Announcements

I. HW5 online today, due in 1 week!

Today’s Lecture

I. Auto configuration
II. BOOTP
III. DHCP

Host Autoconfiguration

- What are the networking parameters needed to configure a host?
- Essential
  - Own IP address
  - subnet mask
  - gateway (default router) IP address
  - DNS server IP address
- Many others would be useful, as well

Host Autoconfiguration (cont’d)

- Choices of configuration
  - static (in configuration file on the local disk)
  - dynamic (from a server)
- How do you ask a server to send configuration information if you don’t have an IP address?
Protocol Choices

- **Minimal**: Reverse ARP (RARP)
  - requests IP address corresponding to MAC address
  - can only provide the client’s IP address

- **Better**: BOOTP
  - provides many other configuration parameter values

- **Best**: DHCP
  - provides limited lifetimes on configuration information

BOOTstrap Protocol (RFCs 951, 1542)

- Single message exchange from server to client
  - provides many items needed at startup, in addition to the IP address

BOOTP Messages

- Client (host) uses the limited broadcast IP address (255.255.255.255) to broadcast the **BOOTP Request** on the local net
  - source IP address = 0.0.0.0 (used only during bootstrapping)
  - multi-homed hosts issue **one** BOOTP Request for each interface

- **BOOTP** server responds, may use the limited broadcast address as destination of the **BOOTP Reply**

BOOTP Reliability

- **BOOTP** runs over UDP
  - client is responsible for ensuring reliable communication

- if no **Reply** after sufficient time, timeout and retransmit **Request**
  - wait “random” delay before retransmission (between 0 and 4 s)
  - double timeout value each time (exponential backoff)

BOOTP Message Format

- **Length** = 236 bytes + Options

<table>
<thead>
<tr>
<th>Field</th>
<th># Bytes</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation Type</td>
<td>1</td>
<td>Request or Reply</td>
</tr>
<tr>
<td>Hardware Type</td>
<td>1</td>
<td>e.g., Ethernet</td>
</tr>
<tr>
<td>Length of physical address</td>
<td>1</td>
<td>6 for Ethernet</td>
</tr>
<tr>
<td># of Hops</td>
<td>1</td>
<td>Initialized to 0, relays increment</td>
</tr>
<tr>
<td>Transaction ID</td>
<td>4</td>
<td>For matching Reply with Request</td>
</tr>
<tr>
<td>Seconds (since booting started)</td>
<td>2</td>
<td>For prioritizing / forwarding Requests</td>
</tr>
<tr>
<td>Flags</td>
<td>2</td>
<td>To indicate response should be broadcast</td>
</tr>
</tbody>
</table>
If client wants specific server to respond

Server Host Name
Name of file containing memory image (in Request, type of OS desired)

Variable

Client Hardware Address

Client IP Address
0 if client doesn’t know
4
4 IP address to use (returned by server)
4
If client wants specific server to respond
4
(Discussed later)
16
So server can unicast response to client
64
If client wants specific server to respond
128
Name of file containing memory image (in Request, type of OS desired)
variable
(Discussed later)

• Encoding of each option: TLV format
  – T = type or tag (1 byte)
  – L = length (1 byte)
  – V = value of option (N bytes)

• Examples of options
  – subnet mask
  – client host name
  – memory image size
  – time of day
  – gateway IP addresses
  – DNS server IP addresses

• BOOTP Relay Agents permit a machine to contact a BOOTP server on a non-local network

• If a server decides to relay a Request...
  – it puts its own IP interface address in the Relay IP Address field
  – and forwards to the BOOTP server
  – clients ignore the Relay IP Address field in a Reply

• Destination server sends Reply message to the relay agent (server)
  – all Replies received by a relay agent are intended for clients on its directly-connected network

• A Relay Agent examines the Relay IP address, Your IP Address, and Client Hardware Address to deliver the Reply message to the client
Dynamic Configuration

• RARP and BOOTP are designed for a relatively static environment

• Problems
  – need to assign one machine different IP addresses at different times
  – need to reuse pool of IP addresses (clients only use addresses temporarily)

• Solution: dynamic address assignment mechanism

Dynamic Host Configuration Protocol

(RFCs 2131, 2132)

• Extends BOOTP to handle dynamic address assignment
  – “leases” an address for a limited time (from 1 sec to forever)
  – backwards-compatible with BOOTP clients, message format is the same

DHCP (cont’d)

• DHCP server
  – is given a set of addresses to manage
  – leases addresses to clients
  – informs client of lease period (during which it will not lease same address to another client)

• At end of the lease period, the client must either renew the lease, or stop using the address

DHCP Client State Diagram

DHCP Messages

• Same format as BOOTP messages

• Client should set Broadcast Flag to 1 if it does not have a valid IP address already

• DHCPoffer message includes configuration parameters, such as Your IP Address

• Same Options as BOOTP, plus some additional ones
**DHCPINFORM Message**

- If client already has IP address but requests other configuration parameters from the server
- Server unicasts to client a DHCPACK with parameters, but
  - Does not allocate new IP address
  - Does not provide lease times

**Some Example Options Fields**

- IP information
  - subnet mask
  - host name and domain name (for client)
  - IP forwarding option
  - default IP TTL
  - interface MTU, maximum datagram reassembly size
  - broadcast address to use
  - static routes option

**Example Options Fields (cont’d)**

- Bootstrapping information
  - local time
  - boot file size
  - image server, root path
  - relay agents to use
- Other
  - ARP cache timeout intervals
  - application parameters
- Lots of "vendor-specific" parameters

**Example DHCP Request (Selected Fields)**

```
Option 50: Requested IP Address = 152.14.62.39
Option 12: Host Name = "mulberry"
Option 55: Parameter Request List
  1 = Subnet Mask
  15 = Domain Name
  3 = Router
  6 = Domain Name Server
  44 = NetBIOS over TCP/IP Name Server
  31 = Perform Router Discover
  33 = Static Route
```

**Example DHCP ACK (Selected Fields)**

```
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Option 12: Host Name = "mulberry"
Option 55: Parameter Request List
  1 = Subnet Mask
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<table>
<thead>
<tr>
<th>Option</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>54</td>
<td>Server Identifier = 152.1.1.107</td>
</tr>
<tr>
<td>1</td>
<td>Subnet Mask = 255.255.255.192</td>
</tr>
<tr>
<td>3</td>
<td>Router = 152.14.62.1</td>
</tr>
<tr>
<td>6</td>
<td>Domain Name Server</td>
</tr>
<tr>
<td></td>
<td>IP Address: 152.1.1.161</td>
</tr>
<tr>
<td></td>
<td>IP Address: 152.1.1.248</td>
</tr>
<tr>
<td>12</td>
<td>Host Name = &quot;mulberry&quot;</td>
</tr>
<tr>
<td>15</td>
<td>Domain Name = &quot;csc.ncsu.edu&quot;</td>
</tr>
<tr>
<td>44</td>
<td>NetBIOS over TCP/IP Name Server = 152.1.2.42</td>
</tr>
<tr>
<td>56</td>
<td>Renewal Time Value = 3 days</td>
</tr>
<tr>
<td>59</td>
<td>Rebinding Time Value = 7 days</td>
</tr>
<tr>
<td>51</td>
<td>IP Address Lease Time = infinity</td>
</tr>
</tbody>
</table>

Summary

1. BOOTP works well, but doesn’t allow limited lifetimes
2. DHCP pretty much universally used to configure hosts
3. Can be combined with user authentication to restrict who can get network access

Next Lecture

- Domain Name System (DNS), Part I