refer to the [Docker container management documentation⁠](https://docs.docker.com/engine/reference/commandline/container/).

ohh k so make a container you use docker run and to restart you use docker start

Exactly! You've got it right:

* docker run: This command is used to create and start a new container from an image. It combines the creation and starting of a container in one step. You use this when you want to launch a new instance of a container.
* docker start: This command is used to start an existing container that has been stopped. It doesn't create a new container; it simply starts one that already exists. This is useful when you want to restart a container without changing its configuration or state.

These commands are fundamental to managing Docker containers. If you need more detailed information, you can always refer to the [Docker CLI documentation⁠](https://docs.docker.com/engine/reference/commandline/cli/).

ok done what kind of projects can I build to showcase in my resume

When building projects to showcase on your resume, it's important to choose ones that demonstrate your understanding of Docker and your ability to apply it in real-world scenarios. Here are some project ideas that can help you stand out:

1. ****Multi-Container Web Application****:
   * Build a full-stack application using Docker Compose to manage multiple services like a React frontend, Node.js backend, and a database (e.g., PostgreSQL or MongoDB).
   * Demonstrate how you can orchestrate these services to work together seamlessly.
2. ****Microservices Architecture****:
   * Develop a set of microservices, each in its own container, that communicate with each other.
   * Use Docker Compose or Kubernetes to manage the deployment and scaling of these services.
3. ****CI/CD Pipeline****:
   * Set up a continuous integration and continuous deployment (CI/CD) pipeline using Docker.
   * Use tools like Jenkins, GitLab CI, or GitHub Actions to automate the building, testing, and deployment of Docker containers.
4. ****Data Processing Pipeline****:
   * Create a data processing pipeline using Docker containers for each stage of the process (e.g., data ingestion, processing, and storage).
   * Use technologies like Apache Kafka, Spark, or Hadoop within Docker containers.
5. ****DevOps Monitoring and Logging****:
   * Set up a monitoring and logging stack using Docker containers with tools like Prometheus, Grafana, and ELK (Elasticsearch, Logstash, Kibana).
   * Showcase how you can monitor and log containerized applications effectively.
6. ****Serverless Functions with Docker****:
   * Implement serverless functions using Docker, possibly with OpenFaaS or AWS Lambda with Docker support.
   * Demonstrate how Docker can be used to package and deploy serverless functions.
7. ****Legacy Application Containerization****:
   * Take a legacy application and containerize it, showing how Docker can be used to modernize and deploy older applications.
   * Highlight the challenges and solutions in containerizing legacy systems.
8. ****Security-Focused Project****:
   * Build a project that emphasizes Docker security best practices, such as using Docker Bench for Security, implementing least privilege, and managing secrets.
   * Demonstrate how to secure Docker containers and the host environment.
9. ****IoT with Docker****:
   * Develop an Internet of Things (IoT) project where Docker containers run on edge devices.
   * Use Docker to manage and deploy applications across multiple IoT devices.
10. ****Game Server Hosting****:
    * Set up a game server using Docker, showcasing how Docker can be used to deploy and manage game servers efficiently.

When showcasing these projects, make sure to include:

* ****Documentation****: Provide clear documentation on how to set up and run your projects.
* ****Source Code****: Host your code on a platform like GitHub or GitLab.
* ****Readme Files****: Include detailed README files explaining the project, its architecture, and how Docker is used.
* ****Live Demos****: If possible, provide a live demo or a video walkthrough of your project.

These projects will not only demonstrate your technical skills but also your ability to apply Docker in various contexts, making you a more attractive candidate to potential employers.

# Docker and Docker Compose: A Comprehensive Guide

Based on our conversation, I've compiled this document to help you understand Docker, Docker Compose, and how they're used in your task manager application.

## Table of Contents

1. [Docker Fundamentals](vscode-webview://1a10bgefd2o38as2bdov2hrlklf6l4gvopd5vc6ilsp5qe6ve9ri/index.html?id=e1bed9d0-79ab-4083-b194-c35e94736c9d&origin=70628854-30df-4de3-a5c8-3725557cb489&swVersion=4&extensionId=sourcegraph.cody-ai&platform=electron&vscode-resource-base-authority=vscode-resource.vscode-cdn.net&parentOrigin=vscode-file%3A%2F%2Fvscode-app)
2. [Docker Compose Basics](vscode-webview://1a10bgefd2o38as2bdov2hrlklf6l4gvopd5vc6ilsp5qe6ve9ri/index.html?id=e1bed9d0-79ab-4083-b194-c35e94736c9d&origin=70628854-30df-4de3-a5c8-3725557cb489&swVersion=4&extensionId=sourcegraph.cody-ai&platform=electron&vscode-resource-base-authority=vscode-resource.vscode-cdn.net&parentOrigin=vscode-file%3A%2F%2Fvscode-app)
3. [Your Task Manager Application Architecture](vscode-webview://1a10bgefd2o38as2bdov2hrlklf6l4gvopd5vc6ilsp5qe6ve9ri/index.html?id=e1bed9d0-79ab-4083-b194-c35e94736c9d&origin=70628854-30df-4de3-a5c8-3725557cb489&swVersion=4&extensionId=sourcegraph.cody-ai&platform=electron&vscode-resource-base-authority=vscode-resource.vscode-cdn.net&parentOrigin=vscode-file%3A%2F%2Fvscode-app)
4. [Managing Containers](vscode-webview://1a10bgefd2o38as2bdov2hrlklf6l4gvopd5vc6ilsp5qe6ve9ri/index.html?id=e1bed9d0-79ab-4083-b194-c35e94736c9d&origin=70628854-30df-4de3-a5c8-3725557cb489&swVersion=4&extensionId=sourcegraph.cody-ai&platform=electron&vscode-resource-base-authority=vscode-resource.vscode-cdn.net&parentOrigin=vscode-file%3A%2F%2Fvscode-app)
5. [Environment Variables and Configuration](vscode-webview://1a10bgefd2o38as2bdov2hrlklf6l4gvopd5vc6ilsp5qe6ve9ri/index.html?id=e1bed9d0-79ab-4083-b194-c35e94736c9d&origin=70628854-30df-4de3-a5c8-3725557cb489&swVersion=4&extensionId=sourcegraph.cody-ai&platform=electron&vscode-resource-base-authority=vscode-resource.vscode-cdn.net&parentOrigin=vscode-file%3A%2F%2Fvscode-app)
6. [Data Persistence](vscode-webview://1a10bgefd2o38as2bdov2hrlklf6l4gvopd5vc6ilsp5qe6ve9ri/index.html?id=e1bed9d0-79ab-4083-b194-c35e94736c9d&origin=70628854-30df-4de3-a5c8-3725557cb489&swVersion=4&extensionId=sourcegraph.cody-ai&platform=electron&vscode-resource-base-authority=vscode-resource.vscode-cdn.net&parentOrigin=vscode-file%3A%2F%2Fvscode-app)
7. [Development Workflow](vscode-webview://1a10bgefd2o38as2bdov2hrlklf6l4gvopd5vc6ilsp5qe6ve9ri/index.html?id=e1bed9d0-79ab-4083-b194-c35e94736c9d&origin=70628854-30df-4de3-a5c8-3725557cb489&swVersion=4&extensionId=sourcegraph.cody-ai&platform=electron&vscode-resource-base-authority=vscode-resource.vscode-cdn.net&parentOrigin=vscode-file%3A%2F%2Fvscode-app)
8. [Troubleshooting](vscode-webview://1a10bgefd2o38as2bdov2hrlklf6l4gvopd5vc6ilsp5qe6ve9ri/index.html?id=e1bed9d0-79ab-4083-b194-c35e94736c9d&origin=70628854-30df-4de3-a5c8-3725557cb489&swVersion=4&extensionId=sourcegraph.cody-ai&platform=electron&vscode-resource-base-authority=vscode-resource.vscode-cdn.net&parentOrigin=vscode-file%3A%2F%2Fvscode-app)

## Docker Fundamentals

### Images vs Containers

* **Images**: Blueprints or templates (like classes in programming)
  + Immutable and layered
  + Created from Dockerfiles or pulled from registries
  + Stored locally or in repositories like Docker Hub
* **Containers**: Running instances of images (like objects in programming)
  + Stateful and isolated
  + Can be started, stopped, and removed
  + Multiple containers can run from the same image

### Dockerfile

A Dockerfile defines how to build a single container image:

FROM node:18-alpine

WORKDIR /app

COPY package\*.json ./

RUN npm install

COPY . .

EXPOSE 3000

CMD ["node", "app.js"]

Copy

Key components:

* FROM: Base image to build upon
* WORKDIR: Sets the working directory
* COPY: Copies files from host to image
* RUN: Executes commands during build
* EXPOSE: Documents which ports the container listens on
* CMD: Default command to run when container starts

## Docker Compose Basics

### What is Docker Compose?

Docker Compose is a tool for defining and running multi-container Docker applications using a YAML file.

### docker-compose.yml Structure

services: # Defines the containers to run

networks: # Defines the networks for container communication

volumes: # Defines persistent storage

Copy

### Key Concepts

* **Services**: Individual containers that make up your application
* **Networks**: Communication channels between containers
* **Volumes**: Persistent data storage that survives container restarts
* **Dependencies**: Order in which services should start

## Your Task Manager Application Architecture

Your application consists of two main services:

### App Service (Node.js Express Backend)

app:

build: . # Build using local Dockerfile

ports:

- "3000:3000" # Map port 3000 to host

env\_file:

- .env # Load variables from .env file

environment: # Set specific environment variables

- MONGODB\_URI=mongodb://mongodb:27017/task-manager

- ACCESS\_TOKEN\_SECRET=your\_access\_token\_secret

- REFRESH\_TOKEN\_SECRET=your\_refresh\_token\_secret

- PORT=3000

depends\_on:

- mongodb # Start MongoDB first

networks:

- task-manager-network

restart: unless-stopped

Copy

### MongoDB Service (Database)

mongodb:

image: mongo:latest # Use official MongoDB image

ports:

- "27017:27017" # Map MongoDB port

volumes:

- mongodb\_data:/data/db # Persist data

networks:

- task-manager-network

restart: unless-stopped

Copy

### Supporting Infrastructure

networks:

task-manager-network: # Network for inter-container communication

driver: bridge

volumes:

mongodb\_data: # Volume for database persistence

Copy

## Managing Containers

### Basic Commands

* **Start containers in detached mode**:

docker compose up -d

Copy

Execute

* **Stop containers without removing them**:

docker compose stop

Copy

Execute

* **Start existing containers**:

docker compose start

Copy

Execute

* **Stop and remove containers**:

docker compose down

Copy

Execute

* **View logs**:

docker compose logs -f

Copy

Execute

### Container Lifecycle

1. **Creation**: docker compose up creates containers if they don't exist
2. **Running**: Containers execute their CMD/entrypoint
3. **Stopped**: Containers can be stopped but still exist
4. **Removed**: Containers can be completely removed

## Environment Variables and Configuration

### Two Methods for Setting Environment Variables

1. **env\_file**:
   * Loads variables from a file (e.g., .env)
   * Good for secrets and environment-specific settings
   * Typically excluded from version control
2. **environment**:
   * Sets variables directly in docker-compose.yml
   * Good for Docker-specific configuration
   * Overrides variables from env\_file

### How Variables Reach Your Application

1. Docker Compose reads configuration
2. Docker sets variables in the container environment
3. Node.js accesses them via process.env
4. Your code uses these values for configuration

## Data Persistence

### Volume Types

* **Named volumes**: Managed by Docker (e.g., mongodb\_data)
* **Bind mounts**: Map host directories to container paths

### MongoDB Data Persistence

volumes:

- mongodb\_data:/data/db

Copy

* Data is stored in the mongodb\_data volume
* Survives container restarts and removals
* Only deleted if you explicitly remove the volume

### Checking Volumes

docker volume ls

Copy

Execute

## Development Workflow

### Option 1: Docker for Everything

* Use volume mounts to sync code changes
* Use nodemon for auto-reloading
* Follow logs with docker compose logs -f

volumes:

- ./:/app

- /app/node\_modules

Copy

### Option 2: Hybrid Approach

* Run MongoDB in Docker
* Run Node.js locally for direct console output

### Updating Code in Containers

* Changes to local files don't automatically update in containers
* Options:
  1. Rebuild: docker compose up -d --build
  2. Use volume mounts for development
  3. Use tools like nodemon for auto-reloading

## Troubleshooting

### Common Issues

1. **Docker daemon not running**:

systemctl start docker

Copy

Execute

1. **Permission issues**:

sudo usermod -aG docker $USER

newgrp docker

Copy

Execute

1. **Context issues**:

docker context ls

docker context use default

Copy

Execute

1. **Container not starting**:

docker compose logs

Copy

Execute

1. **Network issues**:
   * Check if services can resolve each other by name
   * Ensure they're on the same network

### Docker Contexts

* Different environments for Docker commands
* Switch between them with docker context use [name]
* Useful for managing local and remote Docker instances

This document covers the key concepts we discussed about Docker and how your task manager application is structured and managed. Use it as a reference as you continue learning and working with Docker!

:

## 🐳 ****Docker Learning Summary — Multi-Container Apps & Image Layers****

### 📦 ****Sharing a Multi-Container App (Docker Compose)****

You likely use a docker-compose.yml file to orchestrate your multi-container app. Here’s how you can share it:

#### ✅ What to Share:

* docker-compose.yml
* Any Dockerfiles for services you're building
* Source code/config files

### 🚀 Option 1: Share Code (Build Locally)

**Project Structure:**

perl

CopyEdit

my-app/

├── frontend/

│ └── Dockerfile

├── backend/

│ └── Dockerfile

└── docker-compose.yml

**docker-compose.yml:**

yaml

CopyEdit

version: "3.8"

services:

frontend:

build: ./frontend

ports:

- "3000:3000"

backend:

build: ./backend

ports:

- "5000:5000"

**How to run:**

bash

CopyEdit

docker-compose up --build

### 🚀 Option 2: Share Prebuilt Images (Push to Docker Hub)

#### 1. Build and tag images:

bash

CopyEdit

docker build -t yourdockerhubusername/my-frontend:latest ./frontend

docker build -t yourdockerhubusername/my-backend:latest ./backend

#### 2. Push them:

bash

CopyEdit

docker push yourdockerhubusername/my-frontend:latest

docker push yourdockerhubusername/my-backend:latest

#### 3. Update docker-compose.yml:

yaml

CopyEdit

version: "3.8"

services:

frontend:

image: yourdockerhubusername/my-frontend:latest

ports:

- "3000:3000"

backend:

image: yourdockerhubusername/my-backend:latest

ports:

- "5000:5000"

**Now anyone can just run:**

bash

CopyEdit

docker-compose up

### 🧱 How Docker Images Work Internally

When you pull an image like node:18, it has **layers**:

csharp

CopyEdit

[Your App Code]

↓

[Node.js Installed]

↓

[Ubuntu/Debian Base OS Layer]

↓

[Lower system layers or scratch]

* **Images are built in layers**
* node:18 is built **on top of Debian or Ubuntu**
* Your application gets layered above that

### 🧠 Do Containers Have Their Own OS?

* **Yes, but not fully**
* Containers have their own:
  + File system
  + Environment
  + Userspace
* But they **share the host kernel**

This makes them:

* **Lightweight** (unlike full virtual machines)
* **Isolated**
* **Fast to start and stop**

### 🪟 Docker on Windows

#### ✅ Yes, Docker works on Windows.

#### Two Modes:

1. **WSL 2 Backend (Recommended)**
   * Uses Windows Subsystem for Linux
   * Runs **Linux containers**
   * Fast, lightweight
2. **Windows Containers Mode**
   * Runs **Windows containers only**
   * Rarely needed unless you're building Windows-specific apps

# Docker Compose and Containerization: A Comprehensive Guide

This document summarizes key concepts about Docker Compose, volumes, networks, and environment variables based on the task-manager-docker-express project.

## 1. Docker Compose File Structure

The docker-compose.yml file defines multi-container Docker applications with the following main sections:

services: # Container definitions

networks: # Network configurations

volumes: # Persistent data storage

Copy

### Resources for Learning Docker Compose Syntax

* [Docker Compose File Reference](command:_cody.vscode.open?%22https%3A%2F%2Fdocs.docker.com%2Fcompose%2Fcompose-file%2F%22)
* [Docker Compose Getting Started](command:_cody.vscode.open?%22https%3A%2F%2Fdocs.docker.com%2Fcompose%2Fgettingstarted%2F%22)
* [Docker Compose Specification](command:_cody.vscode.open?%22https%3A%2F%2Fgithub.com%2Fcompose-spec%2Fcompose-spec%2Fblob%2Fmaster%2Fspec.md%22)

## 2. Volumes in Docker Compose

Volumes provide persistent data storage for containers.

### Example from the Project

volumes:

mongodb\_data:

# external: true

Copy

### Key Concepts

* **Named Volumes**: mongodb\_data is a named volume that persists MongoDB data
* **Volume Mounting**: - mongodb\_data:/data/db mounts the volume to MongoDB's data directory
* **Persistence**: Data remains even if containers are removed or recreated

### External Volumes

* **Default (external: false)**: Docker Compose manages the volume lifecycle
* **External (external: true)**: Volume must be pre-created and won't be removed by Docker Compose
* **Manual Creation**: docker volume create mongodb\_data

## 3. Networks in Docker Compose

Networks enable container communication and isolation.

### Example from the Project

networks:

task-manager-network:

driver: bridge

Copy

### Key Concepts

* **Custom Networks**: Create isolated communication channels between containers
* **Service Discovery**: Containers can reference each other by service name (e.g., mongodb)
* **Network Drivers**: Define how the network behaves

### Network Drivers

* **bridge**: Default driver, creates an internal network on the host
* **host**: Uses the host's networking directly
* **overlay**: For multi-host networking (Docker Swarm)
* **macvlan**: Assigns MAC addresses to containers
* **none**: Disables networking

### External Networks

* Similar to external volumes, can be pre-created and shared between projects
* Manual creation: docker network create task-manager-network

## 4. Environment Variables in Docker Compose

Environment variables provide configuration to containers.

### Three Ways to Set Environment Variables

1. **env\_file directive**:

env\_file:

- .env

Copy

1. **environment directive**:

environment:

- MONGODB\_URI=mongodb://mongodb:27017/task-manager

- PORT=3000

Copy

1. **Copying .env file** (via Dockerfile):

COPY . .

Copy

(Requires code to load the .env file)

### Best Practice

Choose one method to avoid redundancy:

* Use env\_file for variables in a separate file
* Use environment for variables defined directly in the compose file

## 5. MongoDB Connection URL

The connection string used in the project:

mongodb://mongodb:27017/task-manager

Copy

### Components

* **Protocol**: mongodb:// - Standard MongoDB connection
* **Hostname**: mongodb - Service name in Docker Compose(depends on your container name)
* **Port**: 27017 - Default MongoDB port
* **Database**: task-manager - Database name

## 6. Port Mapping in Docker Compose

Port mapping follows the format "HOST\_PORT:CONTAINER\_PORT":

ports:

- "27017:27017"

Copy

### Connection Paths

1. **Container-to-Container**: Uses the Docker network
   * Connection string: mongodb://mongodb:27017/task-manager
   * Stays within the Docker network
   * Uses service name as hostname
2. **External-to-Container**: Uses host port mapping
   * Connection string: mongodb://localhost:27017/task-manager
   * Goes through the host's port
   * Used for connecting from outside Docker

## 7. Relationship Between Networks and Environment Variables

* **Networks**: Provide the infrastructure for containers to communicate
* **Environment Variables**: Tell the application how to use that infrastructure
* The connection string (MONGODB\_URI) references the network but doesn't create it
* Both proper network configuration and correct environment variables are needed

This document covers the fundamental concepts of Docker Compose as implemented in the task-manager-docker-express project, focusing on volumes, networks, environment variables, and container communication.

# 🔹 DOCKER (Advanced Level)

## ****1. Docker Internals****

### ❓ What happens when you run docker run?

1. Docker CLI talks to **Docker daemon**.
2. Daemon:
   * **Pulls the image** (if not present)
   * **Creates a container** (isolated process)
   * Assigns networking
   * Mounts file systems (UnionFS + volumes)
   * Sets up cgroups (for CPU/memory limits)
   * Starts the **main process** (PID 1 inside the container)

🧠 Internally: it's like spawning a **namespaced process with a layered FS and resource limits**.

### ❓ What are ****layers**** in Docker images?

* Each Dockerfile instruction (like RUN, COPY, etc.) creates a **new layer**.
* These layers are **stacked** to form the final image.
* Docker caches and reuses layers to speed up builds.

✅ If the base layers haven’t changed, Docker will **not rebuild** them.

### ❓ How does the ****Union File System**** work?

* It **combines multiple read-only image layers** + one writable layer.
* From the container’s POV, it looks like a single unified file system.

📦 Example:

pgsql

CopyEdit

ubuntu:20.04 (read-only)

+ apt install curl (read-only)

+ COPY app.py (read-only)

+ <container changes> (writable)

## ****2. Optimization****

### ❓ How to reduce image size?

* Use **multi-stage builds**:

Dockerfile

CopyEdit

FROM node:16 AS builder

RUN npm run build

FROM nginx:alpine

COPY --from=builder /dist /usr/share/nginx/html

* Use **alpine base images**.
* Combine RUN steps and remove temp files.
* Avoid installing tools you don’t need (curl, git, etc.)

### ❓ COPY vs ADD?

| Command | Purpose | Notes |
| --- | --- | --- |
| COPY | Copies files/directories | Always preferred for clarity |
| ADD | Also extracts .tar, supports URLs | Use only when needed |

### ❓ CMD vs ENTRYPOINT?

| Field | Behavior |
| --- | --- |
| CMD | Default args to ENTRYPOINT or app |
| ENTRYPOINT | Main command, cannot be overridden easily |

🔥 Use ENTRYPOINT to run a fixed binary, and CMD for default args.

## ****3. Docker Networking****

### ❓ How do ****bridge, host, overlay**** networks work?

| Network | How It Works | Use Case |
| --- | --- | --- |
| bridge | Default for containers; NAT via docker0 bridge | Local dev |
| host | Container shares host's network stack | Low-latency, fast access |
| overlay | Multi-host virtual network (used by Swarm/K8s) | Cluster networking |

### ❓ Connect two containers without --link?

**Use a custom bridge network**:

bash

CopyEdit

docker network create mynet

docker run -d --name db --network=mynet postgres

docker run -it --network=mynet myapp

Now myapp can reach db using just its name: db:5432

## ****4. Debugging & Performance****

### ❓ Debug container failing to start?

1. Check logs:

bash

CopyEdit

docker logs <container\_id>

1. Start with interactive shell:

bash

CopyEdit

docker run -it --entrypoint /bin/sh myimage

1. Describe container:

bash

CopyEdit

docker inspect <container\_id>

### ❓ Check and limit CPU/RAM?

Limit resources:

bash

CopyEdit

docker run --memory=512m --cpus=1.0 nginx

Check stats:

bash

CopyEdit

docker stats

Inspect limits:

bash

CopyEdit

docker inspect <container> | grep -i memory

## ****5. Security****

### ❓ Scan images for vulnerabilities?

* Use tools like:
  + Docker Scout
  + [Trivy](https://github.com/aquasecurity/trivy)
  + Snyk
  + Clair

Example:

bash

CopyEdit

trivy image nginx:alpine

### ❓ Run containers as non-root?

1. Create a non-root user inside Dockerfile:

Dockerfile

CopyEdit

RUN useradd -m appuser

USER appuser

1. Avoid using root unless necessary.

✅ Also set appropriate file permissions so the non-root user can access needed files.