1. Introduction to DHCP

The **Dynamic Host Configuration Protocol (DHCP)** is a **network protocol** that enables a server to automatically assign an **IP address** and other network configuration parameters to client devices on a network. This allows devices to communicate on an IP network without requiring manual IP configuration.

DHCP is a **client-server protocol** where the DHCP server dynamically assigns IP addresses and other configuration information to DHCP clients.

---

2. The Need for DHCP

Before DHCP, network administrators had to manually assign IP addresses to each device on a network. This was not scalable and led to:

- **IP conflicts** (two devices with the same IP).
- **Configuration errors**.
- Time-consuming network setups.

DHCP solves these issues by **automating** the assignment of IP addresses, subnet masks, gateways, DNS servers, and other settings.

---

3. How DHCP Works – The DORA Process

DHCP operates using a four-step process called **DORA**:

Step	Name	Description
D	**Discover**	The client sends a broadcast packet to discover available DHCP servers.
O	**Offer**	DHCP server responds with an available IP address and configuration details.
R	**Request**	The client requests the offered address from the server.
A	**Acknowledgment**	DHCP server confirms the IP assignment and sends a final configuration packet.

This ensures clients are dynamically assigned unique IP addresses with minimal human intervention.

---

4. DHCP Lease Mechanism

DHCP assigns IP addresses to clients for a **limited duration**, known as the **lease**. Once the lease expires, the client must **renew** the lease or request a new IP.

- **Lease Renewal**: Before the lease expires, the client attempts to renew it.
- **Lease Expiry**: If a lease expires and is not renewed, the IP address is returned to the **available pool**.
- This prevents the exhaustion of IP addresses in the DHCP scope.

---

5. DHCP Server Components

5.1. **Scope**

A **DHCP Scope** defines a range of IP addresses that a DHCP server can assign to clients on a particular subnet.

Example: 192.168.1.100 to 192.168.1.200

5.2. **Exclusion Range**

Specific IP addresses within the scope that should **not be assigned** to clients.

Example: If printers or servers use static IPs, they can be excluded from the pool.

5.3. **Reservations**

Reservations bind a specific **MAC address** to a particular IP address.

Use cases:

- Assigning a permanent IP to printers or servers.
- Ensuring consistent addressing for known devices.

5.4. **Options**

Options define additional network configuration details:

- **Option 003 –** Default Gateway
- **Option 006 –** DNS Server
- **Option 015 –** DNS Domain Name
- Other options include WINS server, PXE boot info, etc.

---

6. DHCP Packet Format

DHCP messages are encapsulated in **UDP** packets:

- Client sends packets from UDP **port 68**

- Server responds from UDP **port 67**

The DHCP packet includes:

- Message Type (Discover, Offer, etc.)
- Client MAC address
- Requested IP address
- Lease time
- Server identifier

---

7. Types of DHCP Messages

1. **DHCPDISCOVER –** Sent by client to locate DHCP servers.
2. **DHCPOFFER –** Server replies with offer.
3. **DHCPREQUEST –** Client requests offered address.
4. **DHCPACK –** Server acknowledges the request.
5. **DHCPNAK –** Server denies the request (e.g., if address is no longer valid).
6. **DHCPDECLINE –** Client rejects offer (e.g., duplicate IP detected).
7. **DHCPINFORM –** Client requests only configuration parameters, not IP (used by statically configured clients).
8. **DHCPRELEASE –** Client releases IP back to server.

---

8. DHCP Deployment Scenarios

- **Single DHCP Server** on small networks.
- **Multiple DHCP Servers** in large enterprise networks for redundancy.
- **DHCP Relay Agent** used when the DHCP server is on a different subnet (uses **BOOTP Relay** or **IP Helper Address** on routers).
- **Split Scope –** DHCP scopes are split between servers to provide high availability.

---

9. DHCP on Windows Server

On **Windows Server (2012/2016/2019/2022)**, DHCP is installed as a **role** via Server Manager or PowerShell.

Installation Steps (GUI):

1. Open **Server Manager**

2. Go to **Manage → Add Roles and Features**
3. Select **DHCP Server**
4. Configure Scope, options, and authorize in **Active Directory** if in domain

Installation Steps (PowerShell):

```
Install-WindowsFeature -Name DHCP -IncludeManagementTools Add-DhcpServerInDC -DnsName
"ServerName.Domain.com" -IpAddress 192.168.1.1
```

---

10. DHCP Authorization

In an **Active Directory environment**, DHCP servers must be **authorized** in AD to prevent rogue DHCP servers.

- Unauthorized servers will not lease addresses.
- Ensures only trusted servers distribute IPs.

---

11. High Availability and Redundancy

To ensure availability, DHCP can be configured with:

DHCP Failover

- Introduced in Windows Server 2012.
- Two servers share the same scope information.
- Modes:
  - **Load Balance**: Both servers assign addresses.
  - **Hot Standby**: One is active; the other takes over in failure.

---

12. DHCP Security Considerations

- **Rogue DHCP Servers**: Unauthorized servers may assign incorrect IPs.
- Use **DHCP snooping** on switches to block rogue servers.
- Enable **IP filtering**, **MAC address reservations**, and **firewalls**.
- In VLAN environments, configure relay agents carefully.

---

13. Limitations of DHCP

- Not suitable for networks requiring **static IPs** for all devices.
- Can be exploited if **not secured properly** (rogue servers).
- IP address assignment may **change** unless reserved or static.

---

14. Real-World Example

Imagine a company with 100 desktops, 10 printers, and several servers. Instead of manually assigning IP addresses:

- The administrator installs a DHCP Server.
- Scope is set to 192.168.10.100 – 192.168.10.200
- Exclude 192.168.10.1 – 192.168.10.20 for static IPs (used by routers and servers).
- Reserve IPs for printers (based on MAC).
- Configure DNS, gateway, and lease duration via DHCP options.

Result:

- All desktops get automatic IPs.
- Printers and servers maintain fixed addresses.
- Simplified and error-free management.

---

15. Conclusion

The DHCP Server is a **critical infrastructure component** in modern networks. It simplifies the management of IP address allocation, reduces errors, and provides flexibility in IP address management. Whether in a small office or a large enterprise network, DHCP ensures efficient and scalable network configuration and operation.