Dynamic Host Configuration Protocol (DHCP)

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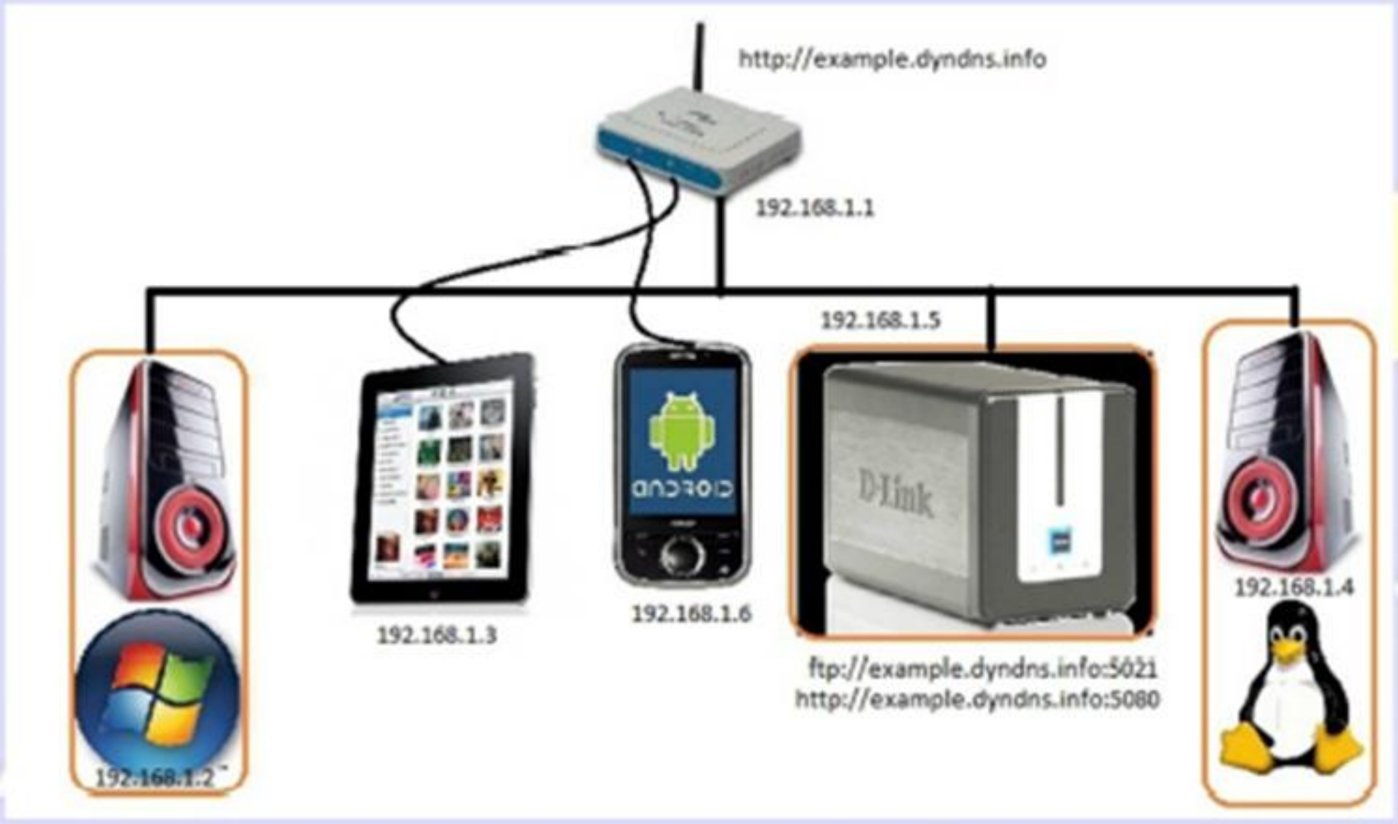
Introduction

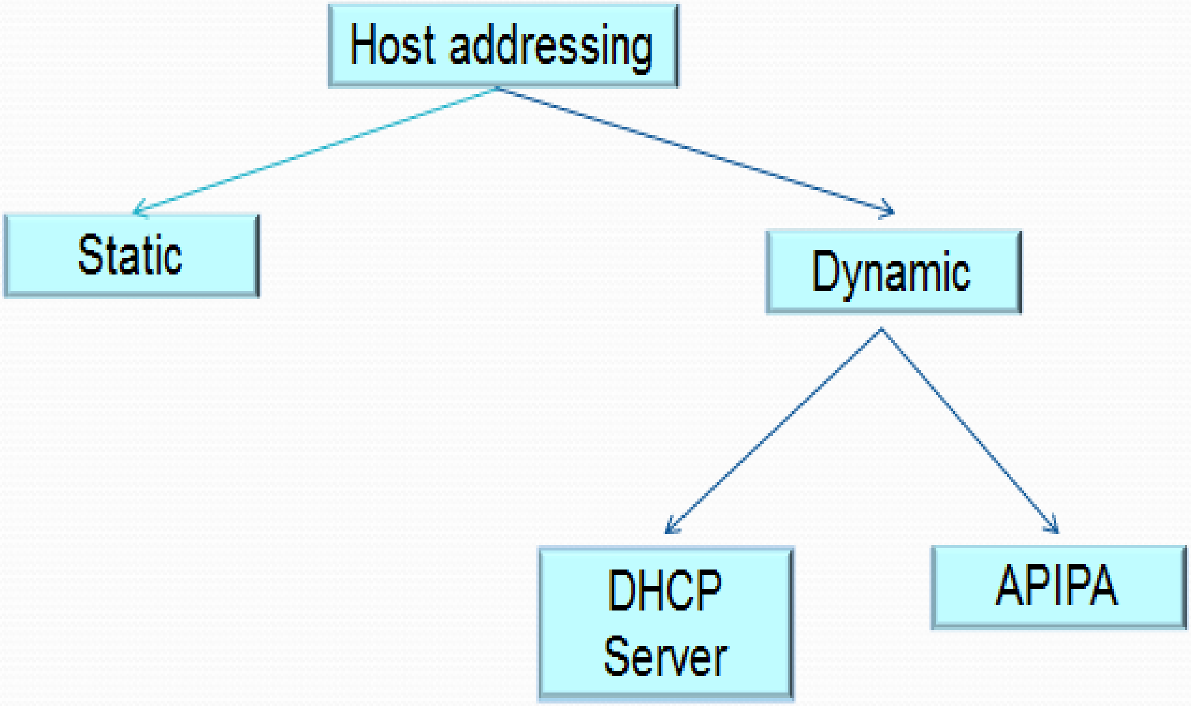
- TCP/IP defines how devices on one network communicate with devices on another network. Any host that uses IPv4 needs four IPv4 setting to work properly:
  - ❑ IP address (Mandatory)
  - ❑ Subnet mask (Mandatory)
  - ❑ Default routers (Mandatory if there is more than one LAN)
  - ❑ DNS server IP address (Translate between IP address and Domain name, not mandatory)

Introduction

- ملاحظة: الـ Host تشير لأي جهاز في الشبكة يأخذ IP مثل الـ Router، الحاسب، التابلت، الـ Switch، الطابعة وذلك لغرض تقديم خدمة أو من أجل لإدارة.


http://example.dyndns.info
192.168.1.1
192.168.1.5
192.168.1.2
192.168.1.3
192.168.1.6
D-Link
ftp://example.dyndns.info:5021
http://example.dyndns.info:5080
192.168.1.4

Assigning Addresses to Hosts using IPv4



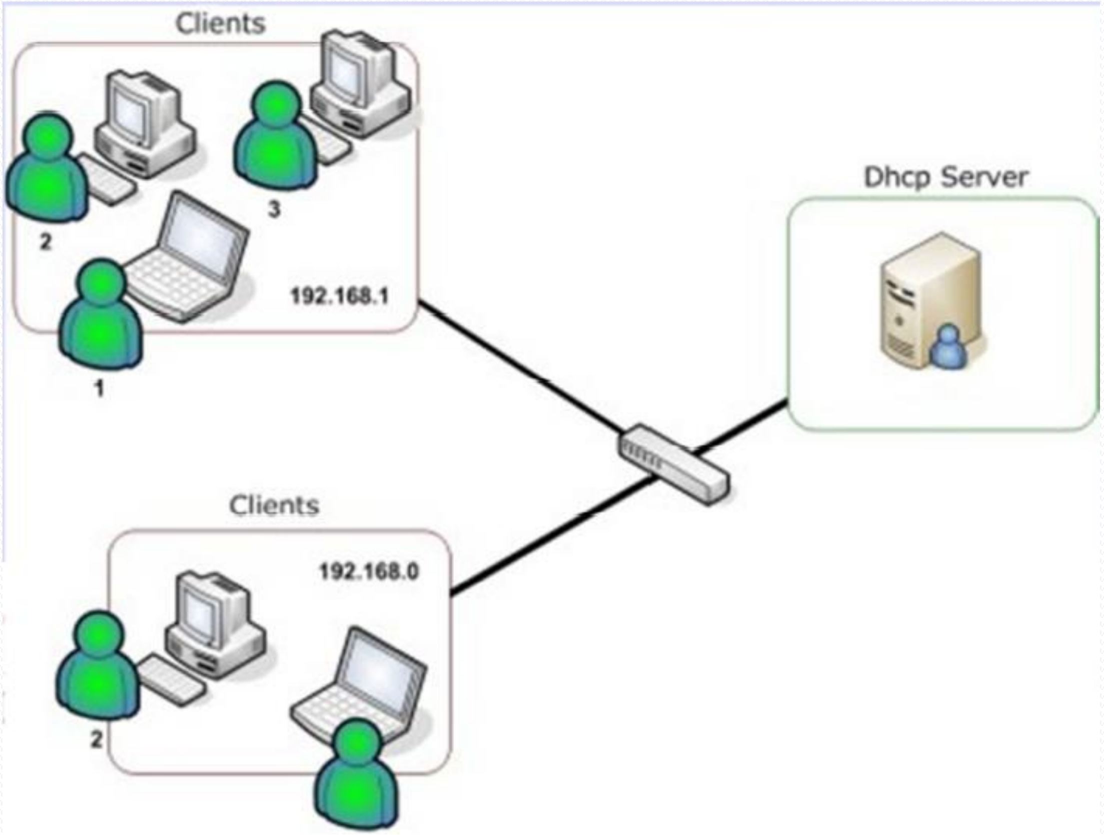
Static → Manually IP address

DHCP Concept

- A DHCP server can manage TCP/IP settings for devices on a network, by automatically or dynamically assigning Internet Protocol (IP) addresses to the hosts.
- The DHCP is a standardized network protocol used on Internet Protocol (IP) networks.
- The DHCP is controlled by a DHCP server that dynamically distributes network configuration parameters, such as IP addresses, for interfaces and services.
- A router or a residential gateway can be enabled to act as a DHCP server.
- A DHCP server enables computers to request IP addresses and networking parameters automatically, reducing the need for a network administrator or a user to configure these settings manually.

DHCP Concept

- In the absence of a DHCP server, each computer or other device (e.g., a printer) on the network needs to be statically (i.e., manually) assigned to an IP address or using APIPA Address.

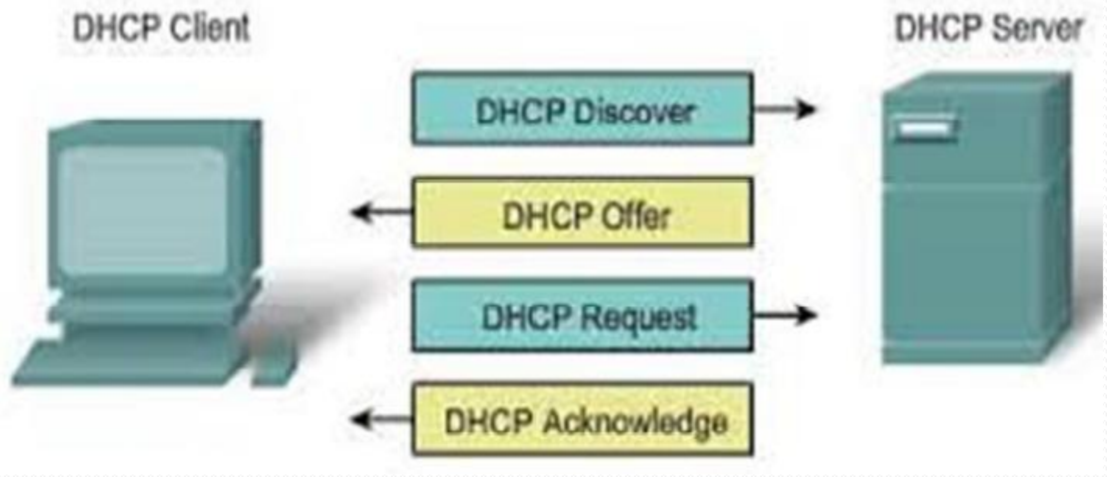


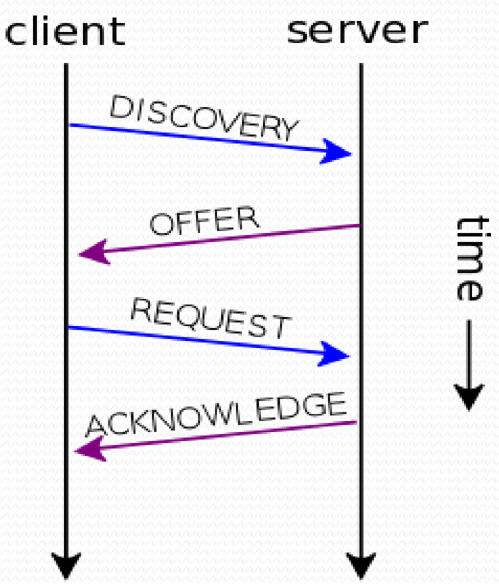
DHCP Concept

- يعتبر بروتوكول الـ DHCP واحد من أهم بروتوكولات البروتوكول TCP/IP وأكثرها استخداما.
- الغالبية العظمى من الأجهزة التي تستخدم البروتوكول IPv4 تستخدم البروتوكول DHCP في إعداد المضيف.
- تتميز العنونة باستخدام الـ DHCP عن العنونة اليدوية أن الجهاز سيأخذ كل الاعدادات الخاصة بالـ IPv4 عن طريق رسائل الـ DHCP.
- إدارة مركزية للعناوين.
- تقليل نسبة الخطاء وعدم وجود تضارب في الـ IP.
- توجد خاصية تأجير في الـ DHCP بحيث أن الجهاز يمكن أن يأخذ العنوان لفترة دائمة أو فترة مؤقتة (الافتراضية).
- ممكن تشغيل الـ DHCP Server عن بعد (مفيد جداً في حالة أجهزة الموبايل).

DHCP Messages

- DHCP operations fall into four phases: server discovery, IP lease offer, IP lease request, and IP lease acknowledgement. These stages are often abbreviated as DORA for discovery, offer, request, and acknowledgement.

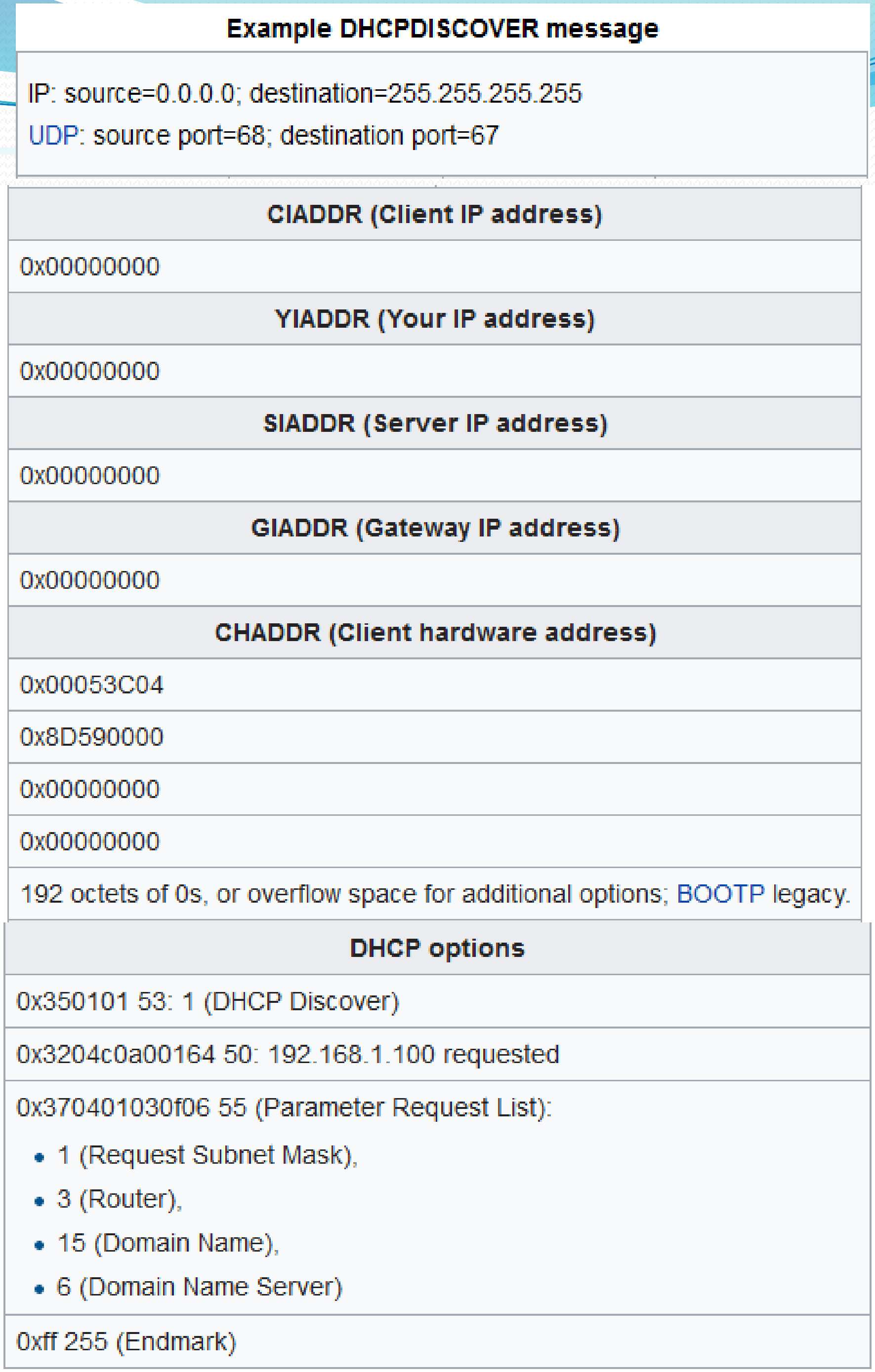




DHCP discovery

- The client broadcasts messages on the network subnet using the destination address 255.255.255.255 or the specific subnet broadcast address.
- A DHCP client may also request its last-known IP address.
- If the client remains connected to the same network, the server may grant the request.
- Otherwise, it depends whether the server is set up as authoritative or not.
- A non-authoritative server simply ignores the request, leading to an implementation-dependent timeout for the client to expire the request and ask for a new IP address.

DHCP discovery

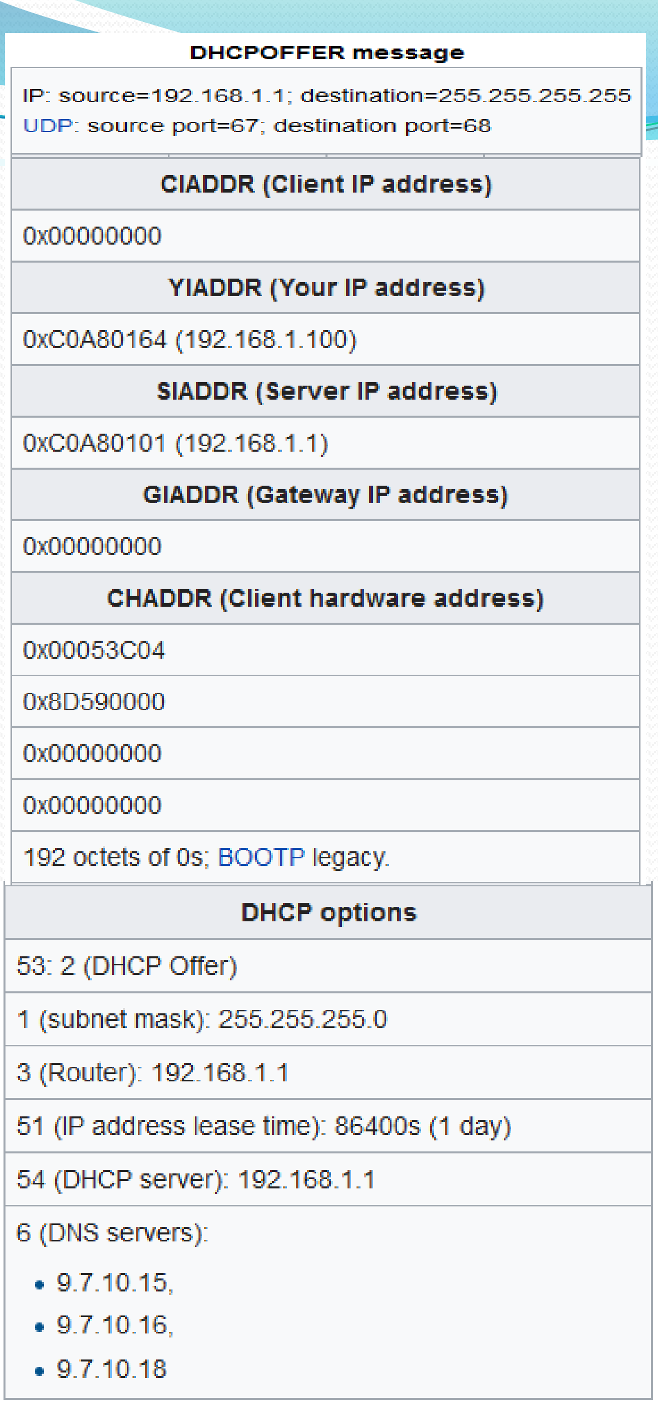


Example DHCPDISCOVER message
IP: source=0.0.0.0; destination=255.255.255.255 UDP: source port=68; destination port=67
CIADDR (Client IP address)
0x00000000
YIADDR (Your IP address)
0x00000000
SIADDR (Server IP address)
0x00000000
GIADDR (Gateway IP address)
0x00000000
CHADDR (Client hardware address)
0x00053C04
0x8D590000
0x00000000
0x00000000
192 octets of 0s, or overflow space for additional options; BOOTP legacy.
DHCP options
0x350101 53: 1 (DHCP Discover)
0x3204c0a00164 50: 192.168.1.100 requested
0x370401030f06 55 (Parameter Request List): • 1 (Request Subnet Mask), • 3 (Router), • 15 (Domain Name), • 6 (Domain Name Server)
0xff 255 (Endmark)

DHCP offer

- When a DHCP server receives a DHCPDISCOVER message from a client, which is an IP address lease request, the server reserves an IP address for the client and makes a lease offer by sending a DHCPOFFER message to the client. This message contains the client's MAC address, the IP address that the server is offering, the subnet mask, the lease duration, and the IP address of the DHCP server making the offer.
- The server determines the configuration based on the client's hardware address as specified in the CHADDR (client hardware address) field. Here the server, 192.168.1.100, specifies the client's IP address in the YIADDR (your IP address) field.

DHCP offer

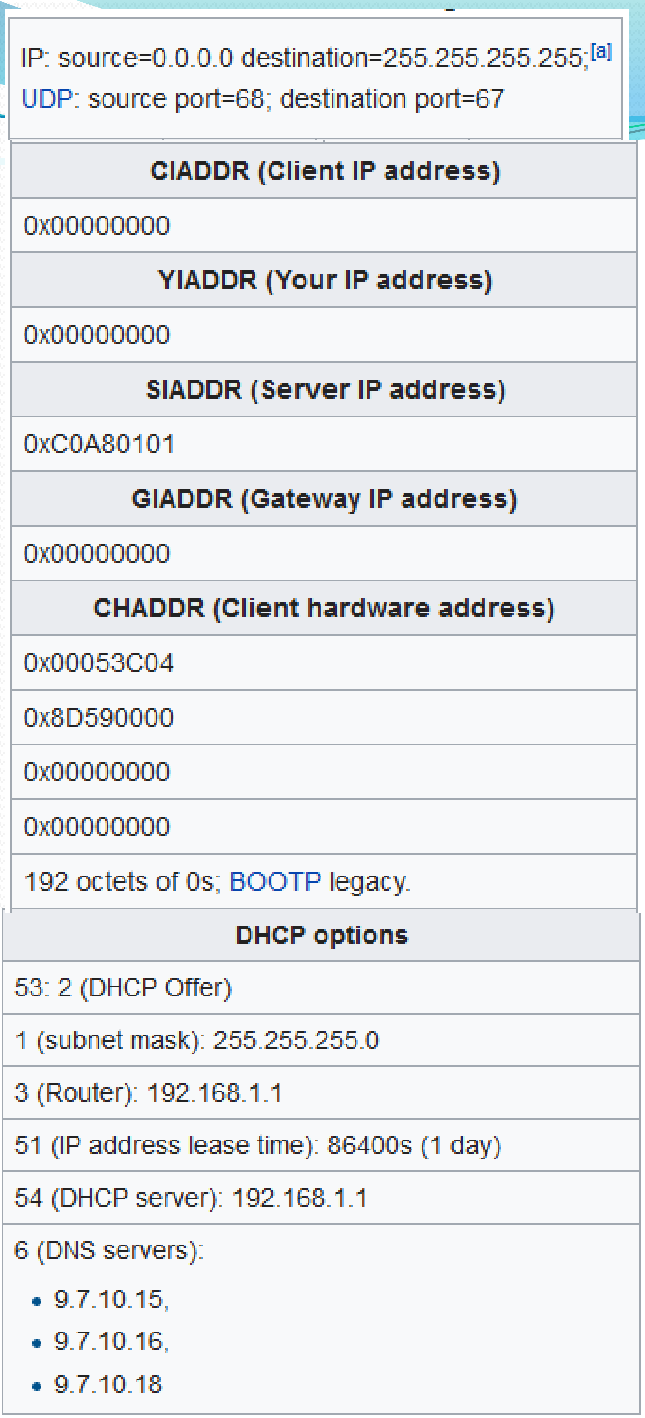


DHCPOFFER message
IP: source=192.168.1.1; destination=255.255.255.255 UDP: source port=67; destination port=68
CIADDR (Client IP address)
0x00000000
YIADDR (Your IP address)
0xC0A80164 (192.168.1.100)
SIADDR (Server IP address)
0xC0A80101 (192.168.1.1)
GIADDR (Gateway IP address)
0x00000000
CHADDR (Client hardware address)
0x00053C04
0x8D590000
0x00000000
0x00000000
192 octets of 0s; BOOTP legacy.
DHCP options
53: 2 (DHCP Offer)
1 (subnet mask): 255.255.255.0
3 (Router): 192.168.1.1
51 (IP address lease time): 86400s (1 day)
54 (DHCP server): 192.168.1.1
6 (DNS servers): • 9.7.10.15, • 9.7.10.16, • 9.7.10.18

DHCP request

- In response to the DHCP offer, the client replies with a DHCP request, broadcast to the server, requesting the offered address. A client can receive DHCP offers from multiple servers, but it will accept only one DHCP offer. A client will unicast a request message to DHCP Server which already knows its IP address.

DHCP request



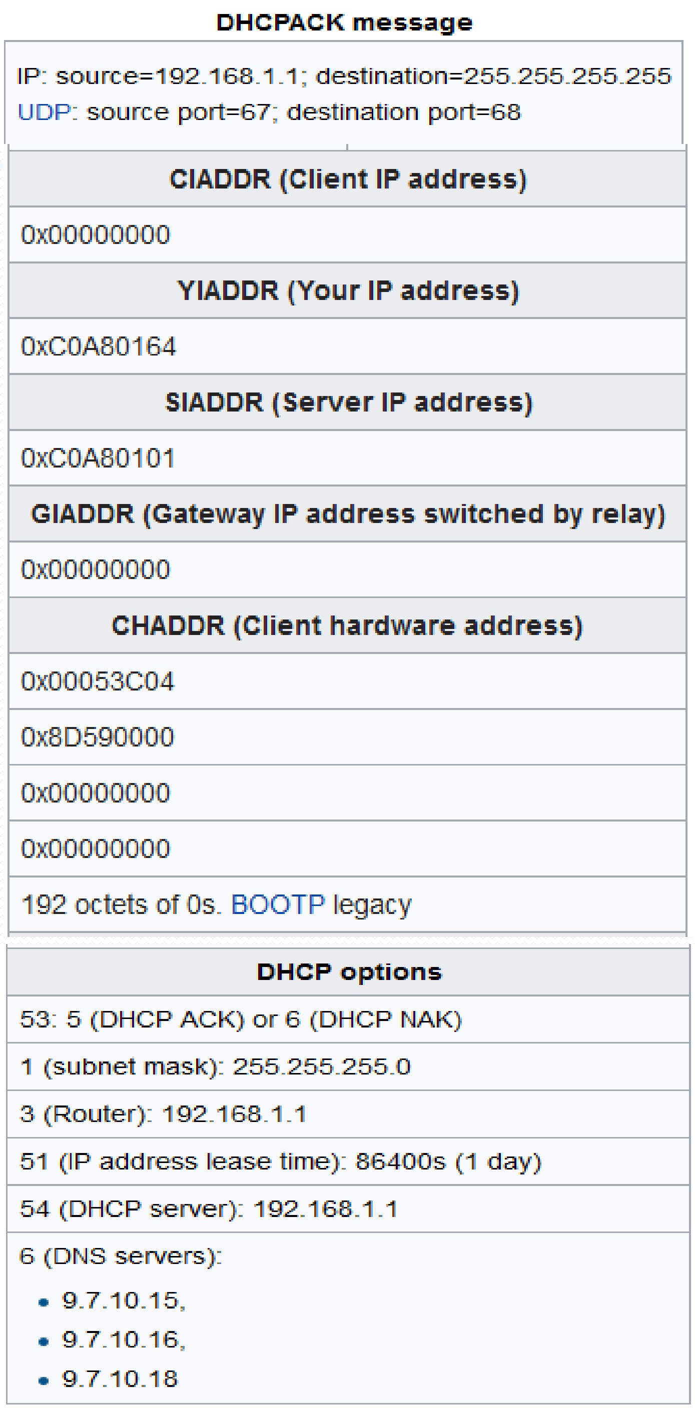
IP: source=0.0.0.0 destination=255.255.255.255;[a]
UDP: source port=68; destination port=67

CIADDR (Client IP address)
0x00000000
YIADDR (Your IP address)
0x00000000
SIADDR (Server IP address)
0xC0A80101
GIADDR (Gateway IP address)
0x00000000
CHADDR (Client hardware address)
0x00053C04
0x8D590000
0x00000000
0x00000000
192 octets of 0s; BOOTP legacy.
DHCP options
53: 2 (DHCP Offer)
1 (subnet mask): 255.255.255.0
3 (Router): 192.168.1.1
51 (IP address lease time): 86400s (1 day)
54 (DHCP server): 192.168.1.1
6 (DNS servers): • 9.7.10.15, • 9.7.10.16, • 9.7.10.18

DHCP acknowledgement

- When the DHCP server receives the DHCPREQUEST message from the client, the configuration process enters its final phase.
- The acknowledgement phase involves sending a DHCPACK packet to the client.
- This packet includes the lease duration and any other configuration information that the client might have requested. At this point, the IP configuration process is completed.

DHCP acknowledgement



DHCPACK message

IP: source=192.168.1.1; destination=255.255.255.255
UDP: source port=67; destination port=68

CIADDR (Client IP address)
0x00000000
YIADDR (Your IP address)
0xC0A80164
SIADDR (Server IP address)
0xC0A80101
GIADDR (Gateway IP address switched by relay)
0x00000000
CHADDR (Client hardware address)
0x00053C04
0x8D590000
0x00000000
0x00000000
192 octets of 0s. BOOTP legacy

DHCP options
53: 5 (DHCP ACK) or 6 (DHCP NAK)
1 (subnet mask): 255.255.255.0
3 (Router): 192.168.1.1
51 (IP address lease time): 86400s (1 day)
54 (DHCP server): 192.168.1.1
6 (DNS servers): • 9.7.10.15, • 9.7.10.16, • 9.7.10.18

DHCP Concept

ملاحظات:

- العمليات السابقة تحدث داخل الشبكة المحلية (LAN) فقط ولا تتعدها إلى شبكات أخرى (أي أن جهاز الـ Router لن يسمح لها بالمرور إلى شبكات أخرى).
- يمكن إعداد DHCP Server لكل شبكة محلية على حدى، أو بالإمكان إعداد DHCP Server وحيد لكل الشبكات المحلية (وهنا يجب إعداد DHCP relay agent).

DHCP relaying

- The DHCP operation begins with clients broadcasting a request. If the client and server are on different subnets, a DHCP Helper or DHCP Relay Agent may be used.

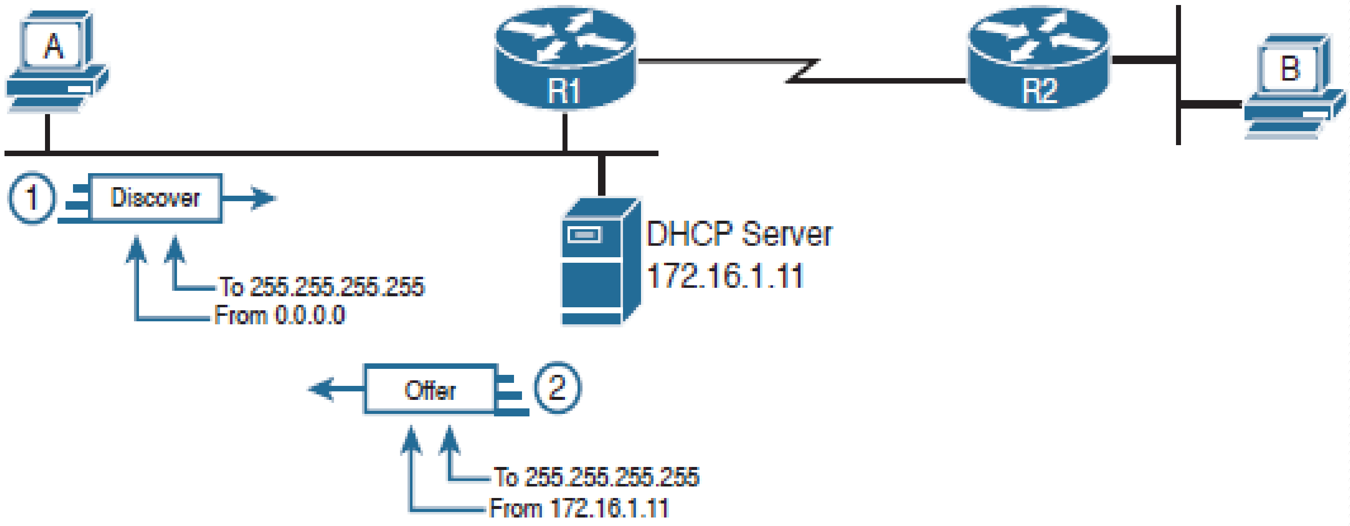


Figure 20-1 *DHCP Discover and Offer*

DHCP relaying

- In small networks, where only one IP subnet is being managed, DHCP clients communicate directly with DHCP servers. However, DHCP servers can also provide IP addresses for multiple subnets. In this case, a DHCP client that has not yet acquired an IP address cannot communicate directly with the DHCP server using IP routing, because it does not have a routable IP address, nor does it know the IP address of a router.

DHCP relaying

- In order to allow DHCP clients on subnets not directly served by DHCP servers to communicate with DHCP servers, DHCP relay agents can be installed on these subnets. The DHCP client broadcasts on the local link; the relay agent receives the broadcast and transmits it to one or more DHCP servers using unicast. The relay agent stores its own IP address in the GIADDR field of the DHCP packet. The DHCP server uses the GIADDR to determine the subnet on which the relay agent received the broadcast, and allocates an IP address on that subnet. When the DHCP server replies to the client, it sends the reply to the GIADDR address, again using unicast. The relay agent then retransmits the response on the local network.

ip helper-address commend

- The **ip helper-address** server-ip subcommand tells the router to do the following for the messages coming in an interface, from a DHCP client:

1) Watch for incoming DHCP messages, with destination IP address 255.255.255.255.

2) Change that packet's source IP address to the router's incoming interface IP address.

3) Change that packet's destination IP address to the address of the DHCP server (as configured in the ip helper-address command).

4) Route the packet to the DHCP server.

ip helper-address commend

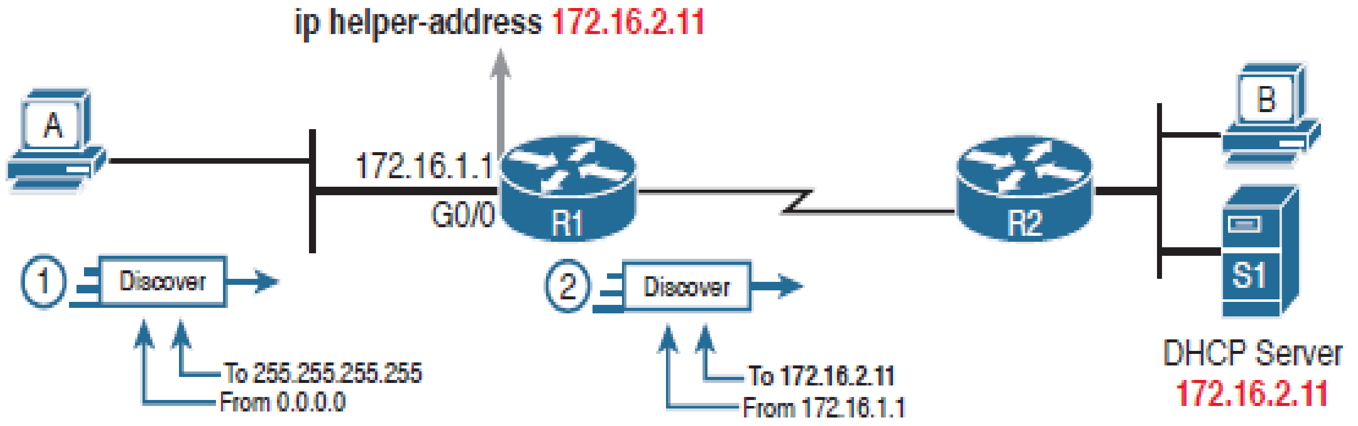


Figure 20-2 *IP Helper Address Effect*

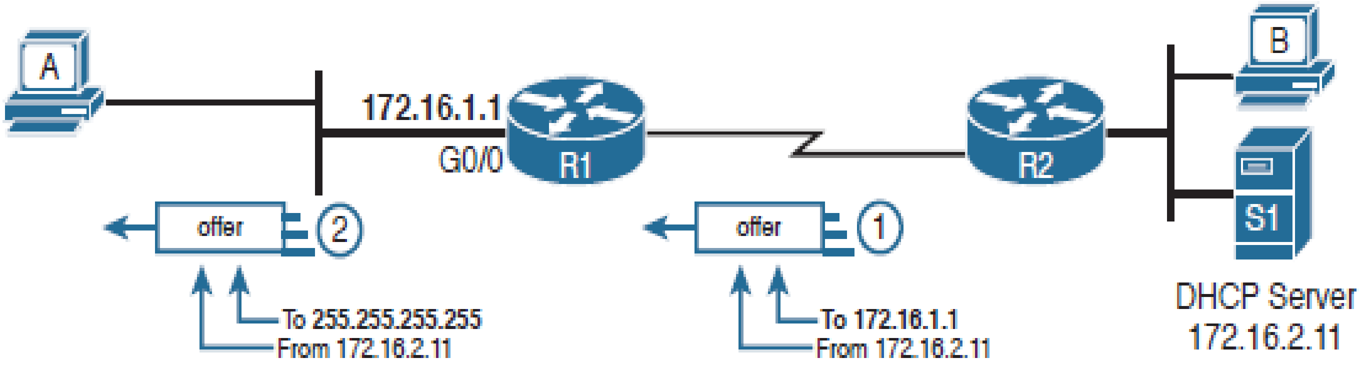


Figure 20-3 *IP Helper Address for the Offer Message Returned from the DHCP Server*

Information Stored at the DHCP Server

1) Subnet ID and mask
2) Reserved (excluded) addresses
3) Default router(s)
4) DNS IP address(es)

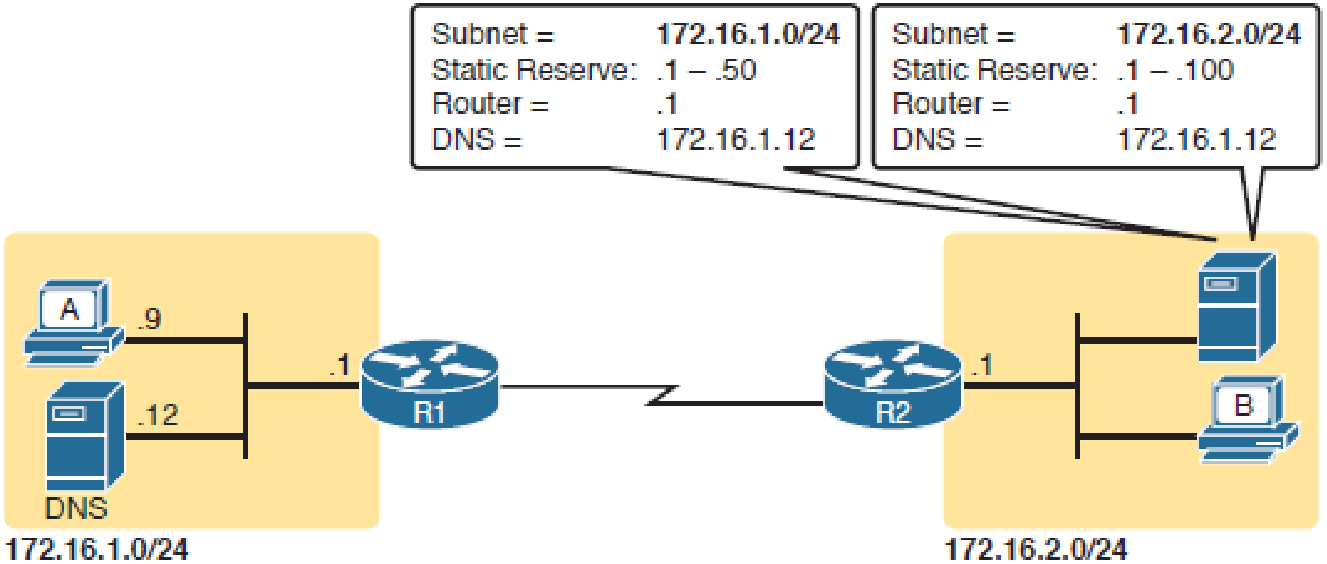
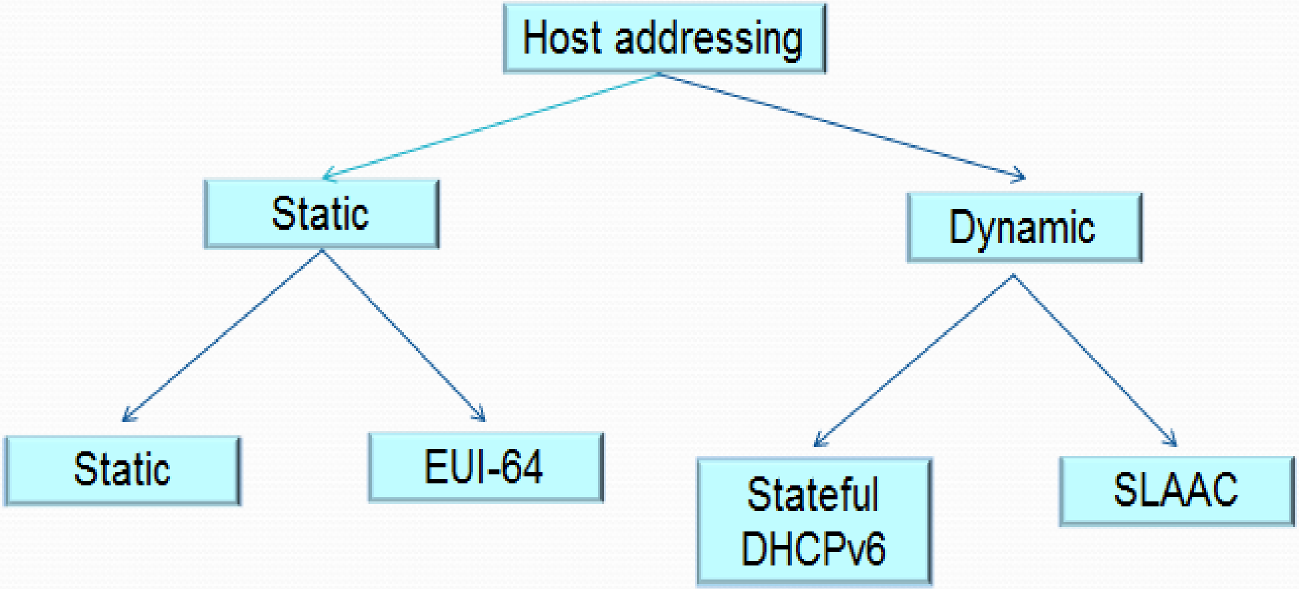


Figure 20-4 *Preconfiguration on a DHCP Server*

Information Stored at the DHCP Server

- The configuration can list other parameters as well. For example, it can set the time limit for leasing an IP address. The server leases an address for a time (usually a number of days), and then the client can ask to renew the lease. If the client does not renew, the server can reclaim the IP address and put it back in the pool of available IP addresses. The server configuration sets the maximum time for the lease.

Assigning Addresses to Hosts using IPv6



Host addressing

Static

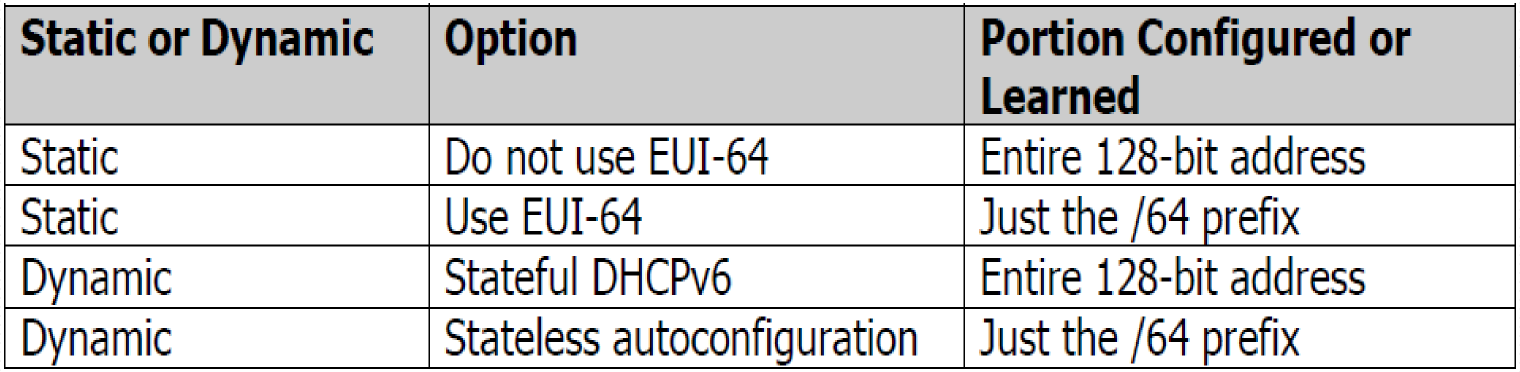
Dynamic

Static

EUI-64

Stateful DHCPv6

SLAAC



Static or Dynamic	Option	Portion Configured or Learned
Static	Do not use EUI-64	Entire 128-bit address
Static	Use EUI-64	Just the /64 prefix
Dynamic	Stateful DHCPv6	Entire 128-bit address
Dynamic	Stateless autoconfiguration	Just the /64 prefix

Dynamic Configuration of Host IPv6 Settings

- DHCP worked well for IPv4, so creating a version of DHCP for IPv6 (DHCPv6) made perfect sense. However, while DHCP has many advantages, one possible disadvantage is that DHCP requires a server that keeps information about each host (client) and its address. The designers of IPv6 wanted an alternative dynamic address assignment tool, one that did not require a server. The answer? SLAAC.

Dynamic Configuration Using Stateful DHCP and NDP

- DHCP for IPv6 (DHCPv6) gives an IPv6 host a way to learn host IPv6 configuration settings, using the same general concepts as DHCP for IPv4. The host exchanges messages with a DHCP server, and the server supplies the host with configuration information, including a lease of an IPv6 address, along with prefix length and DNS server address information.
- **NOTE** The DHCP version is not actually version 6; the name just ends in “v6” in reference to the support for IPv6.
- More specifically, stateful DHCPv6 works like the more familiar DHCP for IPv4 in many other general ways, as follows:

Dynamic Configuration Using Stateful DHCP and NDP

- DHCP clients on a LAN send messages that flow only on the local LAN, hoping to find a DHCP server.
- If the DHCP server sits on the same LAN as the client, the client and server can exchange DHCP messages directly, without needing help from a router.
- If the DHCP server sits on another link as compared to the client, the client and server rely on a router to forward the DHCP messages.
- The router that forwards messages from one link to a server in a remote subnet must be configured as a DHCP Relay Agent, with knowledge of the DHCP server's IPv6 address.
- Servers have configuration that lists pools of addresses for each subnet from which the server allocates addresses.

Dynamic Configuration Using Stateful DHCP and NDP

- Servers offer a lease of an IP address to a client, from the pool of addresses for the client's subnet; the lease lasts a set time period (usually days or weeks).
- The server tracks state information, specifically a client identifier (often based on the MAC address), along with the address that is currently leased to that client.

Dynamic Configuration Using Stateful DHCP and NDP

- DHCPv6 has two major branches of how it can be used: stateful DHCPv6 and stateless DHCPv6. Stateful DHCPv6 works more like the DHCPv4 model, especially related to that last item in the list. A stateful DHCPv6 server tracks information about which client has a lease for what IPv6 address; the fact that the server knows information about a specific client is called state information, making the DHCP server a stateful DHCP server.
- Stateless DHCP servers do not track any per-client information. The upcoming section “Using Stateless Address Auto Configuration” discusses how stateless DHCPv6 servers have an important role when a company decides to use SLAAC .

Stateful DHCPv6

- تشبه DHCPv4 في طريقة الاستئجار.
- الفرق الوحيد أن الـ Default Gateway لا يوفره مخدم الـ DHCP ولكن يتم الحصول عليه من بروتوكول Neighbor Discovery Protocol (NDP)

Differences Between DHCPv6 and DHCPv4

- While stateful DHCPv6 has many similarities to DHCPv4, many particulars differ as well. Figure 31-6 shows one key difference: Stateful DHCPv6 does not supply default router information to the client. Instead, the client host uses the built-in NDP protocol to learn the routers’ IPv6 addresses directly from the local routers.

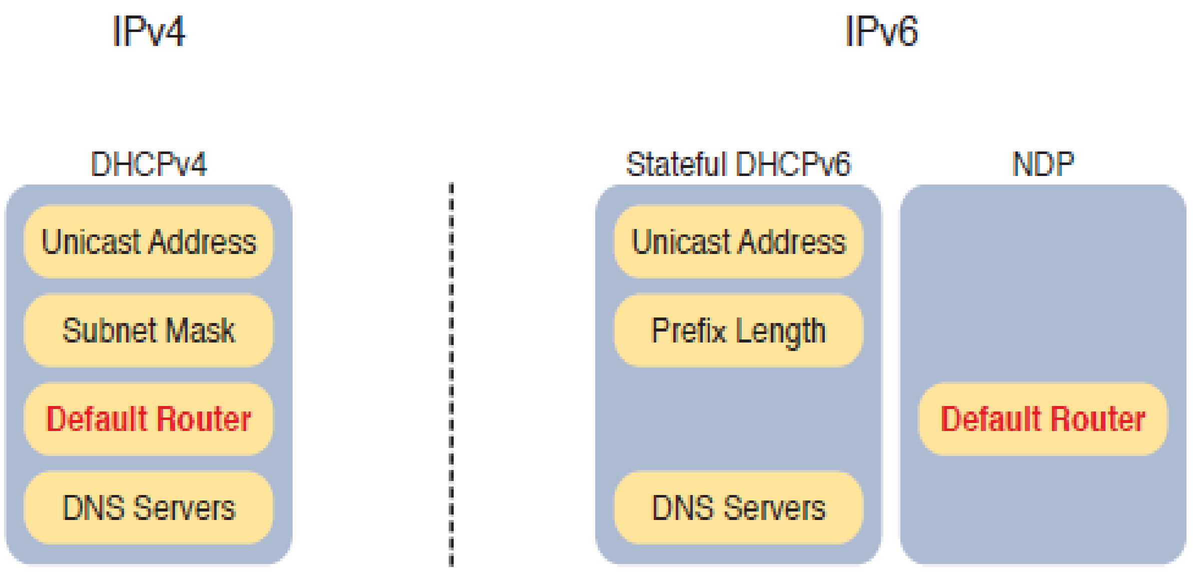


Figure 31-6 *Sources of Specific IPv6 Settings When Using Stateful DHCP*

Differences Between DHCPv6 and DHCPv4

- DHCPv6 also updates the protocol messages to use IPv6 packets instead of IPv4 packets, with new messages and fields as well. For example, Figure 31-7 shows the names of the DHCPv6 messages, which replace the DHCPv4 Discover, Offer, Request, and Acknowledgment (DORA) messages. Instead, DHCPv6 uses the Solicit, Advertise, Request, and Reply messages.

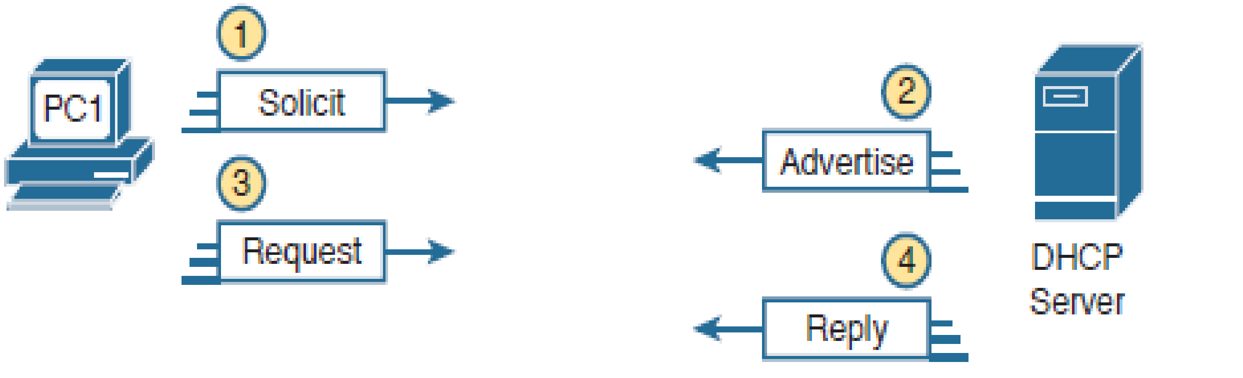


Figure 31-7 *Four Stateful DHCPv6 Messages Between Client and Server*

Differences Between DHCPv6 and DHCPv4

- The four DHCPv6 messages work in two matched pairs with the same general flow as the similar DHCPv4 messages. The Solicit and Advertise messages complete the process of the client searching for the IPv6 address of a DHCPv6 server (the Solicit message) and the server advertising an address (and other configuration settings) for the client to possibly use (the Advertise message). The Request and Reply messages let the client ask to lease the address, with the server confirming the lease in the Reply message.

Using Stateless Address Auto Configuration

- The stateful nature of DHCPv4, as well as its newer cousin stateful DHCPv6, causes some challenges. Someone has to configure, administer, and manage the DHCP server(s). The configuration includes ranges of IP addresses for every subnet. Then, when a host (client) leases the address, the server notes which client is using which address. All these functions work, and work well, but the reliance on a stateful DHCP server requires some thought and attention from the IT staff.
- IPv6's SLAAC provides an alternative method for dynamic IPv6 address assignment—without needing a stateful server. In other words, SLAAC does not require a server to assign or lease the IPv6 address, does not require the IT staff to preconfigure data per subnet, and does not require the server to track which device uses which IPv6 address.

Using Stateless Address Auto Configuration

- The term SLAAC refers to both a specific part of how a host learns one IPv6 setting—its IPv6 address—plus the overall process of learning all four key host IPv6 settings (address, prefix length, default router, and DNS server addresses).

- لا تحتاج للمخدم من أجل تأجير العناوين وخزنها وتحديد فترة الاستئجار.
- تكون العناوين داخلياً بعملية Autoconfiguration وباستخدام بعض التقنيات والبروتوكولات الأخرى.

Building an IPv6 Address Using SLAAC

- When using SLAAC, a host does not lease its IPv6 address, or even learn its IPv6 address. Instead, the host learns part of the address—the prefix—and then makes up the rest of its own IPv6 address. Specifically, a host using SLAAC to choose its own IPv6 address uses the following steps:

1) Learn the IPv6 prefix used on the link, from any router, using NDP RS/RA messages (Router Advertisement (RA), Router Solicitation (RS)).

2) Choose its own IPv6 address by making up the interface ID value to follow the just-learned IPv6 prefix.

3) Before using the address, first use DAD to make sure that no other host is already using the same address.

Combining SLAAC with NDP and Stateless DHCP

- When using SLAAC, a host actually makes use of three different tools to find its four IPv6 settings, as noted in Figure 31-10. SLAAC itself focuses on the IPv6 address only. The host then uses NDP messages to learn both the prefix length and the IPv6 addresses of the available routers on the link. Finally, the host makes use of stateless DHCP to learn the IPv6 addresses of any DNS servers.

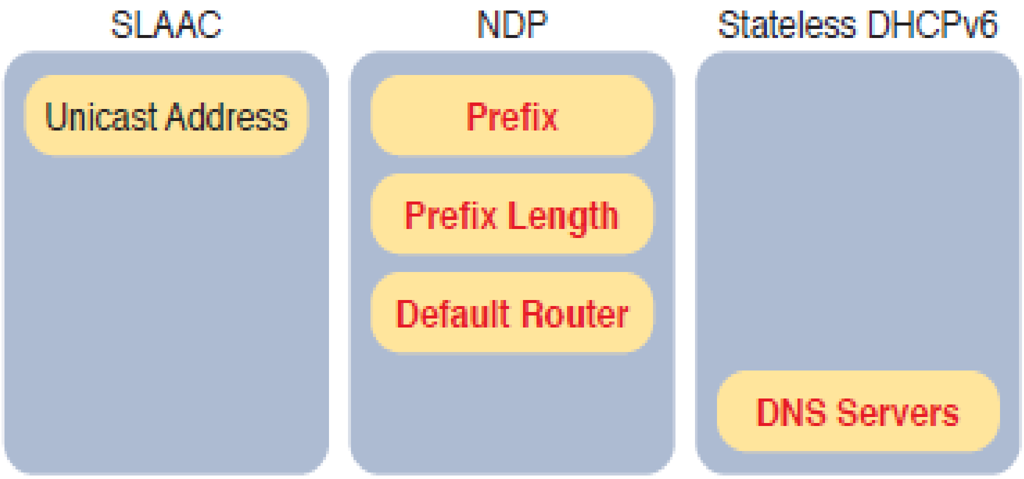


Figure 31-10 *Sources of Specific IPv6 Settings When Using SLAAC*

Combining SLAAC with NDP and Stateless DHCP

- يتم تكوين العنوان بالطريقة الموضحة أدناه:

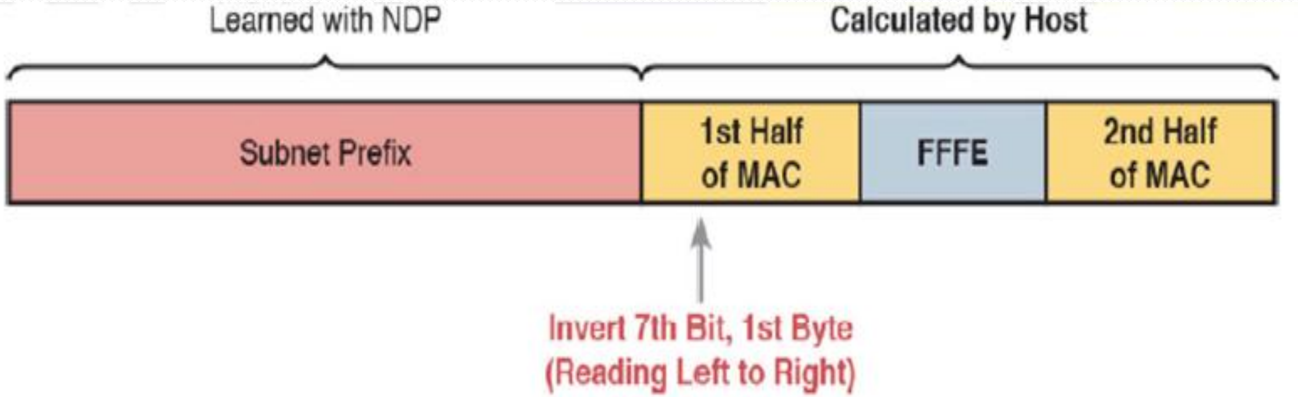


Figure 22-8 *IPv6 Address Format with Interface ID and EUI-64*

- Stateless DHCP solves the last piece of this puzzle when also using SLAAC. The host needs to know the DNS servers’ IPv6 addresses. The solution? Use DHCPv6. However, the host, acting as the DHCPv6 client, asks the server for only the DNS server addresses, and not for a lease of an IPv6 address.

Combining SLAAC with NDP and Stateless DHCP

- So, why does the world need to call this service stateless DHCPv6? The DHCP server with stateless DHCPv6 has far less work to do, and the network engineer has far less administrative work to do. With stateless DHCPv6, the DHCPv6 server

1) Needs simple configuration only, specifically a small number of addresses for the DNS servers, but nothing else

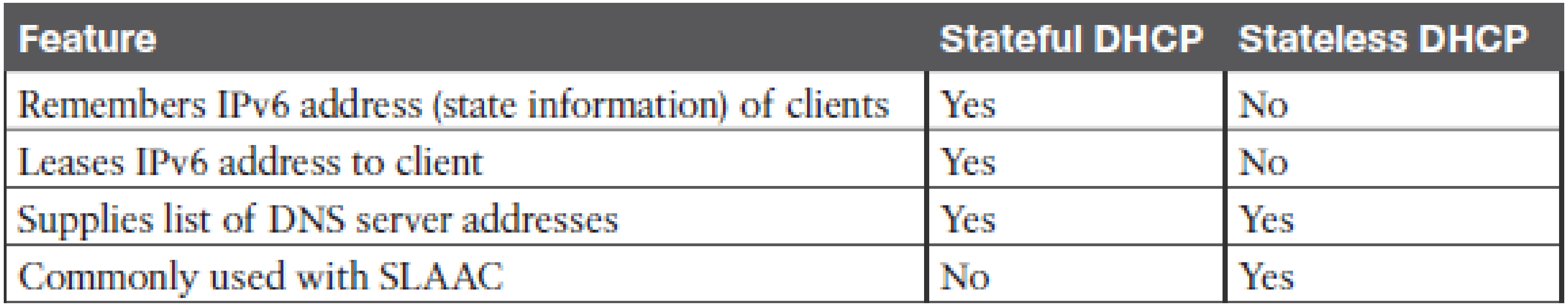
2) Needs no per-subnet configuration: no subnet list, no per-subnet address pools, no list of excluded addresses per subnet, and no per-subnet prefix lengths

3) Has no need to track state information about DHCP leases—that is, which devices lease which IPv6 address—because the server does not lease addresses to any clients

Combining SLAAC with NDP and Stateless DHCP

- Table 31-3 summarizes the key comparison points between stateless DHCP and stateful DHCP.

Table 31-3 Comparison of Stateless and Stateful DHCPv6 Services



Feature	Stateful DHCP	Stateless DHCP
Remembers IPv6 address (state information) of clients	Yes	No
Leases IPv6 address to client	Yes	No
Supplies list of DNS server addresses	Yes	Yes
Commonly used with SLAAC	No	Yes