RARP server is on a different network than the device requesting its IP address. To overcome this problem, another protocol, called *BOOTP*, is used to deliver the RARP request from router to router until the RARP request reaches the RARP server. The BOOTP packets are directed packets, so broadcasts are not introduced on all the networks between the RARP requester and the RARP server.

ATM'S ADDRESS RESOLUTION PROTOCOL

In order for an ATM network to operate with IP networks, there needs to be some mechanism to resolve the IP address to the ARM hardware addresses. This is accomplished with a protocol called ATM'S Address Resolution Protocol (ATMARP), which is part of the Classical IP over ATM model. In this scheme, ATMARP uses an ARP server to handle the address resolution requests. This permits address resolution to occur without the need to support broadcasts.

Review Questions

6.1 Which of the following IP protocols uses a hierarchical addressing or naming structure?
- **a.** DNS
- **b.** ARP
- **c.** BOOTP
- **d.** LDAP

6.2 Write two examples of hierarchical naming and addressing.

6.3 How many octets are in an IPv6 address that does not contain any zeros?

6.4 What is meant by the term *addressing* in computer networks?

6.5 How can a device recognize that an incoming packet is an ARP request?

6.6 How many responses does the sender of an ARP broadcast request expect to receive?

6.7 Suppose that the definition of a Class B network uses 20 out of the 32 bits to define the network address. How many Class B networks are possible in this scenario?

6.8 What is meant by the term *naming* in computer networks?

6.9 What is a top-level domain?

6.10 How long is an Ethernet hardware address?

6.11 What is the name of the addressing standard used by telephones?

6.12 What is meant by the term *multi-homed*?

6.13 What is the reserved bit pattern of the first byte for a Class D address?

6.14 How many possible Class B networks are there?

6.15 What is the Initial Domain Part portion of an ATM address?

6.16 What is the destination physical address in an IP ARP request packet for device 192.168.44.64?

Problems

6.1 Explain what is meant by hierarchical addressing.

6.2 Do you think the current IP addressing scheme could be redesigned to use the device's hardware addresses instead of IP numbers? Explain your answer.

6.3 To provide more subnets, a Class B address is assigned the subnet mask of 255.255.240.0. How many hosts are possible per subnet?

6.4 Using the information in Problem 6.3, how many subnets are possible?

6.5 The ARP and RARP protocol in the IP suite perform similar address resolution functions. Describe at least one major difference between the implementation of the two protocols.

6.6 An organization wants to use the private network number 192.168.90.0 across four subnets. The maximum number of hosts that exist per subnet will be 25. What subnet mask would you use to solve this problem?

6.7 What are the IP addresses used or spanned by the CIDR address 192.168.10.0/20?

6.8 Define the role of a gateway in address resolution.

6.9 What is the purpose of the National Direct Dialing code?

6.10 What is the purpose of a subnet mask?

6.11 Define multicasting.

6.12 The IP network 192.168.130.0 is using the subnet mask 255.255.255.224. What subnet are the following hosts on?

192.168.130.10
192.168.130.67
192.168.130.93
192.168.130.199
192.168.130.222
192.168.130.250

6.13 Explain the closed-form computation method of address resolution.

Answers to Review Questions

6.1 **a.** and **d.** The hierarchical name structure is used by Domain Name Services (DNSs) for names of devices on a TCP/IP network. Another example of an IP protocol that uses hierarchical naming structure is Lightweight Directory Access Protocol (LDAP).

6.2 Two examples of hierarchical naming would be support.cisco.com and www.redcross.org. Two examples of a hierarchical address would be 172.16.3.4 and 512-555-1212.

6.3 An IPv6 address consists of 128 bits or 16 bytes. Octet is another term used for *byte*; therefore, this IPv6 address has 16 octets.

6.4 The process of assigning unique addresses to the different network devices is called *addressing*.

6.5 In an ARP request packet, the frame type is the hexadecimal value 0x806. Thus, when the device investigates the incoming packet, a frame type of 0x806 indicates the packet is an ARP request.

6.6 The sender of an ARP request message expects to receive only one response because only one device should have the IP number contained in the ARP request packet.

6.7 We can express the number of possible networks as the formula:

$$\text{Number of networks} = 2^N - 2$$

where N is the number of bits used for the network portion of the address. Therefore,

$$2^{20} - 2 = 1{,}048{,}572 \text{ networks}$$

6.8 Naming is the process by which devices are assigned, or receive, a unique network name.

6.9 A top-level domain is the first division for a name space. For example, if an authority decided to divide the name space by country and then by states or districts and then by cities, country would be the top-level domain in this example.

6.10 The Ethernet hardware address is a 48-bit, or 6-byte, address.

6.11 The standard for telephone numbers is referred to as ITU-E.164.

6.12 Devices on an IP network that have more than one interface or connection to the same or different networks are called multi-homed systems.

6.13 The bit pattern of the first byte of a Class D address is as follows:

Bit Pattern	Class							
1	1	1	0	x	x	x	x	D

6.14 For a Class B address, the number of bits that can be used for the network portion of the IP address is 14. Six bits from the first byte, and 8 bits from the second byte. Converting 2^{14} to decimal gives us 16,384. Therefore, there are a maximum of 16,284 Class B networks in the IP address space.

6.15 The Initial Domain Part (IDP) is composed of the Authority and Format Indicator (AFI) and Initial Domain Identifier (IDI) values and uniquely identifies an addressing domain across the entire ATM name space.

6.16 FF-FF-FF-FF-FF-FF is the destination physical address in an IP ARP request packet for the device 192.168.44.64. Since the sender does not know the physical address of the destination device, a broadcast packet is sent out with all ones in the destination hardware address field.

Solutions to Problems

6.1 The type of naming scheme that includes information about the location of a system is called hierarchical.

6.2 No, because there is no hierarchy in the hardware addresses and no common portion of the address that is common to all devices. Since there is no common portion of the MAC addresses to distinguish which network segment the devices reside on, the routing tables would have to include the addresses of all devices. This would make the tables very large and unmanageable.

6.3 4094 hosts. The subnet mask of 255.255.240.0 uses 4 bits in the third octet to create the subnets.

```
Binary  11111111.11111111.1111 0000.00000000
Decimal 255.255.240.0
```

Therefore, 12 bits are available for the host address—4 bits from the third byte plus 8 bits from the last byte.

$$\text{Number of hosts} = 2^{12} - 2 = 4094$$

6.4 14 subnets. The subnet mask of 255.255.240.0 uses 4 bits in the third octet to create the subnets.

```
Binary  11111111.11111111.1111 0000.00000000
Decimal 255.255.240.0
```

Therefore, 4 bits are used to create the subnets.

$$\text{Number of subnets} = 2^{4} - 2 = 14$$

6.5 The IP ARP protocol uses the message method to perform address resolution. RARP uses RARP servers to provide the address resolution services.

6.6 255.255.255.192. To create four subnets for the network 192.168.90.0, at least 3 bits of the host address portion must be used to create the subnets. More than 3 bits could be used, except in order to support up to 25 hosts per subnet, the proper mask must be chosen to provide sufficient host addresses. The subnet mask of 255.255.255.192 produces the following:

$$\text{Number of subnets} = 2^{3} - 2 = 6$$

$$\text{Number of hosts per subnet} = 2^{5} - 2 = 30$$

6.7 The CIDR address 192.168.10.0/20 uses 4 bits of the third byte for sequential Class C IP addresses.

Decimal	Binary of Third Byte
192.168.10.0	00001010
192.168.11.0	00001011
192.168.12.0	00001100
192.168.13.0	00001101
192.168.14.0	00001110
192.168.15.0	00001111

Thus, the range of IP addresses is 192.168.10.0 through 192.168.15.0.

6.8 The border router in a subnet that interfaces to other networks is called a *gateway*. Whenever a device wants to send a message to another system outside its segment, it sends the message to the border router, which then sends it on to the destination network or route.

6.9 The term National Direct Dialing (NDD) is used to refer to the special telephone code used to access another area code.

6.10 When a packet arrives at a router, the router needs to be able to determine the IP address's network address. The subnet mask is used to determine which portion of the address is the network portion and which part is the host address. To accomplish this number separation, the router performs an AND operation of the IP address with the subnet mask.

6.11 Class D IP addresses are reserved for multicasting, which provides the ability to send a message to a group of devices that are members of the same multicast group.

6.12 The subnet mask 255.255.255.224, uses 3 bits of the fourth byte, so there are six possible subnets, $2^3 - 2$, where each subnet has a maximum of 30 hosts, $2^5 - 2$.

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
128	64	32	16	8	4	2	1	
0	0	1	-	-	-	-	-	= subnet 32
0	1	0	-	-	-	-	-	= subnet 64
0	1	1	-	-	-	-	-	= subnet 96
1	0	0	-	-	-	-	-	= subnet 128
1	0	1	-	-	-	-	-	= subnet 160
1	1	0	-	-	-	-	-	= subnet 192

The possible host addresses for subnet 32 are

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
128	64	32	16	8	4	2	1	
0	**0**	**1**	0	0	0	0	1	= decimal 33
0	**0**	**1**	1	1	1	1	0	= decimal 62

Subnet 64:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
128	64	32	16	8	4	2	1	
0	**1**	**0**	0	0	0	0	1	= decimal 65
0	**1**	**0**	1	1	1	1	0	= decimal 94

Subnet 96:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
128	64	32	16	8	4	2	1	
0	**1**	**1**	0	0	0	0	1	= decimal 97
0	**1**	**1**	1	1	1	1	0	= decimal 126

Subnet 128:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
128	64	32	16	8	4	2	1	
1	**0**	**0**	0	0	0	0	1	= decimal 129
1	**0**	**0**	1	1	1	1	0	= decimal 158

Subnet 160:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
128	64	32	16	8	4	2	1	
1	**0**	**1**	0	0	0	0	1	= decimal 161
1	**0**	**1**	1	1	1	1	0	= decimal 190

Subnet 192:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
128	64	32	16	8	4	2	1	
1	**1**	**0**	0	0	0	0	1	= decimal 193
1	**1**	**0**	1	1	1	1	0	= decimal 222

IP addresses 192.168.130.10 and 192.168.130.250 cannot be used on a 192.168.130.0 network with the subnet mask of 255.255.255.224. IP numbers 192.168.130.67 and 192.168.130.93 are both on subnet 64. IP numbers 192.168.130.199 and 192.168.130.222 are both on subnet 192.

6.13 In the closed-form computation method, the software address used for each device is selected so that the physical address can be derived from the software address through some form of mathematical computation. This method of address resolution works well in environments where the physical addresses of devices can be set. With that capability, an administrator can construct a physical and software addressing scheme, so the translation from software address to physical address is minimal and fast.