Computer Networking

COMP 177 | Fall 2020 | University of the Pacific | Jeff Shafer

DHCP

Dynamic Host Configuration Protocol

Recap

Past Topics

- Overview of networking and layered architecture
- Wireshark packet sniffer and Scapy packet manipulation
- Wired LAN, Wireless LANs, VLANs
- IPv4, IPv6 ARP, ICMP

Today's Topics

- Dynamic Host Configuration Protocol (DHCP)

Network Configuration

- How does a host get its network interface configured?
  - IP address
  - Network mask
  - Default gateway
  - DNS servers
  - …

Network Configuration

- Static assignment
  - Requires **user** involvement to set in OS
  - We configure hosts in the lab statically
    - It's "educational!" (plus, to make each lab work, you have to be very careful about what IP addresses you use)
  - Datacenters might configure servers statically since they rarely change addresses
- Dynamic assignment
  - Requires no user involvement
  - Represents the bulk of hosts on the Internet
  - Bootstrap Protocol (BOOTP) – *Early generation*
  - Dynamic Host Configuration Protocol (DHCP) – *Modern*

Dynamic Host Configuration Protocol (DHCP)

- Goals of DHCP
  - Plug and play!
  - Allow host to *dynamically* obtain its IP address from network server when it joins network
  - Allow host to renew its lease on in-use address
  - Allow reuse of addresses (if you disconnect your host, someone else can use that address)

DHCP

- DHCP is an *application layer protocol* running on UDP
  - DHCP server: UDP port 67
  - DHCP client: UDP port 68
- **If a host does not have an IP address, then how does it communicate with a DHCP server?**
  - DHCP server may be in the same *broadcast domain* (LAN) as the DHCP client
  - DHCP client can send *link layer broadcast packets*
  - DHCP communications are **never routed** (LAN only)

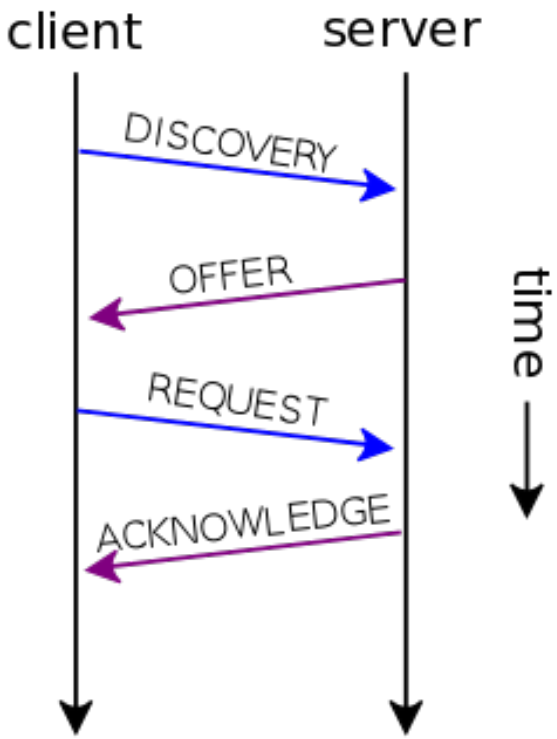
Broadcasting in DHCP

- Two IP addresses are common as source and destination IP addresses of packets that carry DHCP messages
  - Source IP: `0.0.0.0`
    - Used by the DHCP client before acquiring an IP address
  - Destination IP: `255.255.255.255`
    - Used by the DHCP client and DHCP server, indicating a local broadcast (within the LAN)
- After acquiring an IP address, DHCP client can use the valid IP address as the source address
  - DHCPv4: 32-bit IPv4 addresses
  - DHCPv6: 128-bit IPv6 addresses

DHCP

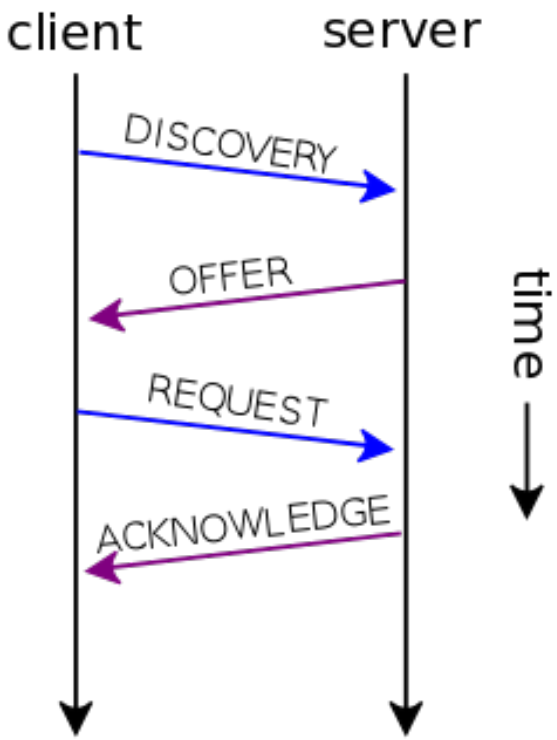
- Four stages to DHCP
  1. **D**iscover *(new host only)*
  2. **O**ffer *(new host only)*
  3. **R**equest
  4. **A**cknowledge

Step 1 – DHCP Discover



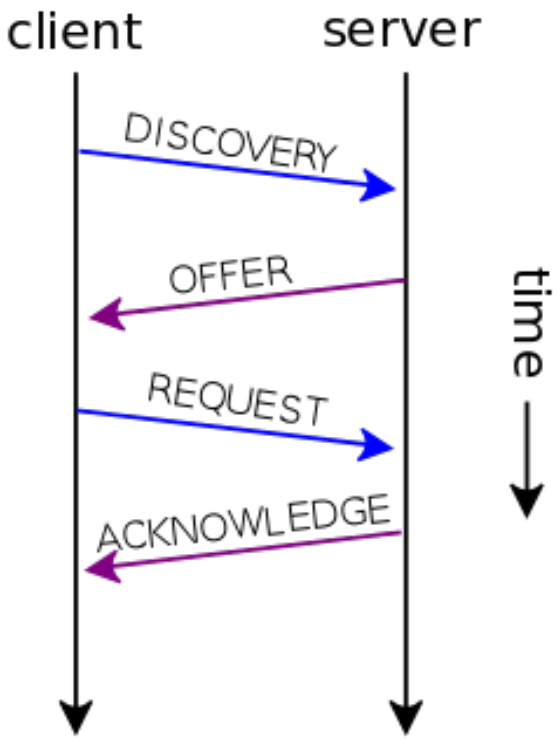
- "Discover DHCP servers on the network"
  - Source IP: `0.0.0.0`
  - Destination IP: `255.255.255.255`
  - Source port: 68
  - Destination port: 67
  - DHCP message type: Discover
- (New host only) Host **broadcasts** "DHCP discover" message to entire subnet
  - DHCP server either located on same subnet, or router has been configured to intercept and forward DHCP messages
  - Router might **be** the DHCP server!

Step 2 – DHCP Offer



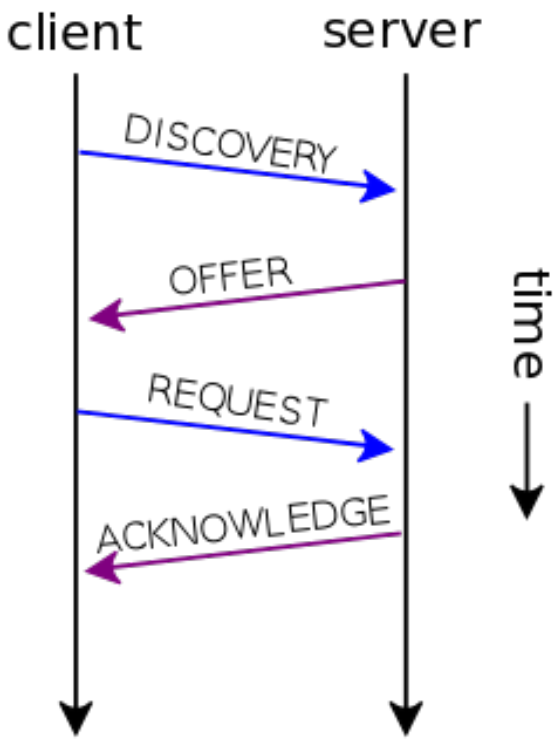
- "DHCP server(s) offer client an IP assignment"
  - Source IP: DHCP server IP
  - Destination IP: `255.255.255.255`
  - Source port: 67
  - Destination port: 68
  - DHCP message type: Offer
- (New host only) DHCP server(s) responds directly to client with "DHCP offer" message
  - Might get several *offers* from different DHCP servers
- Message contains
  - IP address of DHCP server
  - Lease offer to the client: IP address, Subnet, Lease Duration

Step 3 – DHCP Request



- "Host requests the best offer"
  - Source IP: 0.0.0.0
  - Destination IP: 255.255.255.255
  - Source port: 68
  - Destination port: 67
  - DHCP message type: Request
- Host picks the DHCP offer it likes best
- Host requests IP address with a "DHCP request" message
  - Message is **broadcast across subnet**. Why?
    - May have received multiple offers from multiple servers
    - Servers are reserving an IP address for you
    - Need to let all servers know, even the ones you didn't accept (so they can return the address to the pool)

Step 4 – DHCP Ack



- "DHCP server confirms accepted offer"
  - Source IP: DHCP server IP
  - Destination IP: 255.255.255.255
  - Source port: 67
  - Destination port: 68
  - DHCP message type: Acknowledgement
- Only the server whose lease the client requested sends back a "DHCP Ack" message
- Re-confirms the lease and offers additional information (default gateway, DNS servers, etc…)

DHCP – More Than Just IP Address

- DHCP can return more than just allocated IP address on subnet
  - Address of gateway router for client
  - Name and IP address of DNS server(s)
  - Network mask (indicating network versus host portion of address)
  - NTP server (network time)
  - LDAP server (address book)
  - SIP server (Voice-over-IP server)
  - … and many many more possibilities!

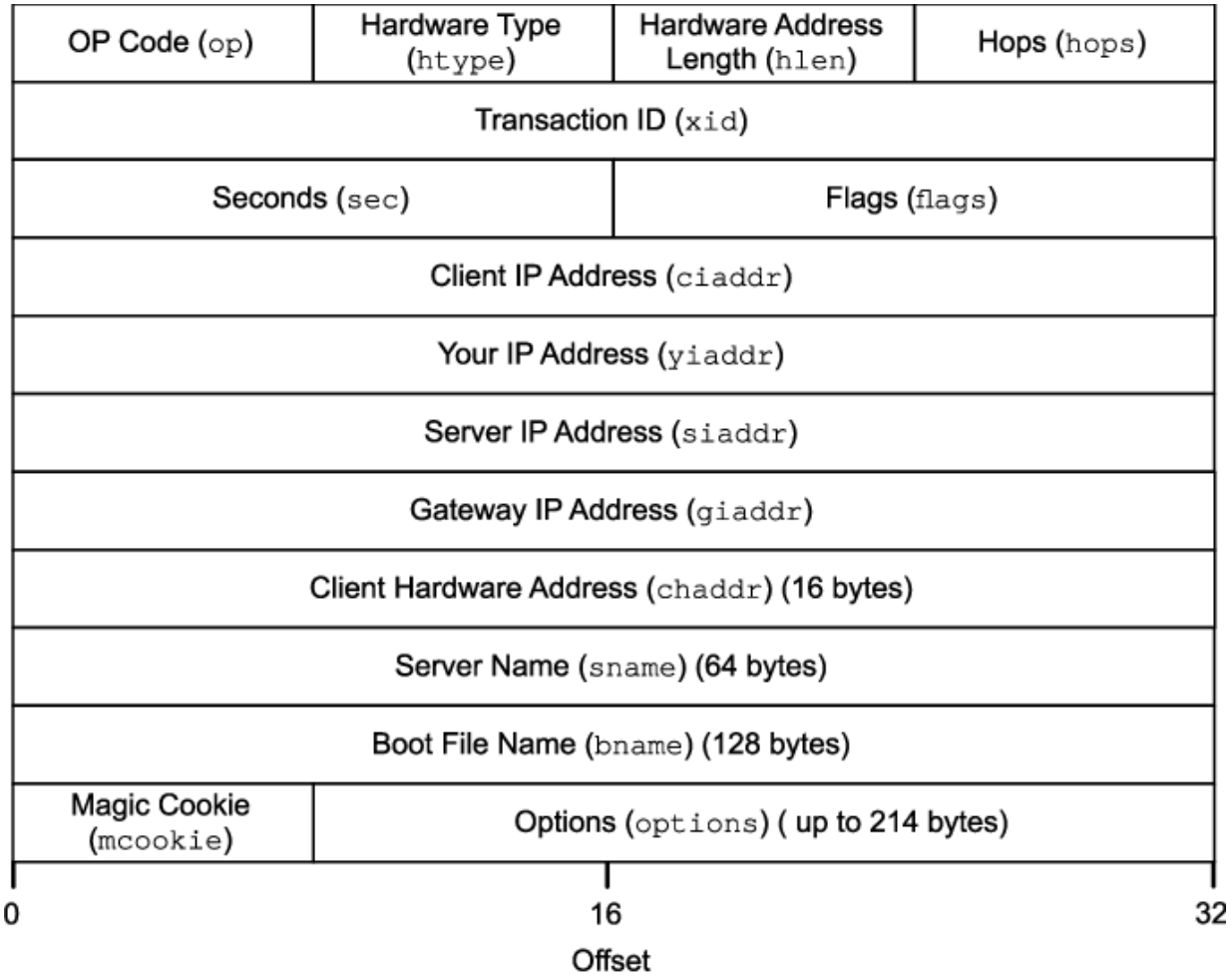
DHCP Lease Time

- The DHCP request, offer, and acknowledgement include a *lease time*
  - Represents the amount of time a client can hold the given IP address
  - Lease time can be in the order of hours or days.
- After *half* of the lease time has elapsed, DHCP client tries to renew the lease by resending its DHCP request
  - DHCP request is sent to the previous (winning) DHCP server in unicast form
- If the DHCP server does not respond, DHCP client sends the DHCP request message in broadcast form
- If broadcast DHCP request fails (no response), the DHCP client begins from scratch by broadcasting DHCP discover message

DHCP Relay

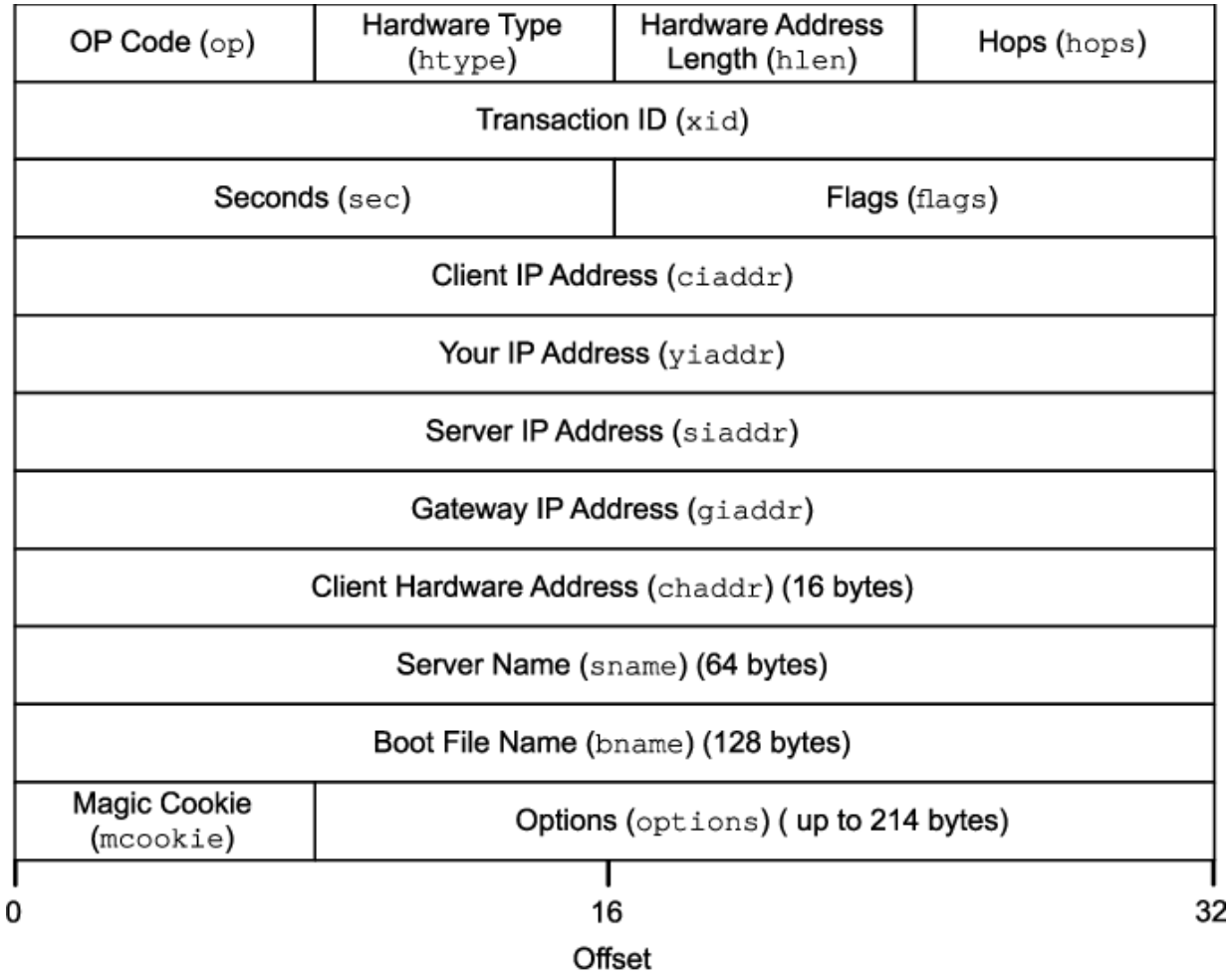
- Design assumption of DHCP is that there is one DHCP server in each broadcast domain (i.e. per LAN)
- What if we want *centralized* DHCP servers in a corporate environment?
  - Single server or small cluster of servers
- DHCP relay agent
  - A relay agent is a software utility that is used on routers to relay DHCP traffic
  - Enables a DHCP client to contact a DHCP server residing beyond the client's broadcast domain

DHCP Header Format



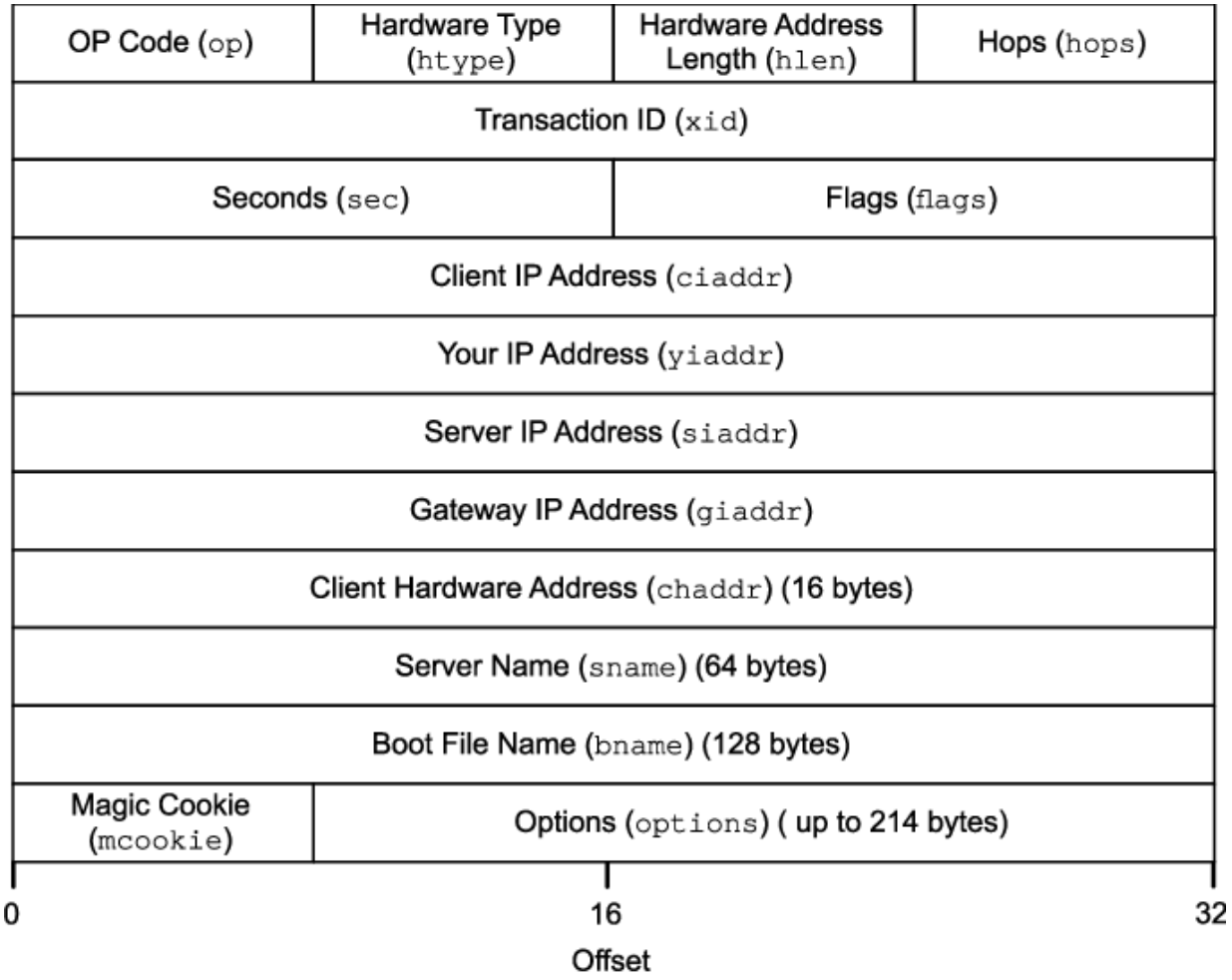
- **Opcode**: 1 for DHCP client messages, 2 for DHCP server messages
- **HW type**: encoding the protocol in link layer
- **HLen**: length of link layer addresses

DHCP Header Format



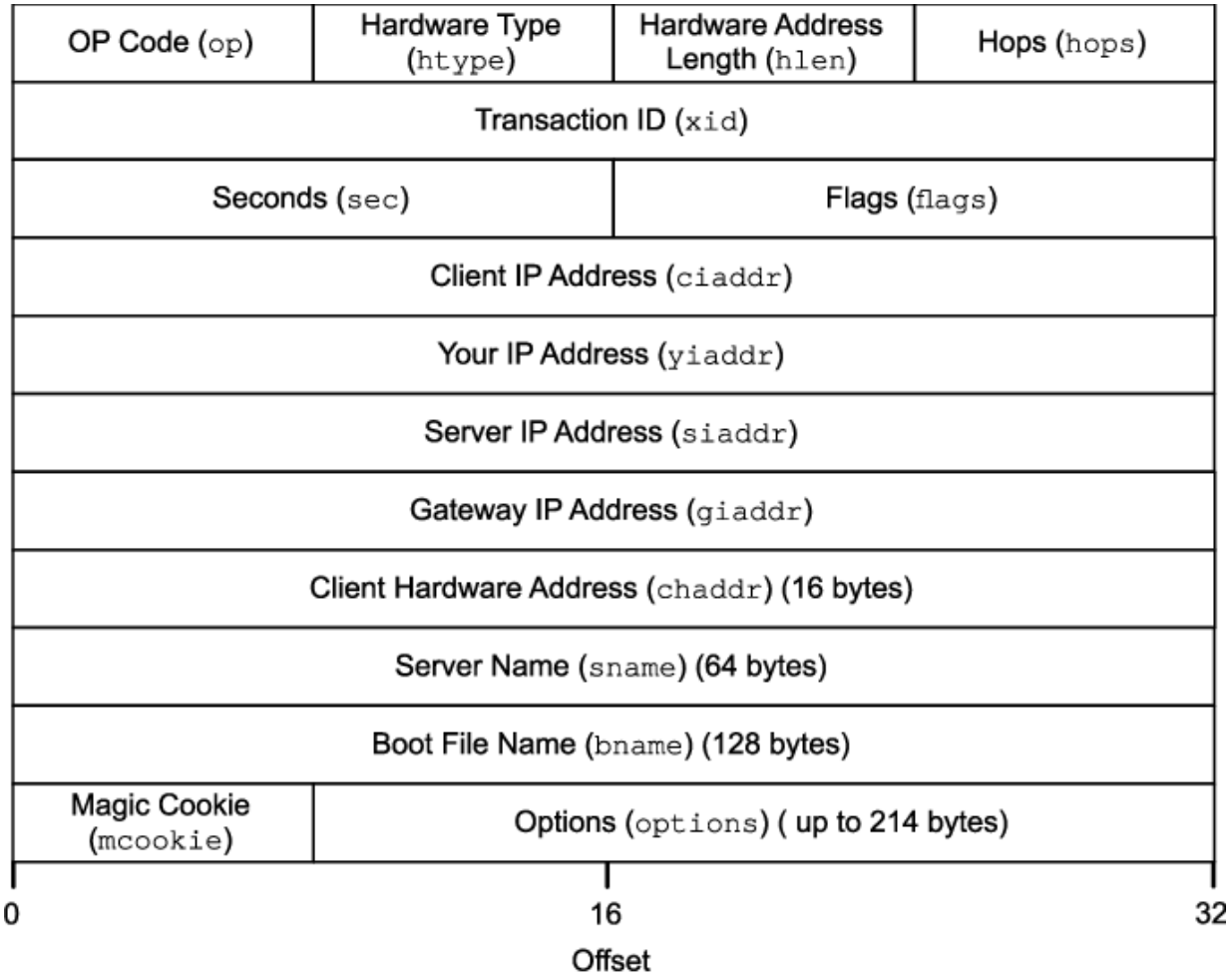
- Hops: the number of hops a DHCP message can travel
- Transaction ID
  - Same for the sequence of discover, offer, request and acknowledgement messages

DHCP Header Format



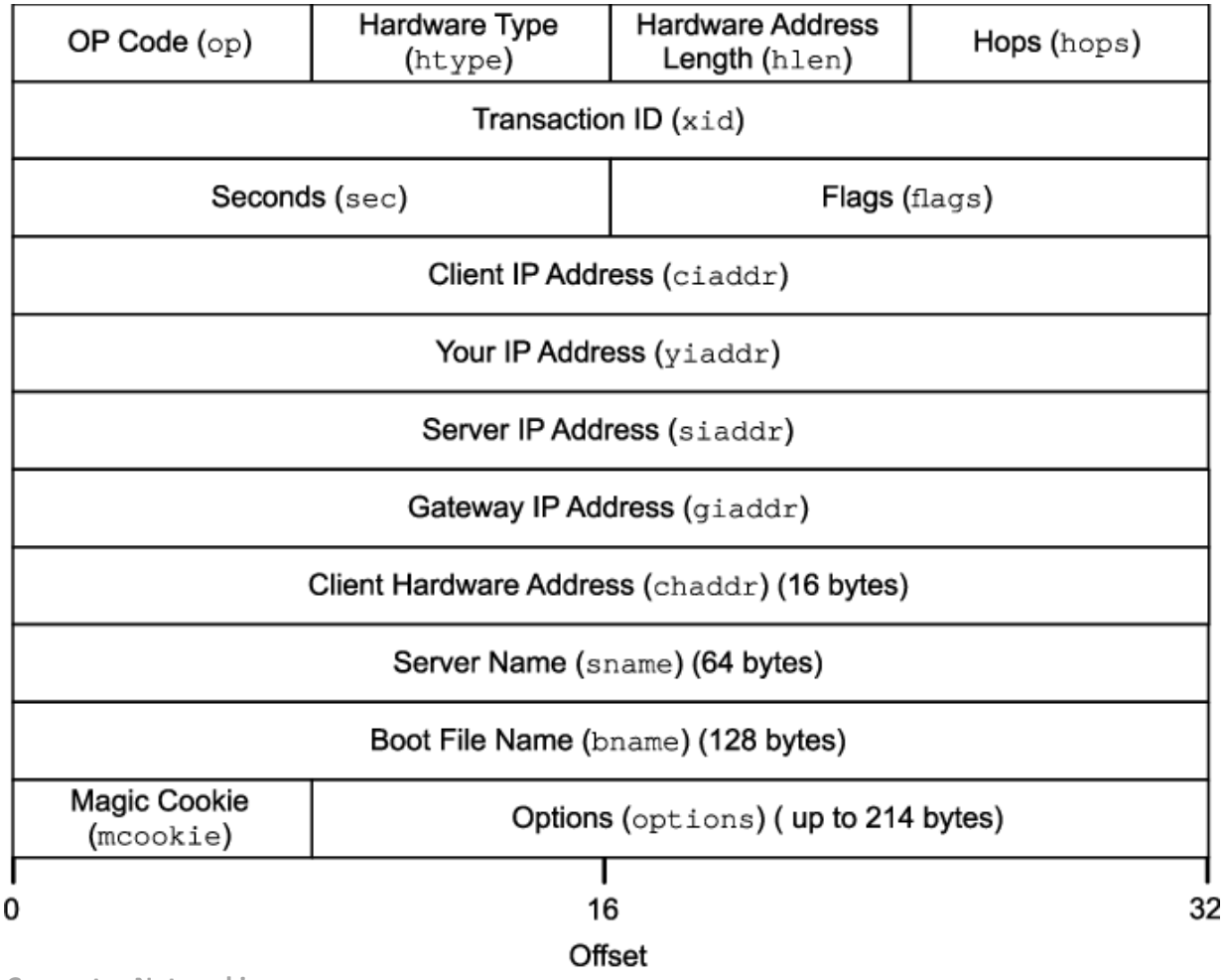
- **Secs**: Number of seconds from the time the DHCP client has started the process of acquiring IP address
- **Flags**: 1 bit in use, 15 bits are reserved
  - **Broadcast bit** allows client to request server *broadcast* response to it (because client cannot receive a unicast reply yet…)

DHCP Header Format



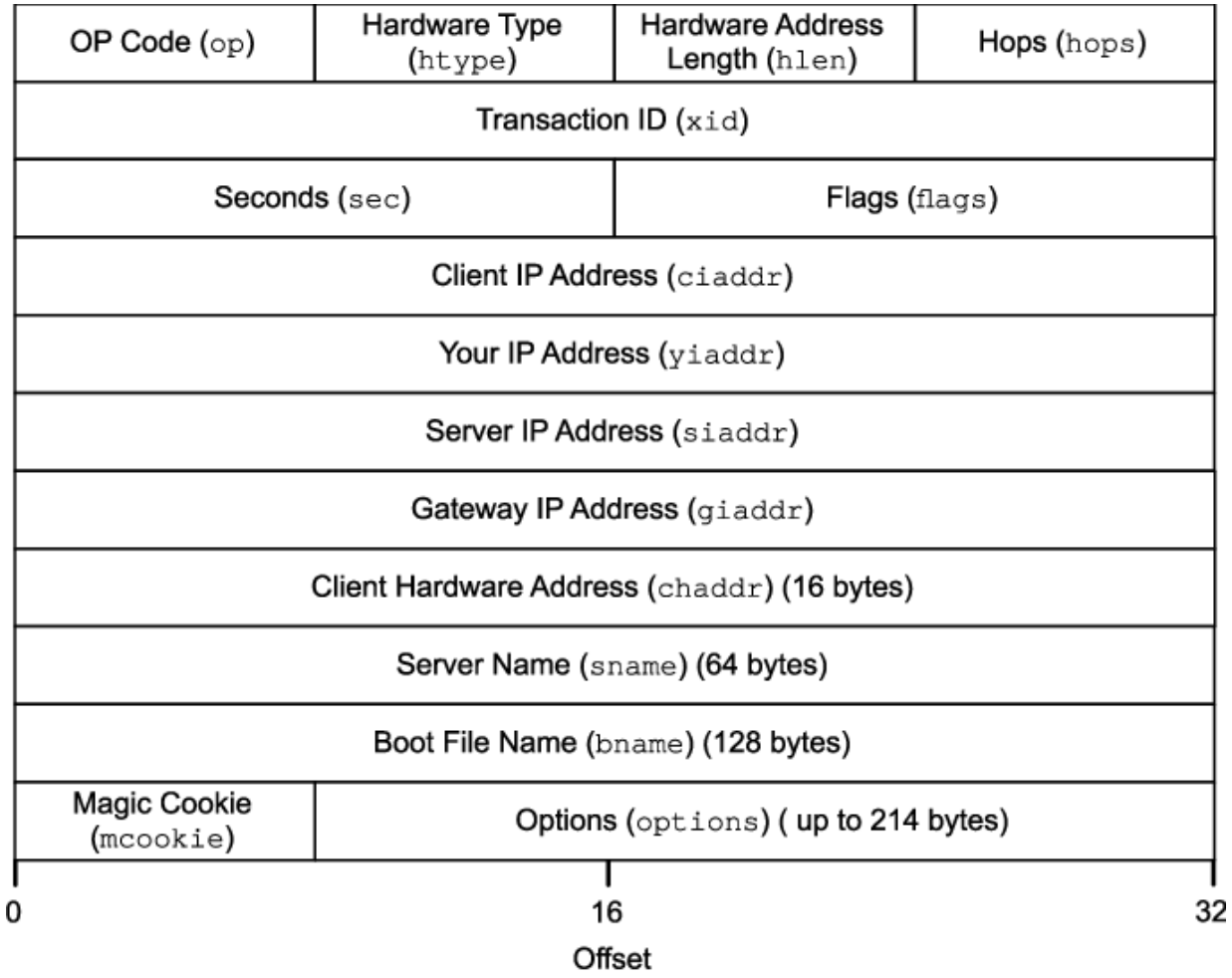
- **CIPAddr**: Client sets this to its valid address (if it has any!)
  - Used in lease time extension

DHCP Header Format



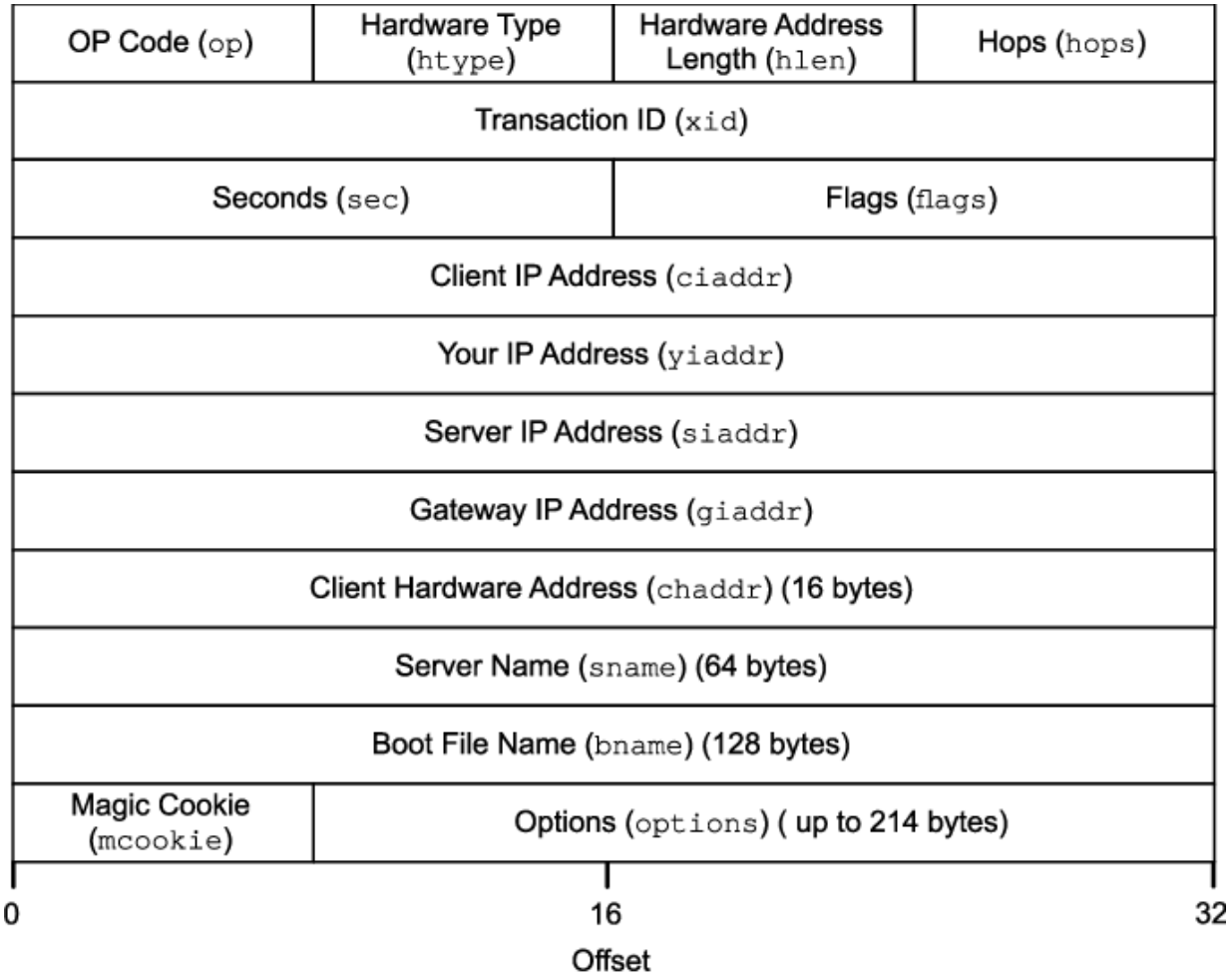
- **YIPAddr**: Server sets this to the assigned IP address of the client
  - Used in DHCP offer and acknowledg ment

DHCP Header Format



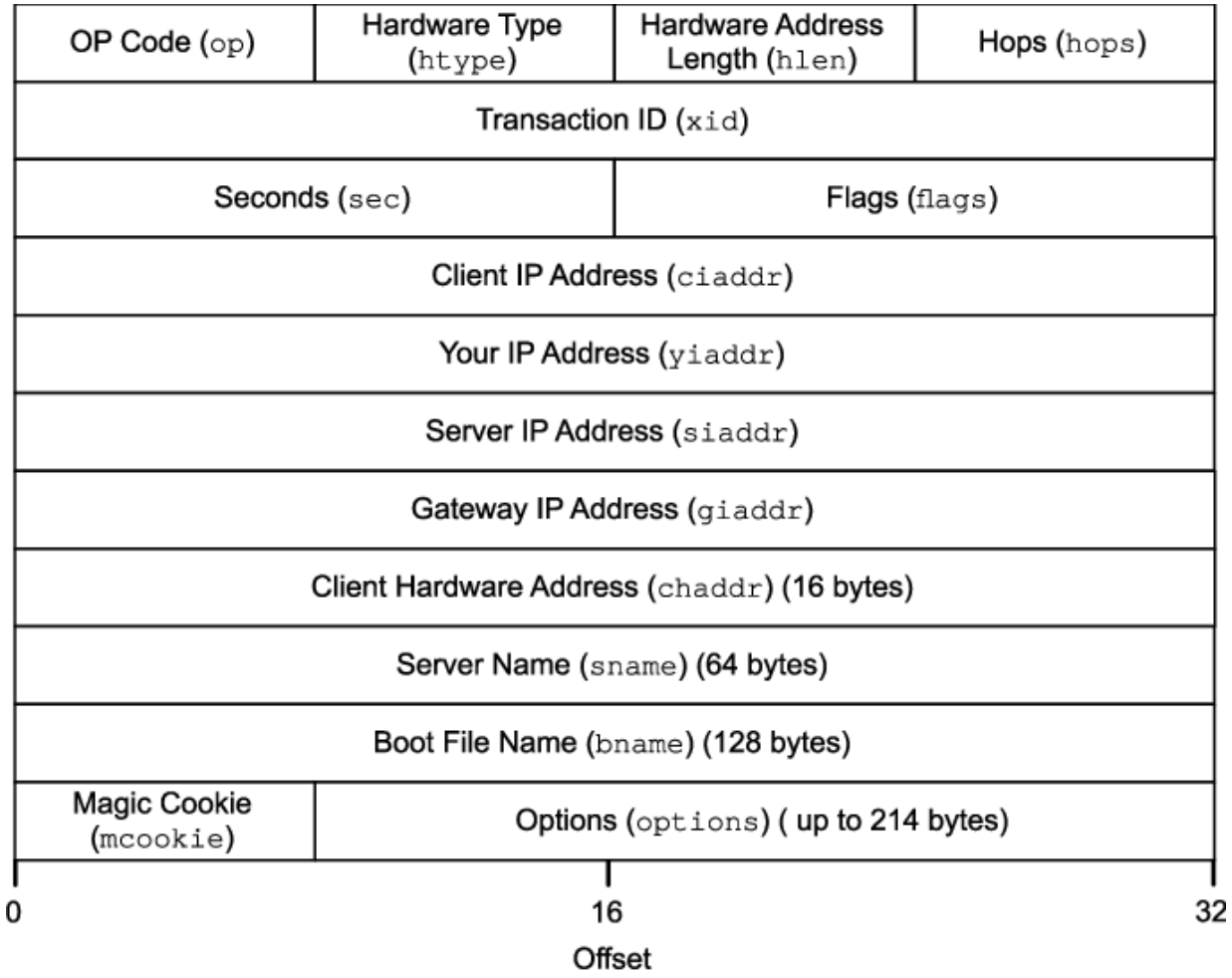
- **SIPAddr**: The address of the DHCP server that the client is supposed to contact in the next step for IP acquisition, lease extension, etc.
  - Used by DHCP server in DHCP offer and acknowledgement
- SIPAddr is not necessarily the same as the IP address of the DHCP server who sends the message

DHCP Header Format



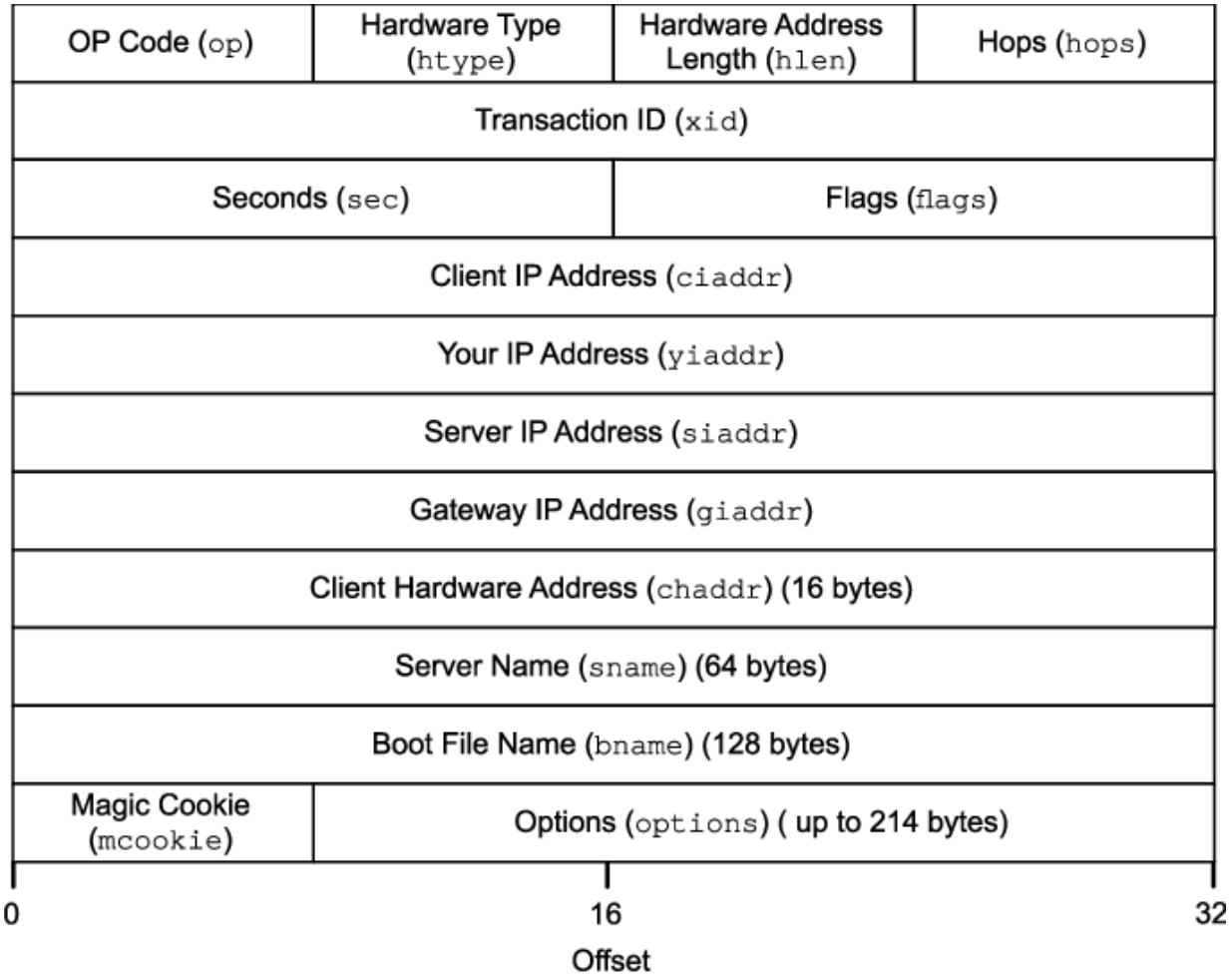
- **GIPAddr**: The address of the relay agent that is supposed to contact a DHCP server in another LAN
  - Set by the relay agent

DHCP Header Format



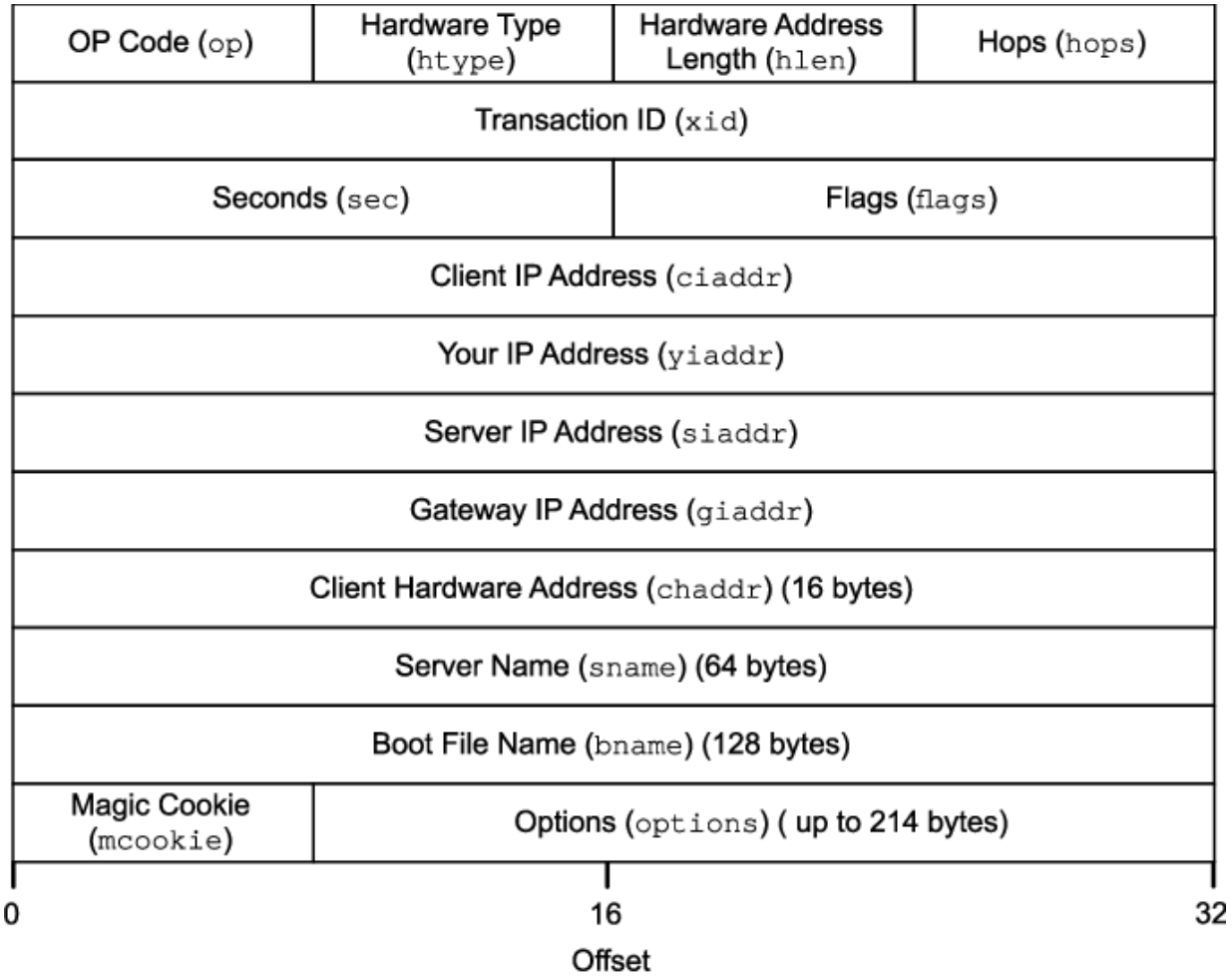
- **CHWAddr**: Link layer address of the DHCP client
  - Set by the client on DHCP discover and request
  - DHCP server uses this address to identify the client

DHCP Header Format



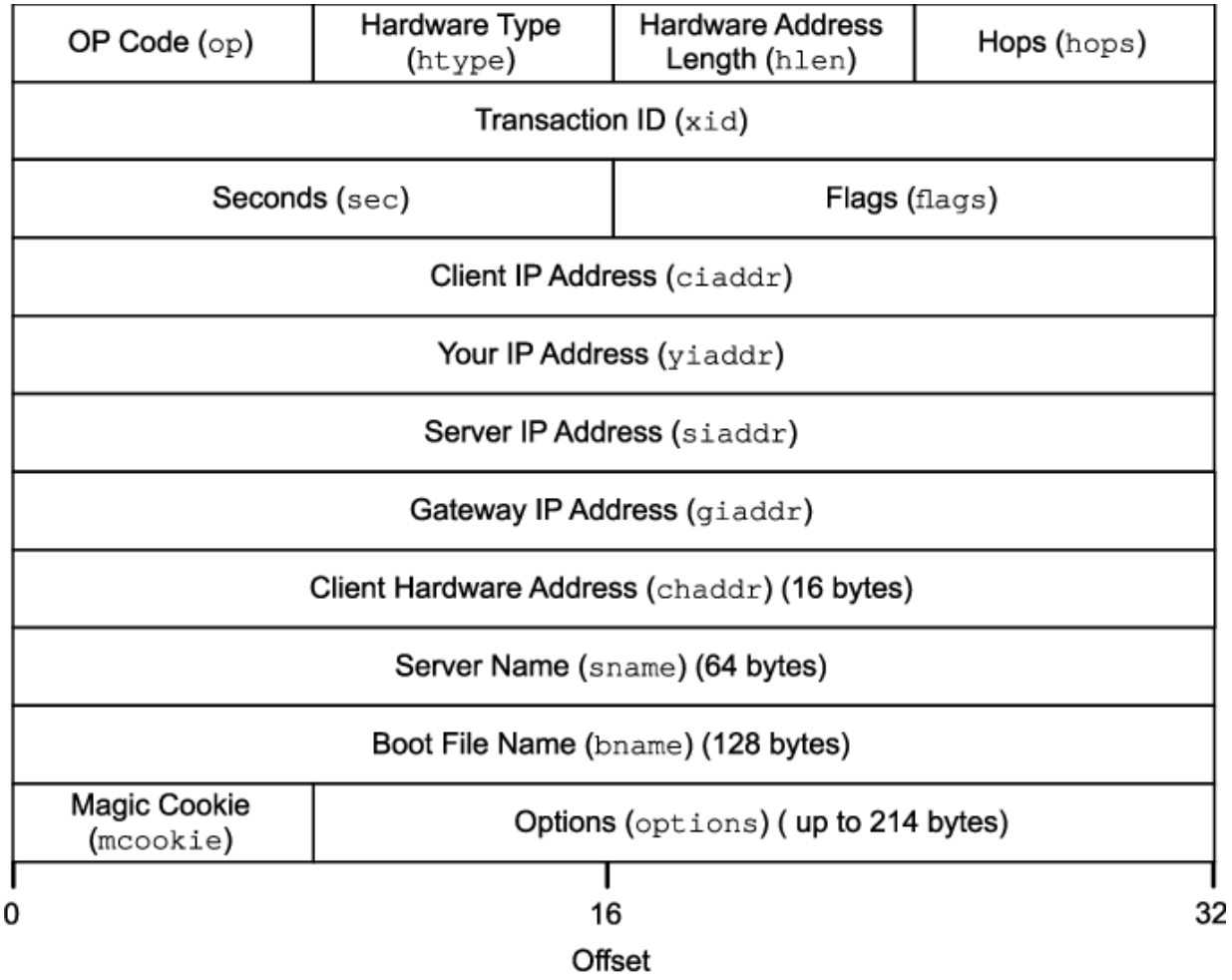
- **SName**: Server puts its host name in this field
  - Used in DHCP offer and acknowledge ment

DHCP Header Format



- **Boot File**: Contains the full directory path and file name of a boot file that can be downloaded by the client to complete its bootstrapping process

DHCP Header Format



- **MCookie**: Fixed value (distinguishes newer DHCP from older BOOTP format)
- **Options**: a variable size of additional options that can be communicated
- Examples: DHCP message type, subnet mask, boot file size, DNS servers, client host names, …

Closing Thoughts

Recap

- Today we discussed
  - DHCP
  - DHCP Messages
  - DHCP Header Format

Next Class

- UDP

Class Activity

CA.11 – DHCP & Wireshark

Due tonight at 11:59pm