Address Resolution: BOOTP & DHCP

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Content

- Alternatives to RARP
- BOOTP Protocol
- DHCP Protocol

Reference: chapter 23

Alternatives to RARP

- During the startup of a diskless computer, it needs to know:
  - Its IP address
  - File server address
  - Nearest router address
  - ……
- RARP drawbacks
  - RARP requires direct access to network hardware → difficult to build server-side application program
  - RARP reply contains limited information
  - RARP cannot be used on networks that dynamically assign hardware addresses

Alternatives to RARP (cont.)

- Alternatives to RARP
  - Two bootstrap protocols
    BOOTP & DHCP
  - Both protocols allows a host to determine its IP address without RARP
  - Two protocols are closely-related
  - DHCP is a successor of BOOTP
  - Both protocols use UDP for communication
    - can be implemented with an application program

BOOTP Protocol

- BOOTP: Bootstrap Protocol
  - Provides information about:

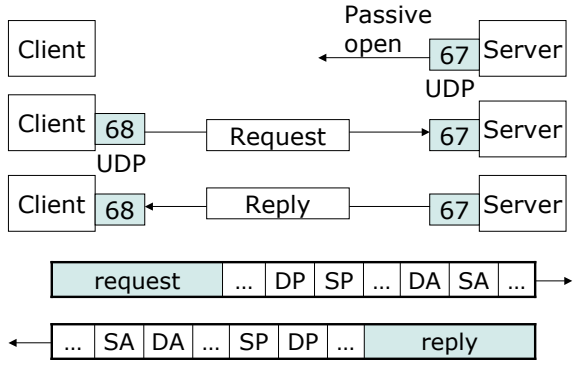
    IP address of the requester, router, name server; subnet mask; ……
- A client / server protocol
  - Client broadcasts BOOTP request
    - Client does not know server's IP address
  - Server usually broadcasts BOOTP reply, even if it knows the client's IP address
    - Client does not know its own IP address before it gets the BOOTP reply

BOOTP Protocol (cont.)

- Use IP to determine IP address
  - How can a computer send BOOTP message in an IP datagram before knowing its IP address?
    - Limited broadcast address
      - all 1s (255.255.255.255)
    - IP software can accept and broadcast datagrams that specify the limited broadcast address even before the software discovers its local IP address

BOOTP Protocol (cont.)

- Operation



BOOTP Protocol (cont.)

- Transmission policy
  - Require UDP to use checksums
  - Request and reply should be sent with the *do not fragment* bit set
  - Multiple replies are allowed; the first reply is accepted and processed
  - Client is responsible for communication reliability
    - Handle datagram loss with conventional technique of *timeout and retransmission*
    - Random retransmission timer is recommended
    - Double the timer after each retransmission before it reaches 60s

BOOTP Protocol (cont.)

- Two-step bootstrap procedure
  - Server provides the client with information to obtain a memory image
    - The server maintains a database that only knows the names of memory images
  - Client uses a second protocol (TFTP) to obtain memory image

  * Advantages
    - Allow clean separation of configuration and storage

BOOTP Protocol (cont.)

- Relay agent
  - Use a remote BOOTP server to serve several LANs
    - Broadcast address cannot reach the server outside of the local network
  - A relay agent is a router that can help send local requests to remote servers
    - When the relay agent receives broadcast request from a client, it forwards it to the remote server
    - The remote server sends the reply to the relay agent, which is then forwarded to the client

BOOTP Protocol (cont.)

- Message format

OP	HTYPE	HLEN	HOPS
Transaction ID			
SECONDS		Unused	
Client IP address			
Your IP address			
Server IP address			
Router IP address			
Client hardware address (16 bytes)			
Server host name (64 bytes)			
Boot file name (128 bytes)			
Vendor-specific area (64 bytes)			

BOOTP Protocol (cont.)

- All fields have fixed length
  - To keep implementation small enough to fit in ROM
- Request and reply have the same format
- Client fills in as much information as it knows, and leaves remaining fields to zero

BOOTP Protocol (cont.)

- OP: operation code
  - Request: 1; reply: 2
- HTYPE: hardware type
  - Ethernet: 1
- HLEN: hardware address length
  - Ethernet HA: 6
- HOPS
  - Maximum # of hops the message can travel
- Transaction ID
  - An integer to match reply with request

BOOTP Protocol (cont.)

- Seconds
  - # of seconds since the client started to boot
- Client IP address & Your IP address
  - If client knows its IP address
    - Place it in the *Client IP address* field
  - If client does not know its IP address
    - Put zero in the *Client IP address* field in the request
    - Server returns client's IP address in *Your IP address* field

BOOTP Protocol (cont.)

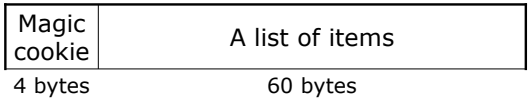
- Server IP address & Server host name
  - If client knows the the name or address of a specific server
    - Fill in the *Server IP address* or *Server host name* field
  - If client not know server's name / address
    - Fill in zero in the field(s)
  - If these fields are non-zero
    - Only server with matching name / address will answer the request
  - If these fields are zero
    - Any server that receives the request will reply

BOOTP Protocol (cont.)

- Router IP address
  - IP address of a router; filled by server
- Client hardware address
  - Supplied by client in the request
- Boot file name
  - Full pathname of the boot file
  - If generic name is used in request (e.g., Unix)
    - Server consults its database to map the generic name into a specific file name
    - Returns the name in the reply
  - If boot file name is zero in request
    - Server selects a memory image for the client (Completely automatic bootstrapping)

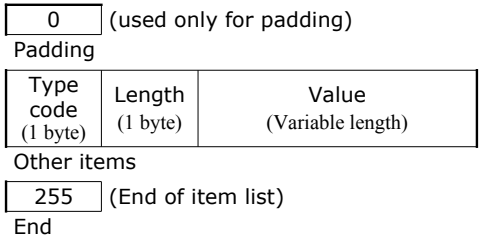
BOOTP Protocol (cont.)

- Vendor-specific area
  - Contain optional information to be passed from server to client
  - Used only in the reply message
  - Format
    - Magic cookie: 99.130.83.99
    - A list of items
    * If magic cookie presents, next 60 bytes are vendor-specific items



BOOTP Protocol (cont.)

- Items in vendor-specific area
  * Most of the items use TLV encoding: (type code, length, value)
    - Length: length of the value field, not the whole item
  * *Padding* and *End* only contain type code



BOOTP Protocol (cont.)

Item	Type code	Length (bytes)	Value
Padding	0	-	-
Subnet mask	1	4	Subnet mask
Time of day	2	4	Time of day
Routers	3	N	IP addresses of N/4 routers
Time server	4	N	IP addresses of N/4 timer servers
.....	.....	.....	.....
Reserved	128-254	variable	Reserved for specific vendor
End	255	-	-

BOOTP Protocol (cont.)

- Limitations of BOOTP
  - BOOTP works well only in a relatively static environment
    - Computers remain at fixed locations
    - BOOTP configuration file is manually created to specify BOOTP parameters for each host; it cannot be changed quickly (static assignment)
  - There must be enough IP addresses to be assigned to each computer

DHCP Protocol

- DHCP: Dynamic Host Configuration Protocol
- DHCP extends BOOTP in 2 ways
  - Allows a computer to acquire all the configuration information in a single message
  - Allows a computer to obtain an IP address quickly and dynamically
    - DHCP server is configured to supply IP addresses
- DHCP port number
  - Server port: 67, client port: 68

DHCP Protocol (cont.)

- 3 types of address assignment
  - Manual configuration
    - Configure a specific address for a specific computer
    - Backward compatible with BOOTP
  - Automatic configuration
    - Assign a permanent address when a computer first attaches to the network
  - Dynamic configuration
    - Server "loans" an address to a computer for a limited time
- DHCP server uses hardware address as client identifier

DHCP Protocol (cont.)

- Dynamic address assignment
  - DHCP server begins with a set of IP addresses
  - The administrator specifies the rules by which the server operates
  - The client exchanges messages with the server to negotiate the use of an address
    - Server does not need not know the identity of a client beforehand
    - Server provides an address for client
    - Client verifies that it accepts the address

DHCP Protocol (cont.)

- Server leases an address to a client for a finite period of time
  - During lease period, server will not lease the same address to another client
  - At the end of lease period, client must renew the lease or stop using the address
  - How long should a lease last?
    - DHCP does not specify a fixed constant for the lease period
    - The client can request a specific lease period
    - The server informs the client of the lease period it grants
    - Extreme case: infinity lease (like permanent address assignments in BOOTP)

DHCP Protocol (cont.)

- Multiple addresses obtaining
  - A DHCP message only provides information about one interface
  - Multi-homed computer
    - It need obtain configuration information for each interface when it boots
    - It should handle each interface separately
- Relay agent in DHCP
  - Relay agent is used if a remote DHCP server serves several LANs

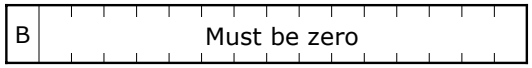
DHCP Protocol (cont.)

- State transitions of DHCP client

  (Fig 23.4 in the textbook)
  - To use DHCP
    - The client broadcasts a message to all servers on the local network, then collects offers from the servers, selects one offer, and verifies acceptance with the server
  - To terminate lease
    - The client sends a release message to the server
  - To renew lease
    - The client sets 3 timers to control lease renewal, rebinding and expiration

DHCP Protocol (cont.)

- Message format
  - DHCP uses the BOOTP message format
    - DHCP server can be programmed to answer BOOTP requests
  - Modify the contents and meanings of some fields
    - Change BOOTP's unused field to 16-bit FLAGS field
      - BROADCAST flag (B): set by the client to force broadcast reply (instead of unicast) from the server



DHCP Protocol (cont.)

- Add several options
  - DHCP option uses the same format as vendor-specific items in BOOTP: (type code, length, value)
  - Options field in DHCP can be up to 312 bytes
  - DHCP honors all the vendor-specific items defined for BOOTP
  - Add options to define lease time, etc
  - Add *DHCP Message Type* option

Type code	Length	Value
53	1	1 (DHCPDISCOVER) 2 (DHCPOFFER) 3 (DHCPREQUEST) …… 7 (DHCPRELEASE)

DHCP Protocol (cont.)

- Add *Option Overload* option

  . *Server host name* field and *Boot file name* field occupy many bytes

  . When an *Option Overload* option presents, the receiver will ignore the usual meaning of these 2 fields, and look for options in these fields instead

DHCP Protocol (cont.)

OP	HTYPE	HLEN	HOPS
Transaction ID			
SECONDS		FLAGS	
Client IP address			
Your IP address			
Server IP address			
Router IP address			
Client hardware address (16 bytes)			
Server host name (64 bytes)			
Boot file name (128 bytes)			
Options (variable length)			

DHCP Protocol (cont.)

- DHCP and domain names
  - DHCP does not interact with the domain name system (DNS)
    - Binding between a host name and the IP address assigned by DHCP must be managed independently
  - What name should a host receive when it obtains an IP address from DHCP?
    - Possibility 1: not receive a name
      - Using an unnamed computer can be inconvenient

DHCP Protocol (cont.)

- Possibility 2: automatically assigned a name along with an IP address
  - Names can be preallocated
  - No change is required to DNS
  - Disadvantage: host receives a new name whenever it receives a new address
- Possibility 3: be assigned a permanent name
  - Permanent name requires coordination between DHCP and DNS
  - There is no protocol that maintains permanent host name while allowing DHCP to change IP addresses