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Dynamic Host Configuration Protocol (DHCP)

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Contents

Chapter 1

DHCP

1.1 Introduction

DHCP (Dynamic Host Configuration Protocol) automates the process of configuring the network parameters of network devices. This protocol is built on a client-server model (see Figure 1.1). DHCP servers allocate network addresses and deliver parameters to dynamically configured devices. These parameters include the assigned IP, the network mask, the IP address of one or more DNS servers and the IP address of the default router. DHCP facilitates network management tasks, especially when a new device goes into the network.

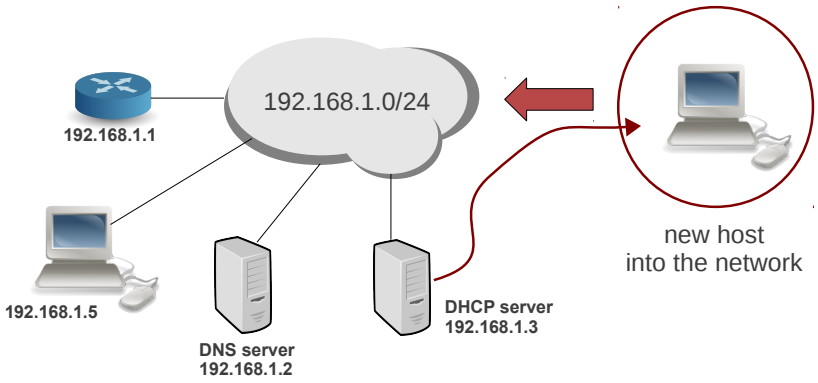

Figure 1.1: DHCP Basic Scenario.

DHCP consists of two components:

- A **mechanism** for allocation of network addresses to devices.
- A **protocol** for delivering network addresses and other host-specific configuration parameters from the DHCP server to the device being configured.

1.2 DHCP Allocation Mechanisms

DHCP supports three mechanisms for IP address allocation:

- **Manual allocation**: A particular IP address is pre-allocated to a network device by an administrator. Typically, the network device is identified by its MAC address but other methods (like secret keys) can also be used.
- **Automatic allocation**: DHCP automatically assigns an IP address permanently to a device, selecting it from a pool of available addresses.
- **Dynamic allocation**: DHCP automatically assigns an IP address to a client for a limited period of time (or until the client explicitly relinquishes the address).

From the three allocation methods, dynamic allocation is by far the one most widely used. Dynamic allocation allows automatic reuse of addresses. In this context, dynamic allocation is useful for example for assigning an address to a client that will be connected to the network temporarily. Or for sharing a limited pool of IP addresses among a group of clients that do not need permanent IP addresses (this is used by internet providers). Finally, we can also use dynamic allocation for assigning an IP address to a new client being permanently connected to a network, where IP addresses are sufficiently scarce that it is important to reclaim them when old clients are retired.

The "**lease**" is the period of time over which a network address is allocated to a client. The dynamic allocation mechanism works as follows:

- A client requests the use of an address for some period of time (lease time).
- The allocation mechanism guarantees that the assigned address will not be reallocated to any other device during the requested time.
- Later, the client may extend its lease with subsequent requests.
- Each time the client requests an address, it usually includes the previously assigned address and the allocation mechanism attempts to assign the same network address.
- If the client does not need the address anymore, she can issue a message to release the address back to the server.
- Finally, the client may ask for a permanent assignment by asking for an infinite lease.

On the other hand, DHCP needs a DHCP database or **persistent storage** of network parameters for network clients. That is to say, the DHCP server has to know the state of configured hosts to operate properly. Typically, DHCP servers store a key-value entry for each client. The key is some unique identifier (e.g., IP-number, hardware-address). The value contains the configuration parameters for the client.

1.3 DHCP protocol

DHCP uses a **message exchange** protocol over the UDP protocol (see Figure 1.2).

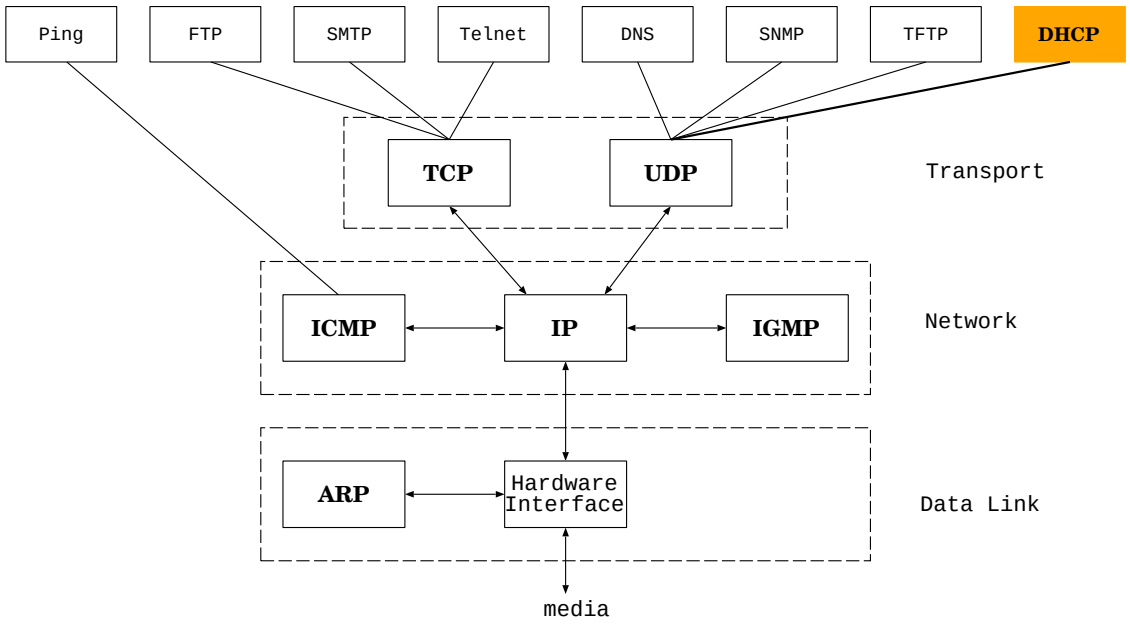

Figure 1.2: DHCP Protocol.

DHCP messages use the ports 67 and 68. Messages from a client to a server are sent to the 'server' port (67), while messages from a server to a client are sent to the 'client' port (68). The DCHP protocol essentially works as it is shown in Figure 1.3.

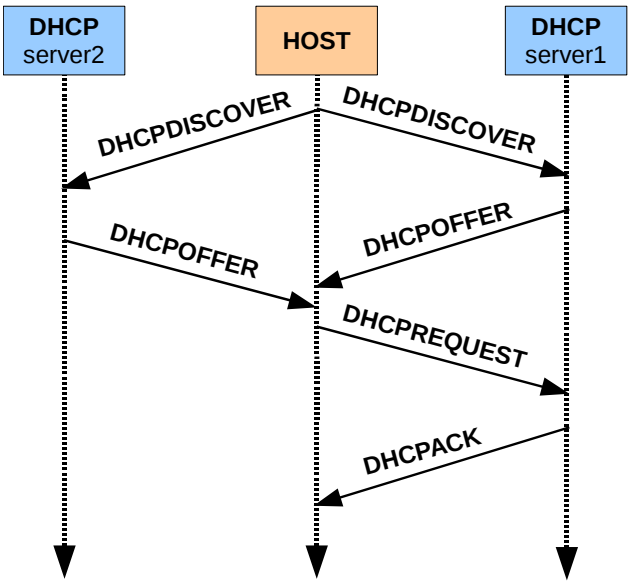

Figure 1.3: DHCP Protocol: Allocate an Address.

To allocate a network address, the client broadcasts a **DHCPDISCOVER** message. Each DHCP server available in the network may respond with a **DHCPOFFER** message that includes an available network address and other configuration parameters. Then, the client selects a server and broadcasts a **DHCPREQUEST** message to request an IP address. The server sends a message (**DHCPACK**) with the requested parameters. The DHCP messages types are:

- **DHCPDISCOVER** Broadcasted by the client to locate available servers.
- **DHCPOFFER** Server to client in response to DHCPDISCOVER offering configuration parameters.
- **DHCPREQUEST** Client message to servers either (a) requesting offered parameters from one server and implicitly declining offers from all others, (b) confirming correctness of previously allocated address after, e.g., system reboot, or (c) extending the lease on a particular network address.
- **DHCPACK** Server to client with configuration parameters, including committed network address.
- **DHCPNAK** Server to client indicating client's notion of network address is incorrect (e.g., client has moved to new subnet) or client's lease as expired
- **DHCPDECLINE** Client to server indicating network address is already in use.
- **DHCPRELEASE** Client to server relinquishing network address and cancelling remaining lease.
- **DHCPINFORM** Client to server, asking only for local configuration parameters; client already has externally configured network address.

In Ethernet, the client uses the destination MAC to figure out which is the intended destination of the DHCP message. Finally, the messages between a client and a server use the same eXchange identifier (Xid) (see Figure 1.4).

1.4 DHCP in Linux

In Linux, the most used software for DHCP server is the version 3 of the Internet Software Consortium's (ISC, http://www.isc.org) implementation.

1.4.1 DHCP Server (`dhcpd`)

You can start/stop the DHCP server with:

```
server# /etc/init.d/dhcp3-server start/stop/status/restart
```

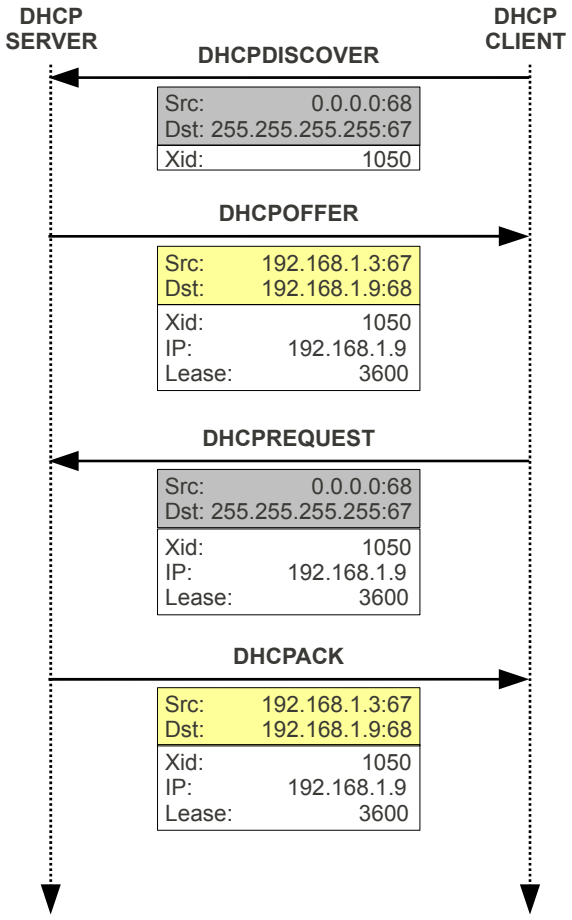

Figure 1.4: DHCP Message Exchange.

When the DHCP server is started, it reads a configuration file, which is typically located in /etc/dhcp3/dhcpd.conf and it starts a network daemon listening to UDP port 67. The configuration file sets up DHCP server parameters, such as network topology, the IP network address range to be assigned, the "lease" time, the network routers to be used, the DNS server to be used by the clients, etc. In addition, the DHCP server keeps a persistent database of leases that it has assigned. This database is a simple ASCII file containing a series of lease declarations. This file can be found in /var/lib/dhcp3/dhcpd.leases. Every time a lease is acquired, renewed or released, its new value is recorded at the end of the lease file. This file is also read every time the DHCP server starts. In this way, the server knows the actual assignment status. Next, we provide a example configuration file for a DHCP server (dhcpd.conf). Each line in the file has the following meaning:

1. This option specifies whether or not the server will attempt to do a DNS update when a lease is confirmed.
2. The default lease time offered to clients (24 hours in the example).
3. Clients request lease times and this parameter is maximum lease time that can be allocated to a client (48 hours in the example).
4. The version 3 DHCP server is non-authoritative by default. This means that if a client requests an address that the server knows nothing about and the address is incorrect for that network segment, the server will not send a DHCPNAK (which tells the client it should stop using the address).
5. This statement causes the DHCP server to do all of its logging on the specified log facility (file in /var/log).
6. This option specifies the domain that will be provided to clients as the default "search" domain.
7. This option specifies a comma separated list of DNS servers that the client should use.
8. The netmask that will be provided to clients.

9. Manual allocation based on the MAC address.
10. Automatic allocation assigns a permanent address to the client (behavior of dynamic-bootp) from the pool of addresses specified. In the example, from 192.168.5.30 to 192.168.5.35. We also set the default router and override the DNS servers configuration.
11. Dynamic allocation assigns a dynamic address to the client.

```
# General parameters of the server
ddns-update-style none;                     # (1)
default-lease-time          86400;          # (2)
max-lease-time              172800;         # (3)
authoritative;                              # (4)
log-facility local7;                        # (5)
# option definitions common to all supported networks.
option domain-name "example.com";           # (6)
option domain-name-servers 192.168.1.3;     # (7)
option subnet-mask 255.255.255.0;           # (8)
# Manual allocation                           (9)
host fantasia {
hardware ethernet fe:fd:00:00:04:01;
fixed-address 192.168.5.150;
}
# Automatic allocation (permanent address)    (10)
subnet 192.168.5.0 netmask 255.255.255.0 {
range dynamic-bootp 192.168.5.30 192.168.5.35;
option routers 192.168.5.1;
option domain-name-servers 192.168.5.1, 192.168.7.4;
}
# Dynamic allocation                          (11)
subnet 10.0.1.0 netmask 255.255.255.0 {
range 10.0.1.100 10.0.1.200;
option routers 10.0.1.1;
option subnet-mask 255.255.255.128;
default-lease-time 60;
max-lease-time 70;
}
```

Notice that options in each particular network override the general options. On the other hand, the network statements must match the configuration of the NICs of the DHCP server.

Finally, the DHCP Server keeps a persistent database of leases that it has assigned. The list of assigned leases is typically stored in /var/lib/dhcp3/dhcpd.leases. The following is an example lease in this file:

```
lease 10.0.1.105 {
  starts 5 2013/04/11 16:29:27;
  ends 5 2013/04/18 16:29:27;
  binding state active;
  next binding state free;
  hardware ethernet 00:10:4b:54:41:85;
  uid "\001\000\020KTA\205";
  client-hostname "alice";
}
```

After reading the dhcpd.conf file, the server reads the dhcpd.leases file to go to the correct state.

1.4.2 DHCP Client (`dhclient`)

You can start/stop the ISC DHCP client for Linux with the command:

```
client# dhclient3
```

The previous command sends a DHCP discover by all the interfaces of the host. However, it is typical to start the DHCP client only in some selected network interfaces. For example, to start the DHCP client on eth1 type:

```
client# dhclient3 eth1
```

If you want to release a lease type:

```
client# dhclient3 -r eth1
```

When the DHCP client is started, it reads a configuration file, which is typically located in /etc/dhcp3/dhclient.conf. The default configuration is in general enough to make the DHCP service work properly.

1.4.3 Commands and Files of DHCP-ISC

The summary of files and commands used by the ISC implementation for Linux of DHCP is shown in Table 1.1.

`/etc/init.d/dhcp3-server`	Script to start/stop the DHCP server
`dhclient`	Command to start/stop/restore the DHCP client
`/etc/dhcp3/dhcpd.conf`	Configuration file for ISC DHCP server
`/etc/dhcp3/dhclient.conf`	Configuration file for ISC DHCP client
`/var/log/syslog`	File where is stored the DHCP event log
`/var/lib/dhcp3/dhcpd.leases`	Current leases of the DHCP server
`/var/lib/dhcp3/dhclient.leases`	Current leases of the DHCP client

Table 1.1: Common DHCP configuration files

1.5 Practices

Exercise 1.1– In this exercise we analize the DHCP service using the scenario *dns-basic*. After the scenario has been started, execute the labels initial and dhcp:

```
phyhost$ simctl dns-basic exec initial
phyhost$ simctl dns-basic exec dhcp
```

1. In **joker**, check if a DHCP server is running and analyze the DHCP configuration file (/etc/dhcp3/dhcpd.conf).
2. Capture with wireshark `tap0` and explain the flow of DHCP messages captured when executing the following command line:

   ```
   alice:~# dhclient3 eth1
   ```

   Capture at least 2 minutes. Which is the assigned IP? Which is the content of the file /etc/resolv.conf of **alice**.

   Take a look at the file /var/lib/dhcp3/dhclient.leases and explain the content of this file. Explain the renew, rebind and expire fields. To do so, you can use the manual page of dhclient.conf.

   Can you access now to **alice** by her name? why?
3. Capture with wireshark `tap0` and explain the flow of DHCP messages captured when executing the following command line:

   ```
   alice:~# dhclient3 -r eth1
   ```
4. Capture with wireshark `tap0` and explain the flow of DHCP and DNS messages captured when you modify the configuration of the DHCP server in the **joker** to activate the manual allocation for alice.example.com. Restart the DHCP server of **joker** and try the configuration.