# Dynamic Host Configuration Protocol (DHCP)

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## DHCP

- RFC 2131
- RFC 2132 — DHCP Options and BOOTP Vendor Extensions.
- DHCP consists of two components:
  - 1. A protocol that delivers host-specific configuration parameters from a DHCP server to a host.
  - 2. A mechanism for the allocation of temporary or permanent network addresses to hosts.

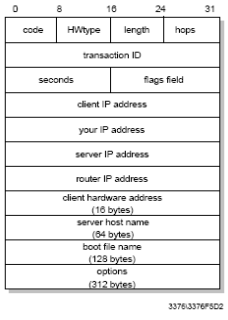


## DHCP

- DHCP supports three mechanisms for IP address allocation:
- 1. Automatic allocation
  - DHCP assigns a permanent IP address to the host.
- 2. Dynamic allocation
  - DHCP assigns an IP address for a limited period of time. Such a network address is called a lease. This is the only mechanism that allows automatic reuse of addresses that are no longer needed by the host to which it was assigned.
- 3. Manual allocation
  - The host's address is assigned by a network administrator.



## DHCP message format



## DHCP message format

- Code. Indicates a request or a reply
  - 1 Request
  - 2 Reply
- HWtype. The type of hardware, for example:
  - 1 Ethernet
  - 6 IEEE 802 Networks
- Length. Hardware address length in bytes.
  - Ethernet and token-ring both use 6.
- Hops. The client sets this to 0.
  - It is incremented by a router that relays the request to another server and is used to identify loops.
  - RFC 951 suggests that a value of 3 indicates a loop.



## DHCP message format

- Transaction ID
  - A random number used to match this boot request with the response it generates.
- Seconds
  - Set by the client. It is the elapsed time in seconds since the client started its boot process.
- Flags field
  - The most significant bit of the flags field is used as a broadcast flag. All other bits must be set to zero, and are reserved for future use.



## DHCP message format

- Client IP address
  - Set by the client. Either its known IP address, or 0.0.0.0.
- Your IP address
  - Set by the server if the client IP address field was 0.0.0.0.
- Server IP address
  - Set by the server.
- Router IP address
  - This is the address of a BOOTP relay agent, not a general IP router to be used by the client.
- Client hardware address
  - Set by the client. DHCP defines a client identifier option that is used for client identification. If this option is not used the client is identified by its MAC address.



## DHCP message format

- Server host name
  - Optional server host name, terminated by X'00'.
- Boot file name
  - The client either leaves this null or specifies a generic name, such as router, indicating the type of boot file to be used.
  - In a DHCPDISCOVER request this is set to null. The server returns a fully qualified directory path name in a DHCPOFFER request. The value is terminated by X'00'.
- Options
  - The first four bytes of the options field of the DHCP message contain the magic cookie (99.130.83.99).
  - The remainder of the options field consists of tagged parameters that are called options.

## DHCP message types

- DHCPDISCOVER
  - Broadcast by a client to find available DHCP servers.
- DHCPOFFER
  - Response from a server to a DHCPDISCOVER and offering IP address and other parameters.
- DHCPREQUEST
  - Message from a client to servers that does one of the following:
    - Requests the parameters offered by one of the servers and declines all other offers
    - Verifies a previously allocated address after a system or network change (a reboot for example)
    - Requests the extension of a lease on a particular address

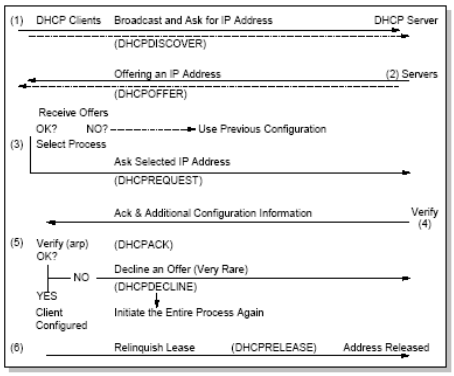


## DHCP message types

- DHCPACK
  - Acknowledgement from server to client with parameters, including IP address.
- DHCPNACK
  - Negative acknowledgement from server to client, indicating that the client's lease has expired or that a requested IP address is incorrect.
- DHCPDECLINE
  - Message from client to server indicating that the offered address is already in use.
- DHCPRELEASE
  - Message from client to server cancelling remainder of a lease and relinquishing network address.
- DHCPINFORM
  - Message from a client that already has an IP address (manually configured for example), requesting further configuration parameters from the DHCP server.



## Allocating a New Network Address






## Allocating a New Network Address

- 1. The client broadcasts a DHCPDISCOVER message on its local physical subnet.
  - At this point, the client is in the INIT state.
  - This message may include some options such as network address suggestion or lease duration.
- 2. Each server may respond with a DHCPOFFER message
  - It includes an available network address (your IP address) and other configuration options.
  - The servers may record the address as offered to the client to prevent the same address being offered to other clients

## Allocating a New Network Address

- 3. The client receives one or more DHCPOFFER messages from one or more servers.
  - The client chooses one based on the configuration parameters offered and broadcasts a DHCPREQUEST message that includes the server identifier option to indicate which message it has selected and the requested IP address option, taken from Your IP Address in the selected offer.



## Allocating a New Network Address

- 4. The servers receive the DHCPREQUEST broadcast from the client.
  - Those servers not selected by the DHCPREQUEST message use the message as notification that the client has declined that server's offer.
  - The server selected in the DHCPREQUEST message commits the binding for the client to persistent storage and responds with a DHCPACK message containing the configuration parameters for the requesting client.
  - The combination of client hardware and assigned network address constitute a unique identifier for the client's lease and are used by both the client and server to identify a lease referred to in any DHCP messages.
  - The Your IP Address field in the DHCPACK messages is filled in with the selected network address.



## Allocating a New Network Address

- 5. The client receives the DHCPACK message with configuration parameters.
  - The client performs a final check on the parameters, for example with ARP for allocated network address, and notes the duration of the lease and the lease identification cookie specified in the DHCPACK message.
  - At this point, the client is configured.
  - If the client detects a problem with the parameters in the DHCPACK message, the client sends a DHCPDECLINE message to the server and restarts the configuration process.
  - On receipt of a DHCPDECLINE, the server must mark the offered address as unavailable
  - If the client receives a DHCPNAK message, the client restarts the configuration process.



## Allocating a New Network Address

- 6. The client may choose to relinquish its lease on a network address by sending a DHCPRELEASE message to the server.
  - The client identifies the lease to be released by including its network address and its hardware address.

## DHCP Lease Renewal Process

- When a server sends the DHCPACK to a client with IP address and configuration parameters, it also registers the start of the lease time for that address.
- This lease time is passed to the client as one of the options in the DHCPACK message, together with two timer values, T1 and T2.
- The client is rightfully entitled to use the given address for the duration of the lease time.
- On applying the received configuration, the client also starts the timers T1 and T2. At this time the client is in the BOUND state.
- Times T1 and T2 are options configurable by the server but T1 must be less than T2, and T2 must be less than the lease time. According to RFC 2132, T1 defaults to (0.5 * lease time) and T2 defaults to (0.875 * lease time).



## DHCP Lease Renewal Process

- When timer T1 expires, the client will send a DHCPREQUEST (unicast) to the server that offered the address, asking to extend the lease for the given configuration.
- The client is now in the RENEWING state.
- The server would usually respond with a DHCPACK message indicating the new lease time, and timers T1 and T2 are reset at the client accordingly.
- The server also resets its record of the lease time. In normal circumstances, an active client would continually renew its lease in this way indefinitely, without the lease ever expiring.



## DHCP Lease Renewal Process

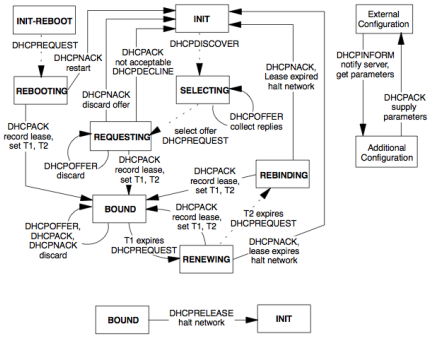
- If no DHCPACK is received until timer T2 expires, the client enters the REBINDING state.
- It now broadcasts a DHCPREQUEST message to extend its lease. This request can be confirmed by a DHCPACK message from any DHCP server on the network.



## DHCP Lease Renewal Process

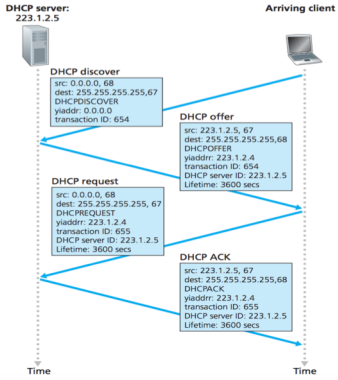
- If the client does not receive a DHCPACK message after its lease has expired, it has to stop using its current TCP/IP configuration.
- The client may then return to the INIT state, issuing a DHCPDISCOVER broadcast to try and obtain any valid address.

## DHCP Client State and DHCP Process






## DHCP simple






## References


- Murhammer, M. W., O. Atakan, S. Bretz, L. R. Pugh, K. Suzuki, D. H. Wood. *TCP/IP Tutorial and Technical Overview*, IBM, 1998.
- W. Stallings. Data and Computer Communications, Ed. Pearson, 8th Edition, 2007.