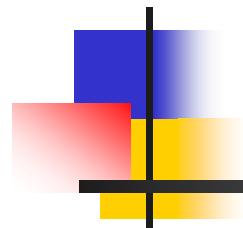


DHCP Basics

(Dynamic Host Configuration Protocol)



BUPT/QMUL

2010-11-02



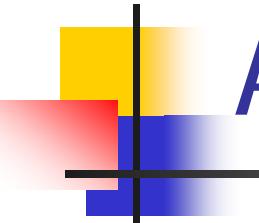
Topics In This Course

Background

- Introduction of Internet
- TCP/IP and OSI/RM
- Sockets

Typical Internet Applications

- DNS (Domain Name System)
- DHCP (Dynamic Host Configuration Protocol)
- Remote Interactive Computing: TELNET/SSH
- File Transfer and Access: FTP/TFTP/NFS
- Email: SMTP/POP/IMAP/MIME
- World Wide Web: HTTP
- Network Management: SNMP
- Multimedia and Voice: SIP / H.323, RTP / RTCP



Agenda

- Some useful information about learning a protocol
- Introduction to DHCP
- DHCP Protocol
- Examples about DHCP configuration

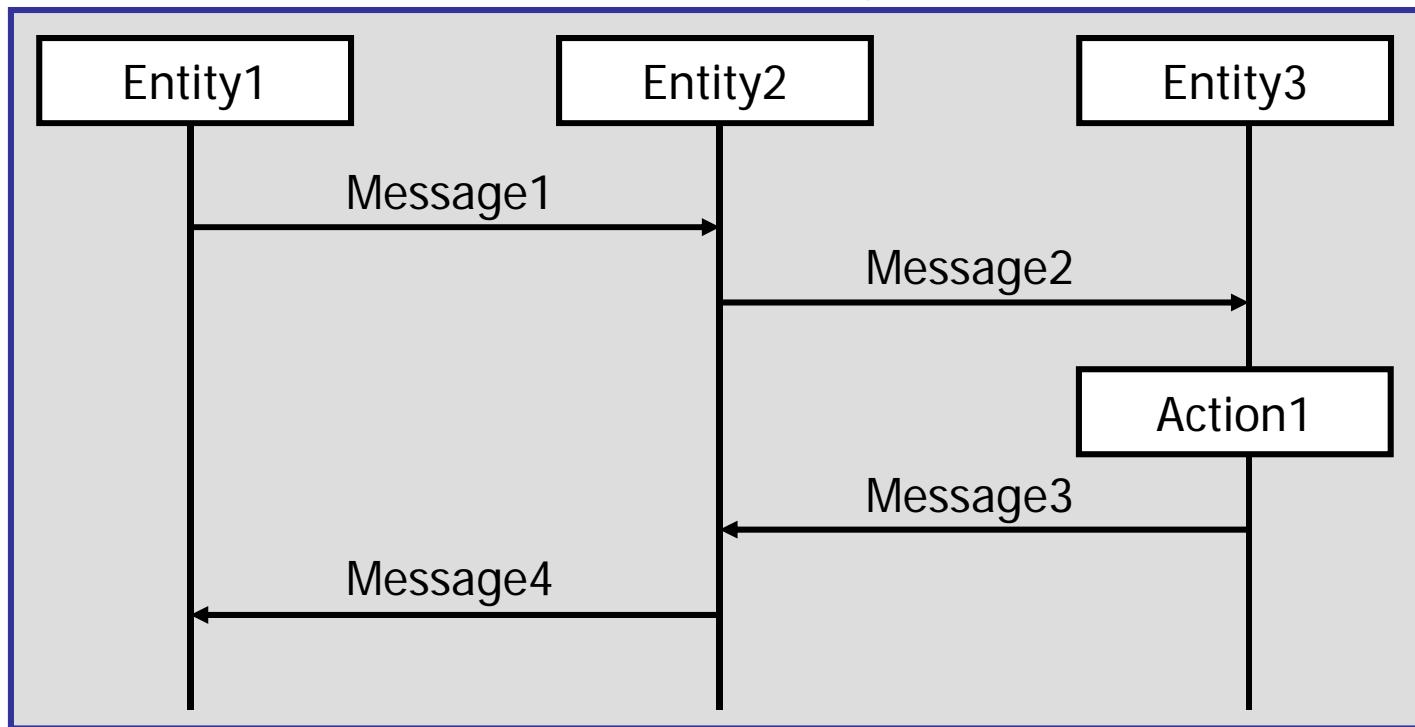
Refer to Chapter 22 of textbook



Some Useful Information About Learning A Protocol

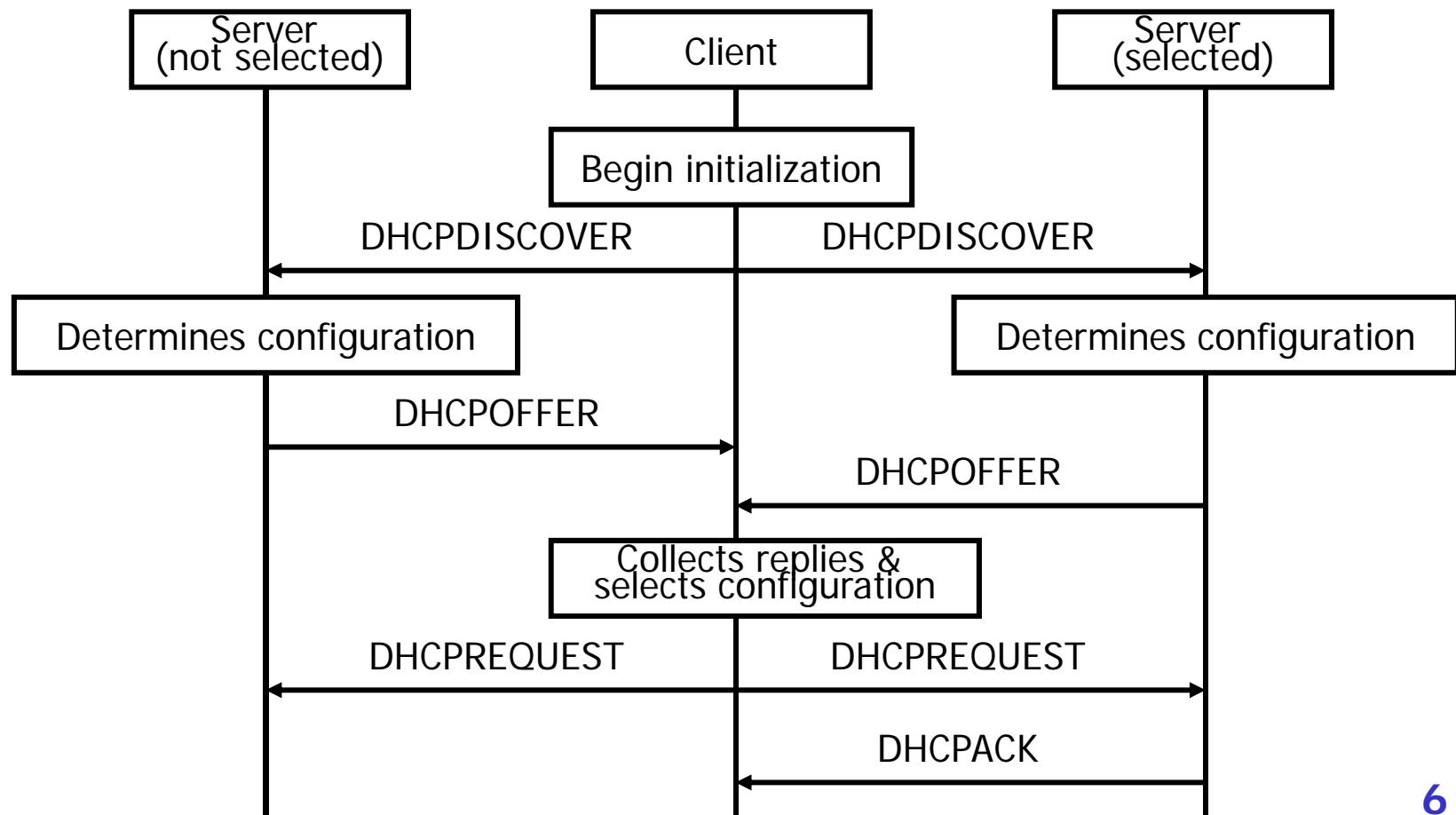
MSC (1)

- Message Sequence Chart
- Define the message exchange sequences between different network elements to complete a specific function
- Basic format: network entity, message, action



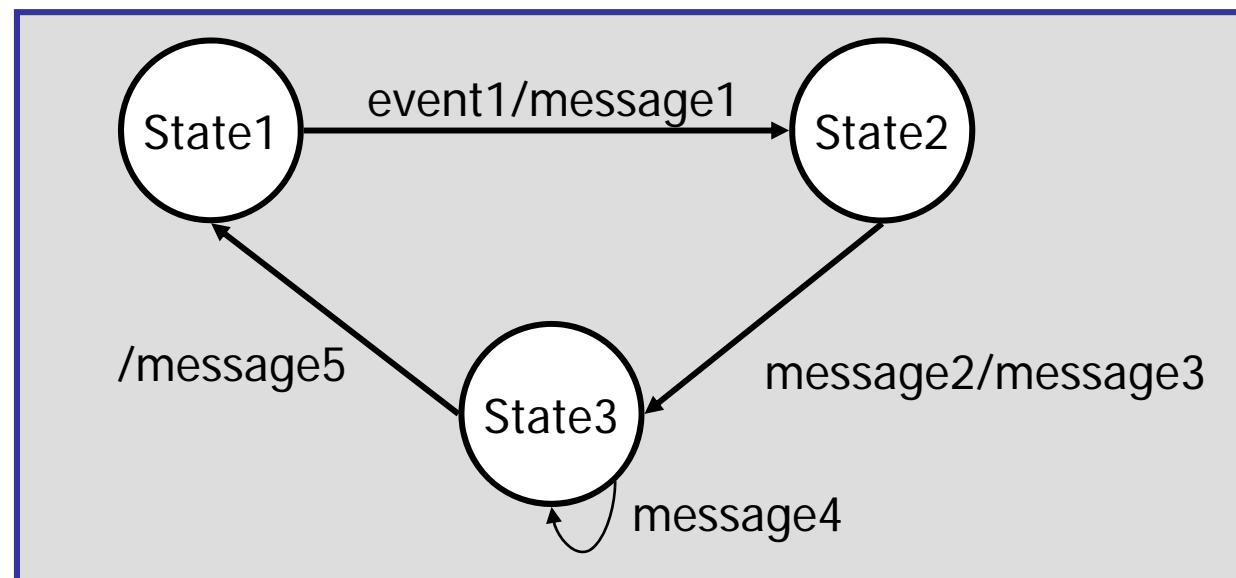
MSC (2)

- A MSC example



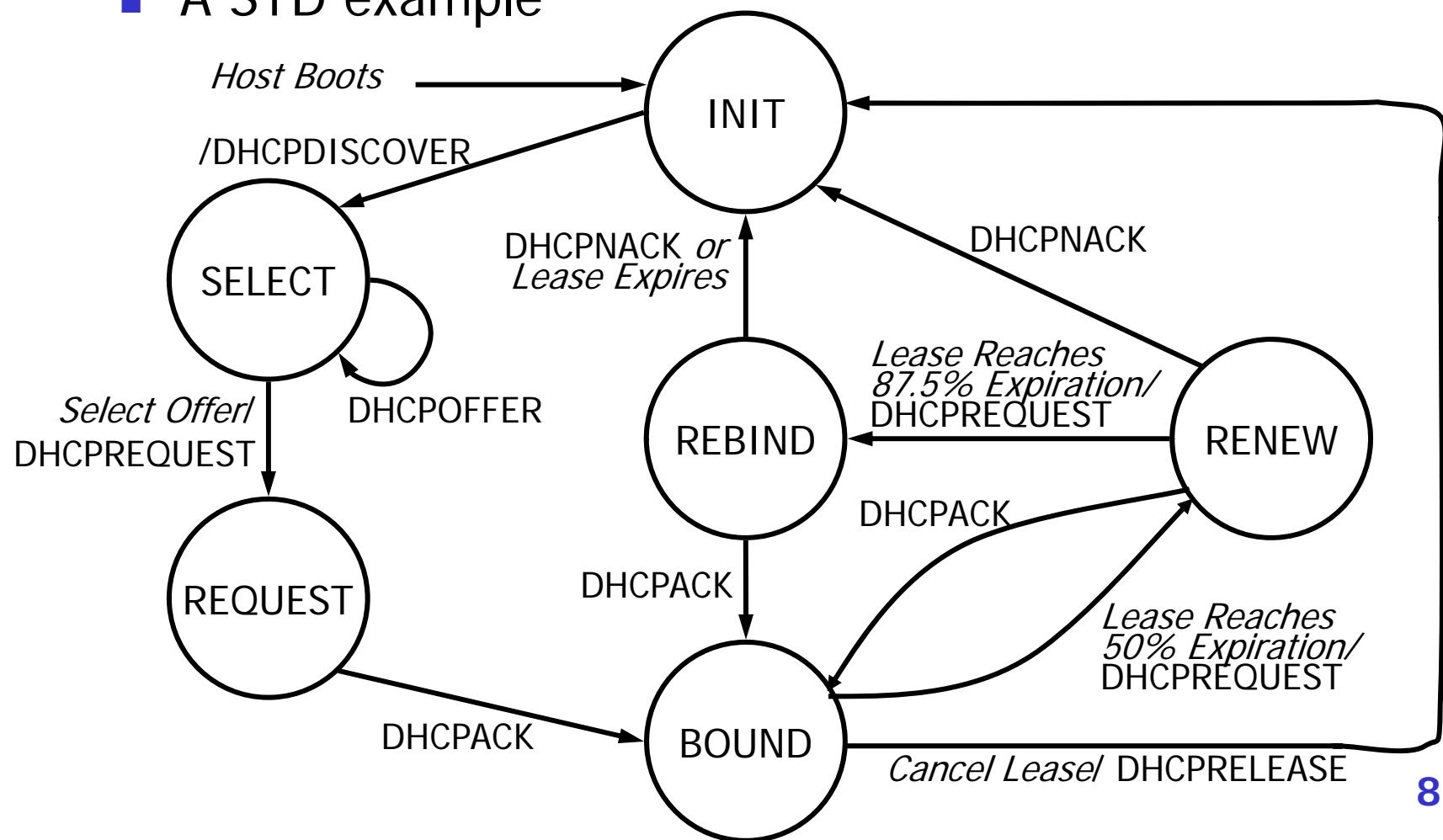
STD (1)

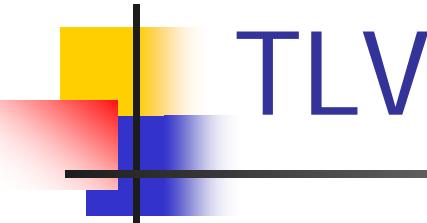
- State Transition Diagram
- Define the state transition relationship in a protocol
- The state transition may be triggered by an event or an incoming message, and may be together with an outgoing message
- Basic format: state, event, incoming message, outgoing message



STD (2)

A STD example





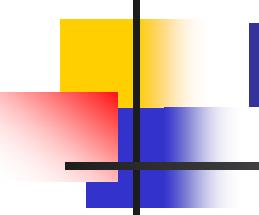
TLV

- Type-Length-Value
- A typical encoding style used in defining the areas with variable length in message
- Each item contains a *type* field, a *length* field, and followed by a *value* of the specified length
- Example

Type	Length
Address Parameter	



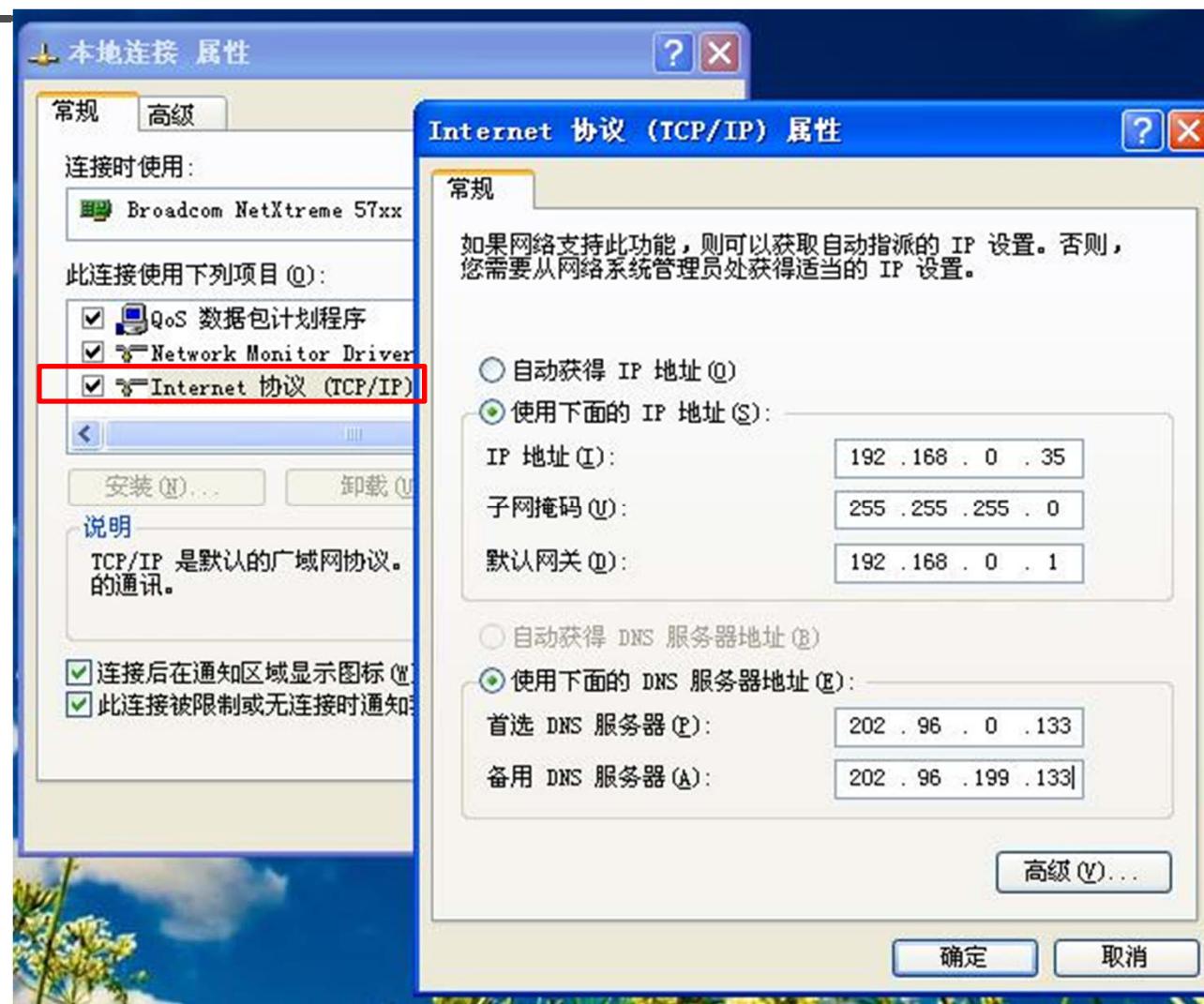
Introduction to DHCP

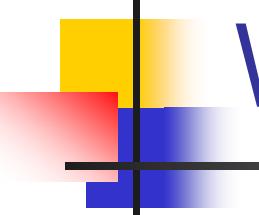


IP Address Allocation

- IP address management
 - Plan / recording / assignment / retrieval /renumbering
- Static allocation
- Dynamic allocation
 - BOOTP (BOOTstrap Protocol)
 - DHCP (Dynamic Host Configuration Protocol)

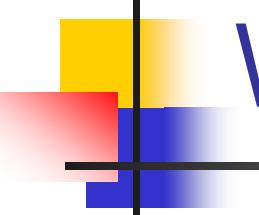
Static Allocation Example





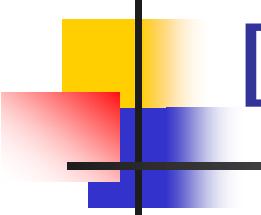
What is BOOTP?

- Bootstrap Protocol
- used by a network client to obtain an **IP address** from a configuration server
- Used by diskless workstation to obtain **boot information** such as boot file name
- TFTP is used to transfer boot file
- originally defined in RFC 951



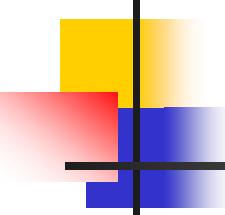
What is DHCP?

- Dynamic Host Configuration Protocol
- Provides **automatic configuration** of remote hosts
- An extension to BOOTP
- Using **UDP** as its transport protocol
- Following client-server paradigm
 - Using port 67 (for server) and 68 (for client)



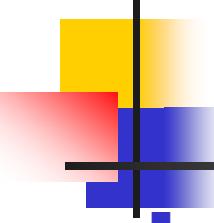
DHCP Client & DHCP Server

- DHCP client
 - A DHCP client is an Internet host using DHCP to obtain configuration parameters such as a network address
- DHCP server
 - A DHCP server is an Internet host that returns configuration parameters to DHCP clients



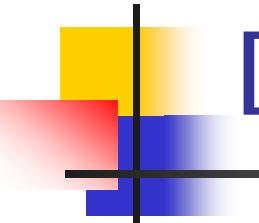
DHCP Lease

- A **DHCP lease** is the amount of time that the DHCP server grants to the DHCP client permission to use a particular IP address
- A typical server allows its administrator to set the lease time
- The optimal time for a lease depends on the particular network and the needs of a particular host



DHCP Features

- *Simple administration*
 - IP addresses, subnet masks, and the default gateway do not need to be manually entered on every client machine
- *Moving machines*
 - When moving a machine to a different subnet, you simply move the machine and it acquires a new IP and subnet mask from the DHCP server on that subnet.
- *Eliminating erroneous IP information*
 - Taking the human factor out of the equation reduces problems, such as duplicate IP addresses
- *Eliminating additional configuration information*
 - WINS servers, DNS servers, and default gateways are some of the widely used configuration option settings possible with DHCP.
- *Efficient use of IP addresses*
 - DHCP can help make the best use of limited IP addresses. All available IP address are put into a pool and used by active clients. Machines that are inactive do not use an IP address.



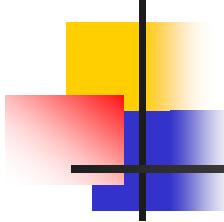
DHCP vs. BOOTP - Similarities

- The **format structure** each uses to exchange messages
- Use of **well-known UDP ports** for client/server communication
- IP address distribution as an integral part of configuration service

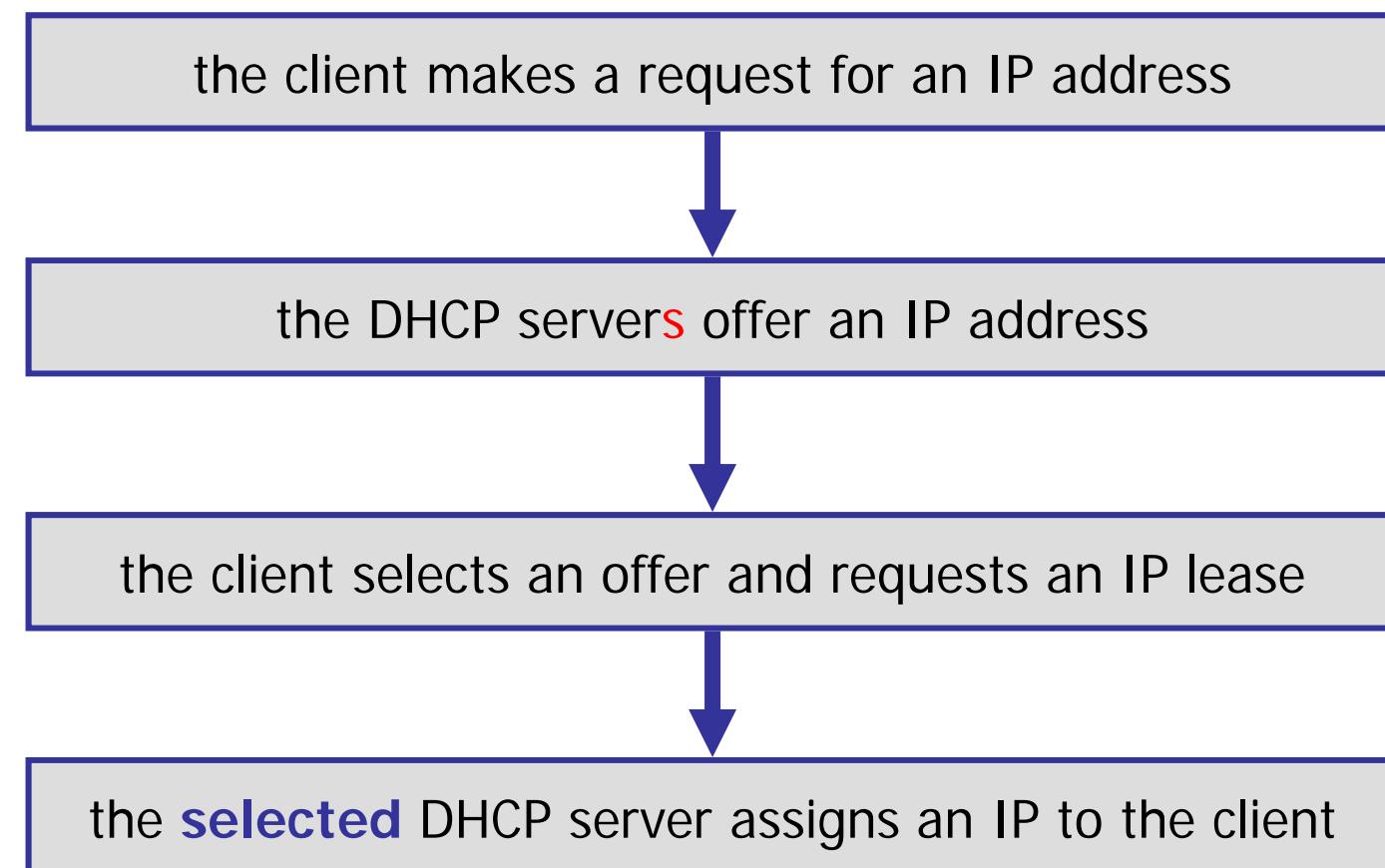


DHCP vs. BOOTP - Differences

- BOOTP
 - Prior to DHCP
 - Configure diskless workstations
 - Do **not rebind** or **renew** configuration
- DHCP
 - After BOOTP
 - Configure frequently relocated networked computers with local hard drives and full boot capabilities
 - Clients automatically enter a rebinding state at set timed intervals to **renew** their leased address allocation

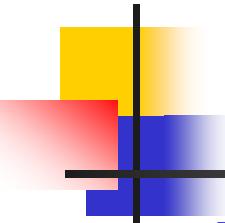


Phases of IP Assignment with DHCP



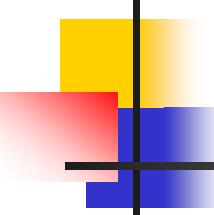


DHCP Protocol



Related RFCs (1)

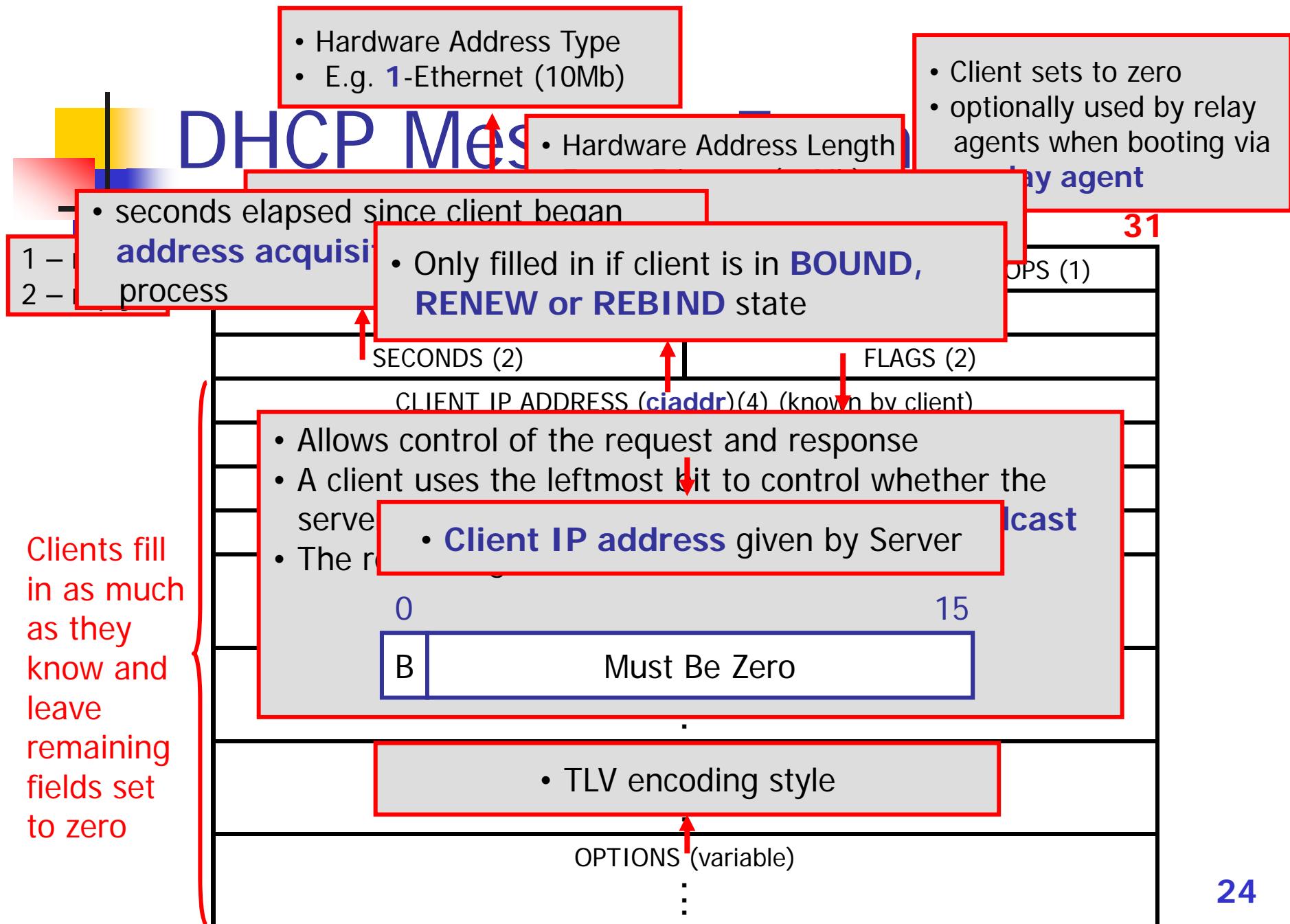
- BOOTP
 - RFC951
- DHCP Specifications
 - **RFC2131**, Dynamic Host Configuration Protocol (<- RFC1541<- RFC1531)
 - RFC3315, Dynamic Host Configuration Protocol for IPv6 (DHCPv6)
 - RFC3396, Encoding Long Options in the Dynamic Host Configuration Protocol (DHCPv4)
 - RFC4361, Node-specific Client Identifiers for Dynamic Host Configuration Protocol Version Four (DHCPv4)
- DHCP Options
 - **RFC2132**, DHCP Options and BOOTP Vendor Extensions (<- RFC 1533<- RFC1497, RFC1395, RFC1084, RFC1048)
 - RFC3442, The Classless Static Route Option for Dynamic Host Configuration Protocol (DHCP) version 4
 - RFC3942, Reclassifying Dynamic Host Configuration Protocol version 4 (DHCPv4) Options
 - RFC4833, Timezone Options for DHCP
- Interoperation between DHCP and BOOTP
 - **RFC1534**, Interoperation Between DHCP and BOOTP



Related RFCs (2)

- Others

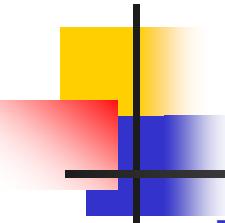
- RFC2485, DHCP Option for The Open Group's User Authentication Protocol
- RFC2563, DHCP Option to Disable Stateless Auto-Configuration in IPv4 Clients
- RFC2610, DHCP Options for Service Location Protocol
- RFC2937, The Name Service Search Option for DHCP
- RFC3004, The User Class Option for DHCP
- RFC3011, The IPv4 Subnet Selection Option for DHCP
- RFC3046, DHCP Relay Agent Information Option
- RFC3118, Authentication for DHCP Messages
- RFC3203, DHCP reconfigure extension
- RFC3319, Dynamic Host Configuration Protocol (DHCPv6) Options for Session Initiation Protocol (SIP) Servers
- RFC3361, DHCP-for-IPv4 Option for Session Initiation Protocol (SIP) Servers
- RFC3397, Dynamic Host Configuration Protocol (DHCP) Domain Search Option
- RFC3736, Stateless DHCP Service for IPv6
- RFC4030, The Authentication Suboption for the DHCP Relay Agent Option
- RFC4477, DHCP: IPv4 and IPv6 Dual-Stack Issues
-



DHCP Message Format

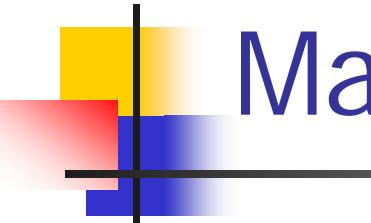
Clients fill
in as much
as they
know and
leave
remaining
fields set
to zero

OP (1)	HTYPE (1)	HLEN (1)	HOPS (1)
TRANSACTION ID (4)			
SECONDS (2)		FLAGS (2)	
CLIENT IP ADDRESS (4)			
YOUR IP ADDRESS (4)			
SERVER IP ADDRESS (4)			
ROUTER IP ADDRESS (4)			
CLIENT HARDWARE ADDRESS (16)			
⋮			
SERVER HOST NAME (64)			
⋮			
BOOT FILE NAME (128)			
⋮			
OPTIONS (variable)			
⋮			



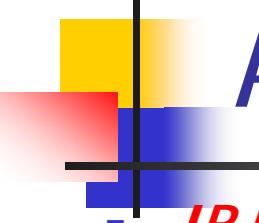
DHCP Message Format

- **OP:** 1 – request, 2 – reply
- **HTYPE:** Hardware Address Type, Defined in the ARP section in the Assigned Numbers RFC, E.g. 1-Ethernet (10Mb)
- **HLEN:** Hardware Address Length, E.g. 6-Ethernet (10Mb)
- **HOPS:** Client sets to zero, optionally used by relay agents when booting via a relay agent
- **TRANSACTION ID:** an integer, Used by the client to match responses with requests
- **SECONDS:** seconds elapsed since client began address acquisition or renewal process
- **FLAGS:** Allows control of the request and response. A client uses the leftmost bit to control whether the server sends the response via unicast or broadcast. The remaining bits are reserved for future use
- **CLIENT IP ADDRESS:** Only filled in if client is in BOUND, RENEW or REBIND state
- **YOUR IP ADDRESS:** Client IP address
- **OPTIONS:** TLV encoding style



Major Operations in DHCP

- Address acquisition
 - Getting an IP address
- Early lease termination
 - Returning IP address before lease expires
- Lease renewal
 - Updating a lease



Address Acquisition: phases

■ *IP lease request*

- To boot up, the client sends a **DHCPDISCOVER broadcast** message, requesting the location of a DHCP server with IP address information
- The DHCPDISCOVER packet is encapsulated in a UDP/IP packet and is sent to the local subnet broadcast address of 255.255.255.255

■ *IP lease offer*

- After requesting a lease, the DHCP client waits for a response and is said to be in a **SELECT** state
- **Any** available DHCP servers with IP addresses to offer respond to the client request with a **DHCPOFFER** message

■ *IP lease selection*

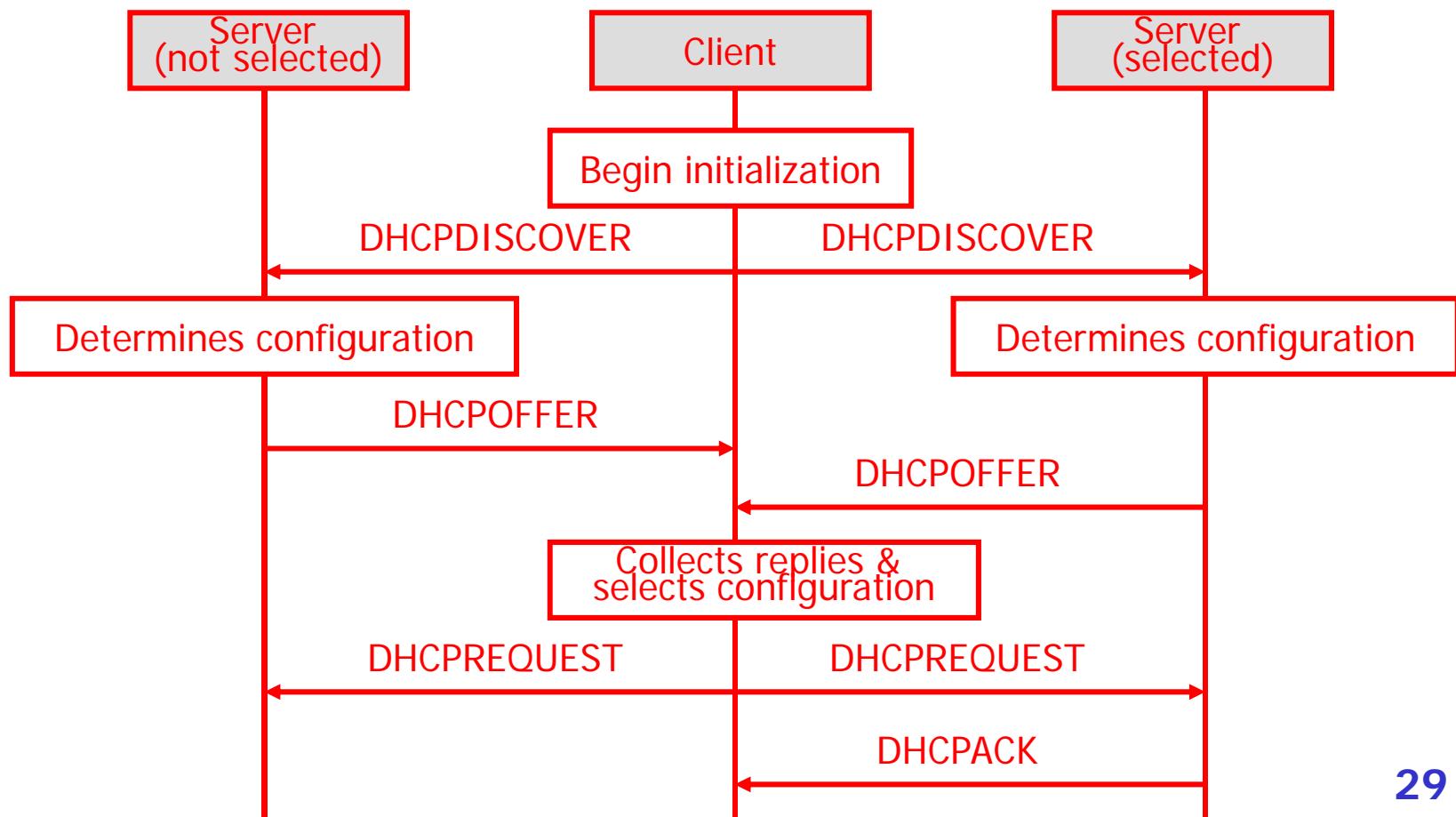
- The client chooses **one** DHCPOFFER from all the offers it receives, regardless of which subnet the DHCP server is located in
- The client then sends a broadcast **DHCPREQUEST** message, requesting a lease

■ *IP lease acknowledgment*

- The DHCP server that made the offer responds to the client with a **DHCPCACK** message while any other DHCP servers that made an offer withdraw
- The IP address is assigned to the client

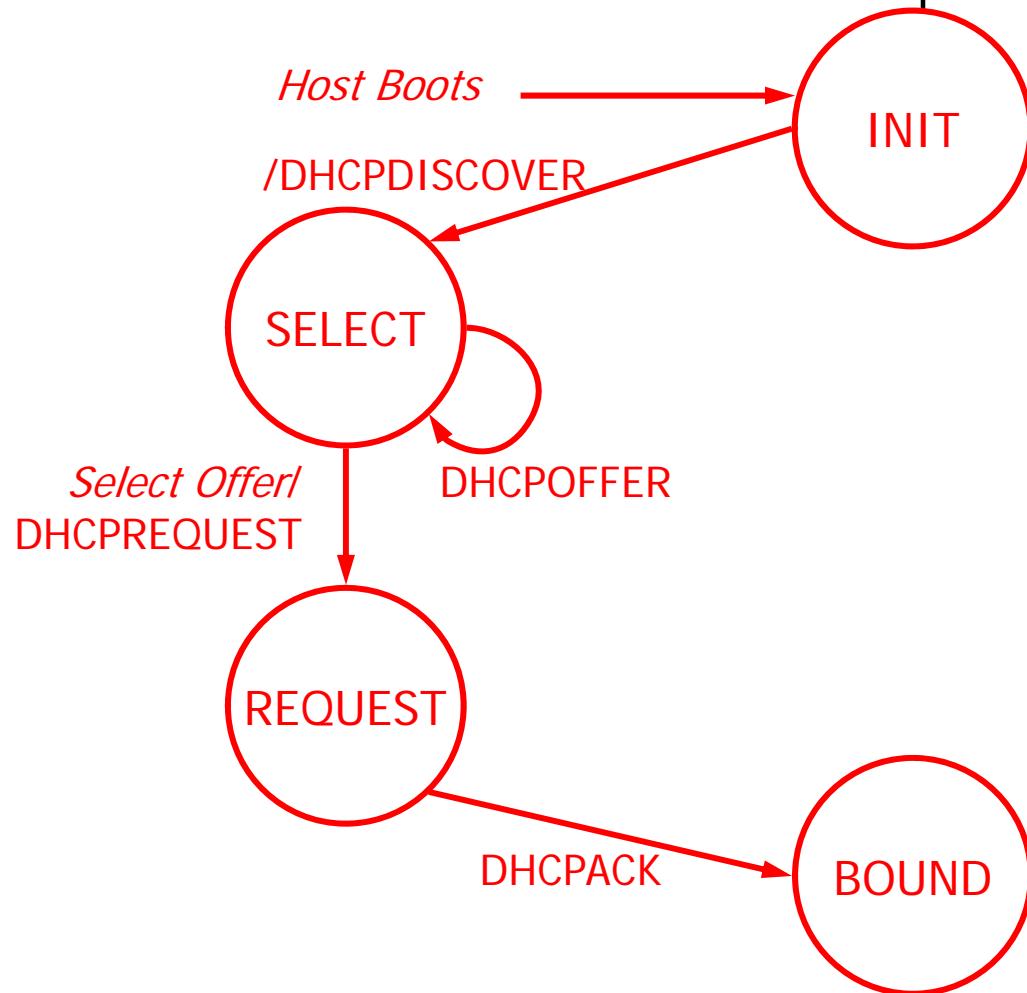
Address Acquisition (2)

- MSC for Address Acquisition



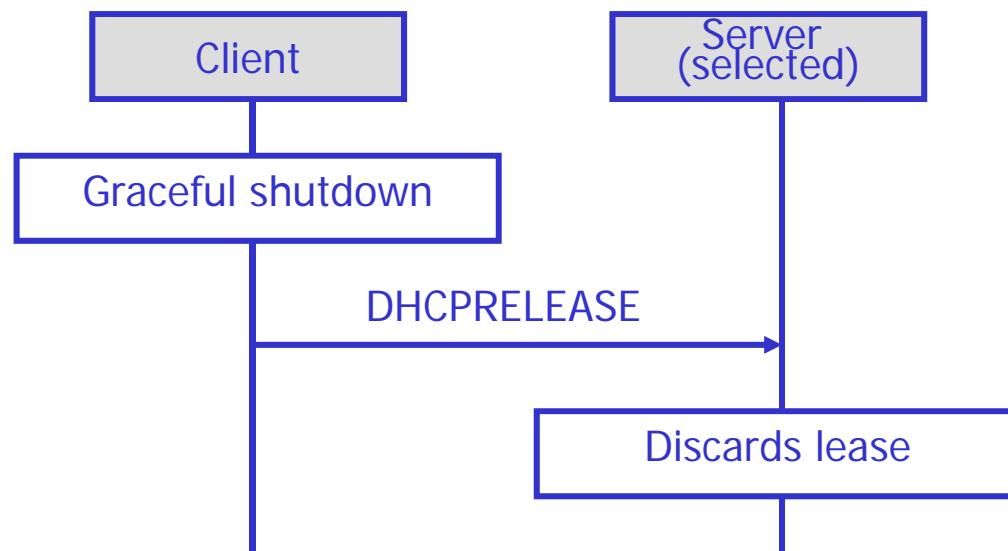
Address Acquisition (3)

- STD of client for Address Acquisition



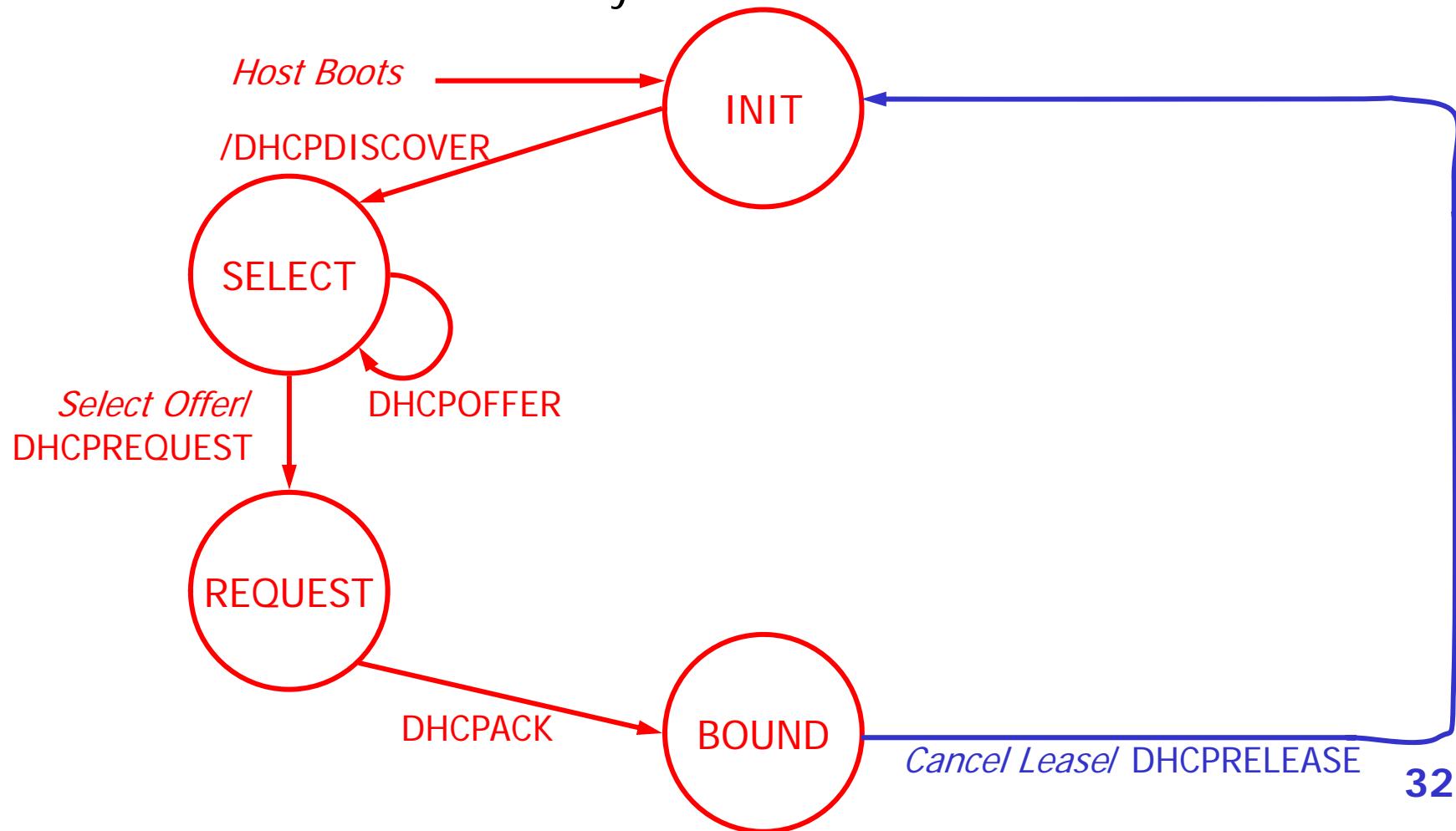
Early Lease Termination (1)

- MSC for Early Lease Termination



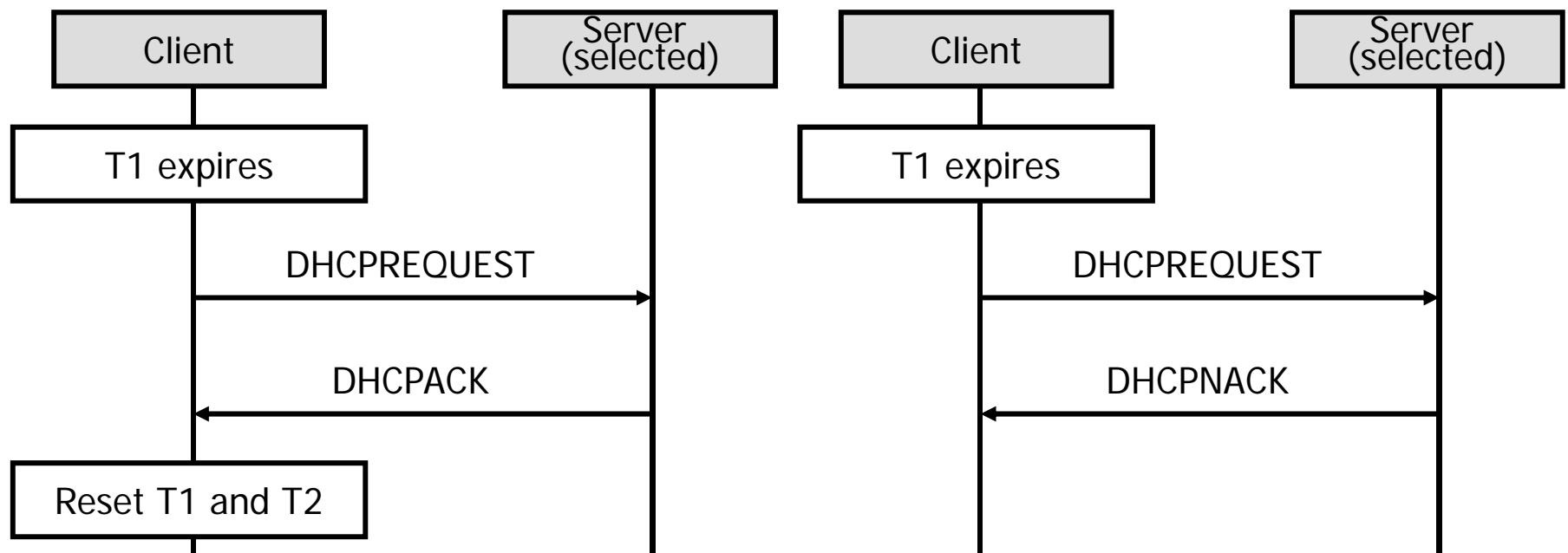
Early Lease Termination (2)

- STD of client for Early Lease Termination



Lease Renewal (1)

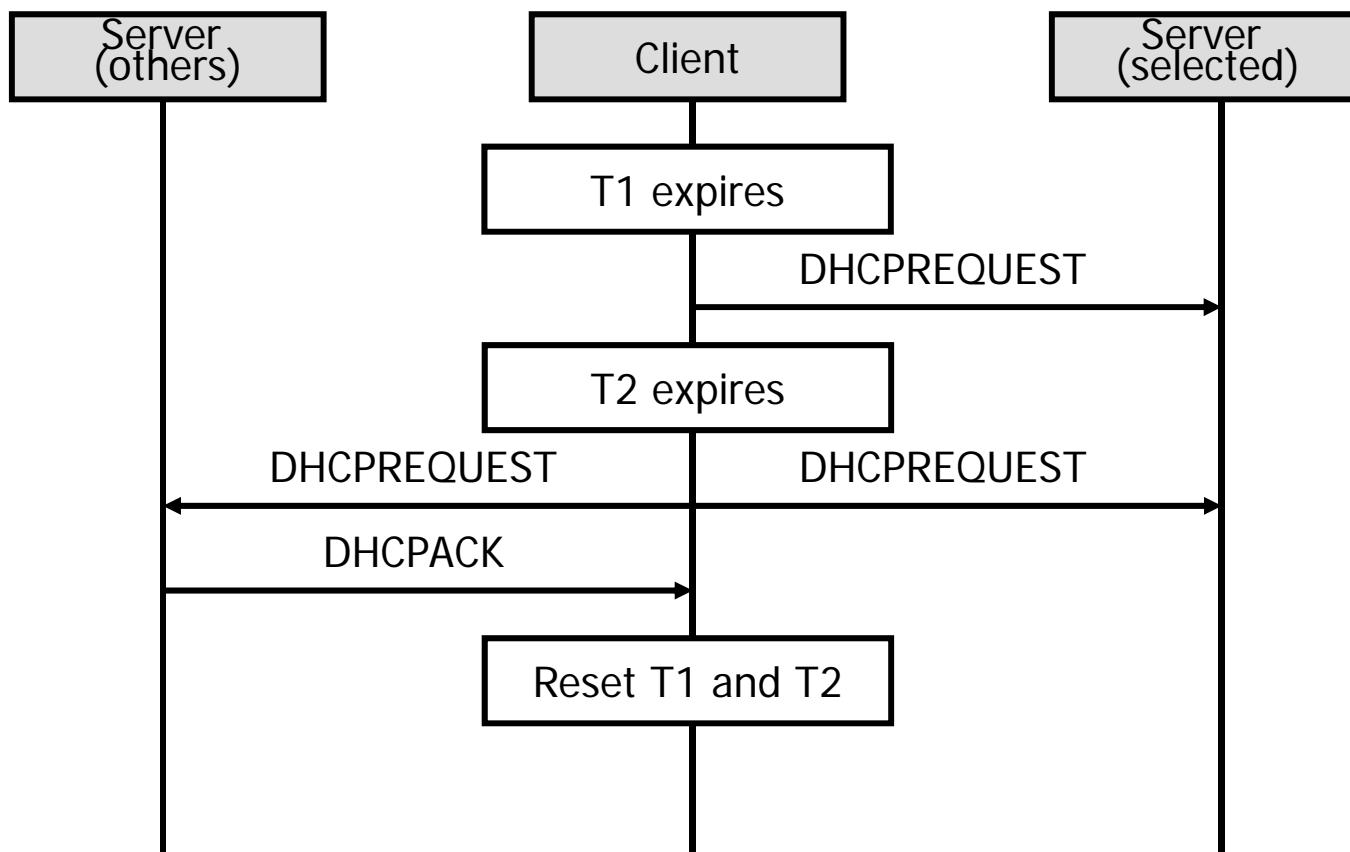
- MSCs for lease renewal



- **T1**: the time at which the client enters the RENEW state and attempts to contact the server that originally issued the client's network address
 - $0.5 * \text{duration_of_lease}$
- **T2**: the time at which the client enters the REBIND state and attempts to contact any server.
 - $0.875 * \text{duration_of_lease}$

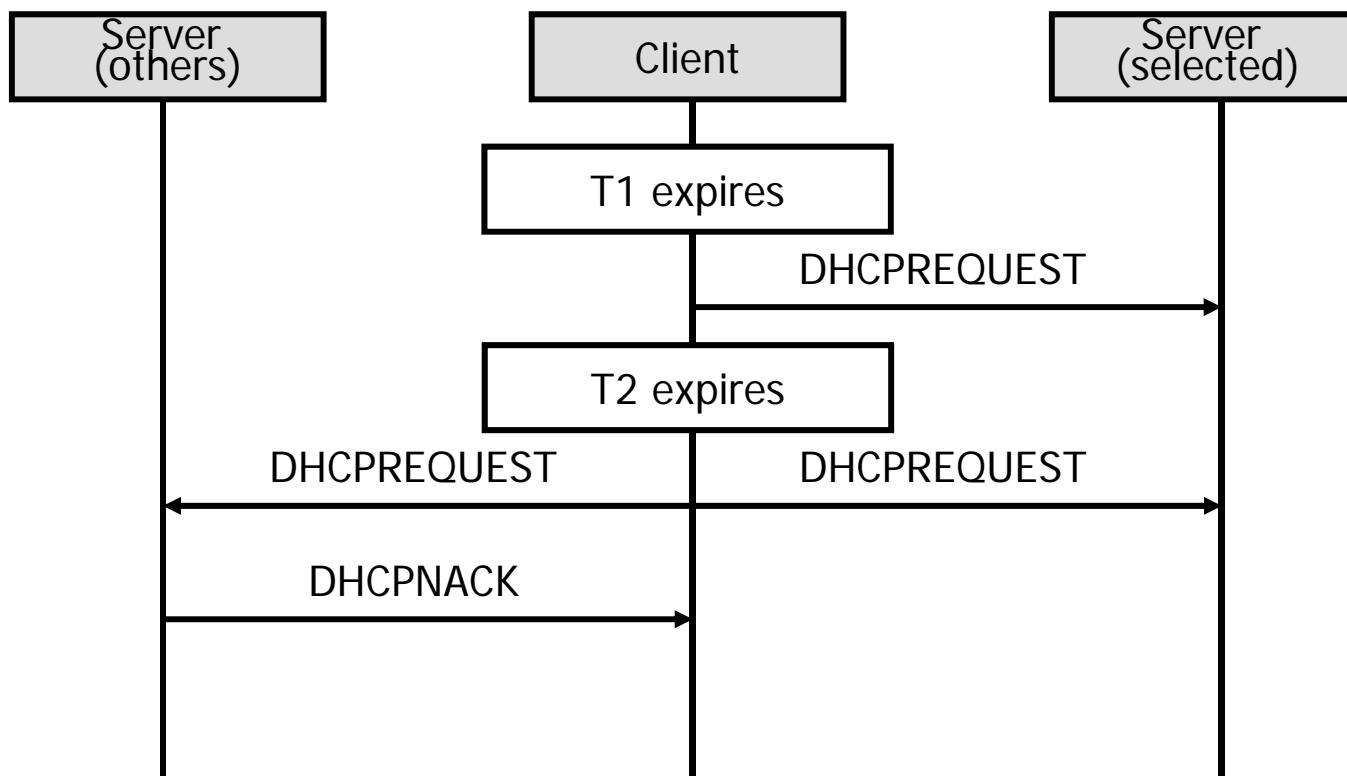
Lease Renewal (2)

- MSCs for lease renewal



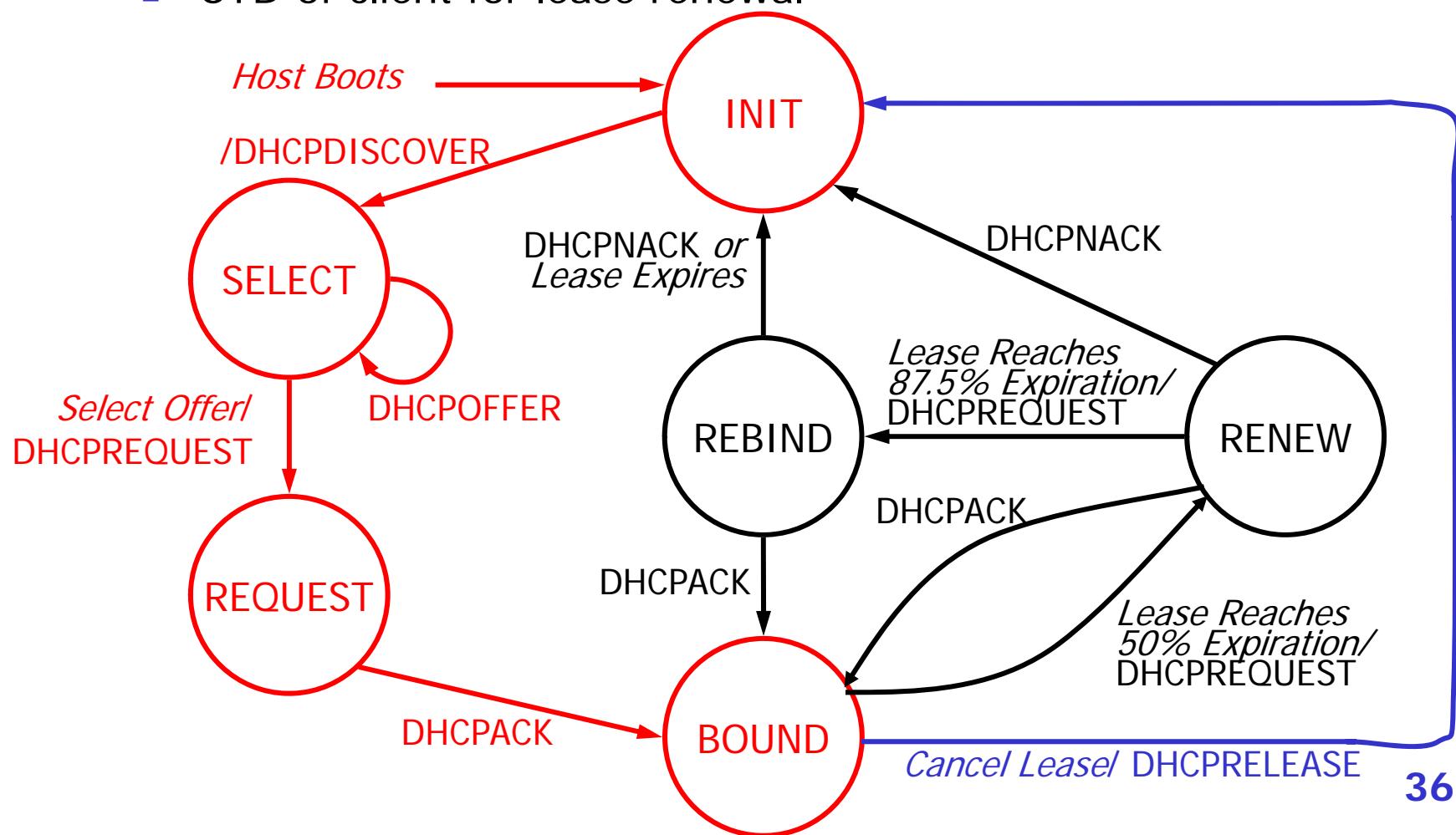
Lease Renewal (3)

- MSCs for lease renewal

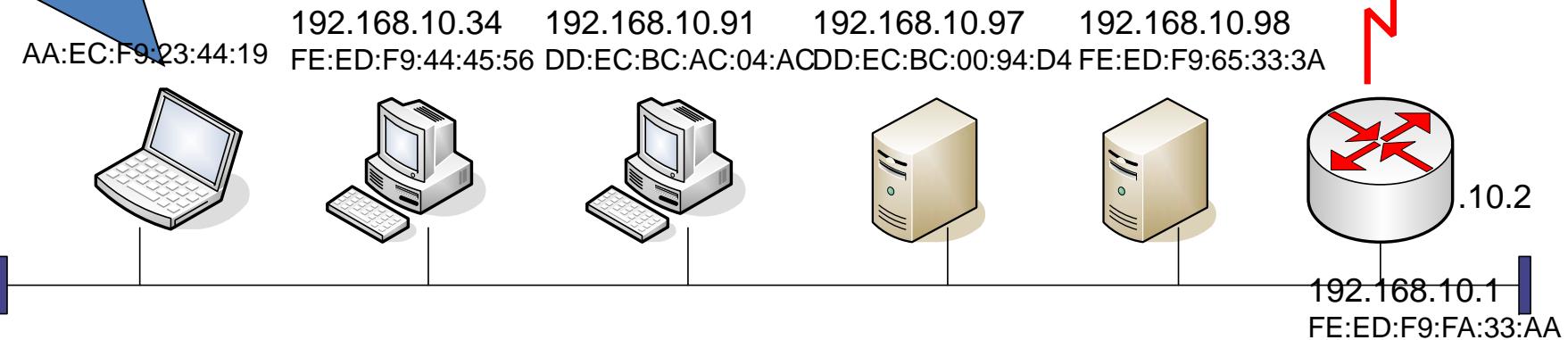


Lease Renewal (4)

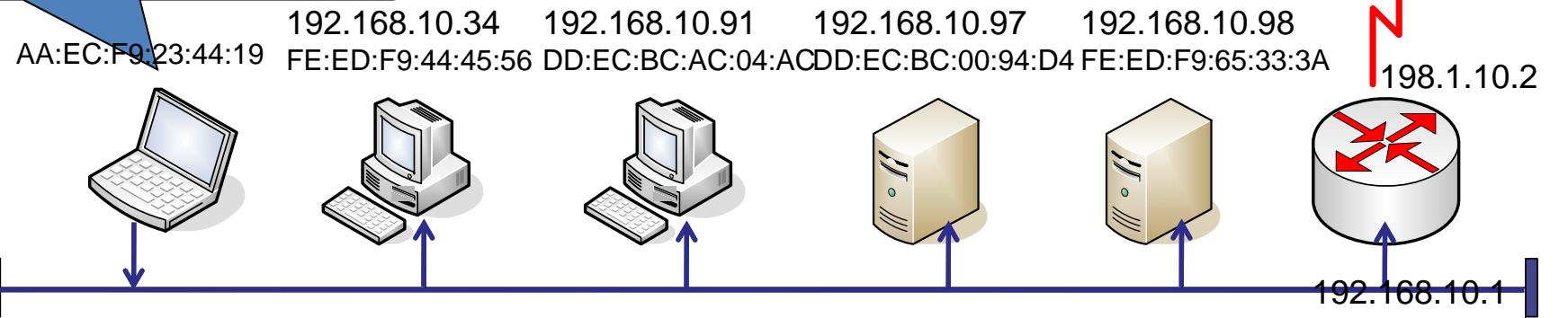
- STD of client for lease renewal



Laptop needs to get
an IP address



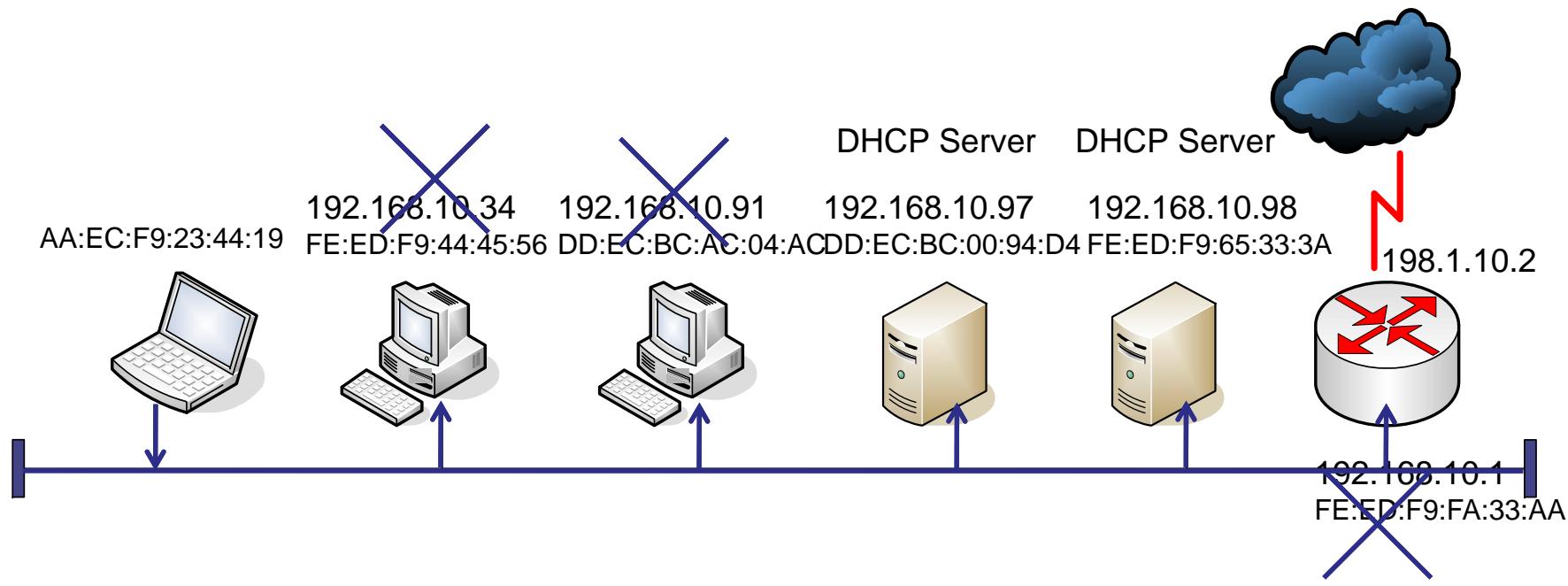
Laptop generates a
DHCPDISCOVER



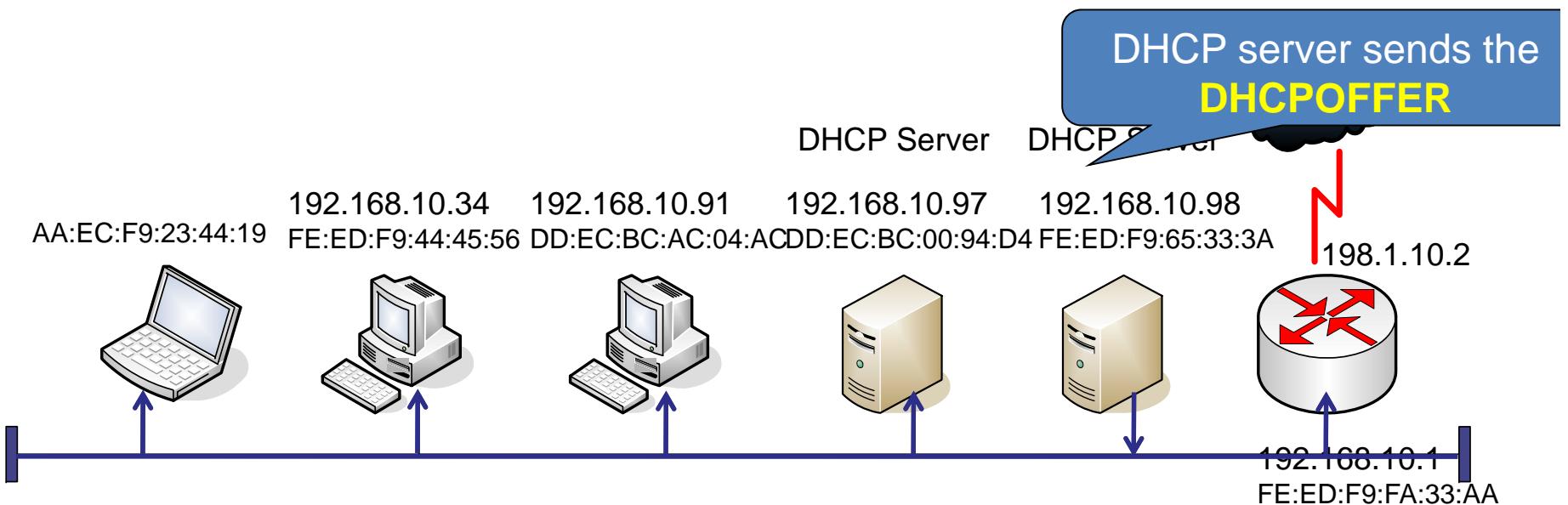
Frame header	Packet header
Source MAC	Source IP
AA:EC:F9:23:44:19	0.0.0.0
Destination MAC	Destination IP
FF:FF:FF:FF:FF:FF	255.255.255.255
Field Type	
0X8035(Ethernet)	

DHCP Message			
1	1	6	0
0	12	Flags	
0	0	0	
0	0	0	
0	0	0	
AA:EC:F9:23:44:19			
53	1	1	

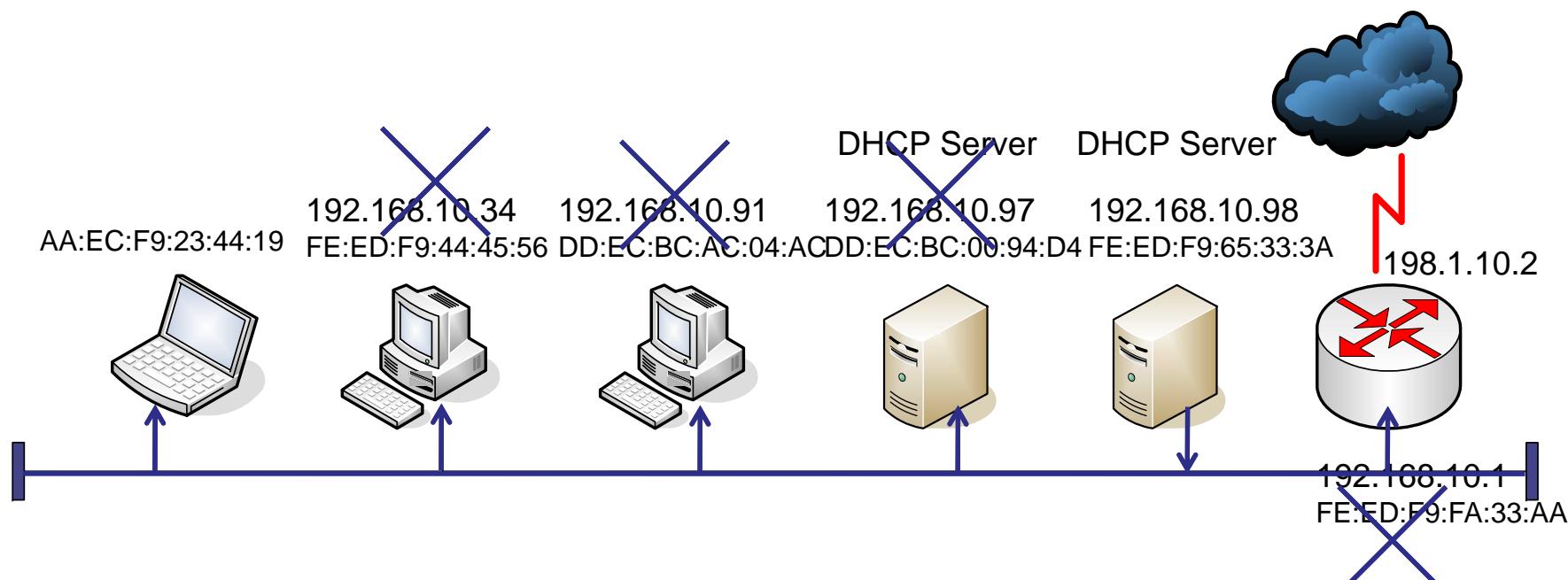
CRC Check



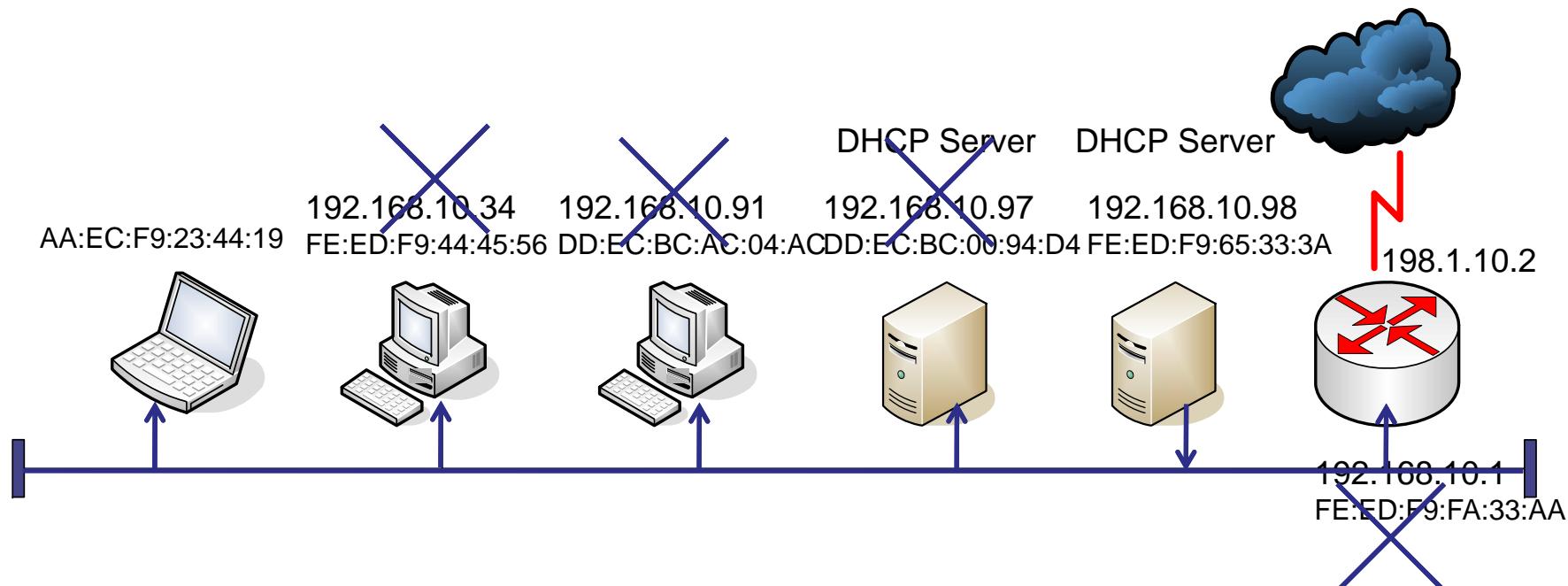
All devices except the DHCP servers
discard the request



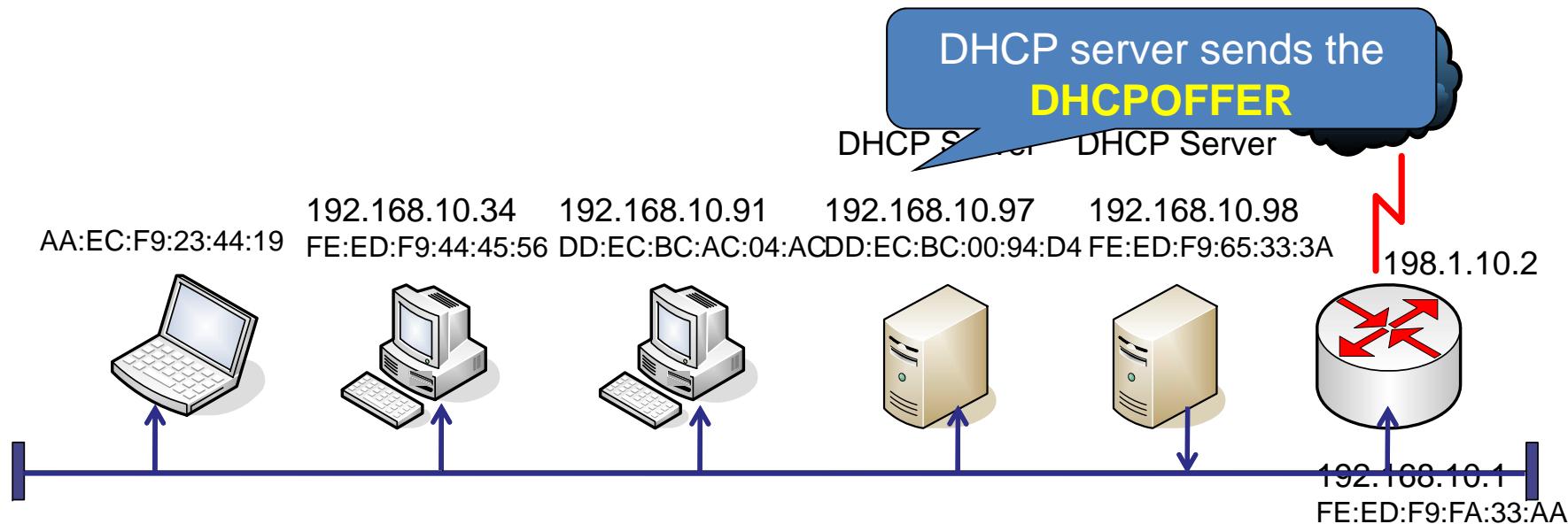
Frame header	Packet header	2	1	6	0	CRC Check
Source MAC	Source IP			12		
FE:ED:F9:65:33:3A	192.168.10.98	0		Flags		
Destination MAC	Destination IP		0			
FF:FF:FF:FF:FF:FF	255.255.255.255	192.168.10.35				
Field Type		192.168.10.98				
0X8035(Ethernet)		0				
		AA:EC:F9:23:44:19				
		53	1	2		



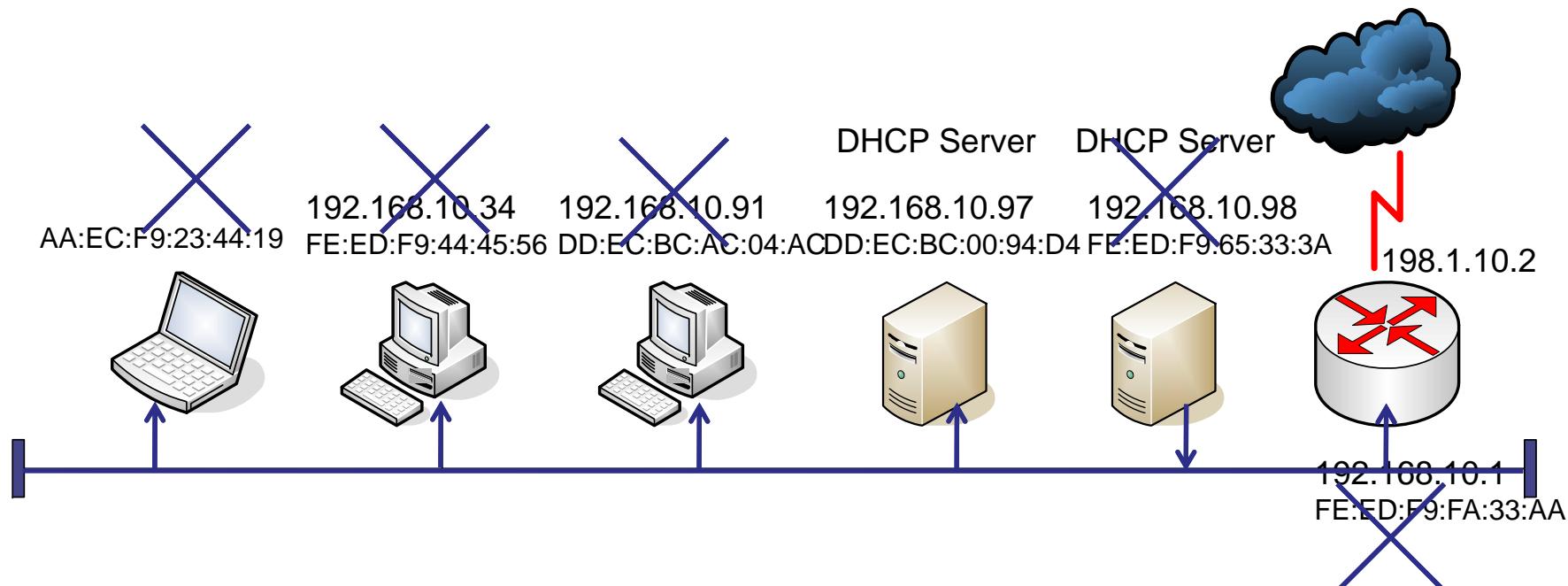
All devices except for the laptop discard the reply



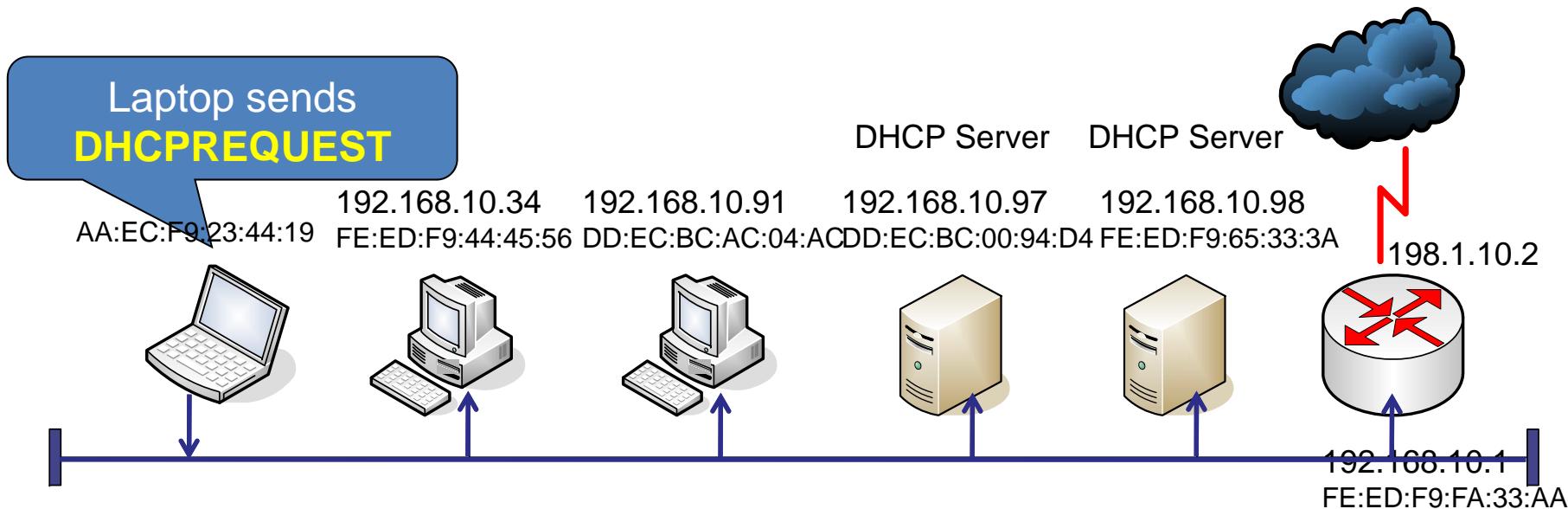
Source IP and MAC address of the DHCP
server are stored in the ARP table



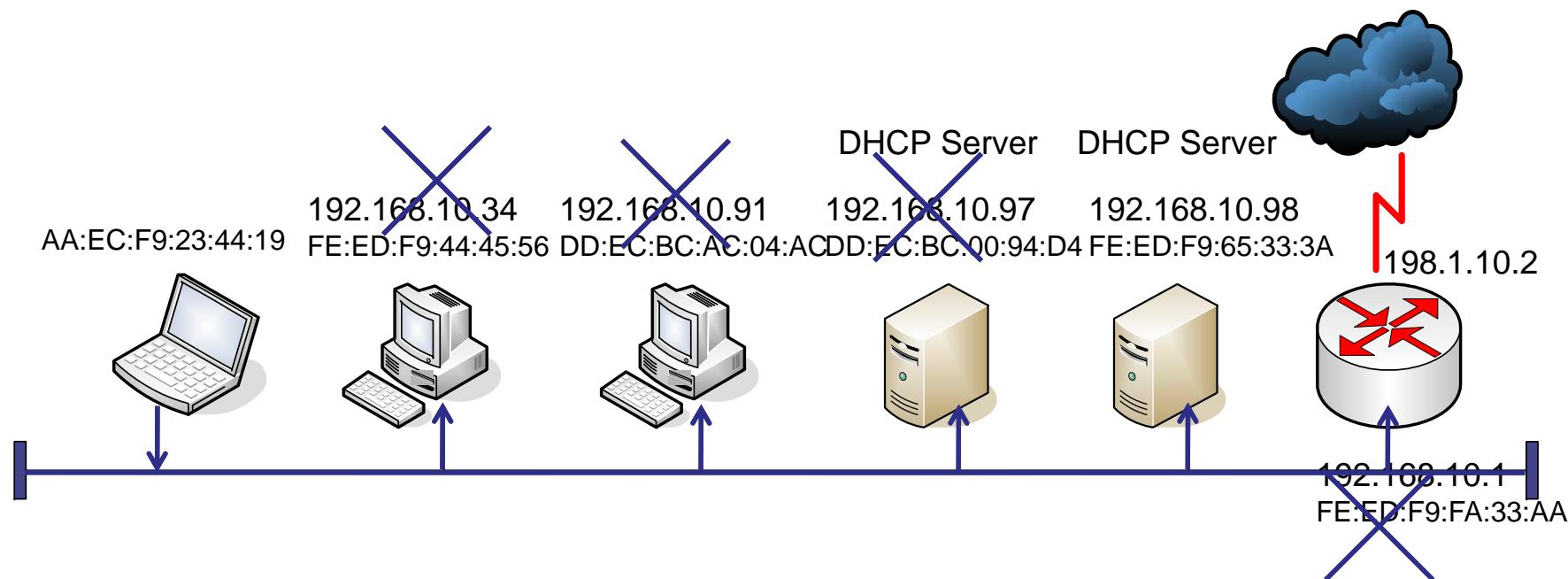
Frame header	Packet header	2	1	6	0	CRC Check
Source MAC	Source IP			12		
DD:EC:BC:00:94:D4	192.168.10.97	0		Flags		
Destination MAC	Destination IP		0			
FF:FF:FF:FF:FF:FF	255.255.255.255	192.168.10.90				
Field Type		192.168.10.97				
0X8035(Ethernet)		0				
		AA:EC:F9:23:44:19				
		53	1	2		



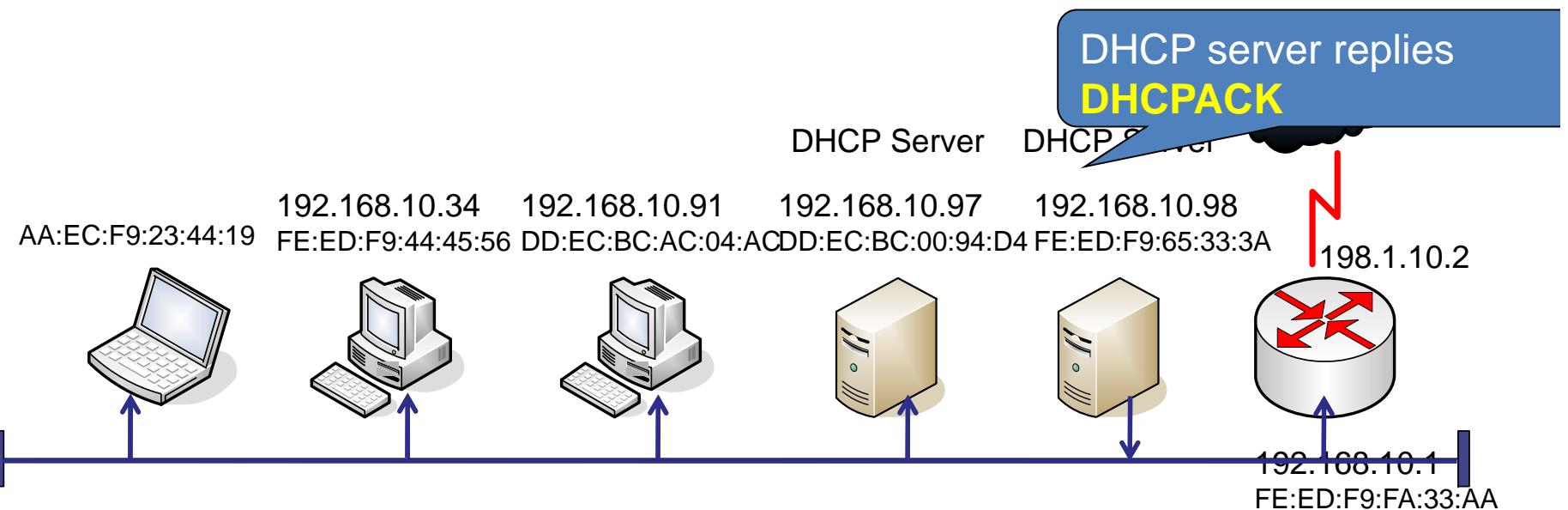
Laptop has already received DHCPOFFER,
discard the frame



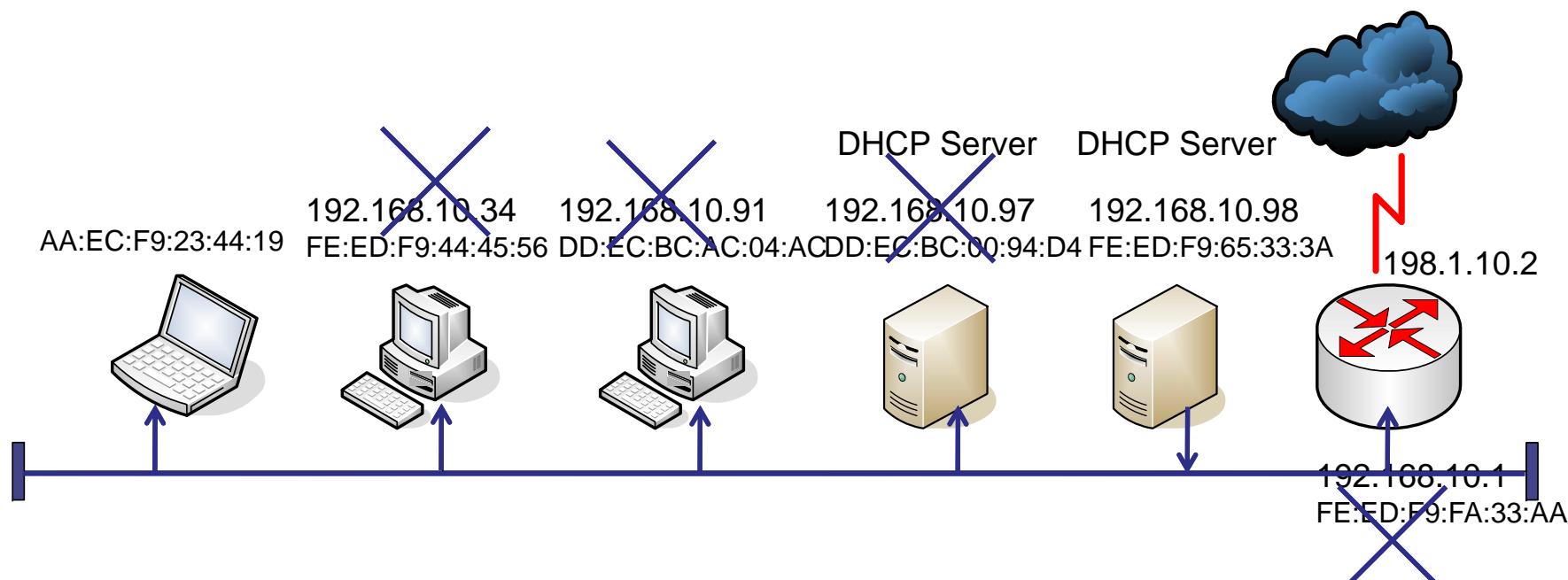
Frame header	Packet header	1	1	6	0	CRC Check
Source MAC	Source IP			12		
AA:EC:F9:23:44:19	0.0.0.0	0		Flags		
Destination MAC	Destination IP		0			
FF:FF:FF:FF:FF:FF	255.255.255.255		0			
Field Type			0			
0X8035(Ethernet)		AA:EC:F9:23:44:19				
		53	1	3		



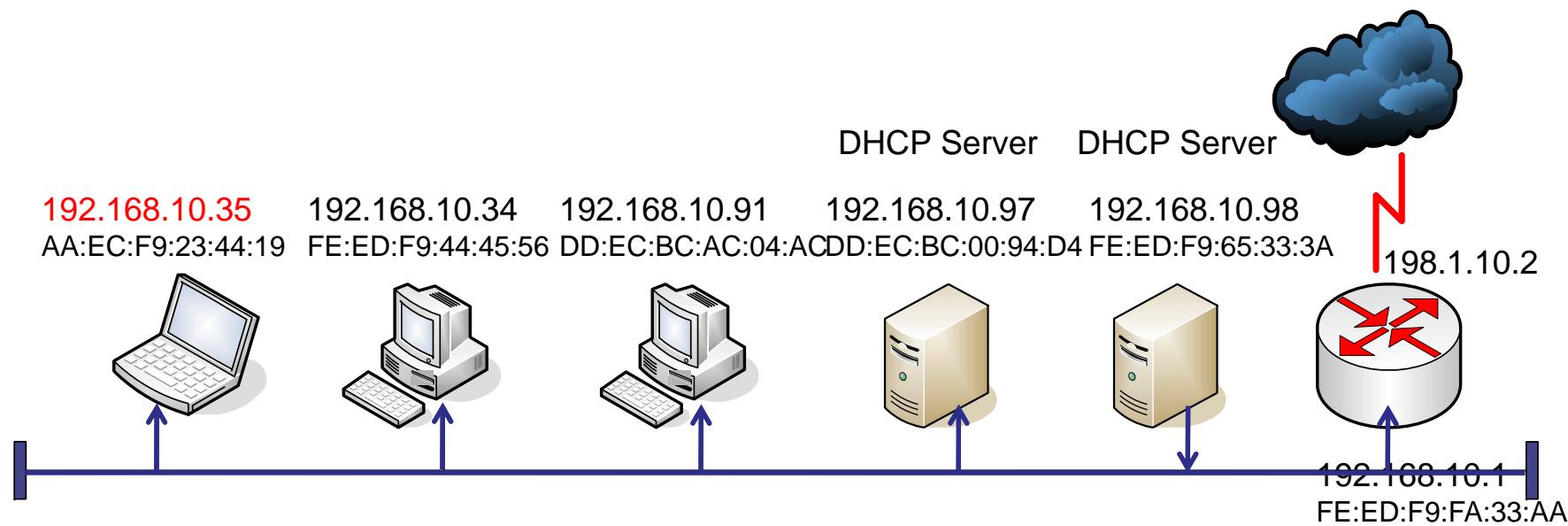
All devices discard the frame except the
DHCP server that sends DHCPOFFER first



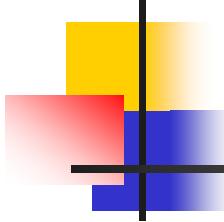
Frame header	Packet header	2	1	6	0	CRC Check
Source MAC	Source IP			12		
FE:ED:F9:65:33:3A	192.168.10.98	0		Flags		
Destination MAC	Destination IP			0		
FF:FF:FF:FF:FF:FF	255.255.255.255			192.168.10.35		
Field Type				192.168.10.98		
0X8035(Ethernet)				0		
		53	1	5		



All devices except for the laptop discard the reply

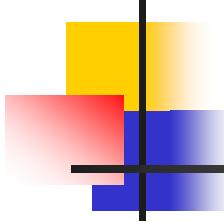


The laptop has the IP address.



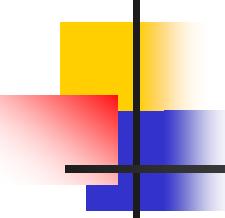
Multicast address allocation

- MADCAP
 - Multicast Address Dynamic Client Allocation Protocol
- Used for conferencing and audio
- The multicast address allocation features
 - A MADCAP server, which distributes multicast addresses
 - MADCAP clients can use client-side APIs to request, renew or release multicast address



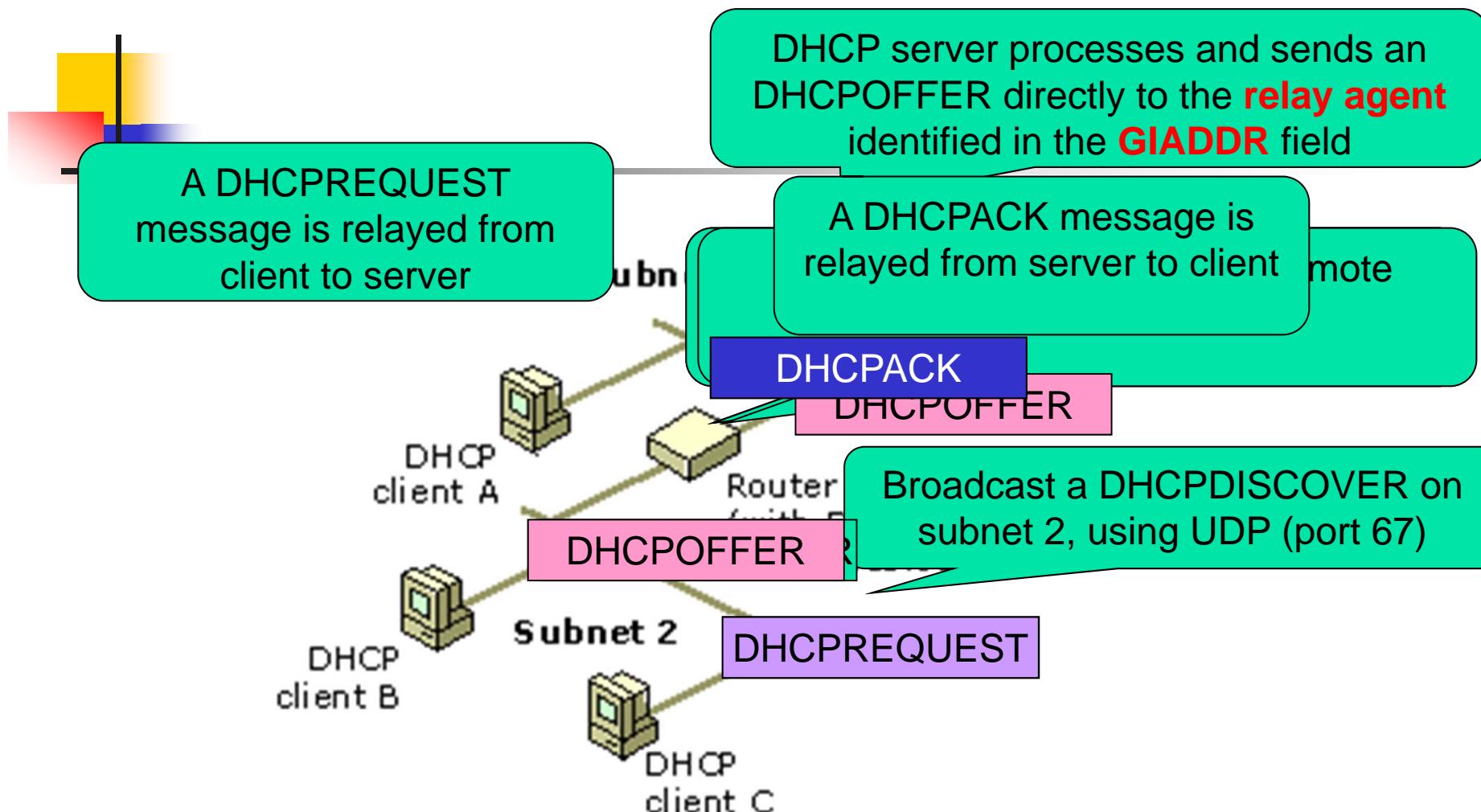
DHCP client alternate configuration

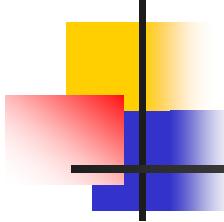
- Static IP address configuration
- Dynamic IP address configuration without alternate configuration
- Dynamic IP address configuration with alternate configuration
 - User can move the computer between one statically configured network (Such as home network) and one or more dynamically configured networks without changing any settings.



DHCP Relay

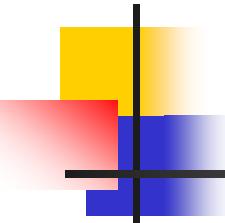
- Used to interconnect hardware and software on **different** physical network segments called **subnets** and **forward** IP packets between each of the subnets.
- Router must comply with **DHCP/BOOTP relay agent** capabilities.
- A **computer** that can function as a relay agent if router cannot function as a relay agent.





Security Problems

- Built on UDP and IP
 - Inherently insecure
- DHCP is an unauthenticated protocol
- Denial-of-service attacks against the DNS server can be made through the DHCP server
- Unauthorized, non-Microsoft DHCP servers can lease IP addresses to DHCP clients

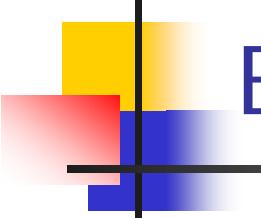


Recommendations

- Ensure that unauthorized persons do not have physical or wireless access to your network.
- Enable audit logging for every DHCP server on your network. Regularly check audit log files, and monitor them when the DHCP server receives an unusually high number of lease requests from clients.
- Use the DHCP audit logs to monitor DNS dynamic updates by the DHCP server.



Examples of DHCP Configuration



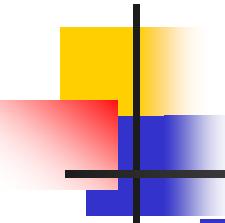
Examples of DHCP Configuration (1)

- Installation and configuration of DHCP server in Windows 2000 Server
 - <http://www.qqread.com/network/server/q580178181.html>
- Installation and configuration of DHCP server in UNIX/LINUX
 - DHCP server configuration file: **/etc/dhcpd.conf**
 - DHCP Lease information file:
/var/lib/dhcp/dhcpd.leases
 - <http://www.qqread.com/linux/2006/08/e802195061.html>
 - <http://www.qqread.com/linux/2006/10/e241268.html>

Examples of DHCP Configuration (2)

- Configuration of DHCP server in a router (NU-MH300)





Summary of DHCP

- DHCP vs. Bootp
- DHCP Server, DHCP Client
- DHCP Lease
- Phases of IP assignment
- DHCP operations
 - Address acquisition(MSC)
 - Early lease termination
 - Lease renewal
- DHCP Relay