

DHCP Principles

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Foreword

- As the network scale expands and the network complexity increases, network configuration becomes more and more complex. In addition, the number of computers and mobile devices (such as mobile laptops or wireless terminals) increases sharply, causing frequent IP address changes and insufficient IP resources. The Dynamic Host Configuration Protocol (DHCP) is used to dynamically allocate IP addresses to hosts.



Objectives

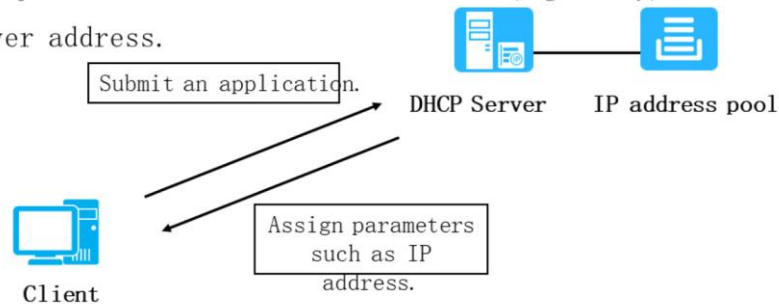
- Upon completion of this course, you will be able to:
 - Master the process of the DHCP protocol.
 - Understand the packet structure used by the DHCP.

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1. Basic DHCP Principles
2. DHCP Relay Principles
3. DHCP Networking Application

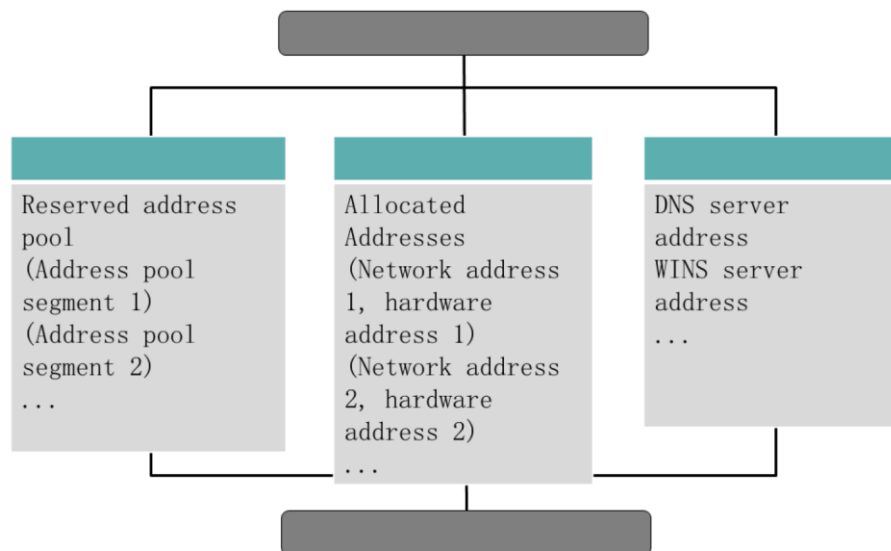
What Is DHCP

- The Dynamic Host Configuration Protocol (DHCP) is a protocol that dynamically provides configuration parameters for Internet terminals. When a terminal submits an application, the DHCP server can provide the terminal with parameters such as the IP address, gateway, and DNS server address.



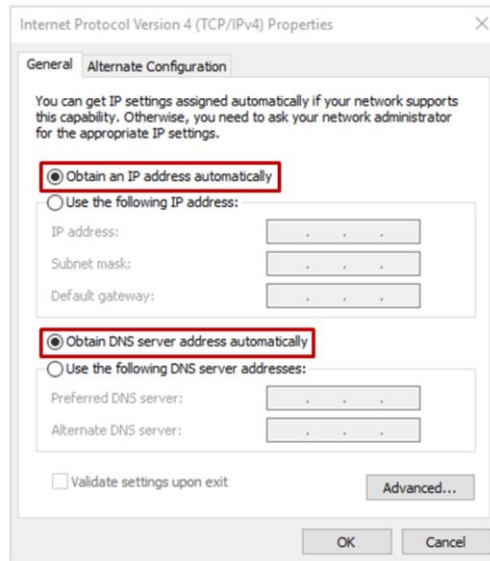
- On a TCP/IP network, each work station must perform basic network configurations before accessing the network and its resources. Key parameters to be configured include IP address, subnet mask, default gateway, and DNS. Additional information, such as IP management policies, may be required.
- On a large network, ensuring that all hosts have correct configurations can be a difficult management task, especially for dynamic networks that contain roaming users and laptops. Computers are often moved from one subnet to another and removed from the network. Manual configuration or reconfiguration of a large number of computers may take a long time, and errors in IP host configuration may cause network communication failures.
- Therefore, a mechanism is required to simplify IP address configuration and implement centralized IP address management. The Dynamic Host Configuration Protocol (DHCP) is designed by the Internet Engineering Task Force (IETF) for this purpose.
- DHCP can reduce configuration errors.
 - The DHCP minimizes the number of errors caused by manual IP address configuration. For example, the possibility of allocating an IP address in use to another device is greatly reduced.

DHCP Server



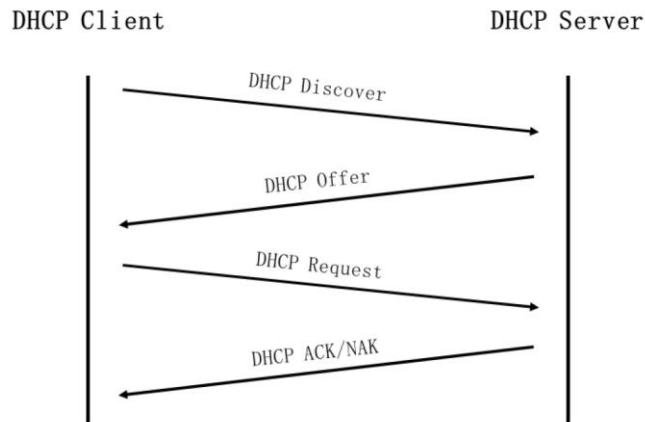
- DHCP server: A DHCP server processes requests for address allocation, lease renewal, and release from clients or relays, and allocates IP addresses and other network configurations to clients.

DHCP Client



- DHCP client: A DHCP client exchanges packets with a DHCP server to obtain the IP address and other network configurations. The DHCP protocol is used to dynamically obtain parameters such as IP addresses from the DHCP server, facilitating client configuration and centralized management.

Address Application Process

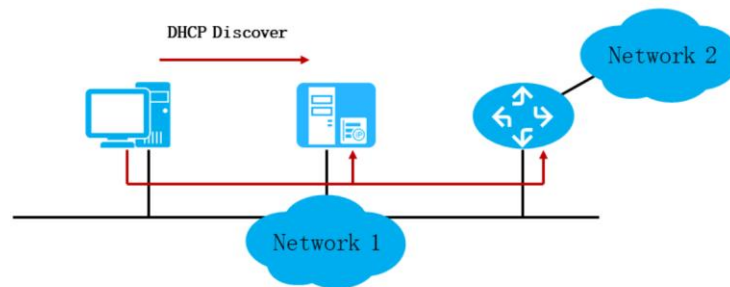


- P8DHCP Discover: A client broadcasts this packet to discover available DHCP servers.
- DHCP Offer: A server sends this packet to respond to the DHCP Discover packet from a client and provides various configuration parameters to the client.
- DHCP Request
 - A client applies for an address and other configuration parameters from a server.
 - A client checks whether the original address and other configuration parameters are correct after restart.
 - A client applies to extend the lease term of the address and other configuration parameters from a server.
- DHCP ACK: A server sends the address to be allocated and other configuration parameters to a client.
- DHCP NAK: A server notifies a client that the requested address is invalid or has expired.
- DHCP Decline: A client notifies a server that an allocated address is being used by another device.
- DHCP Release: A client releases an address used by it.

- DHCP Inform: A client applies for local configuration parameters (after an address has been allocated) from a server.

DHCP Process - Discover

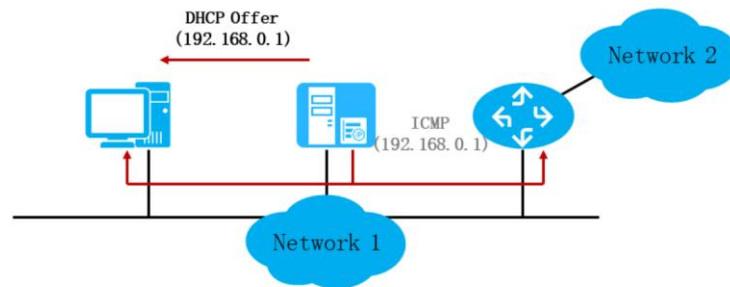
- A client broadcasts DHCP Discover packets on the local network segment to discover DHCP servers on the network.



- Discovery phase: A DHCP client searches for a DHCP server.
- In the discovery phase, a DHCP client searches for a DHCP server by sending a DHCP Discover packet. Because the IP addresses of DHCP servers are unknown to the client, the DHCP client broadcasts the DHCP Discover packet on the network. All DHCP servers that receive DHCP Discover packets send response packets. The DHCP client can then know the locations of DHCP servers on the network.

DHCP Process - Offer

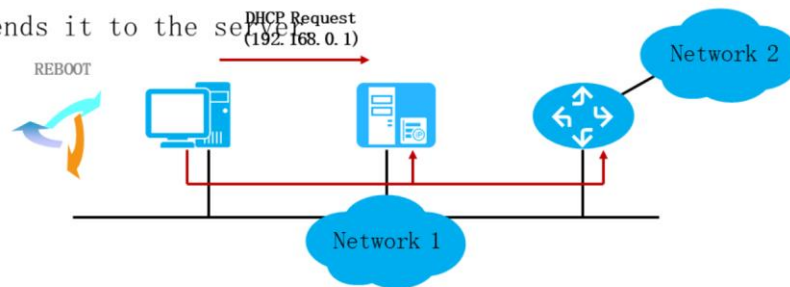
- The server responds to the client with an available IP address. This address is not really allocated, and is checked using the ICMP Echo Request packet before assignment.



- Offer phase: The DHCP server provides an IP address for a DHCP client.
- A DHCP server that receives a DHCP Discover packet from a DHCP client selects an appropriate IP address from its address pool, and sends a DHCP Offer packet carrying the IP address, IP address lease term, and other configuration parameters (such as the gateway address and domain name server address) to the DHCP client.

DHCP Process - Request

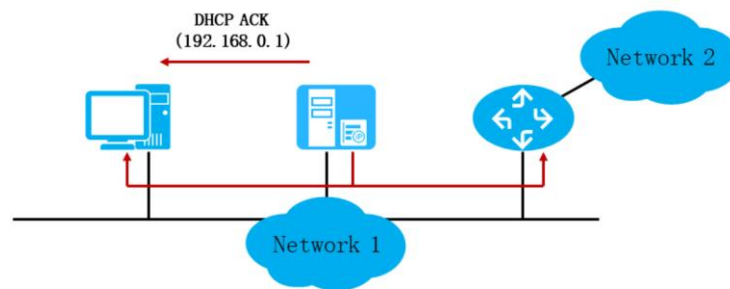
- If a client receives multiple DHCP Offer packets, the DHCP client selects one of them based on the content and responds to it. If the client has obtained an IP address earlier, it writes the address in the Requested IP Address field of the Options field in the DHCP Request packet and sends it to the server.



- Selection phase: A DHCP client selects an IP address.
- If multiple DHCP servers send DHCP Offer packets to a DHCP client, the DHCP client receives only the DHCP Offer packet that arrives first. Then, the DHCP client broadcasts a DHCP Request packet carrying the server identification (Option54), that is, the IP address of the DHCP server selected by the client.
- The DHCP Request packet is sent in broadcast mode to notify all DHCP servers that the client selects the IP address provided by the DHCP server indicated in Option54. Other DHCP servers can therefore reclaim their pre-allocated IP addresses.

DHCP Process - ACK

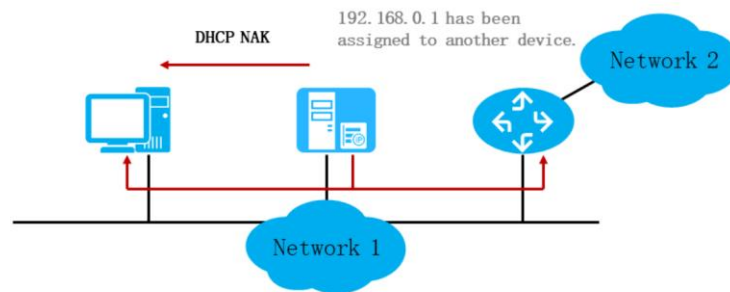
- After receiving the DHCP Request packet, the server binds the network address (network and hardware addresses) of the client to the allocated IP address, and then sends the IP address to the client.



- Confirmation phase: A DHCP server confirms that an IP address is allocated to a DHCP client.
- After receiving a DHCP Request packet from a DHCP client, the DHCP server searches for the corresponding lease record according to the MAC address carried in the DHCP Request packet. If a record is found, the DHCP server sends a DHCP ACK packet containing the IP address and other settings to the client. After receiving the DHCP ACK packet, the DHCP client broadcasts a gratuitous ARP packet to detect whether another host is using the IP address allocated by the server. If no response is received within a specified period, the client uses the IP address.

DHCP Process - NAK

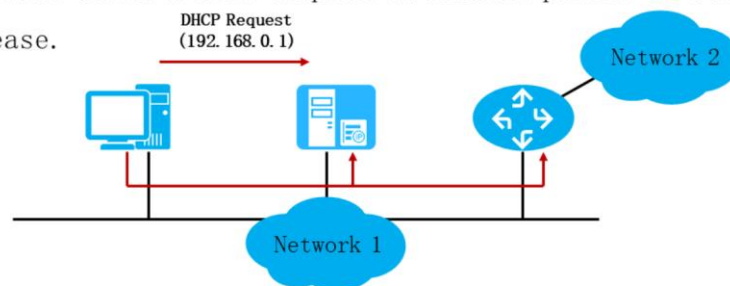
- After receiving the DHCP Request packet, if the server finds that the requested address is unavailable, it responds with a DHCP NAK packet.



- If a DHCP server does not find a lease record after receiving a DHCP Request packet or fails to allocate an IP address due to certain reasons, the DHCP server sends a DHCP NAK packet to notify the DHCP client that no IP address is available. The DHCP client then needs to resend the DHCP Discover packet to apply for a new IP address.
- After obtaining an IP address, a DHCP client checks the status of the gateway in use before going online. If the gateway address is incorrect or the gateway is faulty, the DHCP client requests a new IP address in four-step mode.

DHCP Process - Address Renewal

- When a client address reaches 50% of the lease term (T1), the client sends a DHCP Request unicast packet to renew the lease.
- When a client address reaches 87.5% of the lease term (T2), the client sends a DHCP Request broadcast packet to renew the lease.



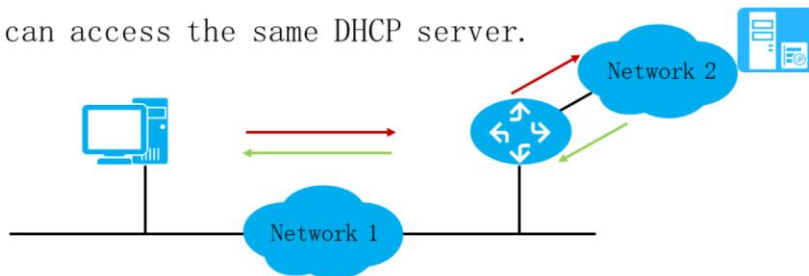
- When an IP address reaches 50% (T1) of the lease term, the DHCP client automatically sends a DHCP Request packet to the DHCP server to renew the lease. If a DHCP ACK packet is received, the lease is renewed successfully. If a DHCP NAK packet is received, the application process is initiated again.
- When an IP address reaches 87.5% (T2) of the lease term, if the DHCP client does not receive any response from the DHCP server, the DHCP client automatically sends a broadcast packet to DHCP servers to renew the IP address lease. If a DHCP ACK packet is received, the lease is renewed successfully. If a DHCP NAK packet is received, the application process is initiated again.
- If a client does not receive any response from any server before its IP address lease term expires, the client stops using the IP address and sends a DHCP Discover packet to request a new IP address.

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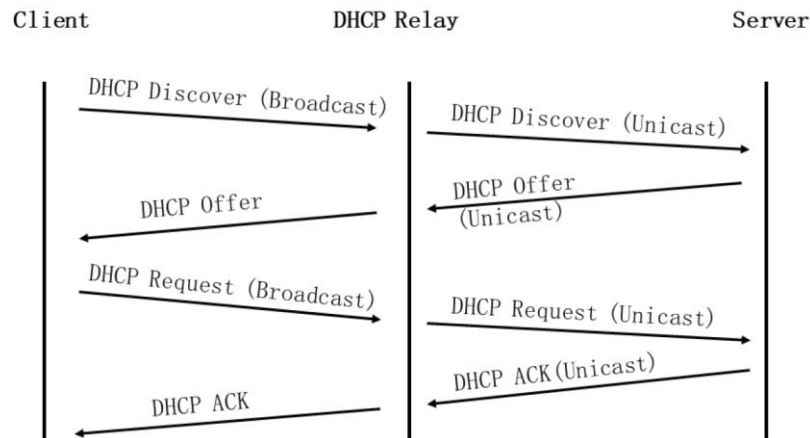
DHCP Relay Principles

- DHCP relay enables packet exchange between DHCP servers and clients on different network segments. Using DHCP relay, DHCP packets are transparently transmitted across network segments to a destination DHCP server. In this way, DHCP clients on the network can access the same DHCP server.



- Before the DHCP relay technology is implemented, the DHCP protocol is applicable only when DHCP clients and servers are in the same subnet and cannot work across network segments. Therefore, a DHCP server needs to be deployed for each subnet, wasting resources.
- DHCP relay solves this problem. A DHCP relay agent serves as a relay between DHCP clients and servers in different subnets. It can relay DHCP packets to destination DHCP servers or clients on different network segments, allowing DHCP clients on different network segments to share the same DHCP server. This mechanism saves costs and facilitates centralized management.

DHCP Relay Process

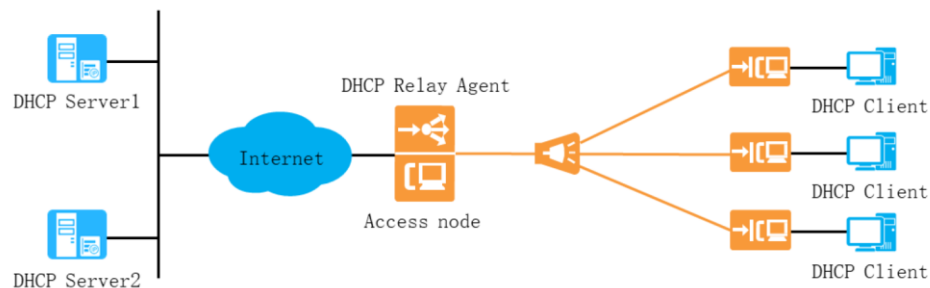


- Upon receiving a request packet from a DHCP client to a DHCP server, a DHCP relay agent processes the packet and sends it to the specified DHCP server on another network segment in unicast mode. The server returns the configuration information to the client through the DHCP relay agent according to information in the request packet. In this way, dynamic configuration of the client is complete.
- When a DHCPv4 client is started and performs DHCPv4 initialization, it broadcasts a Discover packet on the local network to search for a DHCPv4 server.
 - If a DHCPv4 server exists on the local network, the DHCPv4 client can directly obtain an IP address from the DHCPv4 server.
 - If no DHCPv4 server exists on the local network, the DHCPv4 relay agent connected to the local network converts the broadcast Discover packet into a unicast packet and forwards it to a DHCPv4 server on another network segment.
- The DHCPv4 server returns a unicast Offer packet to the DHCPv4 relay agent to confirm that the DHCPv4 client can apply for an IP address. After receiving the Offer packet, the DHCPv4 relay agent converts the unicast packet into a broadcast packet and sends it to the DHCPv4 client.
- The DHCPv4 client sends a Request packet to request an IP address. After receiving the Request packet, the DHCPv4 relay agent converts the broadcast packet into a unicast packet and forwards it to the DHCPv4 server.
- The DHCPv4 server performs the corresponding configurations according to the information in the received Request packet, and sends the configurations to the DHCPv4 client through the DHCPv4 relay agent to complete the dynamic configuration of the DHCPv4 client.

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DHCP Networking Application



- A typical DHCP relay networking consists of the following roles:
- DHCP client: A device that dynamically obtains IP addresses or other network configuration parameters.
- DHCP relay agent: A DHCP client communicates with a DHCP server through the broadcast address in the local link range to obtain the IP address and other network configuration parameters. If the server and client are on different network segments, DHCP relay is required to forward packets. In this way, a DHCP server does not need to be deployed in each network segment, which reduces costs and facilitates centralized management.
- DHCP server: A device that allocates IP addresses and other network configuration parameters to DHCP clients.



Summary

- DHCP concepts
- Typical DHCP packets
- DHCP communication process
- DHCP networking types

Thank You

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