Container Network - Docker Image Layers Explained

Docker image layer sharing and digest

Docker Image Layer Sharing and Digests
In Docker, images are the building blocks of containers. Docker optimizes storage and performance by allowing multiple images to share common layers. This means that if two or more images have the same layers, Docker will reuse those layers rather than storing duplicate copies. This sharing mechanism reduces disk space usage and speeds up image operations.

Usage Scenario
Consider a scenario where you have multiple versions of an application stored in separate Docker images. If these versions share common dependencies or configurations, Docker will share the underlying layers among them, saving storage space and improving performance.

Example
The output of a docker pull command with the -a flag demonstrates Docker's ability to recognize shared layers:

```
$ docker pull -a ubuntu
latest: Pulling from library/ubuntu
...
Digest: sha256:...
Status: Downloaded newer image for ubuntu
docker.io/library/ubuntu:latest

$ docker images
REPOSITORY        TAG       IMAGE ID       CREATED       SIZE
ubuntu            latest    abcdef123456   2 weeks ago    72.9MB
ubuntu            20.04     abcdef123456   2 weeks ago    72.9MB
ubuntu            18.04     123abcdef456   2 weeks ago    69.7MB
```

In this example, we pulled the Ubuntu image with multiple tags (latest, 20.04, 18.04). The docker pull -a ubuntu command downloads all available tags of the Ubuntu image from the Docker Hub repository. The subsequent docker images command displays the list of downloaded images, including their repository, tag, image ID, creation date, and size.

The IMAGE ID for tags latest and 20.04 is the same (abcdef123456), indicating that these tags share the same underlying image layers. This demonstrates image layer sharing, where common layers are reused across different versions or tags of the same image, saving storage space and bandwidth.

Pulling Images by Digests
Using image tags for pulling images can lead to ambiguity and potential issues, especially when tags are mutable. Docker provides a solution to this problem through image digests, which are

immutable identifiers based on the contents of the image.

Explanation
Image digests are cryptographic hashes that uniquely identify Docker images. Unlike tags, which can be changed or reused, digests remain constant even if the image content is modified. This ensures that the pulled image matches the expected content, enhancing reliability and security.

Example
Every time we pull an image, the docker pull command includes the image's digest as part of the information returned. We can also view the digests of images in Docker host's local repository by adding the --digests flag to the docker images command. These are both shown in the following example.

```
$ docker pull alpine
Using default tag: latest
latest: Pulling from library/alpine
08409d417260: Pull complete
Digest: sha256:02bb6f42...44c9b11
Status: Downloaded newer image for alpine:latest
docker.io/library/alpine:latest

$ docker images --digests alpine
REPOSITORY   TAG       DIGEST                    IMAGE ID       CREATED      SIZE
alpine       latest    sha256:02bb6f42...44c9b11     44dd6f223004   9 days ago   7.73MB
```
The snipped output above shows the digest for the alpine image as -

sha256:02bb6f42...44c9b11

Now that we know the digest of the image, we can use it when pulling the image again. This will ensure that we get exactly the image we expect!

```
$ docker pull
alpine@sha256:02bb6f428431fbc2809c5d1b41eab5a68350194fb508869a33cb1af4444c9b11
```
Here, the image is pulled using its digest sha256:02bb6f428431fbc2809c5d1b41eab5a68350194fb508869a33cb1af4444c9b11, ensuring that the exact image with its immutable content is retrieved.

Understanding Multi-Architecture Images in Docker
Docker's simplicity has been a key factor in its widespread adoption. However, with technological advancements, Docker's scope has expanded to support different platforms and architectures, such as Windows and Linux, on various CPU architectures like ARM, x64, PowerPC, and s390x. This evolution has introduced complexities, especially when dealing with images that have multiple versions for different platforms and architectures. This complexity challenged the seamless Docker experience users were accustomed to.

Definition Clarification
In the context of Docker, "architecture" refers to CPU architecture, such as x64 and ARM, while "platform" denotes the operating system (OS) or the combination of OS and architecture.

Introducing Multi-Architecture Images
To address the challenges posed by diverse platforms and architectures, Docker introduced multi-

architecture images. These images enable a single image tag, like golang:latest, to encompass versions for multiple platforms and architectures. With multi-architecture images, users can simply execute a docker pull golang:latest command from any platform or architecture, and Docker automatically retrieves the appropriate image variant.

To facilitate this, Docker Registry API incorporates two essential constructs:

Manifest Lists: These lists enumerate the architectures supported by a specific image tag. Each architecture entry points to its corresponding manifest containing image configuration and layer data.

Manifests: Each supported architecture has its manifest detailing the layers used to construct it.

Operational Overview
When Docker users pull an image, Docker interacts with Docker Hub, checking if a manifest list exists for the image. If so, Docker parses the list to identify an entry corresponding to the user's platform and architecture. Subsequently, Docker retrieves the manifest for the relevant architecture and extracts the cryptographic IDs of its layers. These layers are then fetched from Docker Hub and assembled on the user's Docker host.

Practical Demonstration
To illustrate the concept, consider the following examples executed on Linux ARM and Windows x64 systems. Both commands initiate a container based on the official golang image and execute the go version command. Despite the differing platforms and CPU architectures, Docker seamlessly selects the appropriate image variant:

Linux on ARM64 Example:
$ docker run --rm golang go version
go version go1.20.4 linux/arm64
Windows on x64 Example:
> docker run --rm golang go version
go version go1.20.4 windows/amd64
Manifest Inspection
The docker manifest command allows users to examine the manifest list of any image on Docker Hub. The following example inspects the manifest list for the golang image, showcasing support for Linux and Windows across various CPU architectures.

```
$ docker manifest inspect golang | grep 'architecture\|os'
"architecture": "amd64",
        "os": "linux"
        "architecture": "arm",
        "os": "linux",
        "architecture": "arm64",
        "os": "linux",
        "architecture": "386",
        "os": "linux"
        "architecture": "mips64le",
        "os": "linux"
        "architecture": "ppc64le",
```

```
            "os": "linux"
            "architecture": "s390x",
            "os": "linux"
            "architecture": "amd64",
            "os": "windows",
            "os.version": "10.0.20348.1726"
            "architecture": "amd64",
            "os": "windows",
            "os.version": "10.0.17763.4377"
```

All official images have manifest lists.

Conclusion
Multi-architecture images represent Docker's commitment to flexibility and compatibility across diverse environments. By seamlessly accommodating multiple platforms and architectures under a single image tag, Docker enhances the user experience and simplifies image management across heterogeneous infrastructures.

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Docker Image Layer Sharing and Digests – Explained Like You're 5!

Imagine you have a **big LEGO castle** built with many LEGO bricks. Now, imagine you want to build another castle that looks almost the same but has just a few different pieces.

Would you break the first castle and build the second one from scratch? **No!** That would take too much time and waste LEGO bricks. Instead, you **reuse** the bricks from the first castle and only change a few pieces.

This is **exactly** how Docker works!

What is Docker?

Docker is like a **magic box** that helps computers run applications (software) in small containers. Think of it as putting your favorite toy inside a box so you can play with it anywhere, even on a different table!

What are Docker Images?

Docker **images** are like **LEGO instruction booklets**—they tell Docker how to build a container.

When you run a Docker image, it creates a **container**—like a LEGO castle built from the instructions.

What are Docker Layers?

Instead of building the whole castle again and again, Docker **reuses** parts of it that are the same. These reusable parts are called **layers**.

For example:

1. You make a burger 🍔 with **bread**, **lettuce**, **cheese**, and **meat**.
2. You want to make another burger, but this time with **extra cheese**.

3. Instead of making the whole burger from scratch, you **reuse** the bread, lettuce, and meat—just adding more cheese.

That's exactly how Docker saves time and space. If two images share the same parts, they don't make new copies—they **reuse the same layers**!

How Docker Shares Image Layers

Let's say we download two versions of an app using Docker:

```
bash

docker pull -a ubuntu
```

This downloads **multiple versions** of Ubuntu (a type of operating system).

Now, if we check what images are in our system:

```
bash

docker images
```

We might see something like this:

REPOSITORY	TAG	IMAGE ID	SIZE
ubuntu	latest	abc123	72MB
ubuntu	20.04	abc123	72MB
ubuntu	18.04	def456	69MB

👉 The **Image ID** for **latest** and **20.04** is **the same** (`abc123`).
That means Docker **did not download two separate copies**. It **shared** the common layers! 🚀

What is a Docker Digest?

A **digest** is like a **fingerprint** for an image. It is a long unique code (like a secret passcode) that helps Docker know if an image is **exactly the same** or not.

Example:

```
bash

docker pull alpine
```

This downloads an image called **Alpine** (a small operating system). When downloaded, it shows:

```
bash

Digest: sha256:02bb6f42...44c9b11
```

💡 **Important:**

- **Tags (like "latest") can change**—they might point to different versions over time.
- **Digests never change**—they always point to the exact same image!

If we want to download an image using its **digest** (to make sure we always get the same one), we can do this:

```
bash

docker pull alpine@sha256:02bb6f428431fbc2809c5d1b41eab5a68350194fb508869a33cb1af4444c9b11
```

Now, we are 100% sure that we are getting **the exact same image**, no matter what! 🎯

Multi-Architecture Images (Making Docker Work Everywhere!)

Imagine you have a toy car. 🚗

- Some kids use **big hands** (x64 computers).
- Some kids use **small hands** (ARM computers).
- Some kids play on the **floor** (Linux).
- Some kids play on a **table** (Windows).

You want **one toy car that works for everyone**!

That's what **multi-architecture images** do!
Instead of having different images for different computers, **Docker combines them into one**.

For example:

```
bash

docker run --rm golang go version
```

If you run this command on different computers, you will get:

- **Linux on ARM** → `` `go version go1.20.4 linux/arm64` ``
- **Windows on x64** → `` `go version go1.20.4 windows/amd64` ``

🔍 How does Docker know which one to use?
Docker checks a **manifest list**, which is like a **menu** that tells it which version works best for your computer.

We can **inspect** a manifest list with:

```
bash

docker manifest inspect golang | grep 'architecture\|os'
```

It might show:

```
json

"architecture": "amd64",
"os": "linux"
"architecture": "arm",
"os": "linux",
"architecture": "arm64",
"os": "linux",
"architecture": "amd64",
"os": "windows",
```

That means this image **supports multiple platforms and architectures!**

Conclusion (Why is this important?)

1. **Docker saves space** by **sharing layers** instead of making copies.
2. **Digests ensure security** so we always pull the correct image.
3. **Multi-architecture images** allow one image to work on different computers.

Just like sharing LEGO bricks **saves time and space**, Docker **shares layers** to make everything faster and better! 🚀