Docker container networking

Estimated reading time: 15 minutes

This section provides an overview of the default networking behavior that Docker Engine delivers natively. It describes the type of networks created by default and how to create your own, user-defined networks. It also describes the resources required to create networks on a single host or across a cluster of hosts.

Default Networks

When you install Docker, it creates three networks automatically. You can list these networks using the `docker network ls` command:

```
$ docker network ls

NETWORK ID          NAME                DRIVER
7fca4eb8c647        bridge              bridge
9f904ee27bf5        none                null
cf03ee007fb4        host                host
```

Historically, these three networks are part of Docker's implementation. When you run a container you can use the `--network` flag to specify which network you want to run a container on. These three networks are still available to you.

The `bridge` network represents the `docker0` network present in all Docker installations. Unless you specify otherwise with the `docker run --network=<NETWORK>` option, the Docker daemon connects containers to this network by default. You can see this bridge as part of a host's network stack by using the `ifconfig` command on the host.

```
$ ifconfig
```

```
docker0   Link encap:Ethernet  HWaddr 02:42:47:bc:3a:eb
          inet addr:172.17.0.1  Bcast:0.0.0.0  Mask:255.255.0.0
          inet6 addr: fe80::42:47ff:febc:3aeb/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:9001  Metric:1
          RX packets:17 errors:0 dropped:0 overruns:0 frame:0
          TX packets:8 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:1100 (1.1 KB)  TX bytes:648 (648.0 B)
```

The `none` network adds a container to a container-specific network stack. That container lacks a network interface. Attaching to such a container and looking at its stack you see this:

```
$ docker attach nonenetcontainer

root@0cb243cd1293:/# cat /etc/hosts
127.0.0.1       localhost
::1     localhost ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastprefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters
root@0cb243cd1293:/# ifconfig
lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

root@0cb243cd1293:/#
```

> **Note**: You can detach from the container and leave it running with `CTRL-p CTRL-q`.

The `host` network adds a container on the hosts network stack. You'll find

the network configuration inside the container is identical to the host.

With the exception of the `bridge` network, you really don't need to interact with these default networks. While you can list and inspect them, you cannot remove them. They are required by your Docker installation. However, you can add your own user-defined networks and these you can remove when you no longer need them. Before you learn more about creating your own networks, it is worth looking at the default `bridge` network a bit.

The default bridge network in detail

The default `bridge` network is present on all Docker hosts. The `docker network inspect` command returns information about a network:

```
$ docker network inspect bridge

[
    {
        "Name": "bridge",
        "Id": "f7ab26d71dbd6f557852c7156ae0574bbf62c42f539b50c8ebde0f72
        "Scope": "local",
        "Driver": "bridge",
        "IPAM": {
            "Driver": "default",
            "Config": [
                {
                    "Subnet": "172.17.0.1/16",
                    "Gateway": "172.17.0.1"
                }
            ]
        },
        "Containers": {},
        "Options": {
            "com.docker.network.bridge.default_bridge": "true",
            "com.docker.network.bridge.enable_icc": "true",
            "com.docker.network.bridge.enable_ip_masquerade": "true",
            "com.docker.network.bridge.host_binding_ipv4": "0.0.0.0",
            "com.docker.network.bridge.name": "docker0",
```

```
            "com.docker.network.driver.mtu": "9001"
        },
        "Labels": {}
    }
]
```

The Engine automatically creates a `Subnet` and `Gateway` to the network. The `docker run` command automatically adds new containers to this network.

```
$ docker run -itd --name=container1 busybox

3386a527aa08b37ea9232cbcace2d2458d49f44bb05a6b775fba7ddd40d8f92c

$ docker run -itd --name=container2 busybox

94447ca479852d29aeddca75c28f7104df3c3196d7b6d83061879e339946805c
```

Inspecting the `bridge` network again after starting two containers shows both newly launched containers in the network. Their ids show up in the "Containers" section of `docker network inspect`:

```
$ docker network inspect bridge

{[
    {
        "Name": "bridge",
        "Id": "f7ab26d71dbd6f557852c7156ae0574bbf62c42f539b50c8ebde0f7
        "Scope": "local",
        "Driver": "bridge",
        "IPAM": {
            "Driver": "default",
            "Config": [
                {
                    "Subnet": "172.17.0.1/16",
                    "Gateway": "172.17.0.1"
                }
            ]
        },
```

```
        "Containers": {
            "3386a527aa08b37ea9232cbcace2d2458d49f44bb05a6b775fba7ddd4
                "EndpointID": "647c12443e91faf0fd508b6edfe59c30b642abb
                "MacAddress": "02:42:ac:11:00:02",
                "IPv4Address": "172.17.0.2/16",
                "IPv6Address": ""
            },
            "94447ca479852d29aeddca75c28f7104df3c3196d7b6d83061879e339
                "EndpointID": "b047d090f446ac49747d3c37d63e4307be74587
                "MacAddress": "02:42:ac:11:00:03",
                "IPv4Address": "172.17.0.3/16",
                "IPv6Address": ""
            }
        },
        "Options": {
            "com.docker.network.bridge.default_bridge": "true",
            "com.docker.network.bridge.enable_icc": "true",
            "com.docker.network.bridge.enable_ip_masquerade": "true",
            "com.docker.network.bridge.host_binding_ipv4": "0.0.0.0",
            "com.docker.network.bridge.name": "docker0",
            "com.docker.network.driver.mtu": "9001"
        },
        "Labels": {}
    }
]
```

The `docker network inspect` command above shows all the connected containers and their network resources on a given network. Containers in this default network are able to communicate with each other using IP addresses. Docker does not support automatic service discovery on the default bridge network. If you want to communicate with container names in this default bridge network, you must connect the containers via the legacy `docker run --link` option.

You can `attach` to a running `container` and investigate its configuration:

```
$ docker attach container1

root@0cb243cd1293:/# ifconfig
```

```
eth0      Link encap:Ethernet  HWaddr 02:42:AC:11:00:02
          inet addr:172.17.0.2  Bcast:0.0.0.0  Mask:255.255.0.0
          inet6 addr: fe80::42:acff:fe11:2/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:9001  Metric:1
          RX packets:16 errors:0 dropped:0 overruns:0 frame:0
          TX packets:8 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:1296 (1.2 KiB)  TX bytes:648 (648.0 B)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)
```

Then use `ping` to send three ICMP requests and test the connectivity of the containers on this `bridge` network.

```
root@0cb243cd1293:/# ping -w3 172.17.0.3

PING 172.17.0.3 (172.17.0.3): 56 data bytes
64 bytes from 172.17.0.3: seq=0 ttl=64 time=0.096 ms
64 bytes from 172.17.0.3: seq=1 ttl=64 time=0.080 ms
64 bytes from 172.17.0.3: seq=2 ttl=64 time=0.074 ms

--- 172.17.0.3 ping statistics ---
3 packets transmitted, 3 packets received, 0% packet loss
round-trip min/avg/max = 0.074/0.083/0.096 ms
```

Finally, use the `cat` command to check the `container1` network configuration:

```
root@0cb243cd1293:/# cat /etc/hosts

172.17.0.2      3386a527aa08
127.0.0.1       localhost
```

```
::1     localhost ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastprefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters
```

To detach from a `container1` and leave it running use `CTRL-p CTRL-q`.Then, attach to `container2` and repeat these three commands.

```
$ docker attach container2

root@0cb243cd1293:/# ifconfig
eth0      Link encap:Ethernet  HWaddr 02:42:AC:11:00:03
          inet addr:172.17.0.3  Bcast:0.0.0.0  Mask:255.255.0.0
          inet6 addr: fe80::42:acff:fe11:3/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:9001  Metric:1
          RX packets:15 errors:0 dropped:0 overruns:0 frame:0
          TX packets:13 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:1166 (1.1 KiB)  TX bytes:1026 (1.0 KiB)

lo        Link encap:Local Loopback
          inet addr:127.0.0.1  Mask:255.0.0.0
          inet6 addr: ::1/128 Scope:Host
          UP LOOPBACK RUNNING  MTU:65536  Metric:1
          RX packets:0 errors:0 dropped:0 overruns:0 frame:0
          TX packets:0 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:0
          RX bytes:0 (0.0 B)  TX bytes:0 (0.0 B)

root@0cb243cd1293:/# ping -w3 172.17.0.2

PING 172.17.0.2 (172.17.0.2): 56 data bytes
64 bytes from 172.17.0.2: seq=0 ttl=64 time=0.067 ms
64 bytes from 172.17.0.2: seq=1 ttl=64 time=0.075 ms
64 bytes from 172.17.0.2: seq=2 ttl=64 time=0.072 ms

--- 172.17.0.2 ping statistics ---
3 packets transmitted, 3 packets received, 0% packet loss
round-trip min/avg/max = 0.067/0.071/0.075 ms
/ # cat /etc/hosts
```

```
172.17.0.3      94447ca47985
127.0.0.1       localhost
::1     localhost ip6-localhost ip6-loopback
fe00::0 ip6-localnet
ff00::0 ip6-mcastprefix
ff02::1 ip6-allnodes
ff02::2 ip6-allrouters
```

The default `docker0` bridge network supports the use of port mapping and `docker run --link` to allow communications between containers in the `docker0` network. These techniques are cumbersome to set up and prone to error. While they are still available to you as techniques, it is better to avoid them and define your own bridge networks instead.

User-defined networks

You can create your own user-defined networks that better isolate containers. Docker provides some default **network drivers** for creating these networks. You can create a new **bridge network**, **overlay network** or **MACVLAN network**. You can also create a **network plugin** or **remote network** written to your own specifications.

You can create multiple networks. You can add containers to more than one network. Containers can only communicate within networks but not across networks. A container attached to two networks can communicate with member containers in either network. When a container is connected to multiple networks, its external connectivity is provided via the first non-internal network, in lexical order.

The next few sections describe each of Docker's built-in network drivers in greater detail.

A bridge network

The easiest user-defined network to create is a `bridge` network. This

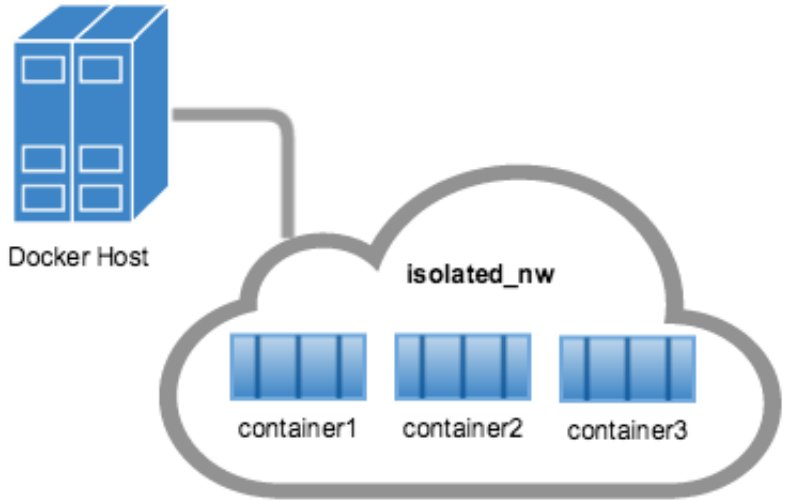
network is similar to the historical, default `docker0` network. There are some added features and some old features that aren't available.

```
$ docker network create --driver bridge isolated_nw
1196a4c5af43a21ae38ef34515b6af19236a3fc48122cf585e3f3054d509679b

$ docker network inspect isolated_nw

[
    {
        "Name": "isolated_nw",
        "Id": "1196a4c5af43a21ae38ef34515b6af19236a3fc48122cf585e3f305
        "Scope": "local",
        "Driver": "bridge",
        "IPAM": {
            "Driver": "default",
            "Config": [
                {
                    "Subnet": "172.21.0.0/16",
                    "Gateway": "172.21.0.1/16"
                }
            ]
        },
        "Containers": {},
        "Options": {},
        "Labels": {}
    }
]

$ docker network ls

NETWORK ID          NAME                DRIVER
9f904ee27bf5        none                null
cf03ee007fb4        host                host
7fca4eb8c647        bridge              bridge
c5ee82f76de3        isolated_nw         bridge
```

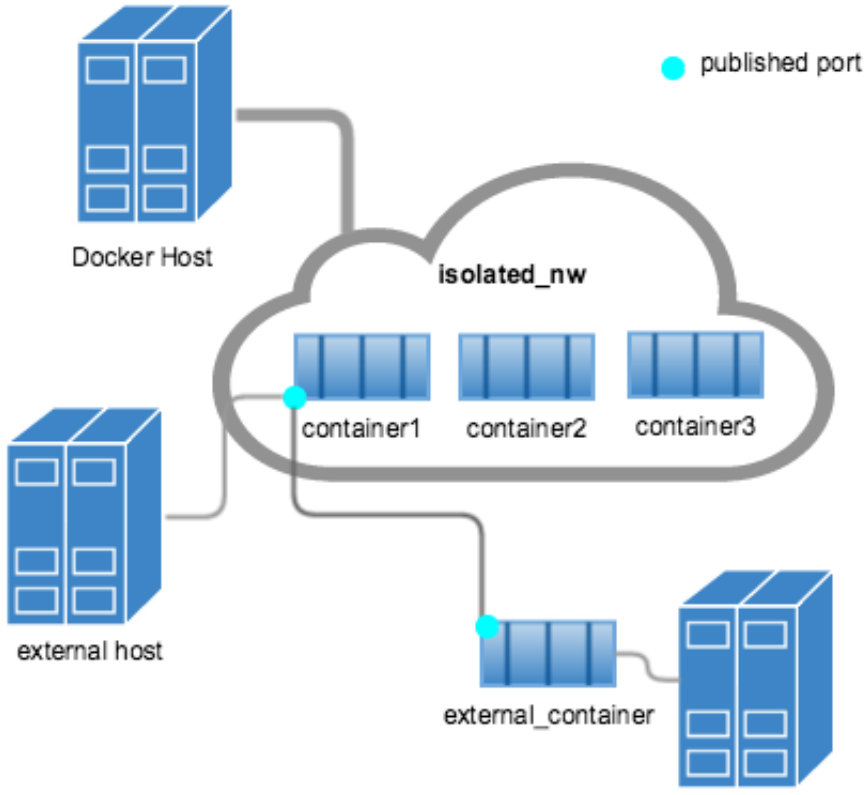
After you create the network, you can launch containers on it using the `docker run --network=<NETWORK>` option.

```
$ docker run --network=isolated_nw -itd --name=container3 busybox

8c1a0a5be480921d669a073393ade66a3fc49933f08bcc5515b37b8144f6d47c

$ docker network inspect isolated_nw
[
    {
        "Name": "isolated_nw",
        "Id": "1196a4c5af43a21ae38ef34515b6af19236a3fc48122cf585e3f305
        "Scope": "local",
        "Driver": "bridge",
        "IPAM": {
            "Driver": "default",
            "Config": [
                {}
            ]
        },
        "Containers": {
            "8c1a0a5be480921d669a073393ade66a3fc49933f08bcc5515b37b814
                "EndpointID": "93b2db4a9b9a997beb912d28bcfc117f7b0eb92
                "MacAddress": "02:42:ac:15:00:02",
                "IPv4Address": "172.21.0.2/16",
                "IPv6Address": ""
            }
        },
        "Options": {},
        "Labels": {}
    }
]
```

The containers you launch into this network must reside on the same Docker host. Each container in the network can immediately communicate with other containers in the network. Though, the network itself isolates the containers from external networks.



Within a user-defined bridge network, linking is not supported. You can expose and publish container ports on containers in this network. This is useful if you want to make a portion of the `bridge` network available to an outside network.



A bridge network is useful in cases where you want to run a relatively small network on a single host. You can, however, create significantly larger networks by creating an `overlay` network.

The `docker_gwbridge` network

The `docker_gwbridge` is a local bridge network which is automatically created by Docker in two different circumstances:

- When you initialize or join a swarm, Docker creates the `docker_gwbridge` network and uses it for communication among swarm nodes on different hosts.
- When none of a container's networks can provide external connectivity, Docker connect the container to the `docker_gwbridge` network in addition to the container's other networks, so that the container can connect to external networks or other swarm nodes.

You can create the `docker_gwbridge` network ahead of time if you need a custom configuration, but otherwise Docker creates it on demand. The following example creates the `docker_gwbridge` network with some custom options.

```
$ docker network create --subnet 172.30.0.0/16 \
                        --opt com.docker.network.bridge.name=docker_gw
                        --opt com.docker.network.bridge.enable_icc=fal
                        docker_gwbridge
```

The `docker_gwbridge` network is always present when you use `overlay` networks.

An overlay network with Docker Engine swarm mode

You can create an overlay network on a manager node running in swarm mode without an external key-value store. The swarm makes the overlay network available only to nodes in the swarm that require it for a service. When you create a service that uses the overlay network, the manager node automatically extends the overlay network to nodes that run service tasks.

To learn more about running Docker Engine in swarm mode, refer to the Swarm mode overview.

The example below shows how to create a network and use it for a service from a manager node in the swarm:

```
# Create an overlay network `my-multi-host-network`.
$ docker network create \
  --driver overlay \
  --subnet 10.0.9.0/24 \
  my-multi-host-network

400g6bwzd68jizzdx5pgyoe95

# Create an nginx service and extend the my-multi-host-network to node
# the service's tasks run.
$ docker service create --replicas 2 --network my-multi-host-network -

716thylsndqma81j6kkkb5aus
```

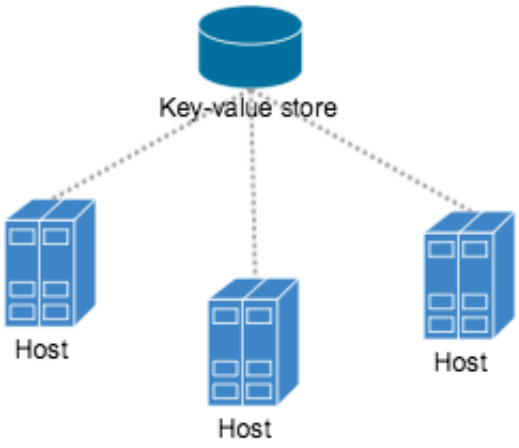
Overlay networks for a swarm are not available to containers started with `docker run` that don't run as part of a swarm mode service. For more information refer to Docker swarm mode overlay network security model.

See also Attach services to an overlay network.

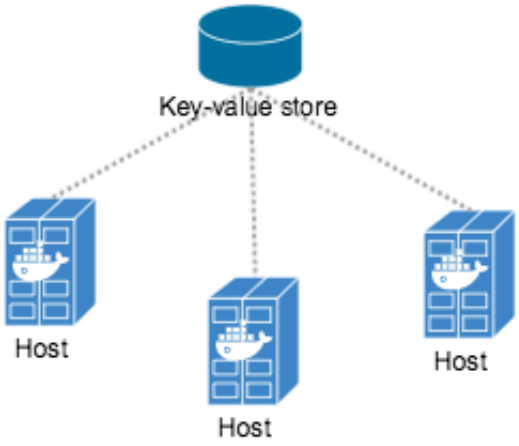
An overlay network with an external key-value store

If you are not using Docker Engine in swarm mode, the `overlay` network requires a valid key-value store service. Supported key-value stores include Consul, Etcd, and ZooKeeper (Distributed store). Before creating a network on this version of the Engine, you must install and configure your chosen key-value store service. The Docker hosts that you intend to network and the service must be able to communicate.

> **Note:** Docker Engine running in swarm mode is not compatible with networking with an external key-value store.



Each host in the network must run a Docker Engine instance. The easiest way to provision the hosts is with Docker Machine.



You should open the following ports between each of your hosts.

Protocol	Port	Description
udp	4789	Data plane (VXLAN)
tcp/udp	7946	Control plane

Your key-value store service may require additional ports. Check your vendor's documentation and open any required ports.

If you are planning on creating an overlay network with encryption (`--opt encrypted`), you will also need to ensure protocol 50 (ESP) traffic is allowed.

Once you have several machines provisioned, you can use Docker Swarm to quickly form them into a swarm which includes a discovery service as well.

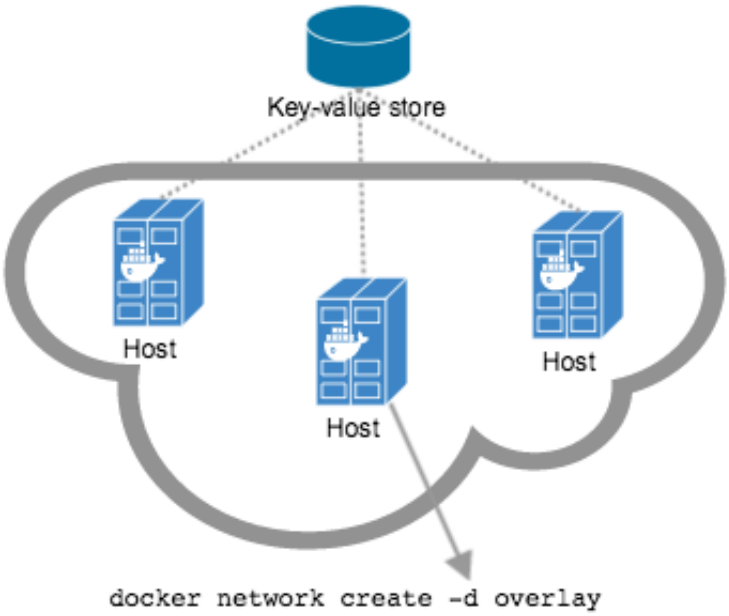
To create an overlay network, you configure options on the `daemon` on each Docker Engine for use with `overlay` network. There are three options to set:

Option	Description
`--cluster-store=PROVIDER://URL`	Describes the location of the KV service.
`--cluster-advertise=HOST_IP|HOST_IFACE:PORT`	The IP address or interface of the HOST used for clustering.
`--cluster-store-opt=KEY-VALUE OPTIONS`	Options such as TLS certificate or tuning discovery Timers

Create an `overlay` network on one of the machines in the swarm.

```
$ docker network create --driver overlay my-multi-host-network
```

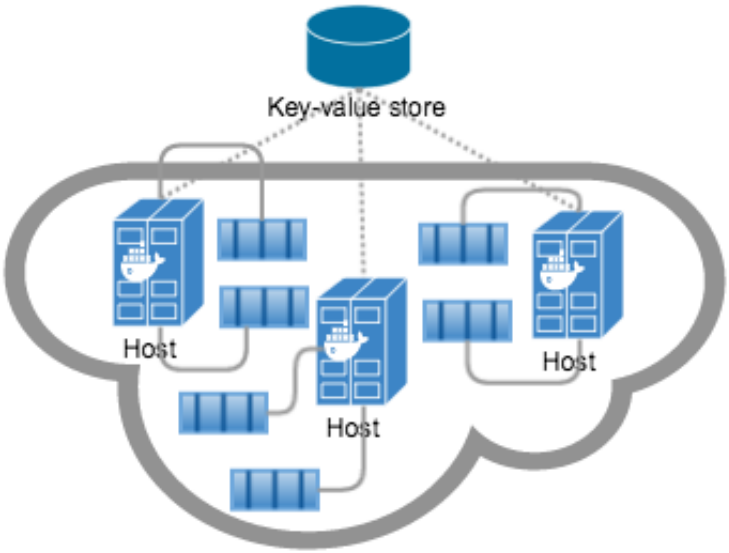
This results in a single network spanning multiple hosts. An `overlay` network provides complete isolation for the containers.



Then, on each host, launch containers making sure to specify the network name.

```
$ docker run -itd --network=my-multi-host-network busybox
```

Once connected, each container has access to all the containers in the network regardless of which Docker host the container was launched on.



If you would like to try this for yourself, see the Getting started for overlay.

Custom network plugin

If you like, you can write your own network driver plugin. A network driver plugin makes use of Docker's plugin infrastructure. In this infrastructure, a plugin is a process running on the same Docker host as the Docker `daemon`.

Network plugins follow the same restrictions and installation rules as other plugins. All plugins make use of the plugin API. They have a lifecycle that encompasses installation, starting, stopping and activation.

Once you have created and installed a custom network driver, you use it like the built-in network drivers. For example:

```
$ docker network create --driver weave mynet
```

You can inspect it, add containers to and from it, and so forth. Of course, different plugins may make use of different technologies or frameworks. Custom networks can include features not present in Docker's default networks. For more information on writing plugins, see Extending Docker and Writing a network driver plugin.

Docker embedded DNS server

Docker daemon runs an embedded DNS server to provide automatic service discovery for containers connected to user defined networks. Name resolution requests from the containers are handled first by the embedded DNS server. If the embedded DNS server is unable to resolve the request it will be forwarded to any external DNS servers configured for the container. To facilitate this when the container is created, only the embedded DNS server reachable at `127.0.0.11` will be listed in the container's `resolv.conf` file. More information on embedded DNS server on user-defined networks can be found in the embedded DNS server in user-defined networks

Links

Before the Docker network feature, you could use the Docker link feature to allow containers to discover each other. With the introduction of Docker networks, containers can be discovered by its name automatically. But you can still create links but they behave differently when used in the default `docker0` bridge network compared to user-defined networks. For more information, please refer to Legacy Links for link feature in default `bridge` network and the linking containers in user-defined networks for links functionality in user-defined networks.

Related information

- Work with network commands
- Get started with multi-host networking
- Managing Data in Containers
- Docker Machine overview
- Docker Swarm overview
- Investigate the LibNetwork project

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