

LTSP protocol review

- the LTSP client has no hard disk, no pen drive, no floppy disk and no cdrom
- it boots up using the network
- when the LTSP client boots up it uses standard network protocols
 - initially it needs to get an IP address, gateway IP address, DNS address and network address
 - it uses DHCP which provides all the above
 - DHCP can also tell it the operating system file it needs to download
 - and which tftp server to download it from
 - the DHCP server also allows options to be passed into the kernel

LTSP protocol review

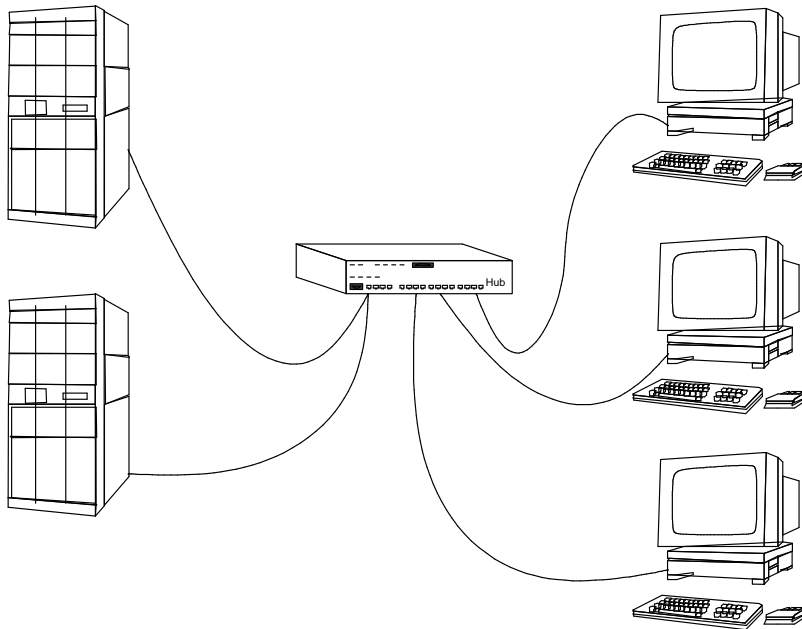
- TFTP server hosts the linux kernel

- once the kernel is loaded into client it is executed and it examines the options
 - these indicate the NFS server from where the root / directory is to be mounted
 - see option `root-path` in the dhcp configuration example

LTSP protocol review

- it mounts / from the prescribed server and runs a program called `/sbin/init`
- this runs all the start up programs and eventually it runs the graphical login session
- this is a client for the protocol which connects to the server
 - this is specified in the `/etc/lts.conf` file (found in the mounted filesystem)

Dynamic IP Address Assignment



- statically assigning IP addresses to computers has limitations
 - computer moves from one subnet to another
 - or if physical number of computers exceed available IP addresses

BOOTP Limitations

- BOOTP provides a configuration setting for a client
 - IP address, operating system, subnet mask, dns server, gateway address
 - a set of static settings from a host identifier to parameters for that host

- a manager must enter parameters for each host on the server
 - BOOTP does not dynamically allocate IP addresses

- nowadays it is common place for laptops to be join/leave different subnet networks

Dynamic Host Configuration Protocol (DHCP)

- has many advantages over BOOTP

- clients can obtain all configuration details in a single message
 - IP address, subnet mask, gateway, operating system server IP address
 - IP addresses allocated dynamically

- when a client boots it broadcasts a DHCP message on the local network
 - client receives (possibly multiple DHCP server offers)
 - selects one server and verifies acceptance

- can build a highly reliable system by using multiple servers

DHCP IP address assignment

- different types of IP address assignment
 - *manual configuration*
 - eg. manager allocates specific addresses per Ethernet address
 - *automatic configuration*
 - DHCP server allocates a permanent IP address when a client boots
 - *dynamic configuration*
 - DHCP server *loans* IP address for a limited time

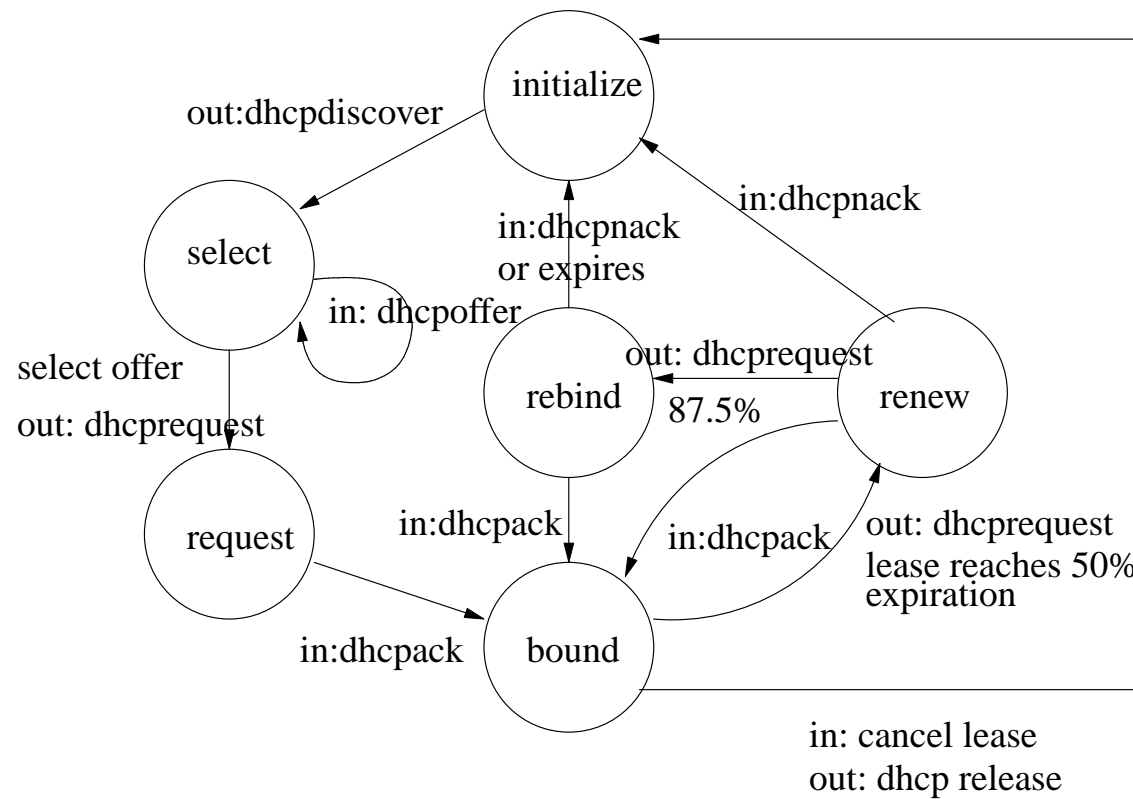
- DHCP servers can be configured to manage different clients with the three different IP address assignments

DHCP leased IP addresses

- DHCP specifies a minimum lease period of 1 hour
 - managers may specify default as 1 hour..oo

- client can release an IP address or request an extension to the lease

DHCP state transition diagram



DHCP state transition diagram

- key
 - in: indicates incoming message to client
 - out: client sends message
 - or event causing action

GNU/Linux dhcp configuration file /etc/dhcp3/dhcpd.conf

```
option domain-name "example.org";
option domain-name-servers 192.168.0.1;

default-lease-time 600;
max-lease-time 7200;

subnet 192.168.0.0 netmask 255.255.255.0 {
    range 192.168.0.21 192.168.0.200;
    option routers 192.168.0.1;
}

host miniitx {
    hardware ethernet 00:40:63:e0:4c:8d;
    option root-path "192.168.0.6:/opt/ltsp/i386" ;
    filename "/tftpboot/lts/2.6.9-ltsp-3/pxelinux.0";
    server-name "192.168.0.6";
    next-server 192.168.0.6 ;
}
```

tftp protocol

- trivial file transfer protocol

- ftp (file transfer protocol) is complex, it uses tcp
 - both client and server require management of multiple tcp connections

- small embedded machines or diskless workstations do not need this functionality
 - also difficult to implement (when all that is required is a file download mechanism)
 - it also doesn't have to be particularly fast

tftp protocol

- tftp code is simple, small and is ideal to be placed into ROM as part of a systems bootstrap process
- unlike ftp it uses UDP/IP rather than TCP/IP
- it implements its own reliable recovery mechanism (sliding window of size 1 otherwise known as idlerq)

tftp protocol

- operation is simple and the designers of tftp have fought to keep it this way over the 20+ years

- sending side (server) sends a file in 512 byte blocks
 - each block is sent
 - sender waits for an acknowledgement, before sending the next

- receiver sends an acknowledgement each time it receives a block

tftp protocol

- client

- initially sends a packet requesting a file transfer

- packet contains:

| 2 octet opcode | n octets | 1 octet | n octets | 1 octet |
|----------------|----------|---------|----------|---------|
| readreq (1) | filename | 0 | mode | 0 |

- trusted clients may also write a file to the server in which case the first two octets have the value 2
- blocks are numbered starting at 1 and each block is 512 bytes
 - any block shorter than 512 bytes indicates the last block (eof)

tftp packet types

- client write request

| | | | | |
|----------------|----------|---------|----------|---------|
| 2 octet opcode | n octets | 1 octet | n octets | 1 octet |
| writereq (2) | filename | 0 | mode | 0 |

- data packet

| | | |
|----------------|----------|------------------|
| 2 octet opcode | 2 octets | up to 512 octets |
| data (3) | block # | data octets... |

- acknowledgement

| | |
|----------------|----------|
| 2 octet opcode | 2 octets |
| ack (4) | block # |

tftp packet types

- error packet

2 octet opcode

2 octets

n octets

1 octet

| | | | |
|-----------|------------|---------------|---|
| error (5) | error code | error message | 0 |
|-----------|------------|---------------|---|

- tftp is symmetric

- each side implements a timeout and retransmission

- if sending side times out (ie it does not receive an ACK)

- it retransmits the last block

- if reading side does not receive a block within a time period it transmits an ACK

tftp configuration in GNU/Linux

- consists of installing the `tftpd` package and adding an entry to the `inetd.conf` file

```
tftp dgram udp wait nobody \  
  /usr/sbin/tcpd /usr/sbin/in.tftpd \  
  --tftpd-timeout 300 --retry-timeout 5 \  
  --mcast-port 1758 --mcast-addr 239.239.239.0-255 \  
  --mcast-ttl 1 --maxthread 100 --verbose=5 /tftpboot
```

- important fields are:
 - `/tftpboot` which limits the `tftp` daemon to transmitting files which are contained below: `/tftpboot`
 - otherwise there could be a security problem
 - configuration details tell `inetd` that this `tftp` is a UDP protocol and that it can serve the files using the multicast feature of IP

Pseudo code for tftp (IdleRQ with symmetric retransmission)

```
transmitTFTPfile () {
  frameno := 0 ;
  while true do {
    m := createNextFrameFromFile(frameno)
    transmitFrameOverUDP(m, frameno)
    repeat
      event := waitForEvent() ;
      case event of

        ackArrived : (* correct ack number arrived *) |

        nackArrived: transmitFrameOverUDP(m, frameno) |
        timeout      : transmitFrameOverUDP(m, frameno)

      esac
    until ackArrived
    inc(frameno)
  }
}
```

tftp client pseudo code

```
receiveFile () {  
  lastblock := 0  
  newblock := 0 ;  
  repeat  
    repeat  
      event := getFrameFromUDP(m) ;  
      case event of  
  
        data : newblock := getBlockNoFromFrame(m) ;  
              transmitAckOverUDP(newblock) |  
        timeout: transmitAckOverUDP(lastblock)  
  
      esac  
    until newblock==lastblock+1 ;  
    lastblock = newblock ;  
    storeFrameInMemory(m)  
  until frame size < 512 bytes  
}
```

Tutorial: Idle RQ Protocol

- warning the code below in this tutorial has a deliberate bug in it

Tutorial: Idle RQ Protocol

- suppose you implement an Idle RQ protocol where the transmitter code is summarised as:

```
n = 1
loop
  sends a frame of data (n)
  event = waitforevent();
  case event of

    timeout: break;
    ack      : n = ack_number()+1 ; break;
    nack     : break

  end
end
end
```

Tutorial: Idle RQ Protocol

- the receiver operates by:

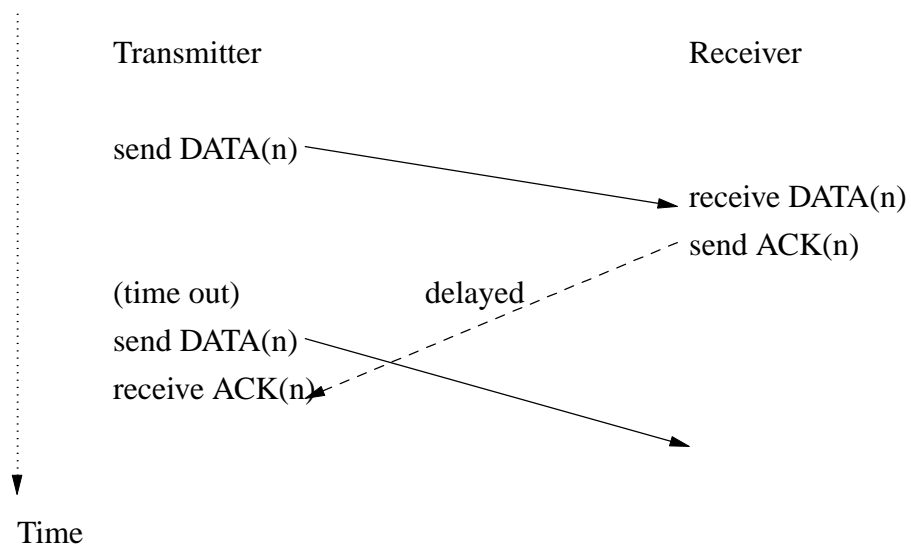
```
receive process
loop
  event = waitforevent();
  case event of

  received frame:  if not duplicate data frame(n)
                   then
                     give frame to higher layer(n)
                   fi
                   send_ack_number (n)

  end
end
```


Tutorial: Idle RQ Protocol

- on running the code and examining the packets sent across the network it is observed that the following packets are transmitted:



Tutorial: Idle RQ Protocol

- write down the next six frame numbers which are transmitted and complete the following diagram
- assume that only ACK(n) is delayed, causing one timeout.