The Network Layer in the Internet

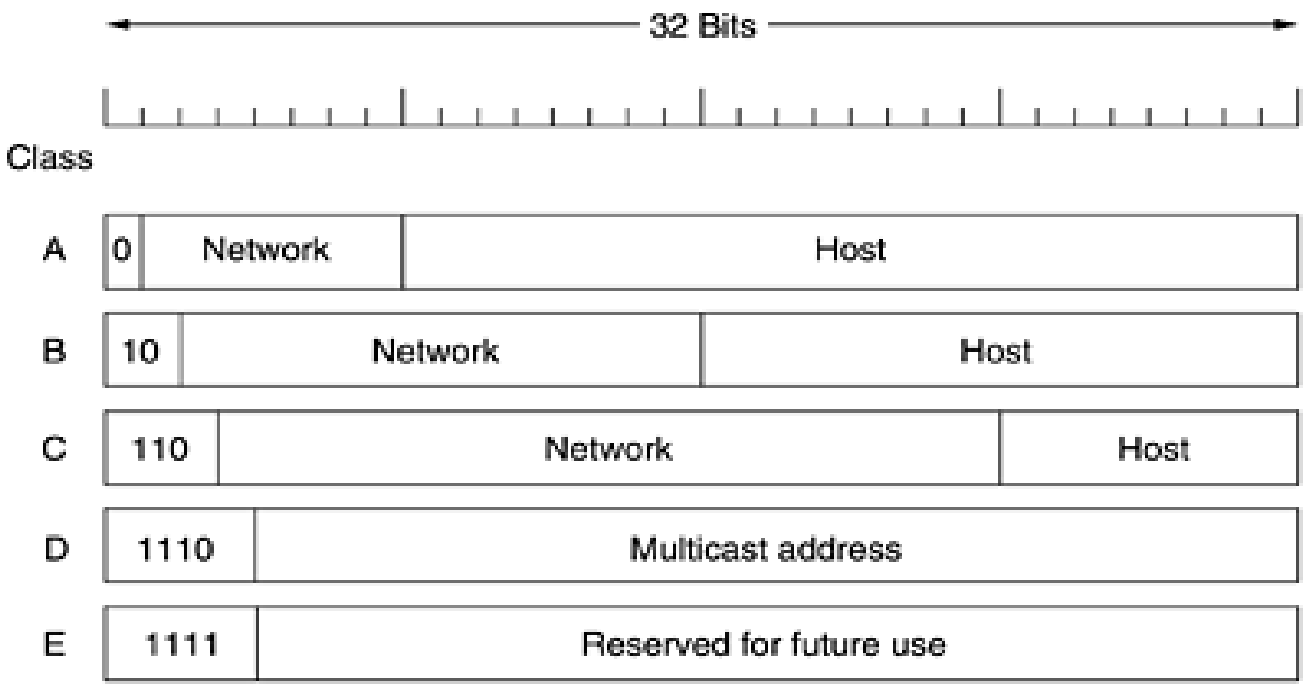
IP Address

- Every host and router on the Internet has an IP address, which encodes its network number and host number.
- The combination is unique: in principle, no two machines on the Internet have the same IP address.
- In the TCP/IP protocol, the unique identifier for a computer is called its IP address.
- There are two standards for IP addresses: **IP Version 4 (IPv4)** and **IP Version 6 (IPv6).**

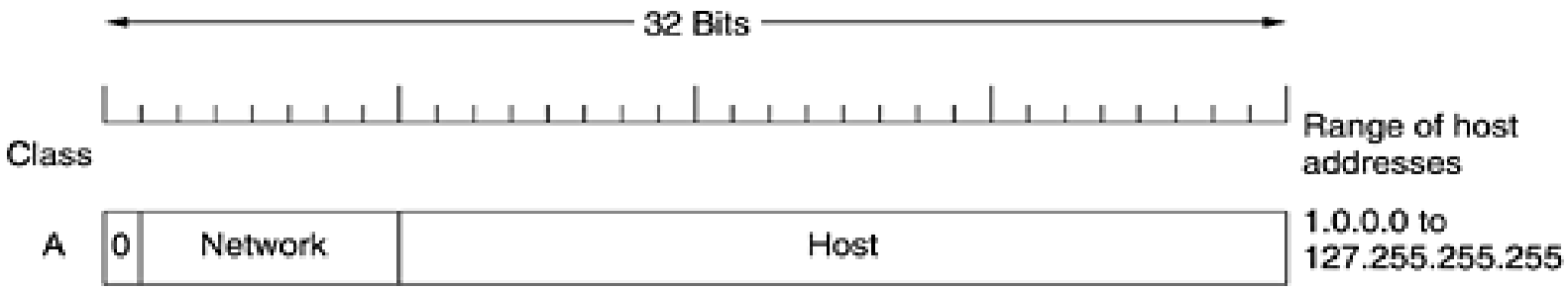
Addresses - IPv4

- All IP addresses are 32 bits long and are used in the *Source address* and *Destination address* fields of IP packets.
- It is important to note that an IP address does not actually refer to a host. It really refers to a network interface, so if a host is on two networks, it must have two IP addresses.
- However, in practice, most hosts are on one network and thus have one IP address.
- The **32** bits of an IPv4 address are broken into **4 octets**, or 8 bit fields (0-255 value in decimal notation).

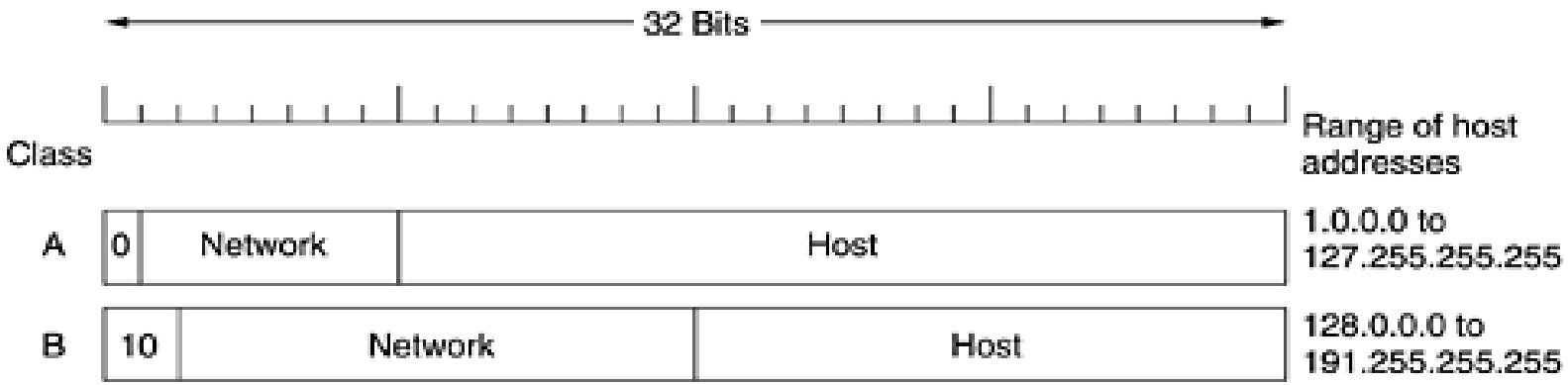
IP address formats



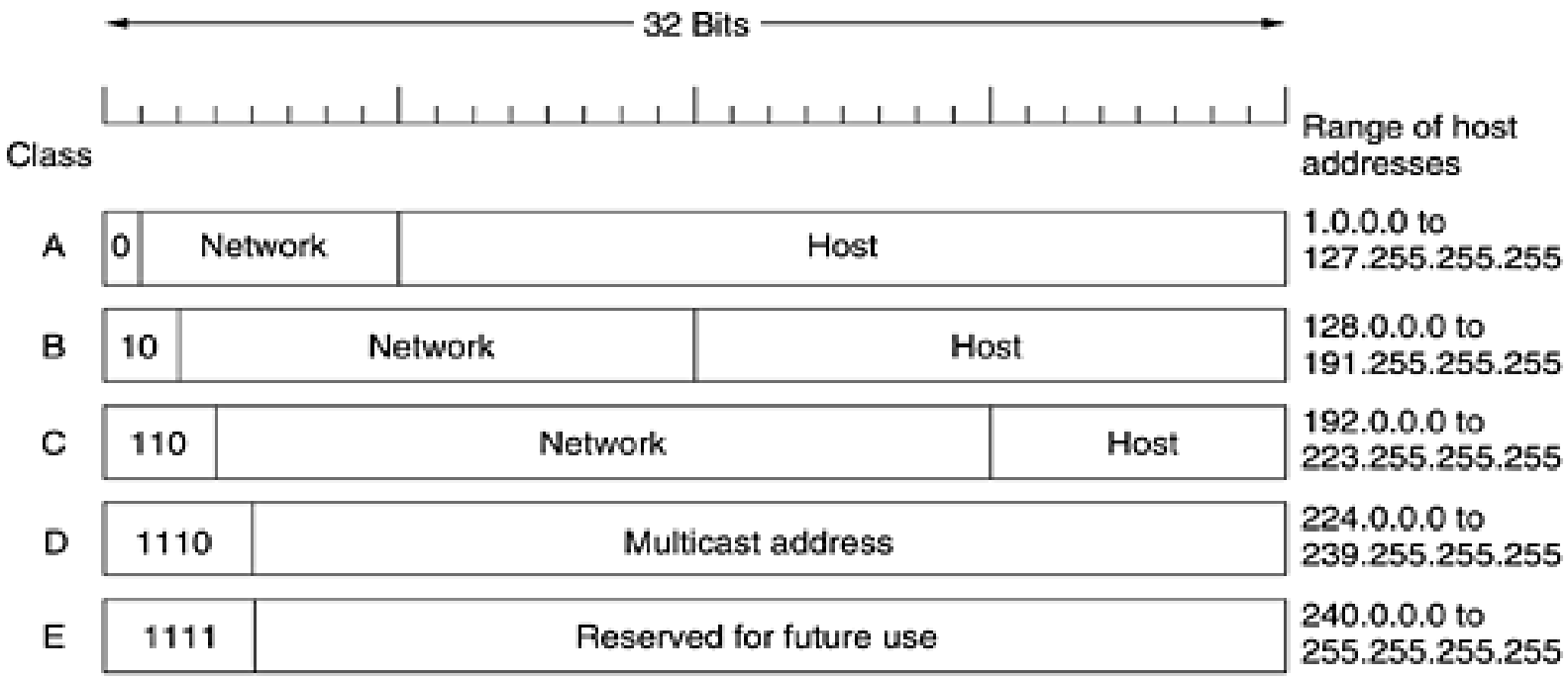
IP address formats



IP address formats



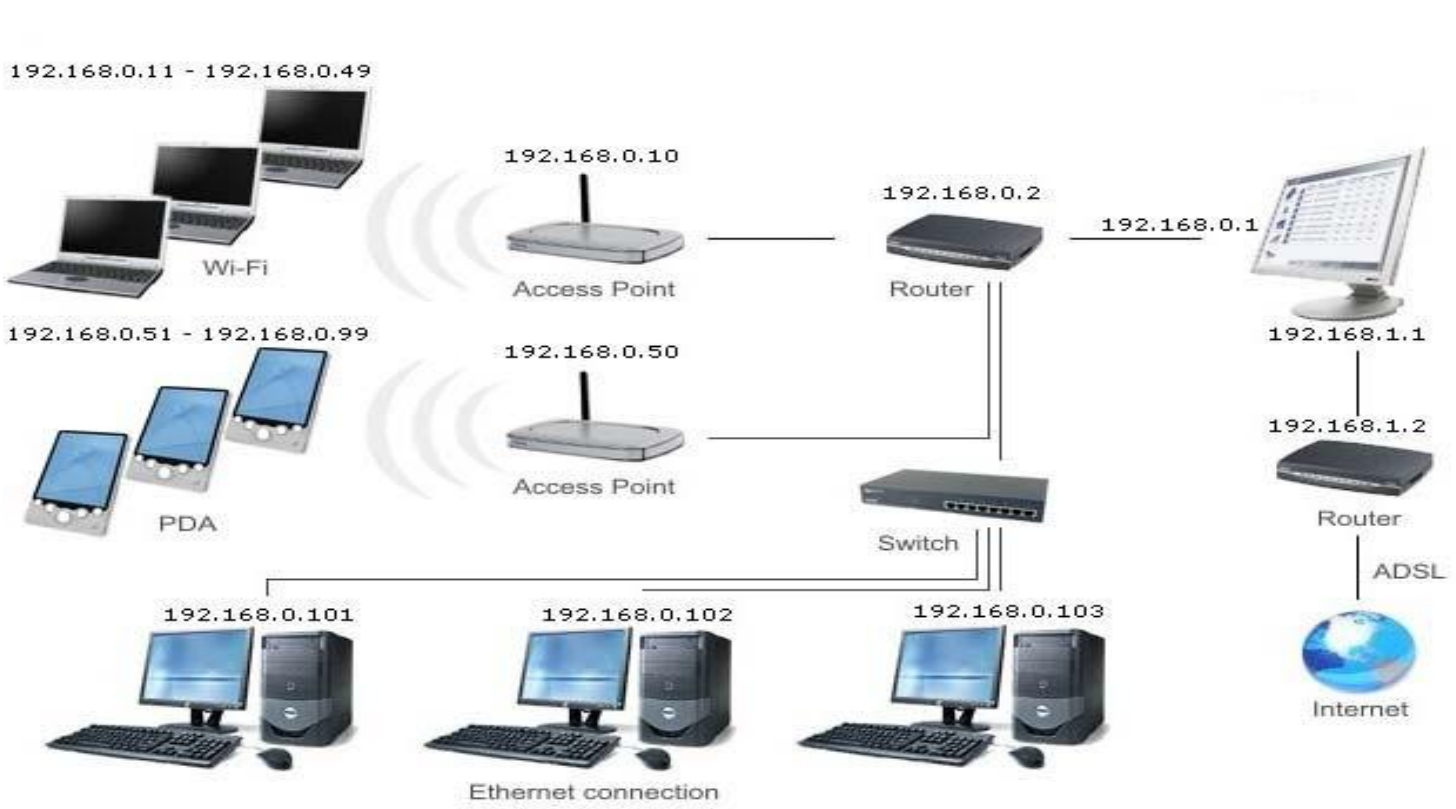
IP address formats



- For networks of different size, The first one (for large networks) to three (for small networks) octets can be used to identify the **network**, while the rest of the octets can be used to identify the **node** on the network.
- The class A formats allow for up to 128 networks with 16 million hosts each,
- The class B formats allow 16,384 networks with up to 64K hosts, and
- The class C formats allow 2 million networks (e.g., LANs) with up to 256 hosts each (although a few of these are special).
- Also supported is multicast, in which a datagram is directed to multiple hosts. Addresses beginning with 1111 are reserved for future use.

- Over 500,000 networks are now connected to the Internet, and the number grows every year. Network numbers are managed by a nonprofit corporation called **ICANN** (**Internet Corporation for Assigned Names and Numbers**) to avoid conflicts.
- In turn, ICANN has delegated parts of the address space to various regional authorities, which then dole out IP addresses to ISPs and other companies.
- Network addresses, which are 32-bit numbers, are usually written in **dotted decimal notation**. In this format, each of the 4 bytes is written in decimal, from 0 to 255.
- For example, the 32-bit hexadecimal address C0290614 is written as 192.41.6.20.
- The lowest IP address is 0.0.0.0 and the highest is 255.255.255.255.

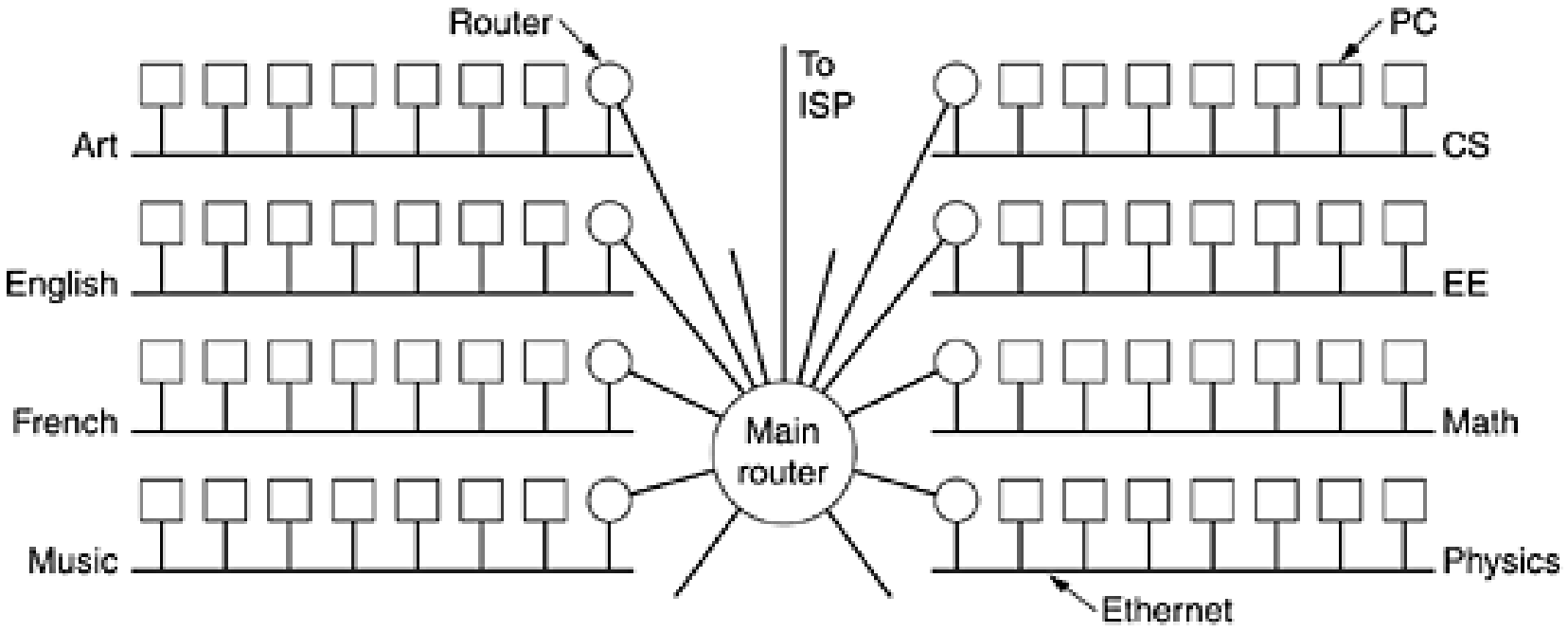
Local Area Network Addresses - IPv4



Subnets

- All the hosts in a network must have the same network number. This property of IP addressing can cause problems as networks grow.
- The solution is to allow a network to be split into several parts for internal use but still act like a single network to the outside world.
- A typical campus network with a main router connected to an ISP or regional network and numerous Ethernets spread around campus in different departments.
- Each of the Ethernets has its own router connected to the main router.
- In the Internet literature, the parts of the network (in this case, Ethernets) are called **subnets.**

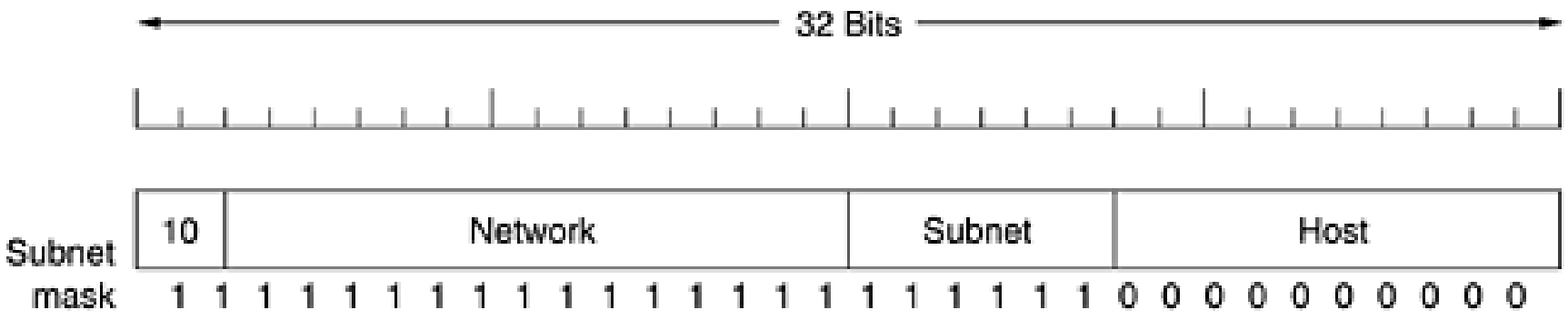
Figure 5-57. A campus network consisting of LANs for various departments.



- When a packet comes into the main router, how does it know which subnet (Ethernet) to give it to?
- One way would be to have a table with large number of entries in the main router telling which router to use for each host on campus.
- This idea would work, but it would require a very large table in the main router and a lot of manual maintenance as hosts were added, moved, or taken out of service.

- Instead, a different scheme was invented. Basically, instead of having a single class B address with 16 bits for the network number and 16 bits for the host number, **some bits are taken away from the host number** to create a subnet number.
- For example, if the university has 35 departments, it could use a 6-bit subnet number and a 10-bit host number, allowing for up to 64 Ethernets, each with a maximum of 1024 hosts.
- To implement subnetting, the main router needs a **subnet mask** that indicates the split between network + subnet number and host.

Figure 5-58. A class B network subnetted into 64 subnets.



- Subnet masks are also written in dotted decimal notation, with the addition of a slash followed by the number of bits in the network + subnet part.
- For the example of Fig. 5-58, the subnet mask can be written as 255.255.252.0. An alternative notation is /22 to indicate that the subnet mask is 22 bits long.
- Example:

In class C network:

IP address **192.168.1.168** subnet mask **255.255.255.0** is written as: **192.168.1.168/24** : Classless Inter-Domain Routing **(CIDR)** notation

- **Example:**

  A network on the Internet has a subnet mask of 255.255.240.0. What is the maximum number of hosts it can handle?

Answer: length of IP address is 32 bits.

255.255.240.0

11111111.11111111. 1111**0000.00000000**

(Network and subnet part is 20 bit) (Host is 12 bit)

So 2 ^12= 4096 host addresses exist

- In a Class B network the subnet mask 255.255.255.0. can accommodate up to _____Ethernets, each with a maximum of _____hosts

Answer:

255.255.255.0.

11111111.11111111.11111111.00000000

(Network part is 16 bit) (Subnet is 8 bit) (Host is 8 bit)

can accommodate up to 2^8=256 Ethernets, each with a maximum of 2^8=256 hosts

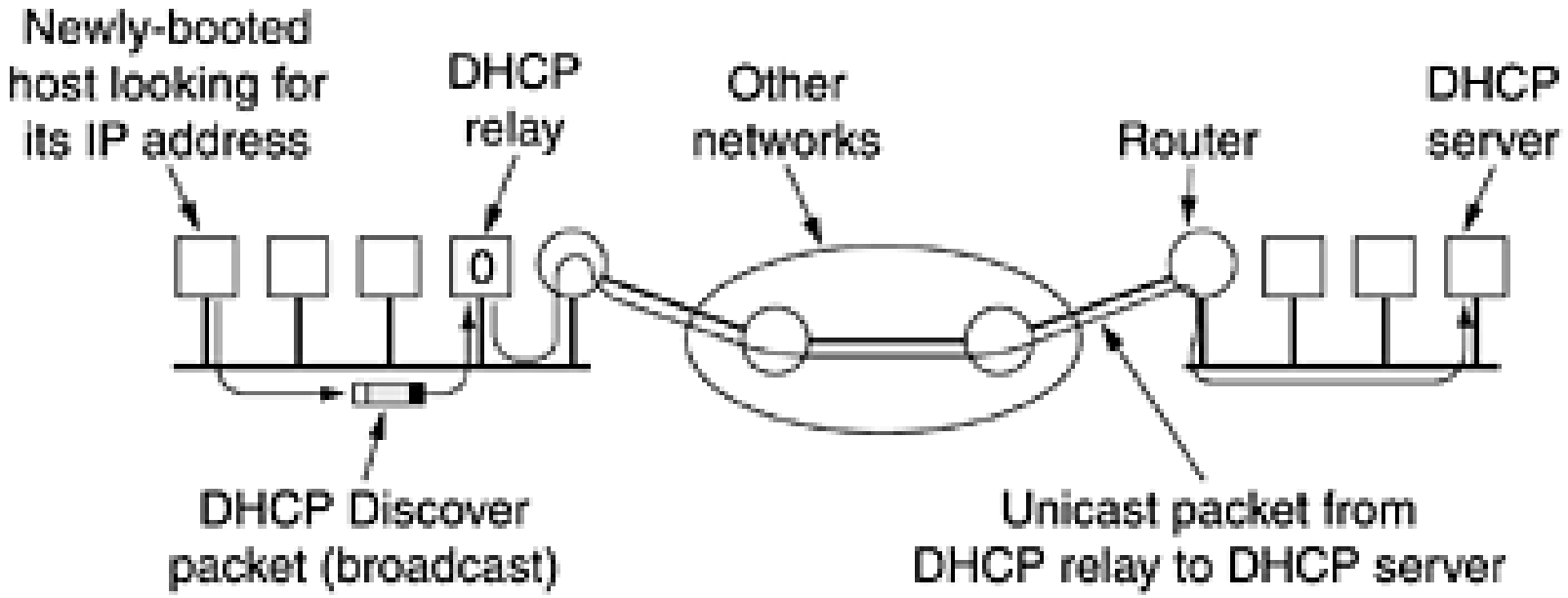
- In a Class B network the subnet mask 255.255.255.0. can accommodate up to _____Ethernets, each with a maximum of _____hosts.

DHCP: **Dynamic Host Configuration Protocol**

- Every computer or device on a network has an IP address for communication purposes.
- There are two ways that a computer can be assigned an IP address: **Static IP** or **Dynamic IP**.
- **Static IP** is where a user assigns a computer or device with an IP address manually.
- Assigning IP address manually for a large networks that has a lot of computers is difficult. And also make sure that all IP addresses are unique (To avoid IP conflict).

- There is a better and easier way to assign a computer an IP address and this is called a dynamic IP.
- A dynamic IP is where the computer gets an IP address automatically from a DHCP server.
- A DHCP server automatically assigns a computer an IP address.
- DHCP is based on the idea of a special server that assigns IP addresses to hosts asking for one. This server need not be on the same LAN as the requesting host.
- Since the DHCP server may not be reachable by broadcasting, a **DHCP relay agent** is needed on each LAN.

Figure 5-63. Operation of DHCP



- To find its IP address, a newly-booted machine broadcasts a DHCP DISCOVER packet.
- The DHCP relay agent on its LAN intercepts all DHCP broadcasts.
- When it finds a DHCP DISCOVER packet, it sends the packet as a unicast packet to the DHCP server, possibly on a distant network.
- The only piece of information the relay agent needs is the IP address of the DHCP server.

- An issue that arises with automatic assignment of IP addresses from a pool is how long an IP address should be allocated.
- If a host leaves the network and does not return its IP address to the DHCP server, that address will be permanently lost. After a period of time, many addresses may be lost.
- To prevent that from happening, IP address assignment may be for a fixed period of time, a technique called **leasing.**
- Just before the lease expires, the host must ask the DHCP for a renewal. If it fails to make a request or the request is denied, the host may no longer use the IP address it was given earlier.