Dynamic Host Configuration Protocol (DHCP)

History

- Diskless workstations
  - Needed to know configuration parameters like IP address, netmask, gateway address etc. on boot
  - Small boot programs on ROM needed to load OS over network (*bootstrap*), need to know boot file server
  - Knows only its h/w address on boot
- RARP (Reverse ARP) can provide some parameters, but complex
- BOOTP (BootstrapProtocol) designed to provide these, and some more
- Main problem with BOOTP – no dynamic IP allocation
  - IP allocated to a device is fixed at BOOTP server (based on its MAC)

DHCP

- Extension of BOOTP – allows dynamic IP allocation
- Similar message format as BOOTP – DHCP server compatible with BOOTP clients
- Can give a wide range of configuration parameters to hosts
  - IP address, netmask, router, DNS server, boot file server, boot file name, time server, domain name, host name, SMTP server, POP3 server, default IP TTL etc. (see RFC 2132)
- Runs on UDP
  - Server on UDP port 67
  - Client on UDP port 68
  - But UDP is encapsulated in IP, and IP header will need source IP address
    - How can a device use UDP before it actually gets an IP?

Motivation

- Move a m/c between networks
- Add a new m/c
- Reclaim unused IP address space
- Configuration of the m/c should be simple and automatic
- Primarily used for network configuration
  - IP, subnet, gateway, DNS
  - Other parameters can be given also as mentioned

DHCP based IP Address Allocation

- Automatic Allocation
  - Permanent address given to host by DHCP, never expires
- Dynamic Allocation
  - IP address given to host for specific time (*lease*)
  - Client host can relinquish before that time or renew after that time
  - Most common allocation method
- Manual
  - Allocated by administrator (specified in a file)
  - DHCP only conveys that information to host

Basic Operation

- Client sends DHCPDISCOVER to DHCP server
- Server replies with DHCPOFFER with offer of parameters
- If client accepts, client sends DHCPREQUEST to server
- Server commits the offer to storage, sends DHCPACK. If any problem, don't commit and send DHCPNACK, client starts again
- Client checks again. If accept, do nothing. If problems, send DHCPDECLINE to server
- Client can release parameters before lease time expiry by DHCPRELEASE

Basic Operation – Address Allocation

- Client broadcasts DHCPDISCOVER message on local subnet
  - Use 255.255.255.255 as destination IP
    - All 1's is limited broadcast IP for broadcast within subnet
  - Source IP set to 0
  - Client's MAC id sent in message for identification
  - Client can request a specific IP and specific lease time
  - Client can specify a preferred DHCP server
  - Clients can specify what parameters are desired (may not want all parameters that the server can give)

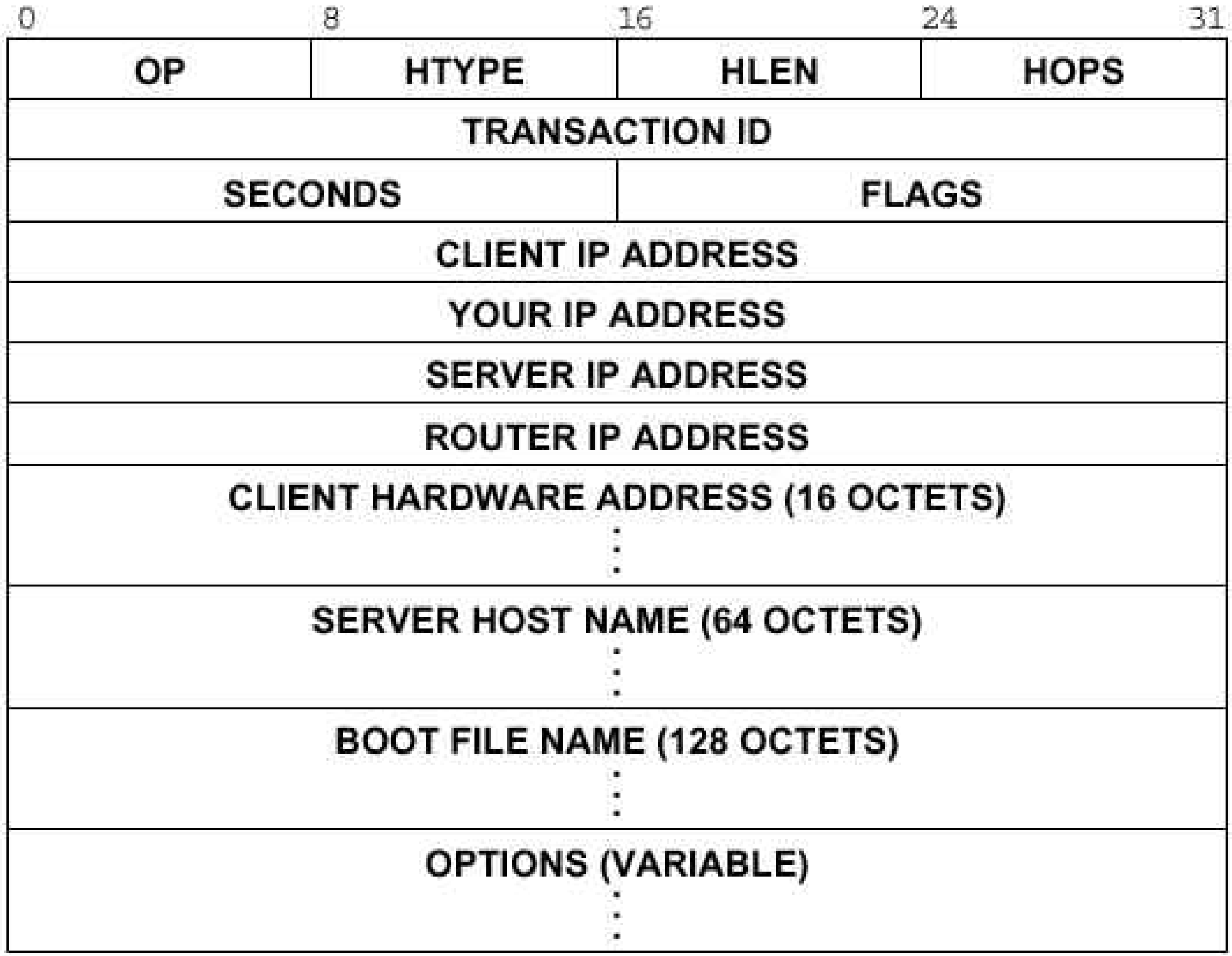
- All DHCP servers, on receiving the DHCPDISCOVER
  - Allocates IP for client
    - Allocate IP requested by client if possible
    - Dynamically allocate an IP from pool of available Ips (DHCP pool configured in the server)
  - Lease time set to whatever client has requested (subject to local policy) or default
  - Selects parameters requested by client, or default set if no specific request
  - Send a DHCPOFER message to client. This is an offer, not a final commitment.
  - Message either unicast to h/w address of client or broadcast. Client should specify broadcast (through a flag bit) in any message to server if it cannot handle unicast before TCP/IP configuration

- Client, on receiving DHCPOFFER
  - Can receive offer from multiple servers
  - Select one server, accept its offer, and send a DHCPREQUEST to it with the configuration parameters
  - Request is broadcast, but a special server identifier field filled with the server chosen, so that other servers know they are being declines
  - Timeout to start rediscovery if no offer within a certain time
  - DHCPREQUEST also sent on boot to confirm earlier allocation, or to renew earlier lease

- Server, on receiving DHCPREQUEST
  - If offer is still valid, commit offer to persistent storage and send DHCPACK to client with the configuration parameters (same as in offer)
  - If unable to satisfy request now, send DHCPNAK
  - Makes earlier offered address available for others if timeout for request

- Client on receiving DHCPACK/NAK
  - If NAK, start entire process again
  - If ACK, make final check (for ex., is IP in use?). If no problem, do nothing. If problem, send DHCPDECLINE
  - Send request again if timeout for ACK/NAK, give up after few tries
- Client can release an IP before its lease expiry by DHCPRELEASE message
- If client has already got IP externally (ex. static IP), but wants other configuration parameters, should use DHCPINFORM message

DHCP Message Format



<table>
<tr><td>0</td><td>8</td><td>16</td><td>24</td><td>31</td></tr>
<tr><td>OP</td><td>HTYPE</td><td>HLEN</td><td colspan="2">HOPS</td></tr>
<tr><td colspan="5">TRANSACTION ID</td></tr>
<tr><td colspan="2">SECONDS</td><td colspan="3">FLAGS</td></tr>
<tr><td colspan="5">CLIENT IP ADDRESS</td></tr>
<tr><td colspan="5">YOUR IP ADDRESS</td></tr>
<tr><td colspan="5">SERVER IP ADDRESS</td></tr>
<tr><td colspan="5">ROUTER IP ADDRESS</td></tr>
<tr><td colspan="5">CLIENT HARDWARE ADDRESS (16 OCTETS)
⋮</td></tr>
<tr><td colspan="5">SERVER HOST NAME (64 OCTETS)
⋮</td></tr>
<tr><td colspan="5">BOOT FILE NAME (128 OCTETS)
⋮</td></tr>
<tr><td colspan="5">OPTIONS (VARIABLE)
⋮</td></tr>
</table>

Figure 23.5 The format of a DHCP message, which is an extension of a BOOTP message. The options field is variable length; a client must be prepared to accept at least 312 octets of options.

- ***operation***: 1 = request, 2 = reply
- ***htype***: hardware type (ethernet etc., integer code for defined types)
- ***hlen***: length of h/w address
- ***hops***: no. of routers the message passes through
- ***xid***: transaction id used to match request and reply
- ***secs***: time since client begun address acquisition/renewal
- ***flags***: top bit indicates if client wants broadcast from server or not
- ***ciaddr***: Client IP address. Filled in by client in some cases when client knows its IP and can respond to ping
- ***yiaddr***: IP address of client. Filled in by server after allocation/renewal
- ***siaddr***: IP of server to handle the next stage
- ***giaddr***: IP of relay agent, if any. 0 indicates no relay
- ***chaddr***: client h/w address
- ***sname***: optional DHCP server name to contact
- ***file***: boot file name
- ***options***: other configuration parameters

Persistent Storage in DHCP

- Once an allocation is committed, it needs to be stored to make it persistent
  - Needs unique id for a client
  - Needs unique id for a lease
- Client id
  - If client supplied an explicit id in client identifier option, use it
  - Else, (IP subnet number, h/w address specified in chadr field)
  - This implies host with multiple interfaces must do a separate DHCP discover etc. for each interface

- Lease id
  - Needed to identify a lease for renewal etc.
  - Id for lease = (client’s id, assigned network address)
- DHCP tries to assign the same address to a client everytime it requests, before or after lease expiry
  - Looks up last lease of client if there in storage, if address is unallocated, assign that
  - Overridden by “requested IP address” option if set by client

Lease Renewal

- Start renewal process before expiry (by default, after 50% lease time is over)
  - Contact original DHCP server
  - Start from DHCPREQUEST step, fill in *ciaddr* field with current IP already allocated
  - Simple UDP communication, since client is fully configured
- If no response to renewal after certain time (by default, after 87.5% of lease time)
  - Contact any DHCP server for renewal (broadcast)
  - Still starts from DHCPREQUEST and uses plain UDP communication
- If lease expires, must start from DHCPDISCOVER again

BOOTP/DHCP Relay

- At least one DHCP server per subnet may be too costly if no. of subnets is large
- Suppose that client machine and DHCP server are in different subnets
- DHCPDISCOVER message will not be forwarded by the router
  - Limited broadcast (all 1 destination IP) is only within the subnet
  - So client's request will not reach the server
- Solution: make the router act as a DHCP relay agent
  - Routers can be configured to give special processing to DHCP packets even if the destination IP is a broadcast IP

- Configure/Enable the router to act as relay agent
  - Also configures the DHCP server addresses in the relay agent
  - Can configure multiple DHCP servers
- Client sets a field (*giaddr*) to 0 when it sends the request
  - 0 indicates client-server on same subnet
- Relay agent checks for packets with destination UDP port 67
- If detected,
  - First relay agent detecting this (*giaddr* = 0) puts its own IP (IP of interface the packet was received in) in this field
    - Not changed by subsequent relays
  - Sends the UDP packet to each of the DHCP servers
    - Source IP = relay agent IP, destination IP = DHCP server IP, source port = 68, destination port = 67
    - UDP packet forwarded normally

- So in essence the first relay agent acts as a proxy client to the DHCP servers
- DHCP server, on receiving a packet, checks the *giaddr* field
  - If 0, client on the same subnet, send as earlier
  - If non-zero, send response (DHCPOFFER) to relay agent
    - Source IP = DHCP server IP, destination IP = relay agent IP (from *giaddr* field), source port = 67, destination port = 68
    - UDP packet forwarded normally
- Relay agent forwards to original client
- Same for all other subsequent messages