Dynamic Host Configuration Protocol (DHCP) and Domain Name System (DNS)

Nick Urbanik <nicku@vtc.edu.hk>
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Organising computers in a large network

Reference books:

The DHCP Handbook, Ralph Droms & Ted Lemon, 2nd edition,

DNS and Bind, Paul Albitz and Cricket Liu, 4th edition

DHCP: Why?

- Manually assigning IP addresses (the alternative to DHCP) causes:
  - More work to set up
  - Much more work to change
  - IP address conflicts
  - Unsatisfied users who configure their own machines to cause more conflicts

DHCP: Why not?

- Last year, on many Tuesday afternoons, our laboratories were disrupted by "network failure"
- This was caused by project students running DHCP servers on our network,
- …and also, by a small router running a DHCP server accidentally plugged into our campus network
- Solution: when detect this, run Ethereal listening on ports 67 and 68
- identify culprit, and turn off rogue server

What can DHCP do?

- Current standard DHCP servers can:
  - Allocate all IP parameters
  - Divide hosts into classes, based on many criteria, such as:
    - Manufacturer
    - Explicitly putting individual machines into different classes
    - Whether the machine is registered
  - Offer different parameters to machines in different classes
  - Dynamically update DNS servers
  - Support a DHCP failover protocol

Internet Software Consortium: ISC DHCP

- ISC makes **reference implementations** of DNS, DHCP
- Available from http://www.isc.org/
- Implemented by people directly involved with the standardisation process
- Provide the most standards compliant, most feature-rich implementations
- ISC DHCP server very robust
  - Computer Centre in TY used MS DHCP on NT 4
  - Crashed twice, with complete loss of database containing MAC addresses of all computers on campus
  - Out of action for two days at a time, long sessions of manual retyping of all the data again
- Replaced with system based on ISC DHCP server on a 486
- Has worked well ever since (no down time)

Characteristics of DHCP

- **All** communication initiated by the client
- Uses UDP on port 68 for client, port 67 for server
  - One DHCP session has a common xid ("transaction ID" in Ethereal), randomly selected by the client
- Uses **unicast** when client has IP address, [and client is **not** in REBINDING state — see later]; **broadcast** otherwise
- Addresses offered from
  - **address pools**, or
  - Fixed addresses allocated to particular computers

Leases

- Server offers IP address and network parameters for a limited time (called a **lease**)
- In practice, leases may very from 30 minutes to a week or so
- Short lease:
  - clients get updated parameters quickly
  - Essential if have more clients than addresses
  - requires more processing power on server
- Long lease:
  - more reliable (clients may continue to operate for a week after DHCP server fails)
  - but takes longer for all clients to get new settings if they change

(Some) Standards for DHCP

- RFC 2131 — Basic DHCP operation
  - excerpts from this appear in exams!
- RFC 2132 — DHCP options: a list of the kinds of things a client can ask a DHCP server for
- IETF Drafts:
  - draft-ietf-dhc-authentication-14.txt
    - supports authentication between clients and servers
  - draft-ietf-dhc-dhcp-dns-12.txt
    - interaction between DHCP and DNS servers
  - draft-ietf-dhc-failover-07.txt
    - supports failover between 2 DHCP servers

DHCP Messages 1

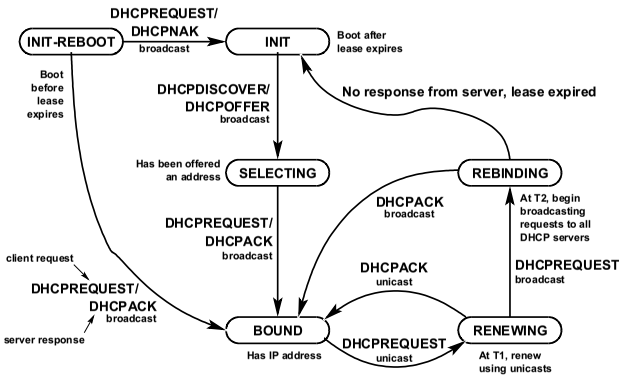
- DHCPDISCOVER — from client
  - client has no address, asking for a new one
- DHCPOFFER — from server
  - Offer of address and other parameters
- DHCPREQUEST — from client
  - Client asks if can use the offered address and parameters
- DHCPACK — from server
  - Server says "yes, go ahead, this address and these parameters are yours; the lease starts now."

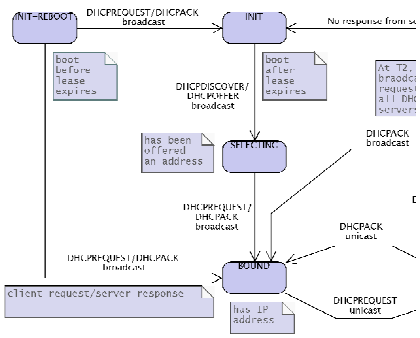
DHCP Messages 2

- DHCPNAK — from server
  - "no, you may not have that address; go to the INIT state"
- DHCPDECLINE — from client
  - Client has detected another machine is using the offered address, and tells the server about this problem
- DHCPRELEASE — from client
  - Server expires the lease immediately
- DHCPINFORM — from client
  - Client already has an IP address, but wants other network settings from the server

State Diagram for DHCP protocol

- See page 34 of RFC 2131 for a more complete state diagram.





DHCP Client States 1

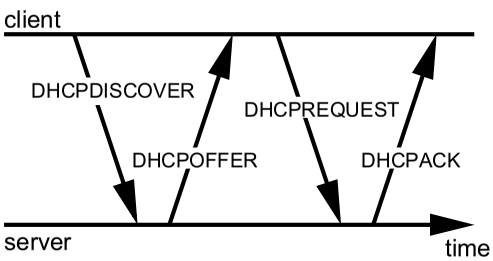
- INIT (client is booting)
  - no IP address yet.
  - next message from client will be a broadcast DHCPDISCOVER.
- INIT-REBOOT (has unexpired lease)
  - has IP address, but is not using it
  - client will next broadcast DHCPREQUEST
  - Will move to BIND state if no response
- SELECTING (has received at least one DHCPOFFER)
  - Waiting for any other DHCPOFFERS
- BOUND (Client has an address)
  - Initiated by client receiving DHCPACK to DHCPREQUEST
  - Send no more messages until T1 (renewal time, configured in client by the server)

DHCP Client States 2

- RENEWING (client has reached **renewal time** T1 in BOUND state)
  - client **unicasts** DHCPREQUEST to server
  - server **unicasts** DHCPACK to client
  - T1 = lease time / 2
- REBINDING (client has reached **rebinding time** T2 without DHCPACK from server)
  - client broadcasts DHCPREQUEST
  - client is looking for another server
  - T2 = lease time * 7/8
  - If lease expires, client goes back to INIT state
    - Any network connections lost—bad for users!! Don't let it happen to them!

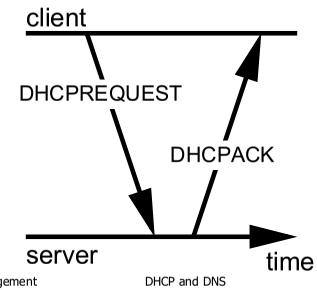
Obtaining an initial configuration

- The client is booting, with no IP lease

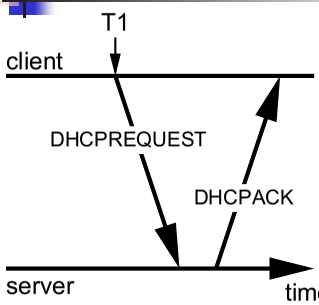


Confirming an IP Address when restarting

- The client's lease has not expired



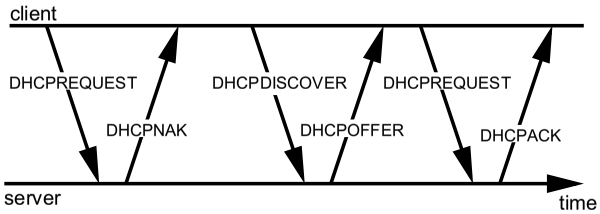
Extending a lease



- Lease is extended at T1 before expires
- Unicast, because address is valid
  - only case of unicast in DHCP protocol
- T1 = leasetime/2

Moving a computer to new subnet

- Refuse old address, issue a new one



Problems on the Network

- Often a computer has a bad configuration
- Faulty hardware may also cause excessive resending of bad packets
- Less often, a person may be doing something naughty on purpose!
- Need some way to:
  - track the location of a computer on the network
  - determine if a computer is managed by the company or is a notebook brought in by a visitor
- Want some way to register company machines

Ways of using DHCP

- There are two fundamentally different ways of using DHCP
- Typified by implementation in Campus, and ICT (till yesterday)
  - (both implemented by Nick!)
  - Fixed addresses for registered clients (Campus network)
  - Dynamic addresses for all comers (ICT till recently)
- Better: can provide automatic registration for clients: see chapter 20 of **The DHCP Handbook**

`/etc/dhcpd.conf`

- This plain text configuration controls behaviour of ISC DHCP server
- ISC DHCP server supports conditional statements, switch statements, substring expressions
  - Almost a complete programming language!
- This text file can be generated by software (Perl programs often used)

`dhcpd.leases`

- This plain text file is generated by the DHCP server
- Can be parsed by a Perl program
- Can be used to determine the MAC address of an unregistered computer

Advantage of text configuration

- Text can be easily generated by a program
- Can be easily checked by a human
- Microsoft DHCP server configuration and lease information is in an undocumented binary format
- reduces what can be done with it
- makes it hard to enter large amounts of information about many computers
  - experience at Tsing Yi Computer Centre

host records with fixed address

- Can specify a fixed address for particular hosts:

```
# Machine type = COMPAQ DESKPRO  Laboratory = A204c
host a204c-03 {
    hardware ethernet 00:01:03:44:1d:62;
    fixed-address 172.19.80.003;
}
# Machine type = COMPAQ DESKPRO  Laboratory = A204c
host a204c-04 {
    hardware ethernet 00:01:03:45:2d:8f;
    fixed-address 172.19.80.004;
}
```

- Can generate these with a Perl program

Method used by Computer Centre

- Uses Samba, ISC DHCP
- Documented on our web site; see the link to "DHCP and DNS System"
  http://ictlab.tyict.vtc.edu.hk/snm/dhcp-dns-system/

Older method used in ICT: free for all!

- Each client is offered:
  - an address in range 172.19.123.1 to 172.19.127.200
  - netmask /18
  - default gateway 172.19.127.254
  - domain name, tyict.vtc.edu.hk
  - name servers 172.19.64.52, 202.40.209.220
  - WINS servers 192.168.68.240, 202.20.100.226
  - NTP server ntp.tyict.vtc.edu.hk
  - a lease of 2 hours (7200 seconds / 3600)
- The DHCP server attempts to create a DNS record for the client
- A separate log file will be created (see man syslog)

Older method used in ICT: free for all!

```
authoritative;
log-facility local1;

option domain-name "tyict.vtc.edu.hk";
ddns-update-style interim;
option netbios-name-servers 192.168.68.240, 202.20.100.226;
option domain-name-servers 172.19.64.52, 202.40.209.220;
option ntp-servers ntp.tyict.vtc.edu.hk;
subnet 172.19.64.0 netmask 255.255.192.0 {
    option routers  172.19.127.254;
    max-lease-time 7200;
    default-lease-time 7200;
    range 172.19.123.1  172.19.127.200;
}
```


Troubleshooting DHCP 1

- Our major problem: unauthorised DHCP servers giving DHCPNAK to all requests
- Solution: use **`ethereal`** in promiscuous mode with filter **`port 67 or port 68`**
- Examine packets from rogue server
- Use **`xnmap`** to gather more information about the rogue server
- Now go and talk with the person responsible

Troubleshooting DHCP 2

- Other problems:
- Examine the dhcpd log using tail –f
  - shows all dhcp messages received and sent by the server
- Examine log on the client
- Use tcpdump or ethereal to collect data
  - analyse it in Ethereal
- Compare with the client state diagram
- Compare with normal, expected behaviour

Automatic Client Registration

- It is good to be able to map IP addresses to particular computers (and users)
- Often computers cause trouble without the user being aware
  - e.g., project students with rogue DHCP servers
- Want convenience for user and sysadmin
- Can use the ISC DHCP server to implement such an automatic registration system.
- Depends on dividing IP hosts into two **classes**: known and unknown.

ISC DHCP host declarations

- The file /etc/dhcpd.conf controls the behaviour of the ISC DHCP server
- It may be edited by external programs and host statements may be added:
- Examples:

```
host a204-16 {
    hardware ethernet 00:08:02:1d:87:72;
}
host a204-17 {
    hardware ethernet 00:08:02:1d:87:02;
}
host a204-18 {
    hardware ethernet 00:08:02:1c:1c:43;
}
```

Known and unknown hosts

- A host is **known** if it has a host declaration

```
subnet 172.19.64.0 netmask 255.255.192.0 {
    option routers 172.19.127.254;

    # Unknown clients get this pool.
    pool {
        option domain-name-servers bogus.tyict.vtc.edu.hk;
        max-lease-time 120;
        range 172.19.120.0  172.19.122.255;
        allow unknown clients;
    }

    # Known clients get this pool.
    pool {
        option domain-name-servers ns.tyict.vtc.edu.hk;
        max-lease-time 28800;
        range range 172.19.123.1  172.19.127.200;
        deny unknown clients;
    }
}
```


Known and unknown hosts

- So the hosts a204-16, a204-17 and a204-18 get full parameters
- Others (without a hosts declaration) get
  - a short lease
  - a bogus name server that redirects all web access to a registration server
- Block the IP addresses from unknown hosts at the firewall
- they get no Internet access
- users are motivated to register

The registration server

- All unregistered hosts get a "bogus" name server that maps all hostnames to itself
- The web browser will go to the registration application, no matter URL entered
- Registration application edits /etc/dhcpd.conf on DHCP server
- Adds the host as a **known host**
- Gets the information from the DHCP lease
- User just needs to enter their user name and LDAP password

Registered computer

- Now the client can either reboot, or wait 60 seconds to T1, and get a long term lease
- The machine becomes a "known host"
- Client can now access Internet conveniently
- Could extend this by adding MAC address to access control list of the appropriate port on the main switch
- Unregistered computers blocked by switch
- Enforces limiting access to registered computers only