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

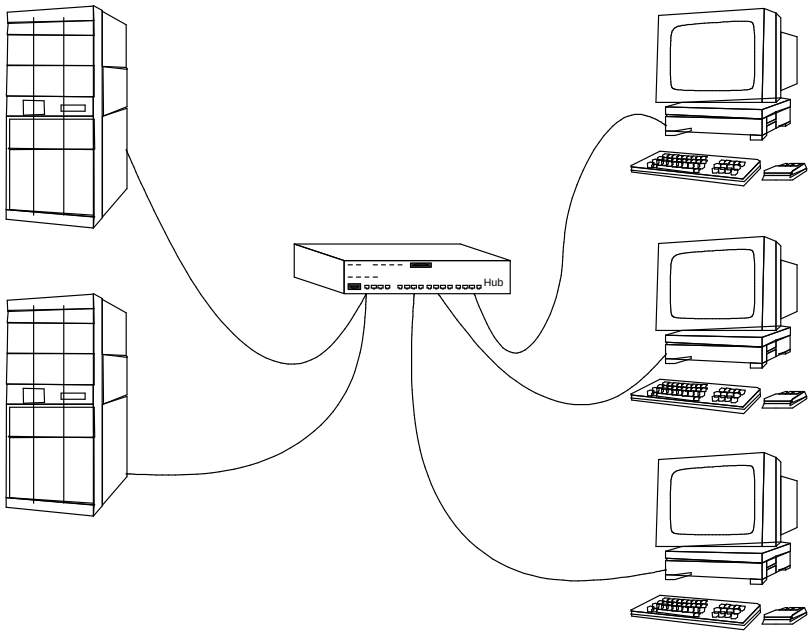
- TFTP server hosts the linux kernel

- 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

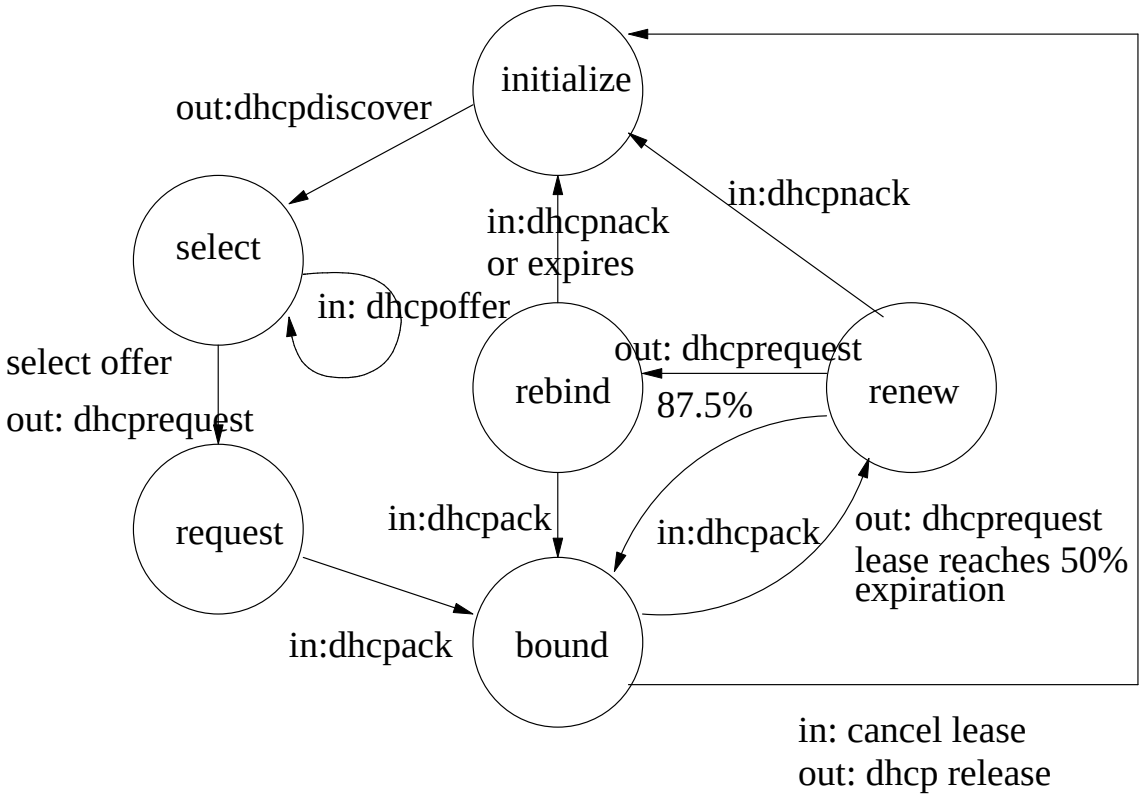
- DHCP servers can be configured to manage different clients with the three different IP address assignments

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
```

Tutorial: Idle RQ Protocol

- the receiver operates by:

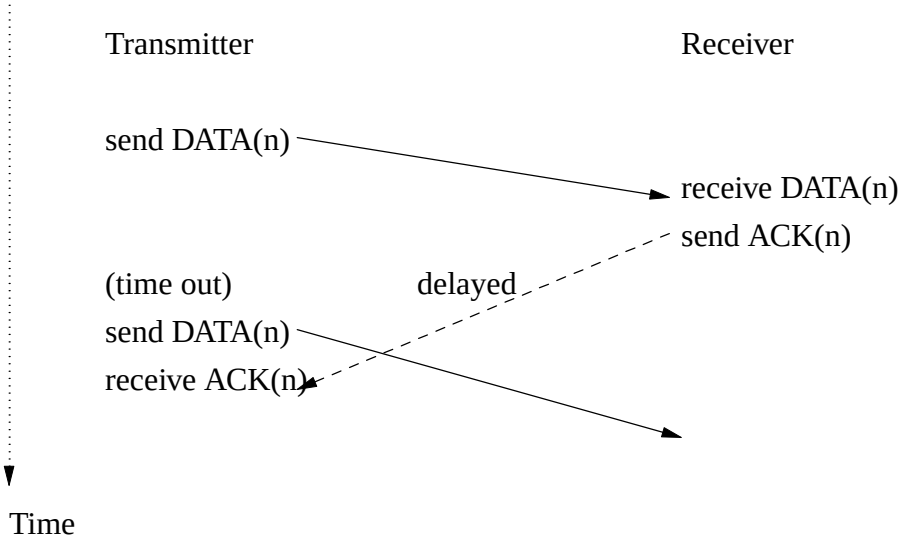
```
receive process
loop
   event = waitforevent();
   case event of

   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.