DHCP (Dynamic Host Connection Protocol)—allows a host to get its configuration from the network, including:

- IP Address & Mask
- Default Gateway
- DNS Server Address

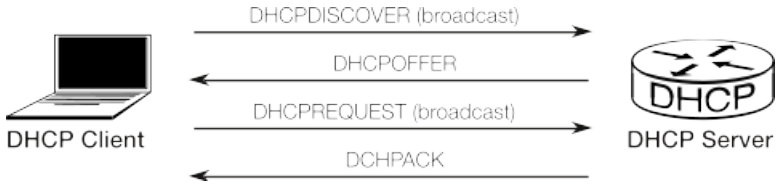
Advantages of using DHCP include reduced configuration errors and portability (coffee shops).

MESSAGES

Clients that do not yet have a configuration use a source address of 0.0.0.0 and broadcast destination 255.255.255.255.

ADDRESS	PURPOSE
0.0.0.0	Source address used by hosts who don't yet have an IP address of their own
255.255.255.255	Broadcast Destination Address—reaches all hosts within a network (broadcast domain), but isn't routed any further

Messages include the following:



MESSAGE	PURPOSE
Discover	Find a server
Offer	Offer to lease a specific IP address to the client. Includes other settings too, e.g. gateway. For clarity, this contains the client ID from the Discover message in case more than one client is pending
Request	The client actually requests the offer. Broadcast in case more than one server had answered (the losers learn they're off the hook).
Acknowledgement	Server finalizes the lease

DHCP Relay—a centralized DHCP server can be supported by routers forwarding DHCP requests as routable unicast. The Discover message's source address is changed to the address of the router interface that received it and the destination is set to the address of the DHCP server.

```
R(config-if)# ip helper-address 10.0.0.56
```

Tells the address of the DHCP server. Placed on the client-facing interface that will likely become the default gateway for that host.

CONFIGURATION

```
R1(config)# ip dhcp excluded-address 192.168.1.1 192.168.1.99
R1(config)# ip dhcp excluded-address 192.168.1.201 192.168.1.254
                  First, tell it what addresses NOT to give out
R1(config)# ip dhcp pool myPool
R1(dhcp-config)# network 192.168.1.0 255.255.255.0
                  You can use CIDR /24 notation if you want.
R1(dhcp-config)# dns-server 208.67.222.222 8.8.8.8
                  OK to have more than one
R1(dhcp-config)# default-router 192.168.1.1
                  If you need to remember that this is "default-router" and not "default-gateway," just remember
                  that you're typing this on a router
R1(dhcp-config)# lease 0 0 5
                  0 days, 0 hours, 5 minutes. Default is one day
R1(dhcp-config)# domain-name example.com
R1(dhcp-config)# next-server 10.0.0.1
                  Optional configs to help the client further configure itself. "Next-server" is the address of a TFTP
                  server for things like IP phones. (The Collaboration Devices certification uses "option 150.")
```

TROUBLESHOOTING DHCP

Problem: Relay-agent—missing or wrong "ip helper address" (sub)interface configuration.

Symptom: Client doesn't get address (in Windows, client will have a link-local in 169.254.0.0 /16).

Isolation:

- What VLAN is the client in, based on access port?
- What router (sub)interface handles that VLAN?
- Is the helper-address even needed? If the DHCP server is running on that same server, there shouldn't be a helper-address.
- Check for the helper-address on the (sub)interface:

```
R5# show ip interface gi0/1
GigabitEthernet0/1 is up, line protocol is up
  Internet address is 10.5.0.1/24
  Broadcast address is 255.255.255.255
  Address determined by setup command
  MTU is 1500 bytes
  Helper address is 10.56.0.6
```

Problem: Relay-Agent—IP address of (sub)interface that does the relaying isn't within a DHCP pool network statement on the centralized server.

Explanation: The centralized DHCP server determines which pool to given an address from based on the source address of the request. That source address (formerly set to 0.0.0.0 by the actual client) had been changed by the relaying router to be its interface address for the interface that received and relayed the actual client request.

Avoiding the Problem: The mask of the pool network statement must always match the actual network mask. Don't use it to limit which addresses are handed out; that's what the "excluded-address" global configuration command is for!

On the Exam: Calculate whether the relaying (sub)interface address is inside the DHCP network statement's subnet.

```
R5# show ip dhcp pool
```

This command doesn't take into account excluded-addresses, so perfect for our purposes. It even gives you the address range that the relaying interface must be within.

```
Pool DATA_POD2 :
 Utilization mark (high/low)    : 100 / 0
 Subnet size (first/next)       : 0 / 0
 Total addresses                : 254
 Leased addresses               : 0
 Pending event                  : none
 1 subnet is currently in the pool :
 Current index        IP address range                  Leased addresses
 10.20.0.1            10.20.0.1       - 10.20.0.254     0
```

Problem: Various pool parameters could be wrong, causing a client to misconfigure itself

Incorrect Parameter	Symptom
Default-Router	Client can't talk to clients off its own (sub)net
DNS-Server	Client can't resolve hostnames
Next-Server	Phones can't find their TFTP server to boot from

Problem: Network problems between the relay agent and the centralized DHCP server.

Some other troubleshooting commands:

```
R5# show ip dhcp binding
Bindings from all pools not associated with VRF:
IP address          Client-ID/              Lease expiration        Type
                    Hardware address/
                    User name
10.25.0.11          0100.1795.388a.4c       May 11 2015 05:48 PM    Automatic
10.25.0.12          0100.1795.7def.a6       May 11 2015 05:48 PM    Automatic

R6# show ip dhcp server statistics
Memory usage         31723
Address pools        1
Database agents      0
Automatic bindings   1
Manual bindings      0
Expired bindings     0
Malformed messages   0
Secure arp entries   0

Message              Received
BOOTREQUEST          0
DHCPDISCOVER         16
DHCPREQUEST          1
DHCPDECLINE          0
DHCPRELEASE          0
DHCPINFORM           0

Message              Sent
BOOTREPLY            0
DHCPOFFER            16
DHCPACK              1
DHCPNAK              0
```

DHCP Troubleshooting Recap

- If you're using a centralized DHCP server, each subnet with clients needs an "ip helper-address" on its router (sub)interface.
- With a centralized DHCP server, the pool's network statements must include the router interface that does the relaying.
- Normal connectivity troubleshooting between the relaying router and the DHCP server.
- Normal connectivity troubleshooting between the client host and the relaying router interface.

ADDRESS CONFLICTS

An IOS (router) DHCP server will ping an address before giving it out, just to be sure that no one has manually configured it onto a host. Hosts may use ARP for the same reason before they start using an offered address. Either way, the DHCP server will hear the problem and blacklist the address.

Note: if you're using Wireshark from a different host, the ping may look like an ARP, because the ping may have needed an ARP to function and ARPs are broadcasts (visible to Wireshark) and pings are unicast (propagation limited by a switch).

```
Router> show ip dhcp conflict
IP address    Detection Method     Detection time
172.16.1.32   Ping                 Feb 16 1998 12:28 PM
172.16.1.64   Gratuitous ARP       Feb 23 1998 08:12 AM
```

Example from Cisco's IOS 12.2 commands reference

Detection Method	Who Detected the Conflict
Ping	Server
Gratuitous ARP	Client

```
Router# clear ip dhcp conflict
```

Put the addresses back in play

TROUBLESHOOTING HOST CONFIGURATION

From the command line:

ifconfig

Unixes (Linux, Macintosh, etc.)

ipconfig /all

Windows (in an MS-DOS window)

DNS—simple, because it's unicast to a configured IP address, with no name lookup of its own.

Default Router (gateway)—simple problems can happen:

- The host's access switchport VLAN must match the default router

```
Switch# show interfaces status
Switch# show vlan brief
Switch# show interfaces switchport
```

- The host subnet must match the default router

```
Router# show interfaces
Router# show ip interface brief
Router# show protocols
Router# show running-config
```

- Port security on the switchport mustn't interfere
- The host's default gateway IP address must match the interface address of the router

```
Host# netstat -rn
```

Shows the routing table on most OSs, including Macintosh. Lists the default gateway as a route to 0.0.0.0 or as a route to "default."

You can also check if ARP on the host has an address for the default gateway.

```
Host# arp -a
```

Windows again

And even compare it to the ARP entry that the router has for itself on the default gateway address (Cisco routers show ARP entries for their own interfaces, unlike most hosts).

```
Router# show arp
```

IPV4 ADDRESS TYPES

Unicast Addresses (A, B, C)—Assigned to hosts, router interfaces, etc. You'll have one address per L3 interface (i.e. maybe more than one per device).

Broadcast Address—delivered to more than one host

Broadcast Type	Description
Local Broadcast Address	255.255.255.255 A limited broadcast to the current subnet. Not routed.
Subnet Broadcast	The highest number in the subnet. Sometimes called an all-hosts broadcast or a directed broadcast because it's routable to that subnet. Cisco-disabled by default, via the "no ip directed-broadcast" interface subcommand.
Network Broadcast	The highest number in each classful network. Sometimes called an "all-subnets broadcast," because it reaches all subnets within the classful network.

Multicast Address (Class D 224-239)—routers send a copy out all interfaces that lead to a host that's listening. Multicast addresses can only be used for destinations, not sources.

ARP doesn't actually work with multicast addresses. Instead, the MAC address is calculated from the multicast address. Literally it's a 25-bit sequence that's only used for multicast (hex 01005E plus one other bit), followed by the last 23 bits of the ip address.

Recap—Table 20-2, page 495, abridged.

	Unicast	Broadcast	Multicast
Primarily used by the most common user apps (web, etc.)	X		
Primarily used by overhead processes (DHCP, ARP) to send a message to multiple devices		X	
Primarily used by server applications that send the same data at the same time to multiple hosts			X
Assigned to hosts via DHCP	X		
Useful only as a destination address, never a source		X	X
Uses Class A, B, and C addresses	X		
Uses Class D addresses			X