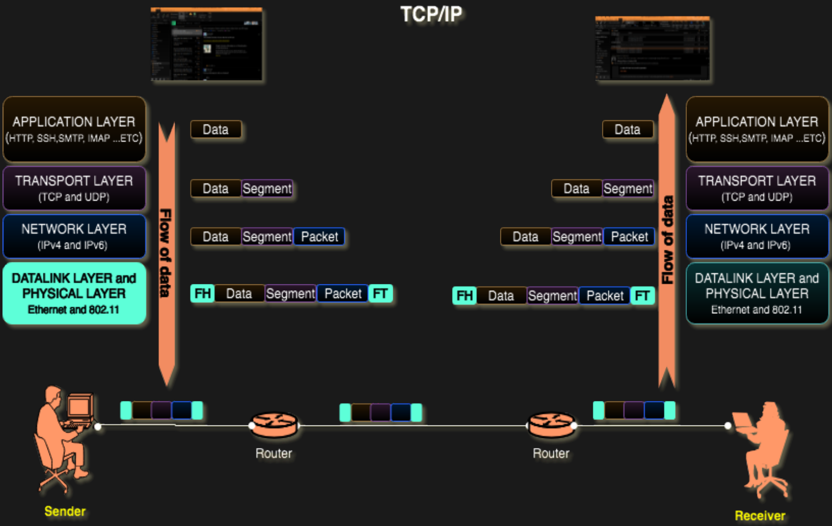
TK1104 - Digital Technology

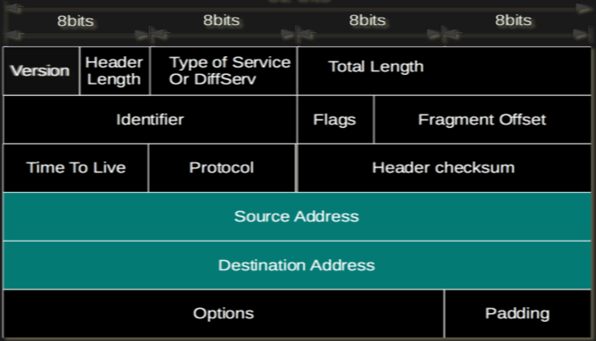
Static IP & DHCP

Ismail Hassan

TCP/IP Model


TCP/IP
APPLICATION LAYER
(HTTP, SSH,SMTP, IMAP ...ETC)
TRANSPORT LAYER
(TCP and UDP)
NETWORK LAYER
(IPv4 and IPv6)
DATALINK LAYER and PHYSICAL LAYER
Ethernet and 802.11
Flow of data
Data
Data Segment
Data Segment Packet
FH Data Segment Packet FT
Router
Router
Sender
Receiver

IPv4 Header



32 bits

8bits | 8bits | 8bits | 8bits

Version | Header Length | Type of Service Or DiffServ | Total Length

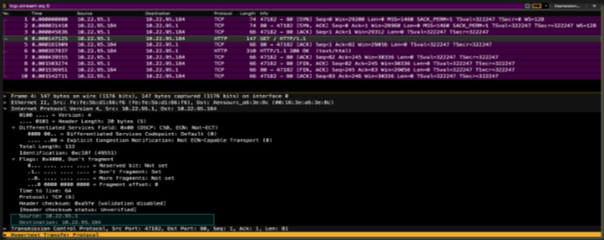
Identifier | Flags | Fragment Offset

Time To Live | Protocol | Header checksum

Source Address

Destination Address

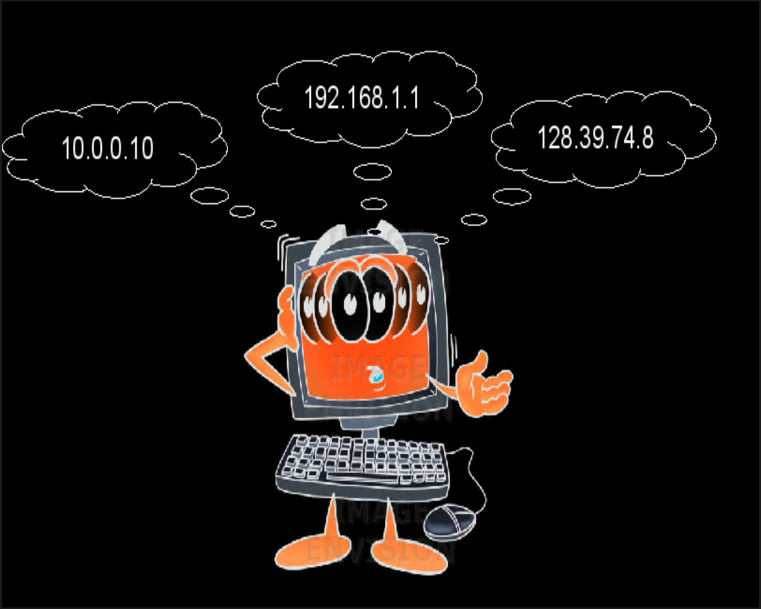
Options | Padding



```
tcp.stream eq 0
No.  Time         Source        Destination   Protocol Length Info
   1 0.000000000  10.22.95.1    10.22.95.184  TCP       74 47182 → 80 [SYN] Seq=0 Win=29200 Len=0 MSS=1460 SACK_PERM=1 TSval=322247 TSecr=0 WS=128
   2 0.000031410  10.22.95.184  10.22.95.1    TCP       74 80 → 47182 [SYN, ACK] Seq=0 Ack=1 Win=28960 Len=0 MSS=1460 SACK_PERM=1 TSval=322247 TSecr=322247 WS=128
   3 0.000045836  10.22.95.1    10.22.95.184  TCP       66 47182 → 80 [ACK] Seq=1 Ack=1 Win=29312 Len=0 TSval=322247 TSecr=322247
   4 0.000147125  10.22.95.1    10.22.95.184  HTTP     147 GET / HTTP/1.1
   5 0.000161909  10.22.95.184  10.22.95.1    TCP       66 80 → 47182 [ACK] Seq=1 Ack=82 Win=29056 Len=0 TSval=322247 TSecr=322247
   6 0.000357837  10.22.95.184  10.22.95.1    HTTP     310 HTTP/1.1 200 OK  (text/html)
   7 0.000439555  10.22.95.1    10.22.95.184  TCP       66 47182 → 80 [ACK] Seq=82 Ack=245 Win=30336 Len=0 TSval=322247 TSecr=322247
   8 0.001503274  10.22.95.1    10.22.95.184  TCP       66 47182 → 80 [FIN, ACK] Seq=82 Ack=245 Win=30336 Len=0 TSval=322247 TSecr=322247
   9 0.001536951  10.22.95.184  10.22.95.1    TCP       66 80 → 47182 [FIN, ACK] Seq=245 Ack=83 Win=29056 Len=0 TSval=322247 TSecr=322247
  10 0.001542711  10.22.95.1    10.22.95.184  TCP       66 47182 → 80 [ACK] Seq=83 Ack=246 Win=30336 Len=0 TSval=322247 TSecr=322247

▸ Frame 4: 147 bytes on wire (1176 bits), 147 bytes captured (1176 bits) on interface 0
▸ Ethernet II, Src: fe:fe:5b:d1:66:f6 (fe:fe:5b:d1:66:f6), Dst: Xensourc_a6:3e:8c (00:16:3e:a6:3e:8c)
▾ Internet Protocol Version 4, Src: 10.22.95.1, Dst: 10.22.95.184
    0100 .... = Version: 4
    .... 0101 = Header Length: 20 bytes (5)
  ▾ Differentiated Services Field: 0x00 (DSCP: CS0, ECN: Not-ECT)
      0000 00.. = Differentiated Services Codepoint: Default (0)
      .... ..00 = Explicit Congestion Notification: Not ECN-Capable Transport (0)
    Total Length: 133
    Identification: 0xc18f (49551)
  ▾ Flags: 0x4000, Don't fragment
      0... .... .... .... = Reserved bit: Not set
      .1.. .... .... .... = Don't fragment: Set
      ..0. .... .... .... = More fragments: Not set
      ...0 0000 0000 0000 = Fragment offset: 0
    Time to live: 64
    Protocol: TCP (6)
    Header checksum: 0xa5fe [validation disabled]
    [Header checksum status: Unverified]
    Source: 10.22.95.1
    Destination: 10.22.95.184
▸ Transmission Control Protocol, Src Port: 47182, Dst Port: 80, Seq: 1, Ack: 1, Len: 81
▸ Hypertext Transfer Protocol
```

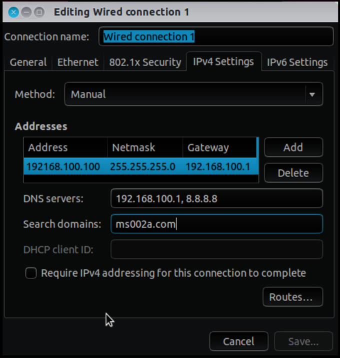
- How does the computer know which IP address to use?



Static (Manual) configuration

- We can manually set an IP address to a machine through a configuration file or a GUI

Manual network configuration (GUI)



Editing Wired connection 1

Connection name: Wired connection 1

Method: Manual

Addresses

Address	Netmask	Gateway
192168.100.100	255.255.255.0	192.168.100.1

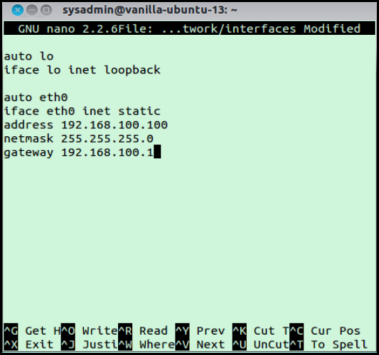
DNS servers: 192.168.100.1, 8.8.8.8

Search domains: ms002a.com

DHCP client ID:

☐ Require IPv4 addressing for this connection to complete

Manual network configuration in text mode



```
sysadmin@vanilla-ubuntu-13: ~
 GNU nano 2.2.6File: ...twork/interfaces Modified

auto lo
iface lo inet loopback

auto eth0
iface eth0 inet static
address 192.168.100.100
netmask 255.255.255.0
gateway 192.168.100.1
```

^G Get H^O Write^R Read ^Y Prev ^K Cut T^C Cur Pos
^X Exit ^J Justi^W Where^V Next ^U UnCut^T To Spell

- It is also possible to use command line tools to configure the network

Challenges with manual configuration

- The challenge:
  - IP addresses are difficult to remember and difficult to manually configure on large networks
  - We need a way to automatically assign IP addresses

Challenges with manual configuration

- The challenge:
  - IP addresses are difficult to remember and difficult to manually configure on large networks
  - We need a way to automatically assign IP addresses
- Solution:
  - Dynamic Host Configuration Protocol (DHCP)
    - DHCP provides a simple and an automatic way of configuring network interfaces

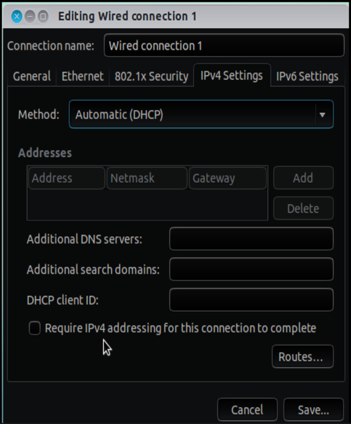
Dynamic Host Configuration Protocol (DHCP)

- DHCP provides a mechanism to offer configuration information to the machines in a TCP/IP network
  - Prior to DHCP, administrators had to enter all this information manually into a file.
  - This does not scale and could lead to errors due to incorrect configuration)
  - Keeping the information updated was cumbersome and difficult to manage
- DHCP allows client machines to automatically receive network related information, i.e IP address, DNS and default gateway
  - There are many DHCP options that can be set in addition to IP, DNS and gateway
  - `http://www.iana.org/assignments/bootp-dhcp-parameters/bootp-dhcp-parameters.xhtml`

Client-side configuration

- Machines can be configured to receive IP, DNS, and gateway information from a DHCP server through a configuration file or GUI

DHCP network configuration (GUI)



Editing Wired connection 1

Connection name: Wired connection 1

Method: Automatic (DHCP)

Addresses

Address	Netmask	Gateway

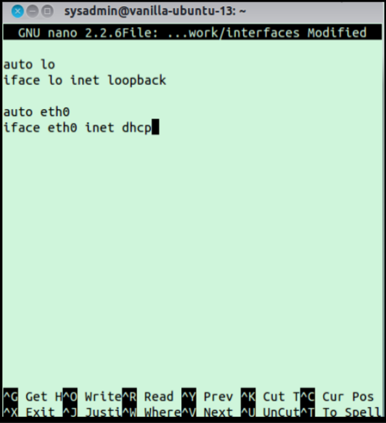
Additional DNS servers:

Additional search domains:

DHCP client ID:

□ Require IPv4 addressing for this connection to complete

DHCP network configuration in text mode



sysadmin@vanilla-ubuntu-13: ~

```
  GNU nano 2.2.6File: ...work/interfaces Modified

auto lo
iface lo inet loopback

auto eth0
iface eth0 inet dhcp
```

```
^G Get H^O Write^R Read ^Y Prev ^K Cut T^C Cur Pos
^X Exit ^J Justi^W Where^V Next ^U UnCut^T To Spell
```

DHCP: How it works!

- A client sends a message to the network segment it belongs to and requests an IP to any existing DHCP server

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  - The client will try to renew the lease period when 50% of the lease time is used up

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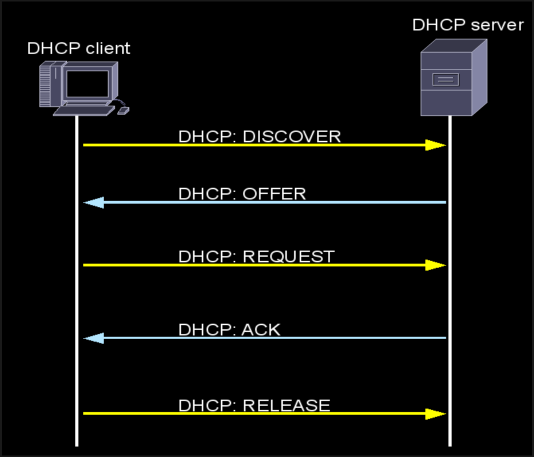
- When the lease time expires, the client must ask the DHCP server to keep the address or get a new address
  - The client will try to renew the lease period when 50% of the lease time is used up
- The lease time is configured on the server and may vary:
  - from 30 seconds to 24 hours or longer

DHCP Messages Overview

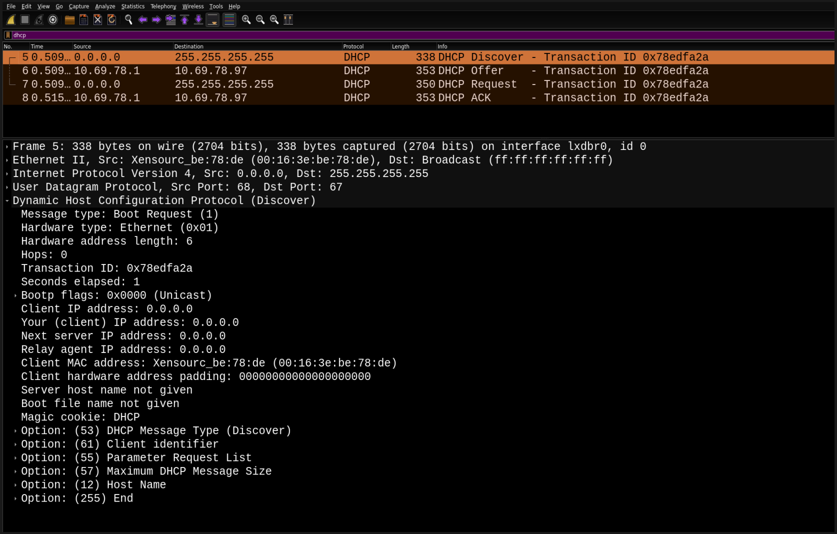
- Multiple messages are sent back and forth between a client and the DHCP server before it can successfully obtain an IP address



DHCP: DISCOVER Message Type

- A client using the DHCP protocol will broadcast (adr 255.255.255.255) a DISCOVER message type to all the machines on its subnet to find out the address of any DHCP server that is connected to that network

DHCP DISCOVER


File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
dhcp

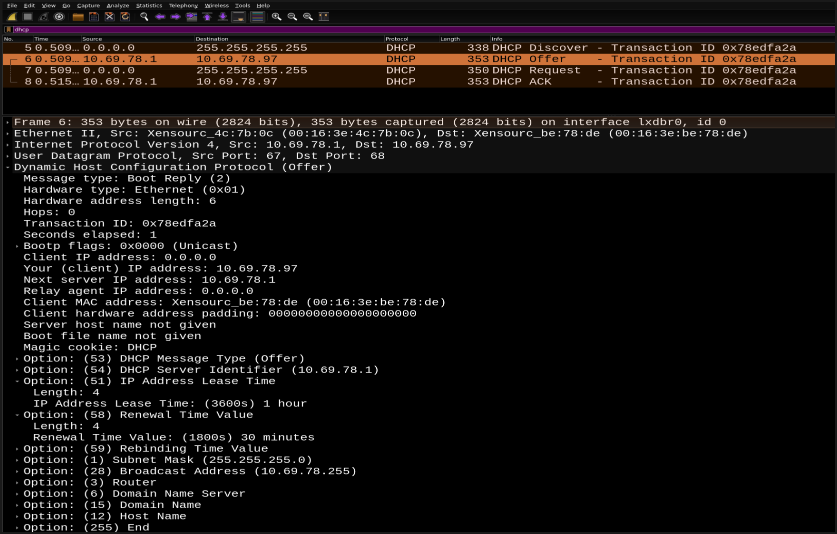
```
No. Time     Source      Destination      Protocol  Length Info
  5 0.509... 0.0.0.0     255.255.255.255  DHCP      338 DHCP Discover - Transaction ID 0x78edfa2a
  6 0.509... 10.69.78.1  10.69.78.97      DHCP      353 DHCP Offer    - Transaction ID 0x78edfa2a
  7 0.509... 0.0.0.0     255.255.255.255  DHCP      350 DHCP Request  - Transaction ID 0x78edfa2a
  8 0.515... 10.69.78.1  10.69.78.97      DHCP      353 DHCP ACK      - Transaction ID 0x78edfa2a
```

```
Frame 5: 338 bytes on wire (2704 bits), 338 bytes captured (2704 bits) on interface lxdbr0, id 0
Ethernet II, Src: Xensourc_be:78:de (00:16:3e:be:78:de), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
Internet Protocol Version 4, Src: 0.0.0.0, Dst: 255.255.255.255
User Datagram Protocol, Src Port: 68, Dst Port: 67
Dynamic Host Configuration Protocol (Discover)
  Message type: Boot Request (1)
  Hardware type: Ethernet (0x01)
  Hardware address length: 6
  Hops: 0
  Transaction ID: 0x78edfa2a
  Seconds elapsed: 1
  Bootp flags: 0x0000 (Unicast)
  Client IP address: 0.0.0.0
  Your (client) IP address: 0.0.0.0
  Next server IP address: 0.0.0.0
  Relay agent IP address: 0.0.0.0
  Client MAC address: Xensourc_be:78:de (00:16:3e:be:78:de)
  Client hardware address padding: 00000000000000000000
  Server host name not given
  Boot file name not given
  Magic cookie: DHCP
  Option: (53) DHCP Message Type (Discover)
  Option: (61) Client identifier
  Option: (55) Parameter Request List
  Option: (57) Maximum DHCP Message Size
  Option: (12) Host Name
  Option: (255) End
```

DHCP: OFFER Message Type

- Sent from server in response to a DISCOVER. It contains an IP address, other information configuration as well (network mask, DNS servers, default gateway, search domains, etc)

DHCP OFFER



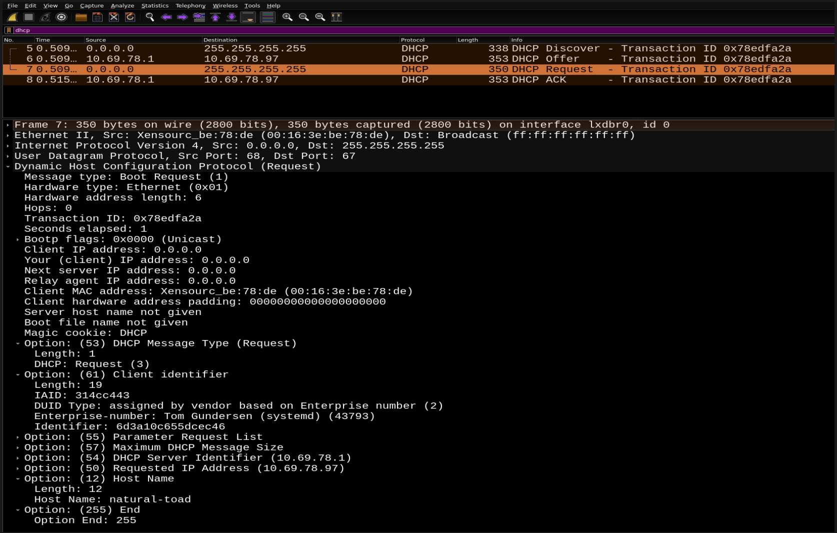
```
No.  Time      Source       Destination        Protocol  Length  Info
  5 0.509... 0.0.0.0      255.255.255.255    DHCP         338 DHCP Discover  - Transaction ID 0x78edfa2a
  6 0.509... 10.69.78.1   10.69.78.97        DHCP         353 DHCP Offer     - Transaction ID 0x78edfa2a
  7 0.509... 0.0.0.0      255.255.255.255    DHCP         350 DHCP Request   - Transaction ID 0x78edfa2a
  8 0.515... 10.69.78.1   10.69.78.97        DHCP         353 DHCP ACK       - Transaction ID 0x78edfa2a
```

```
Frame 6: 353 bytes on wire (2824 bits), 353 bytes captured (2824 bits) on interface lxdbr0, id 0
Ethernet II, Src: Xensourc_4c:7b:0c (00:16:3e:4c:7b:0c), Dst: Xensourc_be:78:de (00:16:3e:be:78:de)
Internet Protocol Version 4, Src: 10.69.78.1, Dst: 10.69.78.97
User Datagram Protocol, Src Port: 67, Dst Port: 68
Dynamic Host Configuration Protocol (Offer)
  Message type: Boot Reply (2)
  Hardware type: Ethernet (0x01)
  Hardware address length: 6
  Hops: 0
  Transaction ID: 0x78edfa2a
  Seconds elapsed: 1
  Bootp flags: 0x0000 (Unicast)
  Client IP address: 0.0.0.0
  Your (client) IP address: 10.69.78.97
  Next server IP address: 10.69.78.1
  Relay agent IP address: 0.0.0.0
  Client MAC address: Xensourc_be:78:de (00:16:3e:be:78:de)
  Client hardware address padding: 00000000000000000000
  Server host name not given
  Boot file name not given
  Magic cookie: DHCP
  Option: (53) DHCP Message Type (Offer)
  Option: (54) DHCP Server Identifier (10.69.78.1)
  Option: (51) IP Address Lease Time
    Length: 4
    IP Address Lease Time: (3600s) 1 hour
  Option: (58) Renewal Time Value
    Length: 4
    Renewal Time Value: (1800s) 30 minutes
  Option: (59) Rebinding Time Value
  Option: (1) Subnet Mask (255.255.255.0)
  Option: (28) Broadcast Address (10.69.78.255)
  Option: (3) Router
  Option: (6) Domain Name Server
  Option: (15) Domain Name
  Option: (12) Host Name
  Option: (255) End
```

DHCP: REQUEST Message Type

- Sent by the client to request a specific IP address
  - Usually the IP that was sent by the OFFER message, but is also used to renew leases. Can also be sent to try to get the same address after a restart

DHCP REQUEST



dhcp

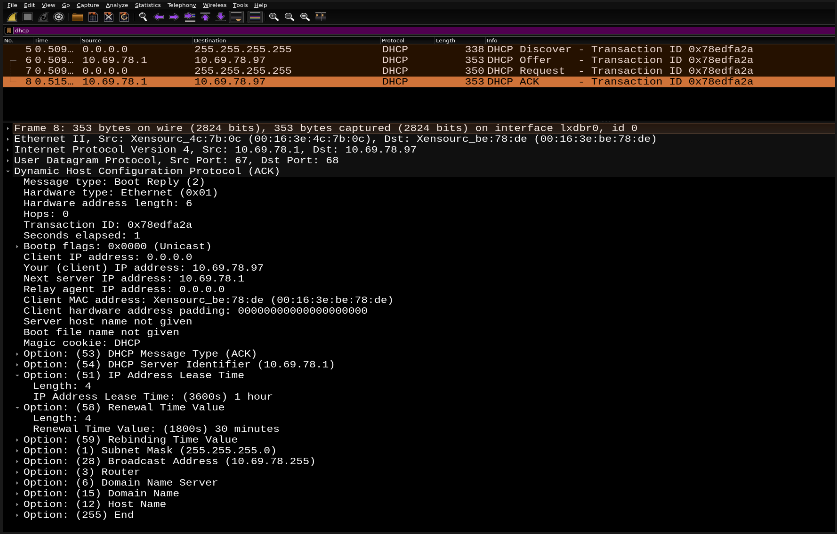
```
No.  Time      Source       Destination       Protocol  Length  Info
   5 0.509…  0.0.0.0      255.255.255.255   DHCP         338 DHCP Discover  - Transaction ID 0x78edfa2a
   6 0.509…  10.69.78.1   10.69.78.97       DHCP         353 DHCP Offer     - Transaction ID 0x78edfa2a
   7 0.509…  0.0.0.0      255.255.255.255   DHCP         350 DHCP Request   - Transaction ID 0x78edfa2a
   8 0.515…  10.69.78.1   10.69.78.97       DHCP         353 DHCP ACK       - Transaction ID 0x78edfa2a
```

```
› Frame 7: 350 bytes on wire (2800 bits), 350 bytes captured (2800 bits) on interface lxdbr0, id 0
› Ethernet II, Src: Xensourc_be:78:de (00:16:3e:be:78:de), Dst: Broadcast (ff:ff:ff:ff:ff:ff)
› Internet Protocol Version 4, Src: 0.0.0.0, Dst: 255.255.255.255
› User Datagram Protocol, Src Port: 68, Dst Port: 67
˅ Dynamic Host Configuration Protocol (Request)
    Message type: Boot Request (1)
    Hardware type: Ethernet (0x01)
    Hardware address length: 6
    Hops: 0
    Transaction ID: 0x78edfa2a
    Seconds elapsed: 1
  › Bootp flags: 0x0000 (Unicast)
    Client IP address: 0.0.0.0
    Your (client) IP address: 0.0.0.0
    Next server IP address: 0.0.0.0
    Relay agent IP address: 0.0.0.0
    Client MAC address: Xensourc_be:78:de (00:16:3e:be:78:de)
    Client hardware address padding: 00000000000000000000
    Server host name not given
    Boot file name not given
    Magic cookie: DHCP
  ˅ Option: (53) DHCP Message Type (Request)
      Length: 1
      DHCP: Request (3)
  ˅ Option: (61) Client identifier
      Length: 19
      IAID: 314cc443
      DUID Type: assigned by vendor based on Enterprise number (2)
      Enterprise-number: Tom Gundersen (systemd) (43793)
      Identifier: 6d3a10c655dcec46
  › Option: (55) Parameter Request List
  › Option: (57) Maximum DHCP Message Size
  › Option: (54) DHCP Server Identifier (10.69.78.1)
  › Option: (50) Requested IP Address (10.69.78.97)
  ˅ Option: (12) Host Name
      Length: 12
      Host Name: natural-toad
  ˅ Option: (255) End
      Option End: 255
```

DHCP: ACK/NACK Message Type

- Sent by the server in response to a REQUEST
  - ACK - Request accepted, client can start using the IP address it requested
  - NACK - Something is wrong with the client's REQUEST.For example, it requested an IP address that they are not supposed to have. Probably assigned to someone else.

DHCP ACK

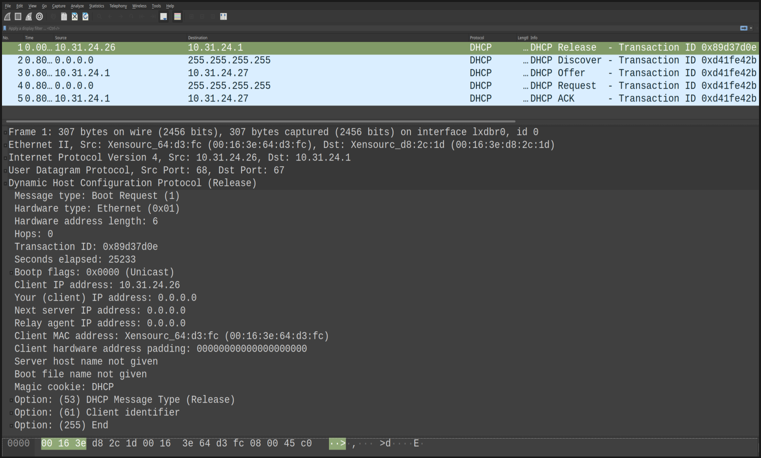

File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
dhcp

```
No. Time     Source       Destination       Protocol Length Info
  5 0.509…   0.0.0.0      255.255.255.255   DHCP        338 DHCP Discover  - Transaction ID 0x78edfa2a
  6 0.509…   10.69.78.1   10.69.78.97       DHCP        353 DHCP Offer     - Transaction ID 0x78edfa2a
  7 0.509…   0.0.0.0      255.255.255.255   DHCP        350 DHCP Request   - Transaction ID 0x78edfa2a
  8 0.515…   10.69.78.1   10.69.78.97       DHCP        353 DHCP ACK       - Transaction ID 0x78edfa2a
```

```
› Frame 8: 353 bytes on wire (2824 bits), 353 bytes captured (2824 bits) on interface lxdbr0, id 0
› Ethernet II, Src: Xensourc_4c:7b:0c (00:16:3e:4c:7b:0c), Dst: Xensourc_be:78:de (00:16:3e:be:78:de)
› Internet Protocol Version 4, Src: 10.69.78.1, Dst: 10.69.78.97
› User Datagram Protocol, Src Port: 67, Dst Port: 68
⌄ Dynamic Host Configuration Protocol (ACK)
    Message type: Boot Reply (2)
    Hardware type: Ethernet (0x01)
    Hardware address length: 6
    Hops: 0
    Transaction ID: 0x78edfa2a
    Seconds elapsed: 1
  › Bootp flags: 0x0000 (Unicast)
    Client IP address: 0.0.0.0
    Your (client) IP address: 10.69.78.97
    Next server IP address: 10.69.78.1
    Relay agent IP address: 0.0.0.0
    Client MAC address: Xensourc_be:78:de (00:16:3e:be:78:de)
    Client hardware address padding: 00000000000000000000
    Server host name not given
    Boot file name not given
    Magic cookie: DHCP
  › Option: (53) DHCP Message Type (ACK)
  › Option: (54) DHCP Server Identifier (10.69.78.1)
  ⌄ Option: (51) IP Address Lease Time
      Length: 4
      IP Address Lease Time: (3600s) 1 hour
  ⌄ Option: (58) Renewal Time Value
      Length: 4
      Renewal Time Value: (1800s) 30 minutes
  › Option: (59) Rebinding Time Value
  › Option: (1) Subnet Mask (255.255.255.0)
  › Option: (28) Broadcast Address (10.69.78.255)
  › Option: (3) Router
  › Option: (6) Domain Name Server
  › Option: (15) Domain Name
  › Option: (12) Host Name
  › Option: (255) End
```

DHCP: RELEASE Message Type

- Sent by the client to end lease time
  - Strictly not necessary, but is a polite thing to do (could only let the lease period expire)



```
No.  Time    Source       Destination      Protocol  Lengtl Info
  1 0.00… 10.31.24.26  10.31.24.1         DHCP      … DHCP Release  - Transaction ID 0x89d37d0e
  2 0.80… 0.0.0.0      255.255.255.255    DHCP      … DHCP Discover - Transaction ID 0xd41fe42b
  3 0.80… 10.31.24.1   10.31.24.27        DHCP      … DHCP Offer    - Transaction ID 0xd41fe42b
  4 0.80… 0.0.0.0      255.255.255.255    DHCP      … DHCP Request  - Transaction ID 0xd41fe42b
  5 0.80… 10.31.24.1   10.31.24.27        DHCP      … DHCP ACK      - Transaction ID 0xd41fe42b
```

```
Frame 1: 307 bytes on wire (2456 bits), 307 bytes captured (2456 bits) on interface lxdbr0, id 0
Ethernet II, Src: Xensourc_64:d3:fc (00:16:3e:64:d3:fc), Dst: Xensourc_d8:2c:1d (00:16:3e:d8:2c:1d)
Internet Protocol Version 4, Src: 10.31.24.26, Dst: 10.31.24.1
User Datagram Protocol, Src Port: 68, Dst Port: 67
Dynamic Host Configuration Protocol (Release)
 Message type: Boot Request (1)
 Hardware type: Ethernet (0x01)
 Hardware address length: 6
 Hops: 0
 Transaction ID: 0x89d37d0e
 Seconds elapsed: 25233
 Bootp flags: 0x0000 (Unicast)
 Client IP address: 10.31.24.26
 Your (client) IP address: 0.0.0.0
 Next server IP address: 0.0.0.0
 Relay agent IP address: 0.0.0.0
 Client MAC address: Xensourc_64:d3:fc (00:16:3e:64:d3:fc)
 Client hardware address padding: 00000000000000000000
 Server host name not given
 Boot file name not given
 Magic cookie: DHCP
 Option: (53) DHCP Message Type (Release)
 Option: (61) Client identifier
 Option: (255) End
0000  00 16 3e d8 2c 1d 00 16  3e 64 d3 fc 08 00 45 c0   ··>·,··· >d····E·
```

ISC DHCP server implementations

- ISC DHCP is open-source software that implements Dynamic Host Configuration Protocol
  - It is the default client and server package on most Linux distributions
  - Server components:
    - Daemon: *dhcpd*
    - Configuration file: *dhcpd.conf*
    - State database: *dhcpd.leases*
  - Client components:
    - Agent: *dhclient*
    - Configuration file: *dhclient.conf*
    - State database: dhclient."*interface*".leases

DHCP server Demo!

Next!

Domain Name System (DNS)