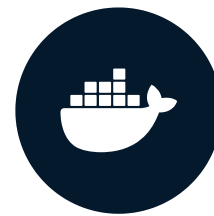


Networking refresher

INTERMEDIATE DOCKER



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What is networking?

- A computer network consists of systems communicating via a defined method
- Varying levels of communication, physical or logical, referred to as *protocols*
- Common physical networks include Ethernet and WiFi
- Logical networking includes TCP/IP, HTTP, and SMTP
- Networks are defined in various layers or levels. Often referred to as a networking stack



¹ Photo by Jordan Harrison on Unsplash.

Networking terms

- Host
 - General term for a computer
- Network
 - Group of hosts
- Interface
 - Actual connection from a host to a network, such as Ethernet or WiFi
 - Can be virtual, meaning entirely in software
- LAN
 - Local Area Network, or set of computers at a given location
- VLAN
 - Virtual LAN, or a software LAN

Internet Protocol

- IP
 - Internet protocol, method to connect between networks using IP addresses
- IPv4
 - Version of IP supporting 4.2 billion addresses, currently exhausted
- IPv6
 - Newer version of IP, supporting 2^{128} addresses, still being deployed

IPv4: 10.10.10.1

IPv6: 2001:0db8:85a3:0000:0000:8a2e:0370:7334

TCP / UDP

- TCP
 - Transmission Control Protocol, used to reliably communicate between hosts on IP networks
- UDP
 - User Datagram Protocol, used to communicate between hosts on IP where communication is not required.

Ports

- Port
 - Addresses services on a given host, a value between 0 and 65535, used to communicate between hosts via TCP or UDP
 - Ports below 1024 are typically reserved for privileged accounts
 - Values above 1024 are usually ephemeral or temporary ports
 - Applications **listen** on a port.

Application protocols

- HTTP/HTTPS
 - Application protocol, defaulting to TCP port 80 for web communication. Secure version on TCP 443
- SMTP
 - Email transfer protocol, over TCP port 25
- SNMP
 - Network management protocol, over UDP port 161

Docker and networking

- Can communicate between containers
- Can communicate with the host system
- Depending on settings can communicate with external hosts
- Typical communication is handled by exposing ports from container to host
- Acts like a translation between containers and hosts

Docker and IP

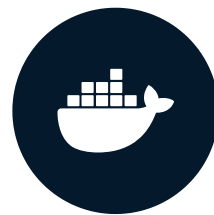
- Containers can have IP addresses
- Use `ifconfig <interface>` or `ip addr show <interface>` from within container to find addresses
- Use `ping -c <x> <host>` to verify connectivity
 - `ping -c 3 myhost`

```
repl@4221eef4-d3b6-45ef-b95a-71e78ac62619:~$ ifconfig eth0
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 9001
    inet 10.4.77.205 netmask 255.255.255.255  broadcast 0.0.0.0
    inet6 fe80::5457:73ff:fe94:f6e4 prefixlen 64  scopeid 0x20<link>
    ether 56:57:73:94:f6:e4  txqueuelen 0  (Ethernet)
    RX packets 1811  bytes 272039 (272.0 KB)
    RX errors 0  dropped 0  overruns 0  frame 0
    TX packets 1295  bytes 137826 (137.8 KB)
    TX errors 0  dropped 1 overruns 0  carrier 0  collisions 0
```

Let's practice!
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Making network services available in Docker

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Network services

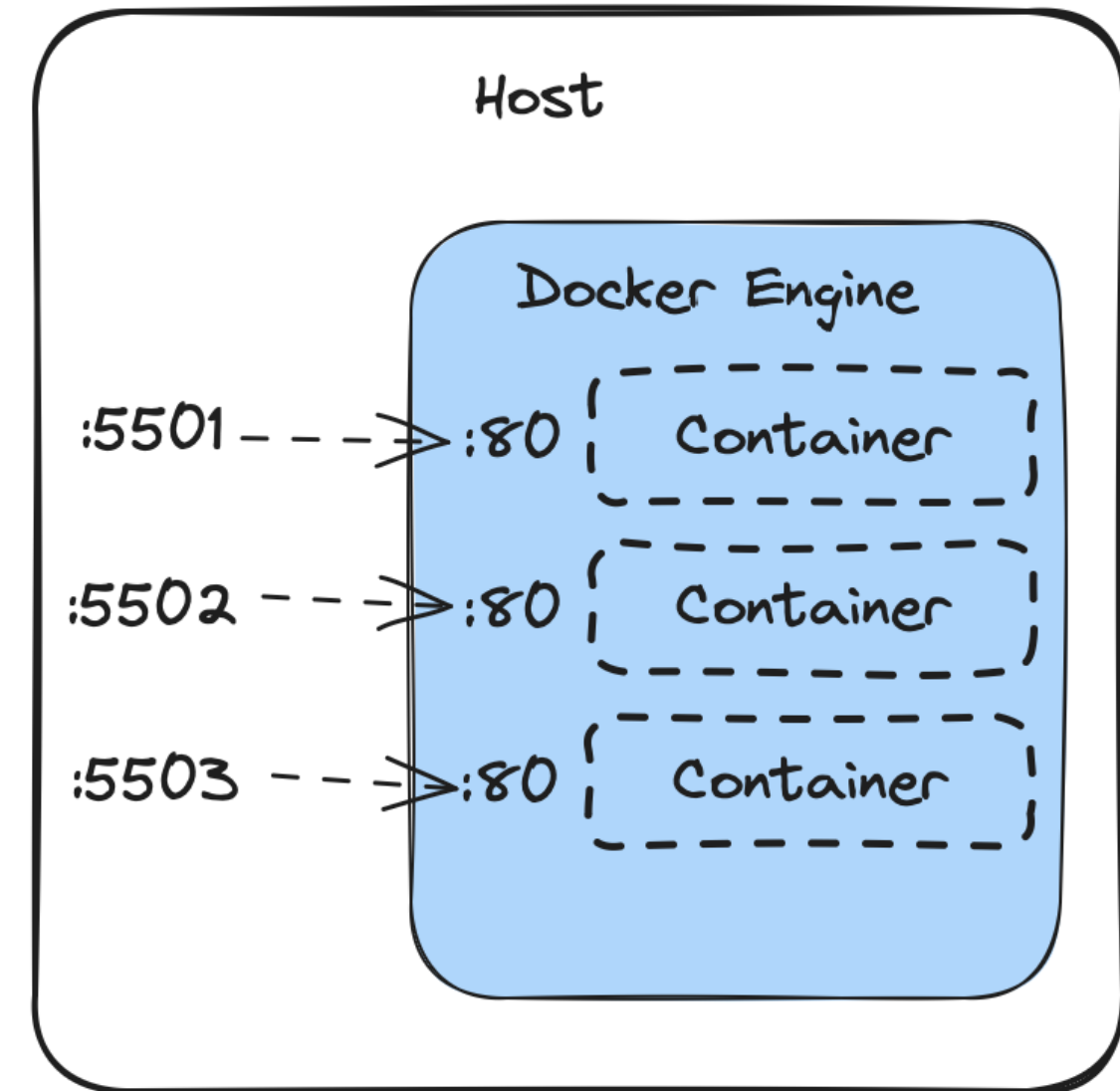
- Network services **listen** on a given port
- Only one program can listen on an IP:port combo at a given time
 - For example, 10.1.2.3:80 would be listening on 10.1.2.3 on port 80.
- Consider trying to debug different versions of a web server that listens on port 80
 - Could only run one copy of the application at a time given that it listens only on that port

Containerized services

- Wrapping application in a container means that each container can now listen on that port (as the IP:port combo is different, each container has a different IP)
- Can have multiple copies of the containers running at once
- But how to connect to container's version of application from the host?

Port mapping

- The answer is the use of **port mapping**, or port forwarding / translation
- Port mapping takes a connection to a given IP:port and automatically forwards it to another IP:port combo
- In this case, we could map an unused port on our host and point it to port 80 on the container(s)
- The Docker engine can handle this automatically if we configure it to



Enabling port mapping

- To enable port mapping on a given container, we use the `docker run` command, and the `-p` flag
- `-p <host port>:<container port>`
- `-p 5501:80`
- Can have multiple `-p` flags for different ports

```
repl@host:~$ docker run -p 5501:80 nginx
```

```
repl@host:~$ docker ps -a
```

| CONTAINER ID | IMAGE | ... PORTS | NAMES |
|--------------|-------|---|----------------|
| 84266724ff47 | nginx | ... 0.0.0.0:5501->80/tcp, :::5501->80/tcp | coiled_elgama1 |

Let's practice!
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Exposing ports with Dockerfiles

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Exposing services

- `EXPOSE` command
- Defines which ports the container will use at runtime
- Can be defined as `<number>` , `<number>/tcp` , or `<number>/udp`
 - Such as `EXPOSE 80` or `EXPOSE 80/tcp`
- Multiple entries permitted
- Used as a documentation method

Using the `-p` / `-P` flags

- Still requires use of `-p` or `-P` options to `docker run` to make the ports available outside the container
- The `-P` option will automatically map an ephemeral port to the exposed port(s). Must use `docker ps -a` to see which ports are mapped.
- Using `-p<host port>:<container port>` allows use of specific ports.

EXPOSE example

```
# Dockerfile
FROM python:3.11-slim
ENTRYPOINT ["python", "-mhttp.server"]
# Let the Docker engine know
# port 8000 should be available
EXPOSE 8000
```

- Create a container from the image

```
docker run pyserver
```

- Print the state of the container

```
docker ps -a
```

| CONTAINER ID | IMAGE | ... | PORTS | NAMES |
|--------------|----------|-----|----------|-------------|
| 8c3d320255ae | pyserver | ... | 8000/tcp | angry_chaum |

Making ports reachable

- Automatically map temporary port from host to the container

```
docker run -P pyserver
```

```
docker ps -a
```

| CONTAINER ID | IMAGE | ... | PORTS | NAMES |
|--------------|----------|-----|-------------------------|------------------|
| 6bb458ef25da | pyserver | ... | 0.0.0.0:55001->8000/tcp | beautiful_lamarr |

Finding exposed ports

- `docker inspect` provides a lot of information

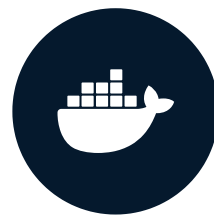
```
docker inspect <id>
```

```
"NetworkSettings": {  
  "Bridge": "",  
  "Ports": {  
    "8000/tcp": [{  
      "HostIp": "0.0.0.0",  
      "HostPort": "55001"  
    }]  
  },  
  ...  
}
```

Let's practice!
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Docker networks

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Docker networking

- Docker has extensive networking options
- Can create networks to communicate between containers, host, and external systems
- Will cover various commands to interact with networks.

Docker networking types

- Docker supports different networking types, using drivers
 - **bridge**: Default driver, allows connections out, connections in if exposed
 - **host**: Allows full communication between host and containers
 - **none**: Isolate container from network communications
 - Many others, including custom drivers
- Will mostly use the bridge driver to create our own networks

Working with Docker networks

Several commands:

- `docker network`
 - `docker network <command>`
 - `docker network <command> --help`
 - `docker network ls` to list all docker networks on the host
 - `docker network create` to create a network
 - `docker network rm` to remove a network

Docker network example

- Create a Docker network named `mynetwork`

```
rep1@host:~$ docker network create mynetwork
```

```
5ff0febab98f73b74dd753eb44a30f7d7291052b3b1d58b0134589221cb8e33d
```

```
rep1@host:~$ docker network ls
```

| NETWORK ID | NAME | DRIVER | SCOPE |
|--------------|-----------|--------|-------|
| 2edc5ae4838c | bridge | bridge | local |
| a92988382711 | host | host | local |
| 5ff0febab98f | mynetwork | bridge | local |
| 5464ed866dad | none | null | local |

Attaching containers to networks

- How to connect container to a network?
- `docker run --network <networkname> ...`
- `docker run --network mynetwork ubuntu bash`
- Can also connect containers later
 - `docker network connect <networkname> <container>`
 - `docker network connect mynetwork ubuntu-B`

docker network inspect

- How to check details of network?
- `docker network inspect <networkname>`
- Provides configuration info and IP addresses assigned to containers

```
repl@host:~$ docker network inspect mynetwork
```

docker network inspect example

```
"Name": "mynetwork",  
...  
"Driver": "bridge",  
...  
Containers: {      "2be08aa942029191350d4bceb8816254af8713dd6f7dcbadcab8f068f"  
    "Name": "unruffled_kare",  
    "EndpointID": "29739356ae200e1e901d2eabef05efaca0fb37e1a4e1a4c3bf369"  
    "MacAddress": "02:42:ac:12:00:02",  
    "IPv4Address": "172.18.0.2/16",  
    "IPv6Address": ""  
}
```

Let's practice!
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