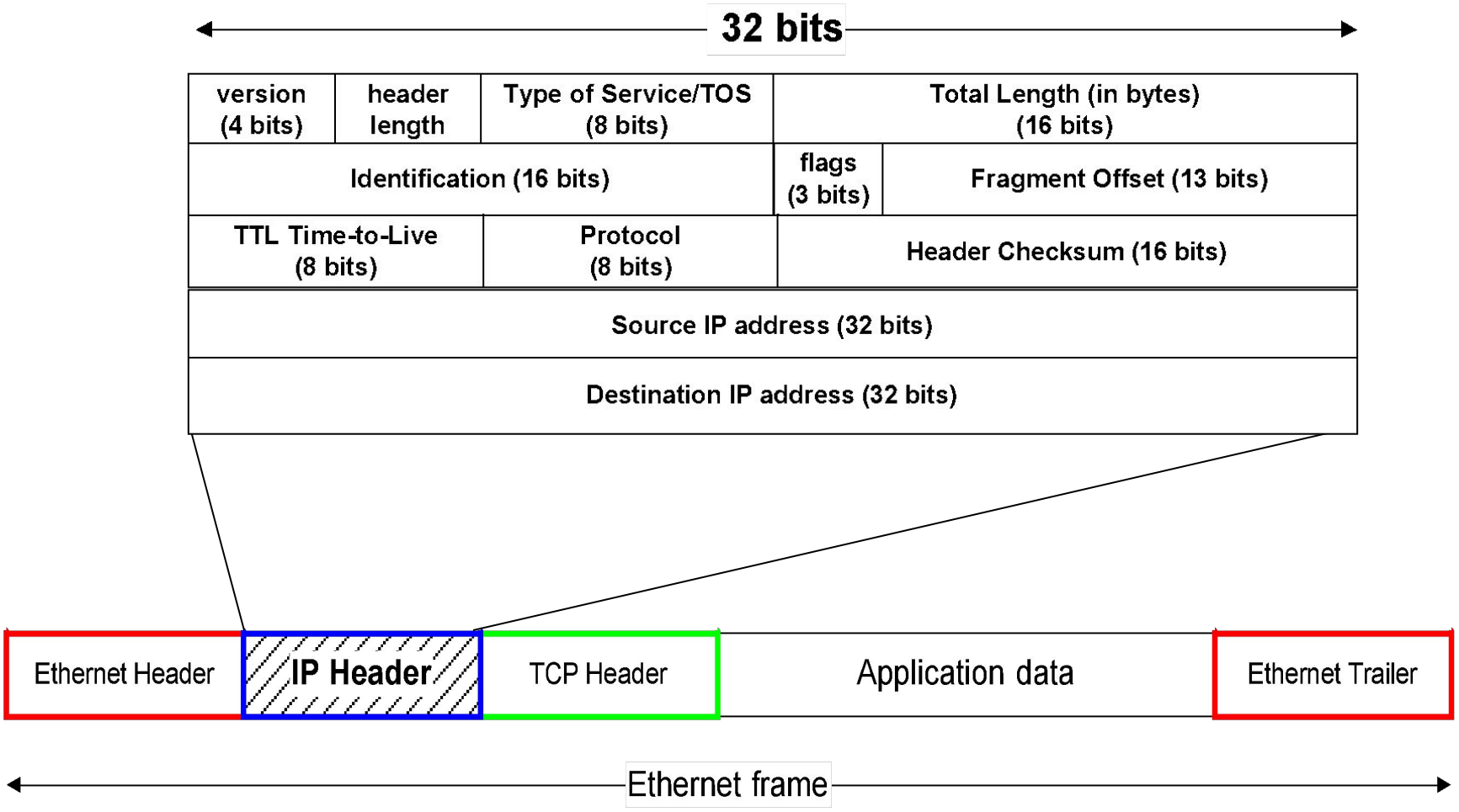
# IP Addressing

# IP Addresses



# What is an IP Address?

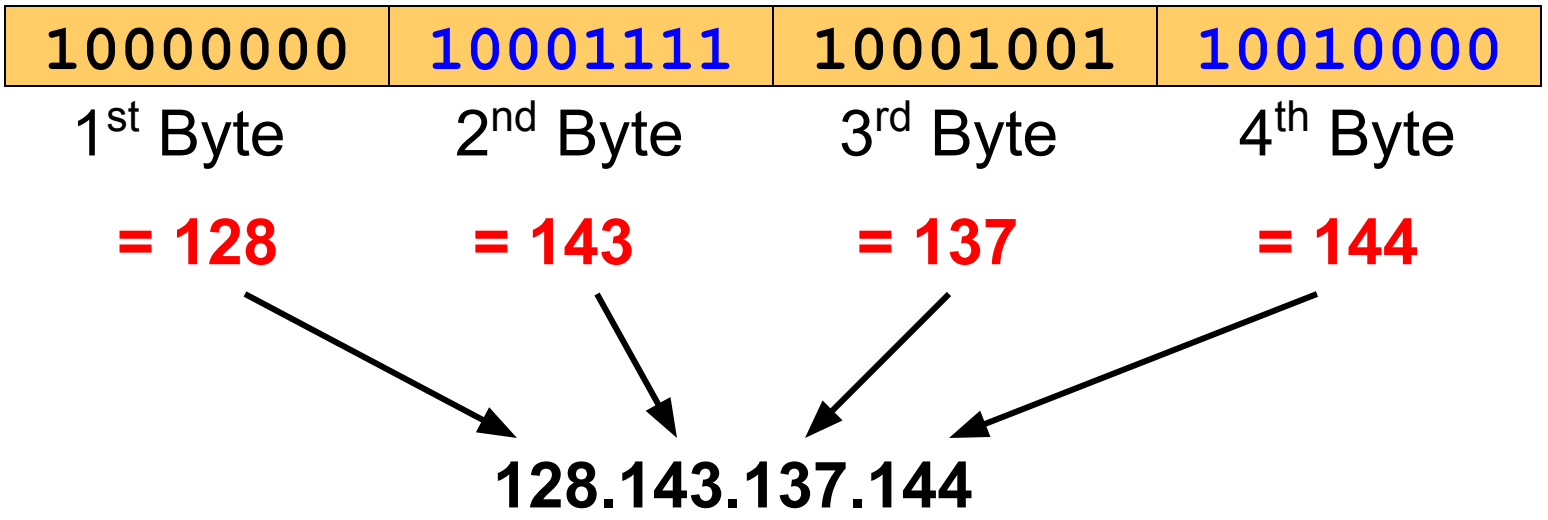
- An IP address is a unique global address for a network interface

- An IP address:
  - is a **32 bit long** identifier
  - encodes a network number (**network prefix**) and a **host number**

# Dotted Decimal Notation

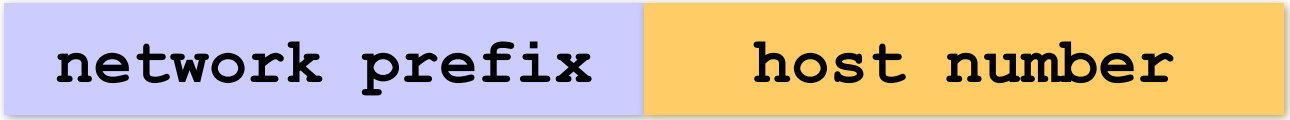
- IP addresses are written in a so-called ***dotted decimal notation***
- Each byte is identified by a decimal number in the range [0..255]:

- **Example:**



# Network prefix and Host number

- The network prefix identifies a network and the host number identifies a specific host (actually, interface on the network).



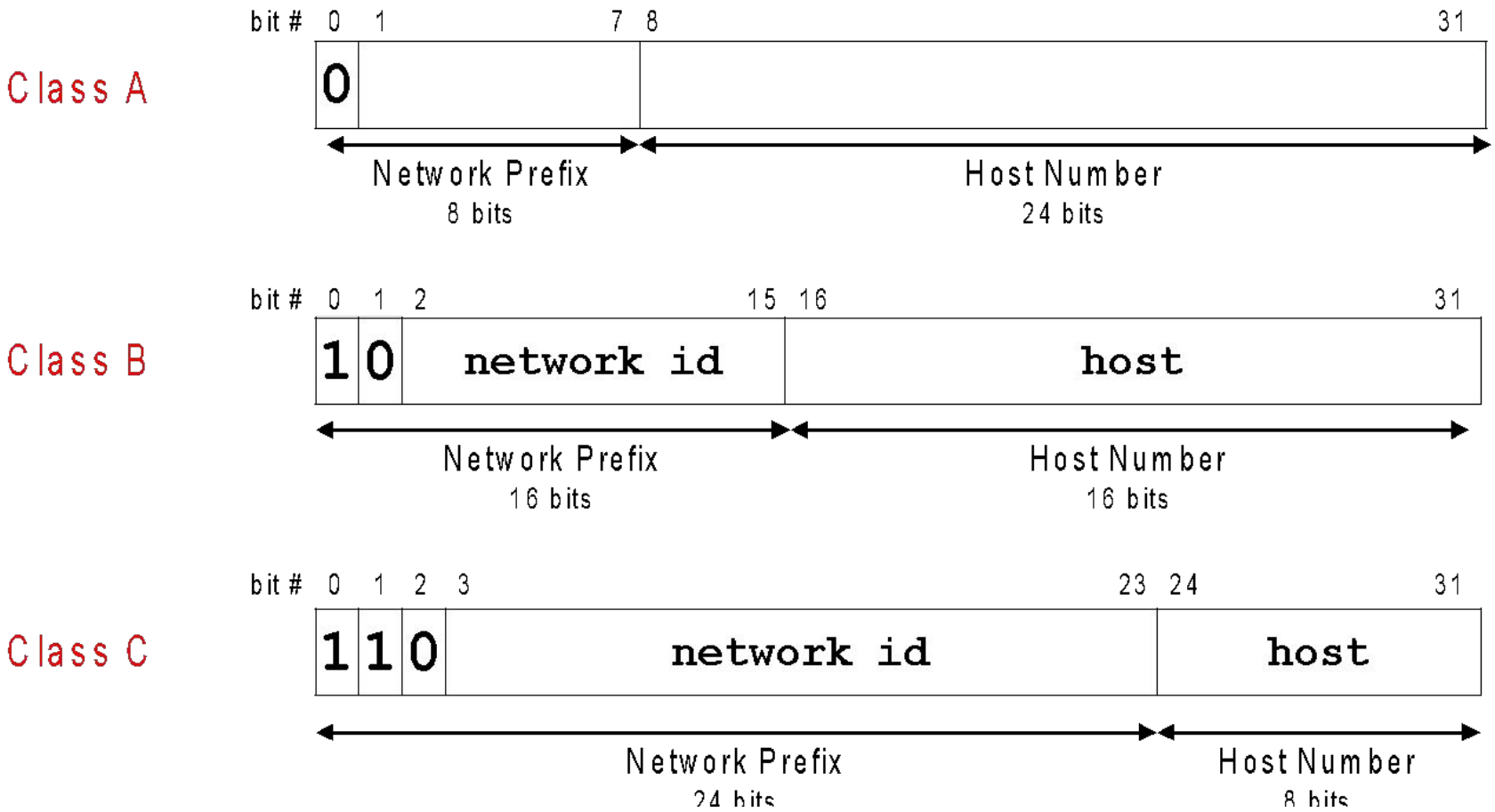

- **How do we know how long the network prefix is?**
  - The network prefix **used** to be implicitly defined
    - **class-based addressing, A,B,C,D**
  - The network prefix now is flexible and is indicated by
    - **prefix/netmask (classless Interdomain routing)-CIDR**

# The old way: Classful IP Adresses

- When Internet addresses were standardized (early 1980s), the Internet address space was divided up into classes:
  - **Class A:** Network prefix is 8 bits long
  - **Class B:** Network prefix is 16 bits long
  - **Class C:** Network prefix is 24 bits long

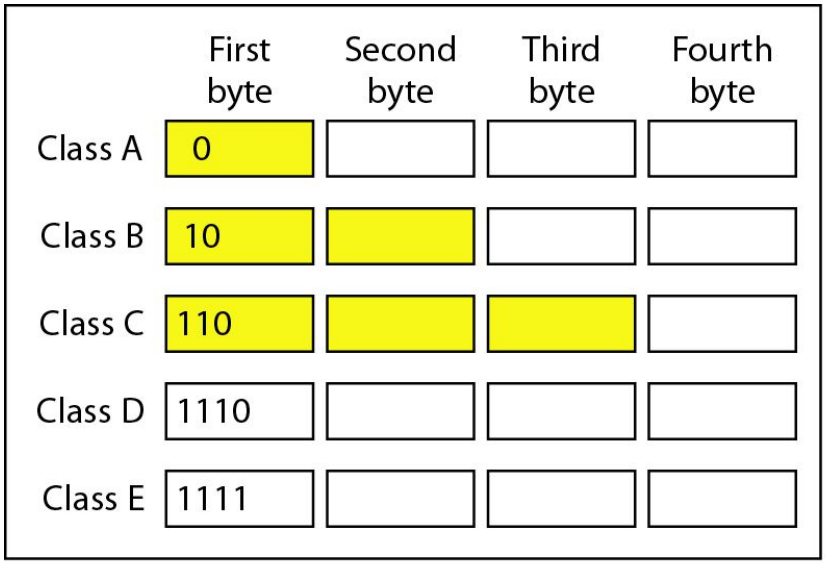
- Each IP address contained a key which identifies the class:
  - **Class A:** IP address starts with “0”
  - **Class B:** IP address starts with “10”
  - **Class C:** IP address starts with “110”

# The old way: Internet Address Classes

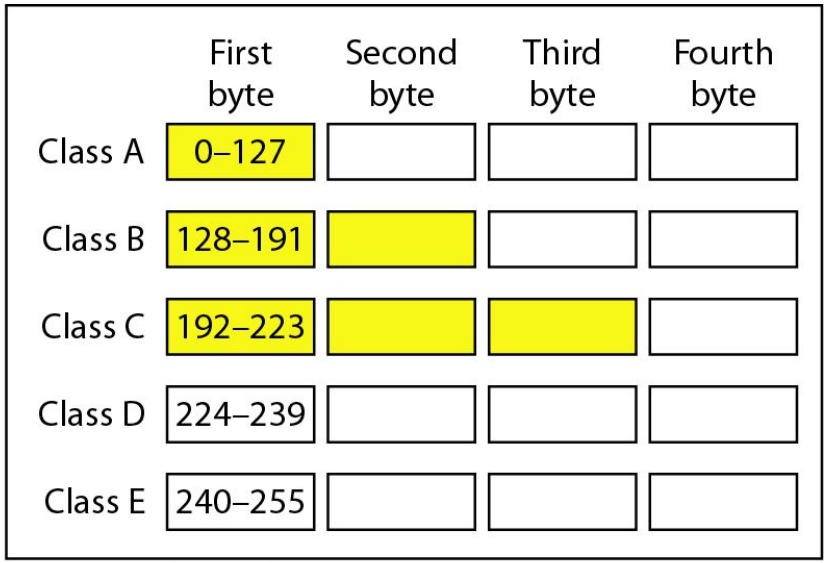


# The old way: Internet Address Classes






a. Binary notation




b. Dotted-decimal notation

# *Example*

***Find the class of each address.***

***a.*** **0**0000001 00001011 00001011 11101111

***b.*** **110**00001 10000011 00011011 11111111

***c.*** **14**.23.120.8

***d.*** **252**.5.15.111

***Solution***

***a. The first bit is 0. This is a class A address.***

***b. The first 2 bits are 1; the third bit is 0. This is a class C address.***

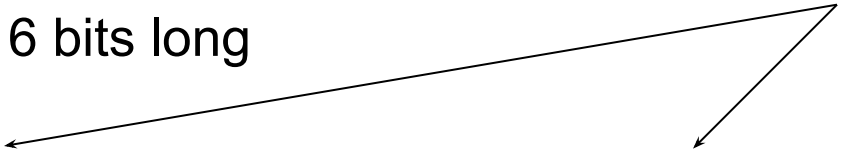
***c. The first byte is 14; the class is A.***

***d. The first byte is 252; the class is E.***

# Example

**Example**: www.google.com

- IP address is 128.143.137.144
  - Is that enough info to route datagram??? -> No, need netmask or prefix at every IP device (host and router)
- Using Prefix notation IP address is: **128.143.137.144/16**
  - Network prefix is 16 bits long



- Network mask is: **255.255.0.0** or hex format: **ffff0000**

-----> **Network id** (IP address **AND** Netmask) is: **128.143.0.0**

-----> **Host number** (IP address **AND** inverse of Netmask) is: **137.144**

# Problems with Classful IP Addresses

- The original classful address scheme had a number of problems
- In classful addressing, a large part of the available addresses were wasted.

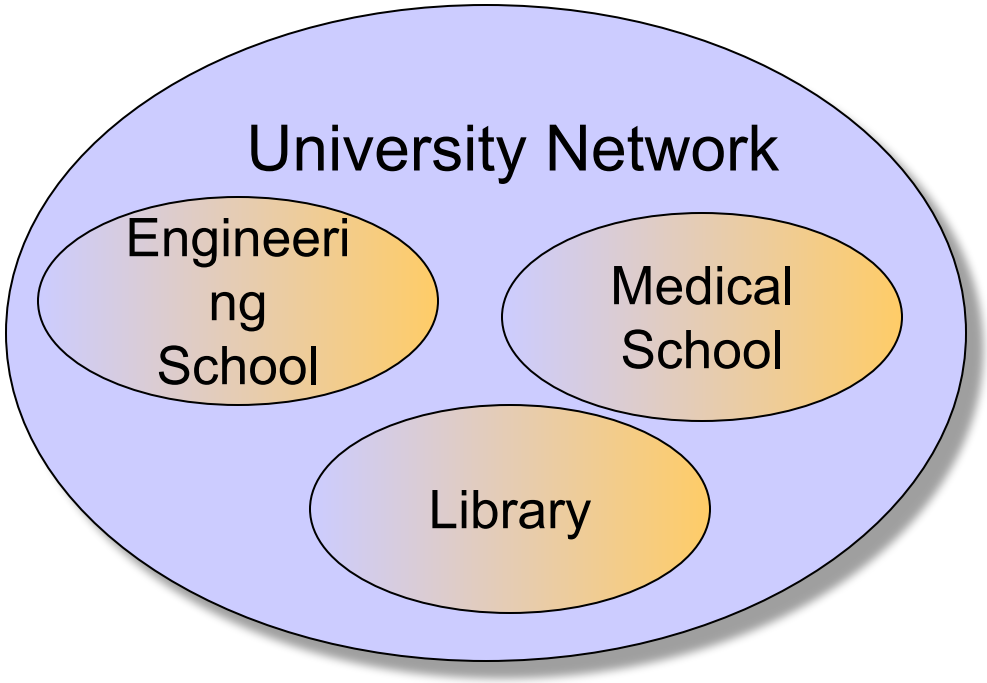
**Problem 1. Inflexible.** Assume a company requires 2,000 addresses

- Class A and B addresses are overkill
- Class C address is insufficient (requires 8 Class C addresses)

**Alternate is: Subnetting**

# Subnetting

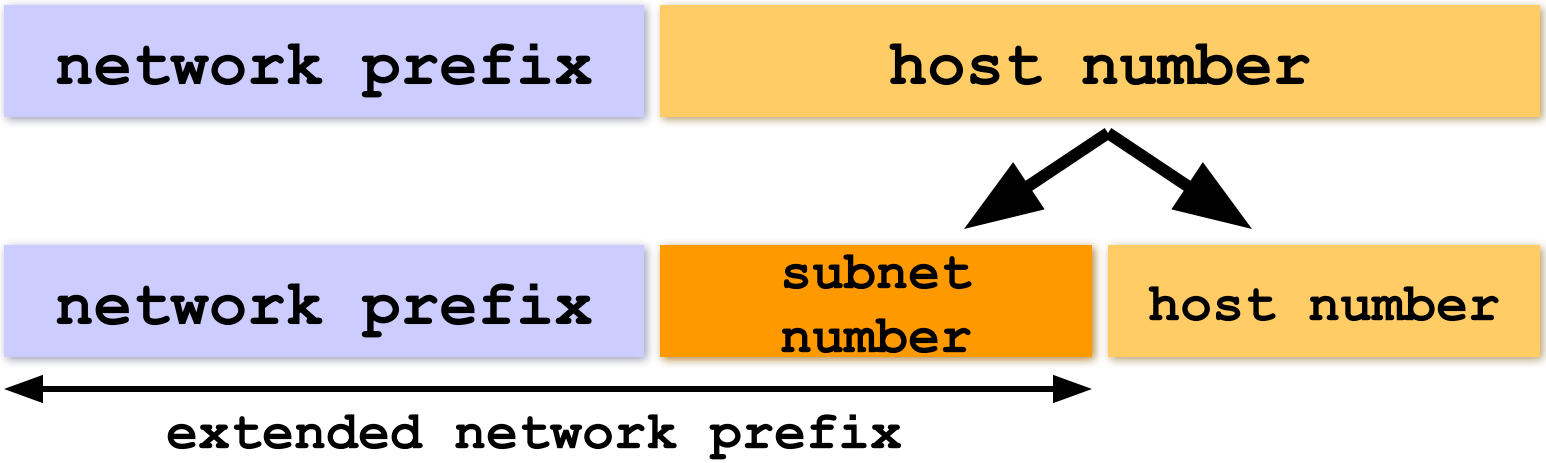
- **Problem**: Organizations have multiple networks which are independently managed
  - **Solution 1:** Allocate an address for each network
    - Difficult to manage
    - From the outside of the organization, each network must be addressable ie have an identifiable address.
  - **Solution 2:** Add another level of hierarchy to the IP addressing structure




→ **Subnetting**

# Basic Idea of Subnetting

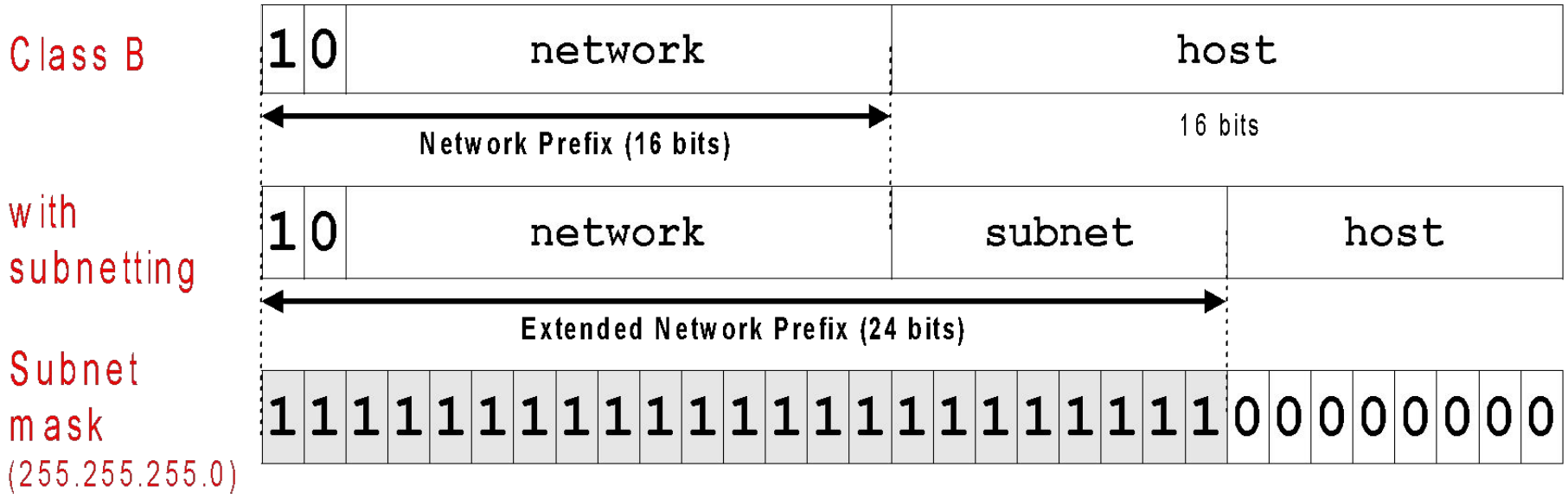
- Split the host number portion of an IP address into a **subnet number** and a (smaller) **host number**.
- Result is a 3-layer hierarchy




- Then:
  - Subnets can be freely assigned within the organization
  - Internally, subnets are treated as separate networks
  - Subnet structure is not visible outside the organization

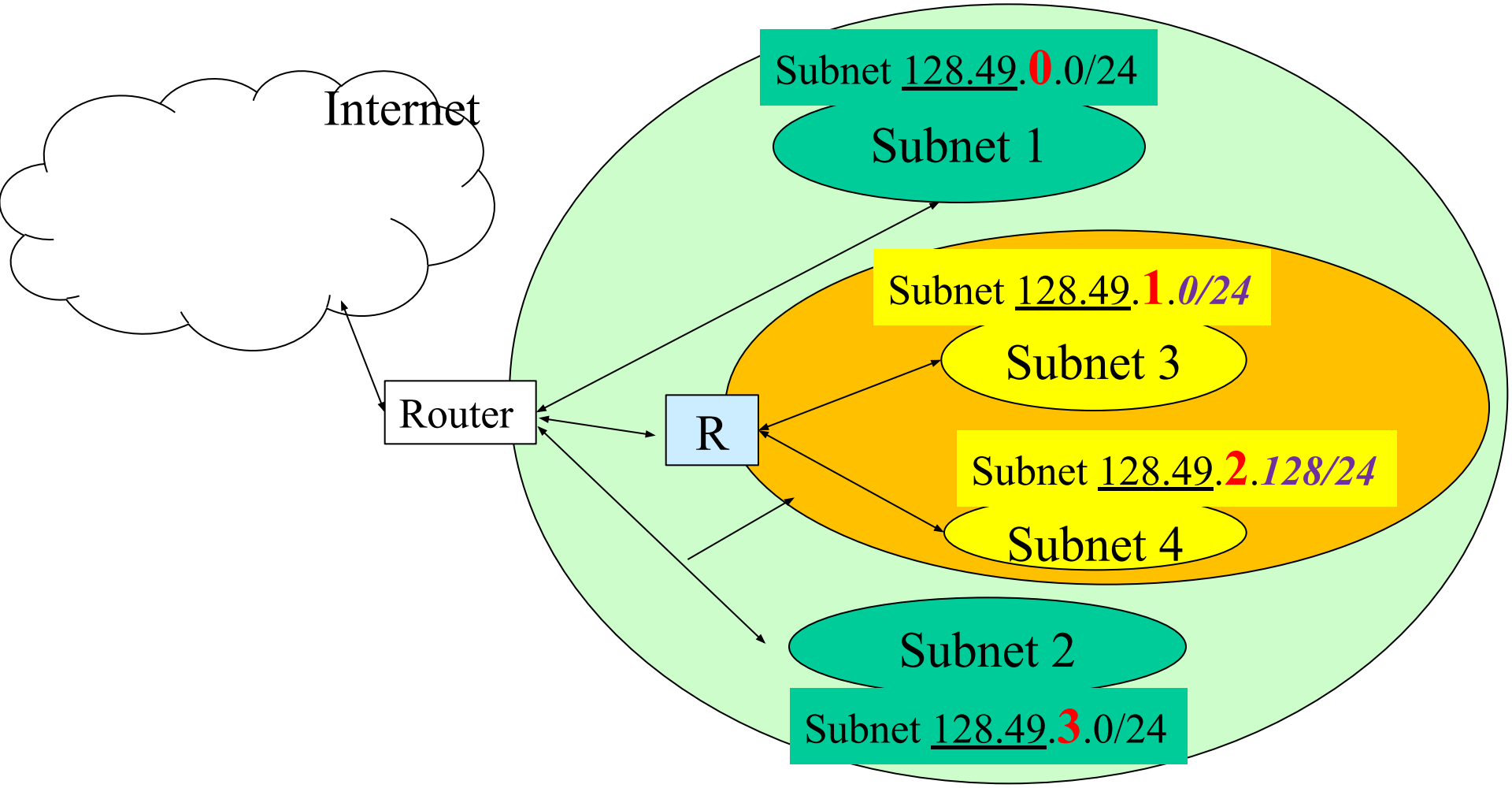
# Subnet Masks

- Routers and hosts use an **extended network prefix** (**subnet mask)** to identify the start of the host numbers




* There are different ways of subnetting. Commonly used netmasks for university networks with /16 prefix (Class B) are 255.255.255.0 and 255.255.0.0

# Example of a Subnetting Plan

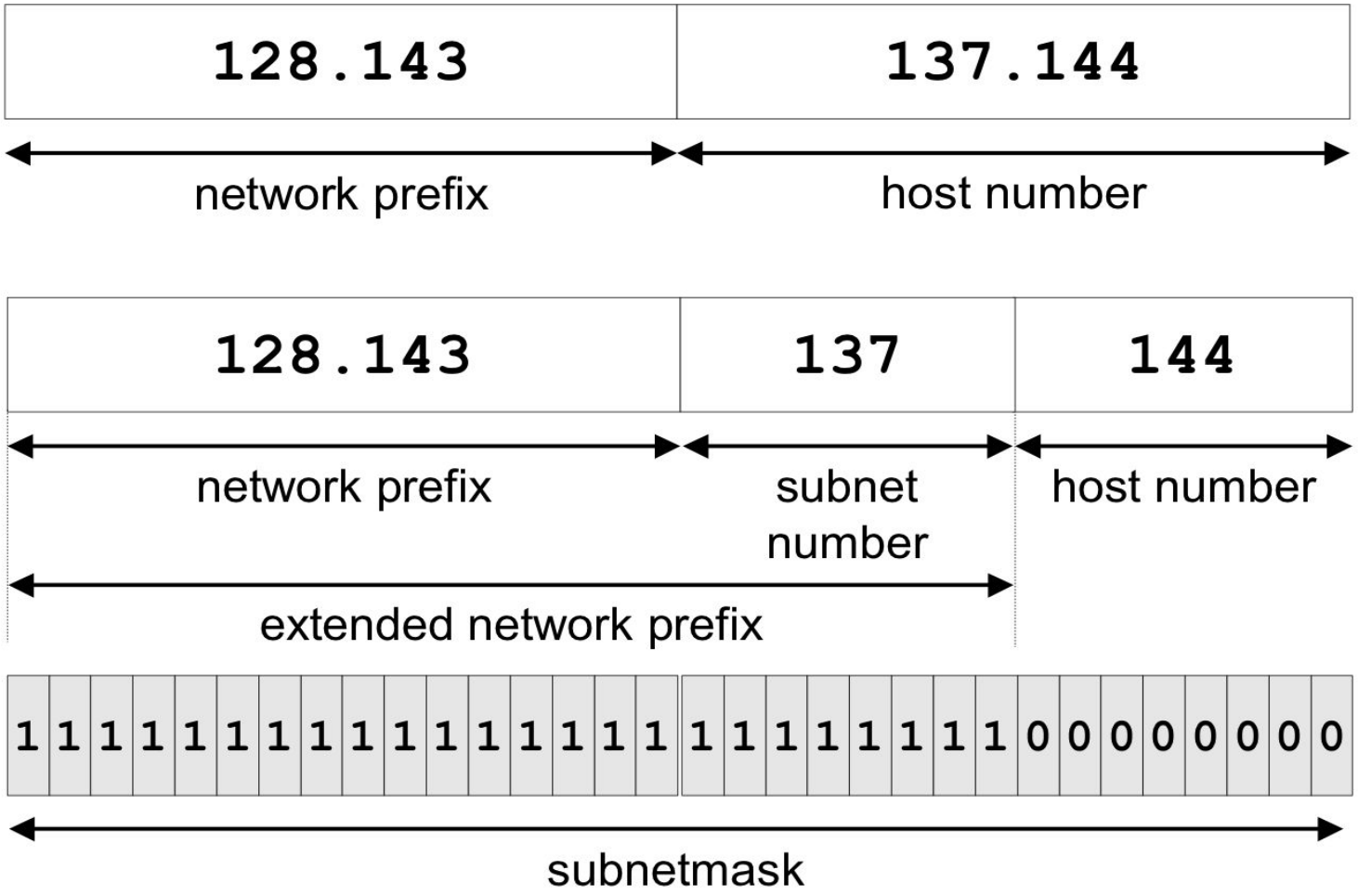


# Advantages of Subnetting

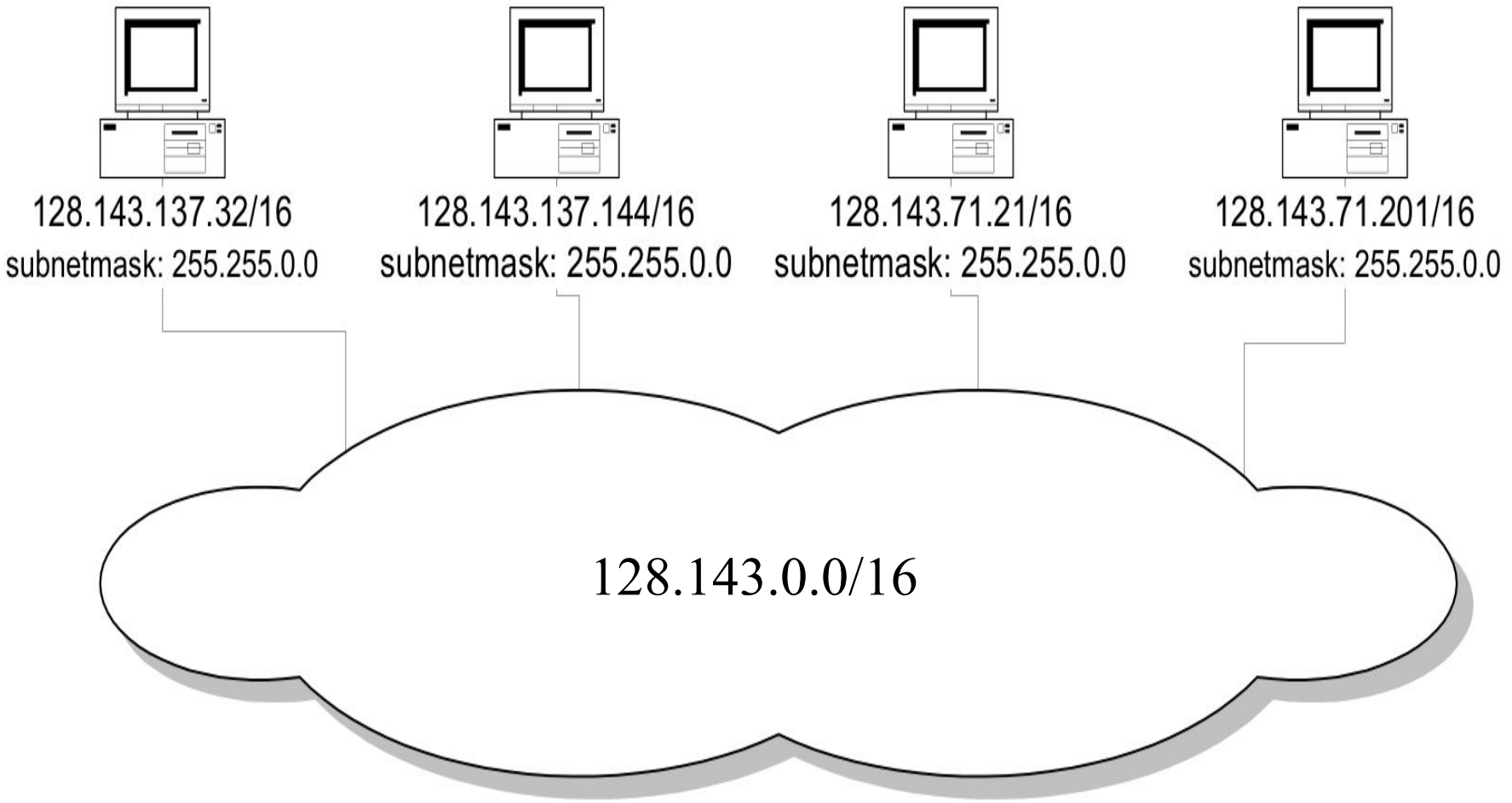
- With subnetting, IP addresses use a 3-layer hierarchy:
  - » Network
  - » Subnet
  - » Host
- Improves efficiency of IP addresses by not consuming an entire address space for each physical network.
- Reduces router complexity. Since external routers do not know about subnetting, the complexity of routing tables at external routers is reduced.

- Note: Length of the subnet mask need not be identical at all subnetworks.

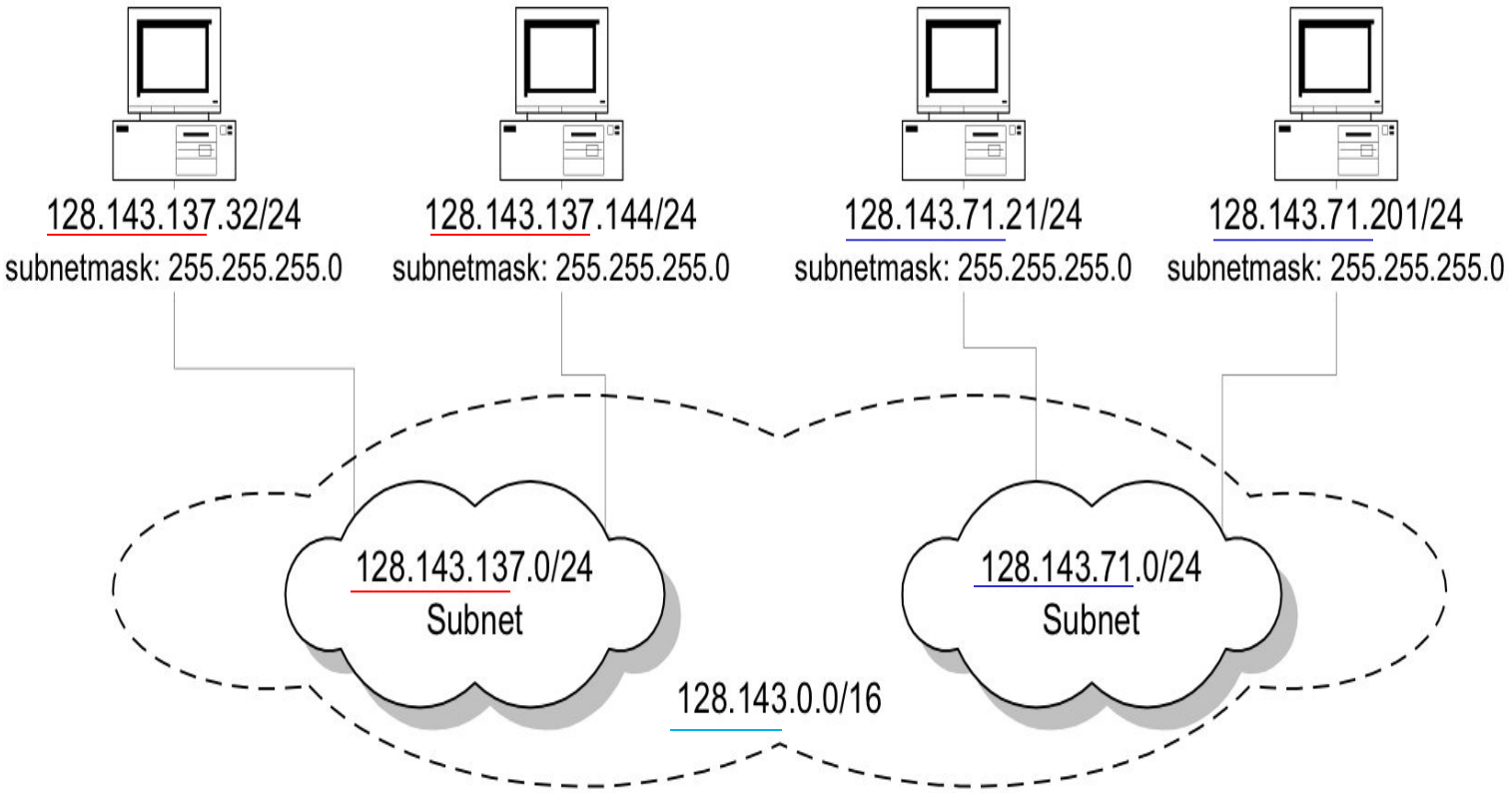
# Subnetting Example



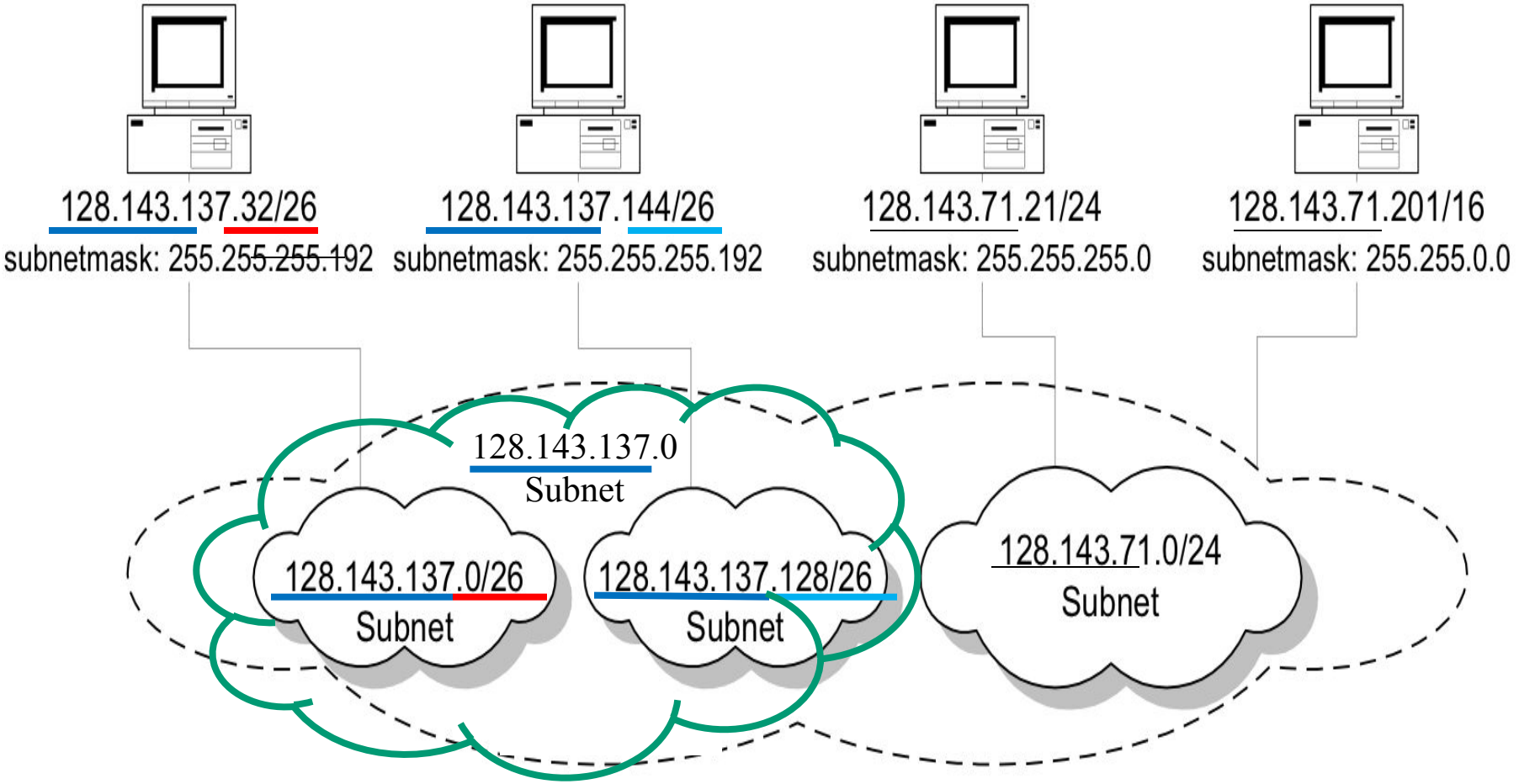
# Network without subnets



# Same Network with Subnets



# Same network with different subnetmasks



# Subnetting Example

- An organization with 4 departements has the following IP address space: 10.2.22.0/23. As the systems manager, you are required to create subnets to accommodate the IT needs of 4 departments. The subnets have to support to 200, 61, 55, and 41 hosts respectively. What are the 4 **subnet network** numbers?

- Solution:
  - 10.2.22.0/24 (256 addresses > 200)
  - 10.2.23.0/26 (64 addresses >61)
  - 10.2.23.64/26 (64 addresses > 55)
  - 10.2.23.128/26 (64 addresses > 41)