DHCP and DNS

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

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
  - See experience with Tsing Yi Computer Centre

Experience at Tsing Yi CC

- At Tsing Yi Computer Centre:
  - 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.”

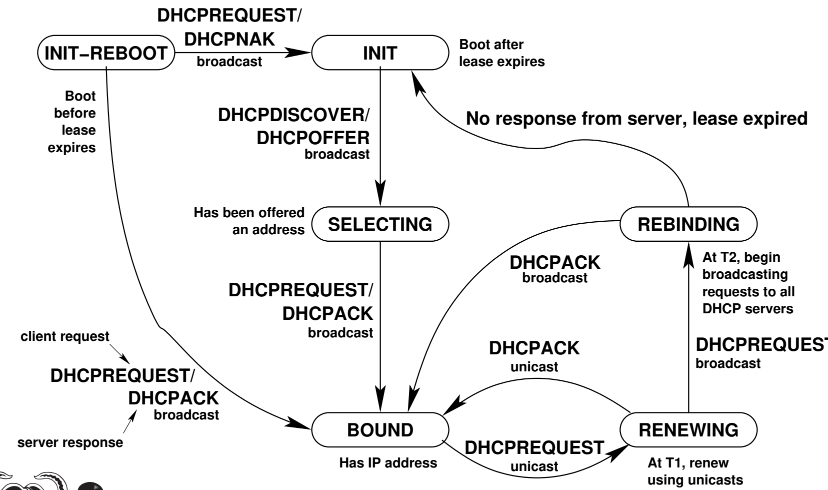
DHCP Messages — 2

- `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



DHCP Client States — 2

- `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 `DHCPOFFER`s

DHCP Client States — 3

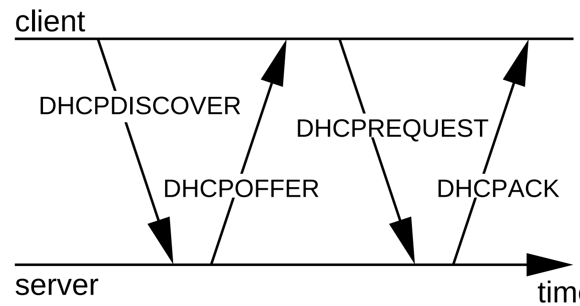
- `BOUND` (Client has an address)
  - Initiated by client receiving `DHCPACK` to `DHCPREQUEST`
  - Send no more messages until T1 (renewal time, configured in client by the server)
- `RENEWING` (client has reached *renewal time* $T1$ in `BOUND` state)
  - client *unicasts* `DHCPREQUEST` to server
  - server *unicasts* `DHCPACK` to client
  - $T1 =$ lease time$/2$

DHCP Client States — 4

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

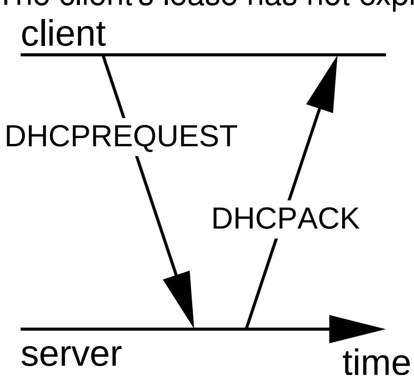
Obtaining an initial configuration

- The client is booting, with no IP lease



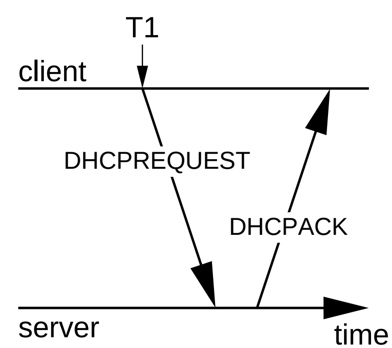
Confirming an IP Address when restarting

- The client's lease has not expired



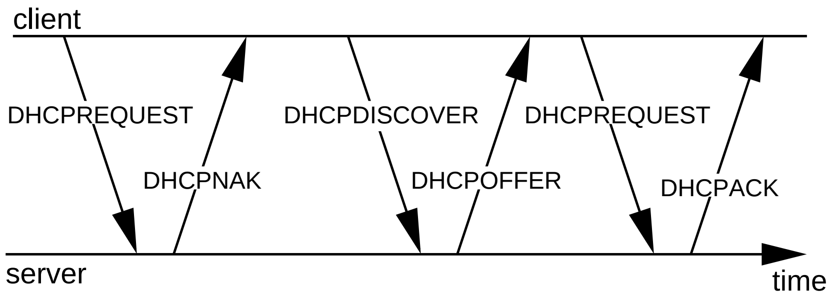
Extending a lease

- 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 last week)
  - (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/`

Method Currently used by ICT

- Fixed DHCP and DNS records generated from an Excel spreadsheet
- Same as older method used by Computer Centre
- . . . but also use the Perl module `Spreadsheet::ParseExcel`, which can read an Excel Spreadsheet directly — see `parse-excel.pl` at the URL in slide 28
- Generates DNS records also, using `h2n`

`h2n`—not a bird flu

- According to `http://www.menandmice.com/6000/61_recent_survey.html`, 68% of DNS servers in .com domain are misconfigured.
- System administrators can make many mistakes
- Best to generate DNS resource records with a progam rather than by hand
- `h2n`, available from `http://www.deer-run.com/~hal/h2n/` and `http://examples.oreilly.com/dns4/`
- input: a file in host table format (of `/etc/hosts`)
- output is all the resource records, and DNS server configuration file.

Method Currently used by ICT—2

- `cron` job runs every 2 minutes, and does the following:

```
if ⟨excel spreadsheet⟩ is newer than /etc/dhcpd.conf
    parse ⟨excel spreadsheet⟩ into a ⟨hostfile⟩
    append any other required  host files to this ⟨hostfile⟩
    if generate /tmp/dhcpd.conf from ⟨hostfile⟩
        move /tmp/dhcpd.conf to /etc/dhcpd.conf
        restart DHCP server
        ensure ⟨excel spreadsheet⟩ is not newer than /etc/dhcpd.conf
        stop DNS server
        wait for it to stop
        generate DNS resource records from ⟨hostfile⟩
        remove DNS journal files
        start DNS server
```


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 ($2 = 7200$ 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 DHCP server 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

Making it easy for customers to register their computers

Avoiding manual misconfigured settings

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

Registration Application

- A web application
- User interface is very simple — enter only:
  - user name
  - password
- Application knows IP address from web server
- Looks up MAC address from DHCP leases file
- Edits `/etc/dhcpd.conf`, adds a host record
- Can assign a fixed or dynamic address

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

Fixed or Dynamic Addresses

- Would it be better to have known host records for registered computers and *dynamic addresses*, registered *dynamically* with the DNS server. . .
- Or is it better to have *fixed addresses* and *fixed* DNS records?
- I think that dynamic updates to DNS provide no additional benefit, and simply make the system more complex.
- I recommend making the system as simple as possible
  - both for the system administrator and the users
  - . . . bot no simpler.