Networking Technologies and Applications

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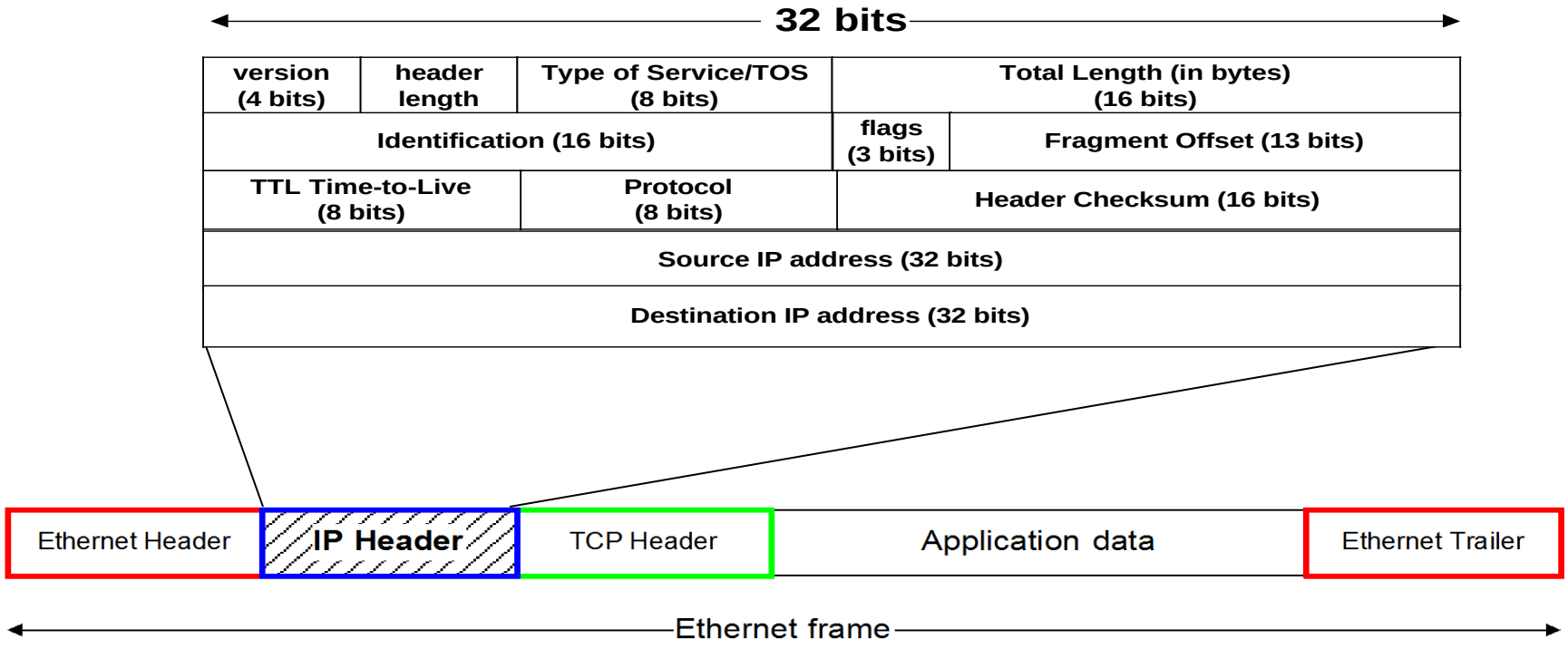
IP(v4) Addresses



What is an IP Address?

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

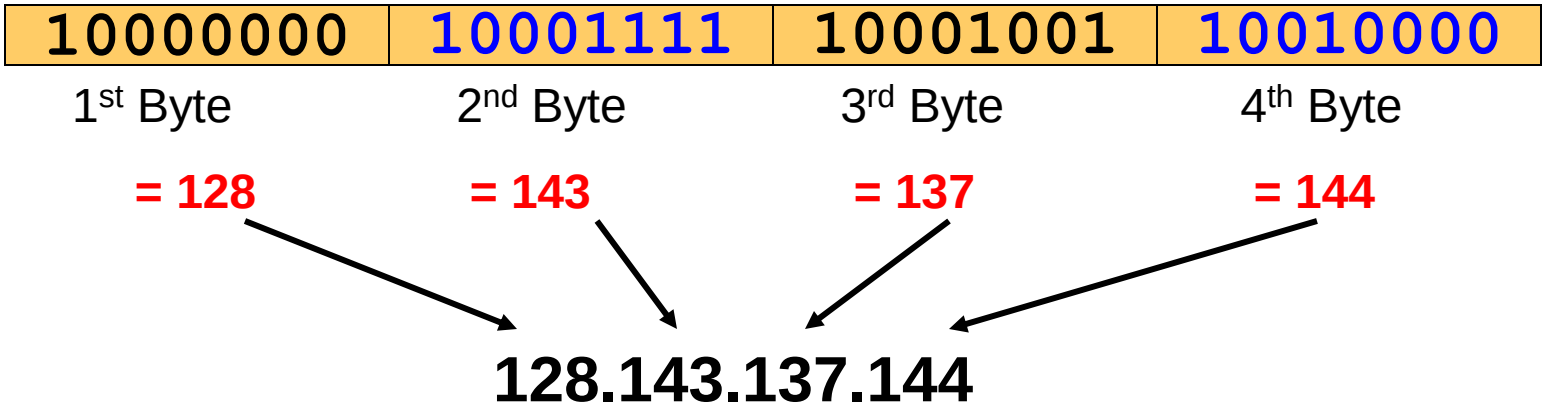
- An IP(v4) address:

  - 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

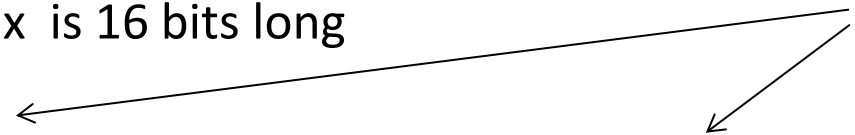
- The network prefix identifies a network and the host number identifies a specific host (actually, interface on the network).

- **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 a **prefix**/**netmask (classless).**

Example

Example: argon.cs.virginia.edu

- 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**

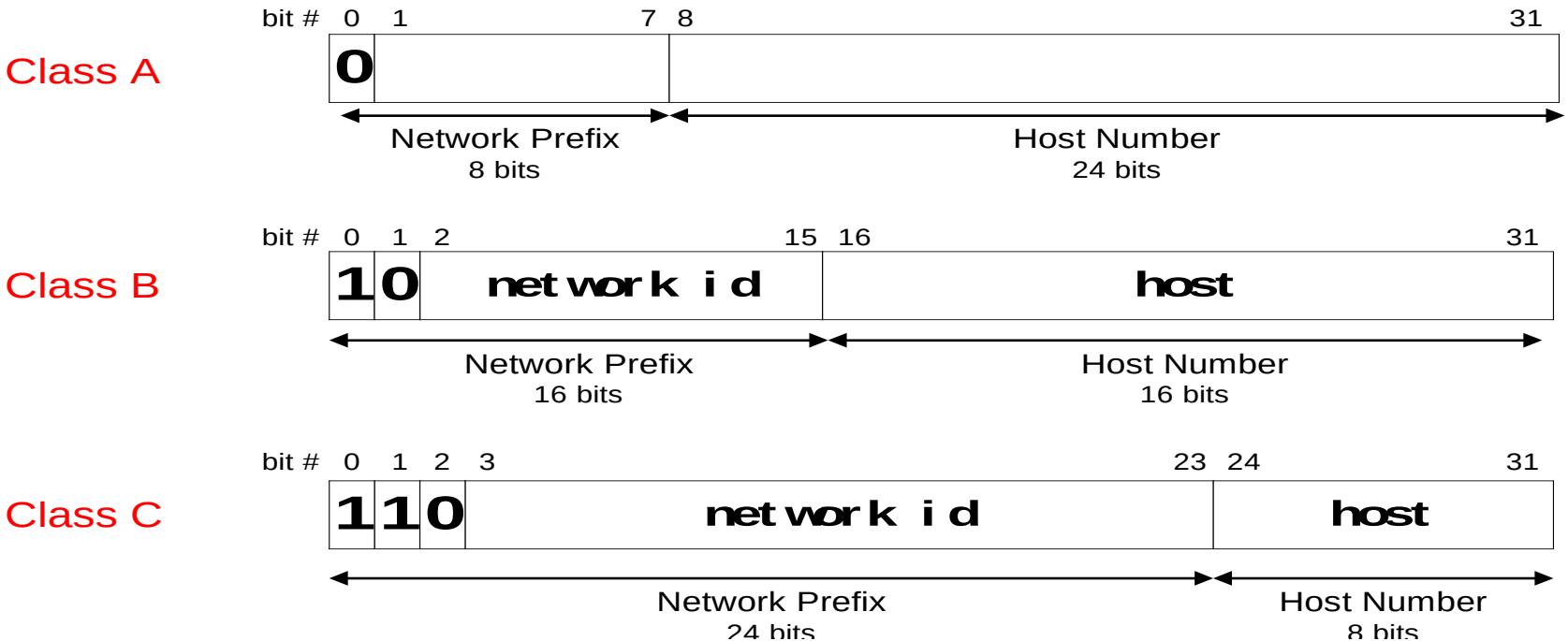
  -----> **Host number** (IP address **AND** inverse of Netmask) is: **137.144**

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"

	Number of networks	Maximum nr. of hosts on a network	Value of first byte
Class A	126	16,777,214	1 – 126
Class B	16,384	65,534	128 – 191
Class C	2,097,152	254	192 - 223

The old way: Internet Address Classes



The old way: Internet Address Classes

- We will learn about multicast addresses later in this course.

Addressing rules

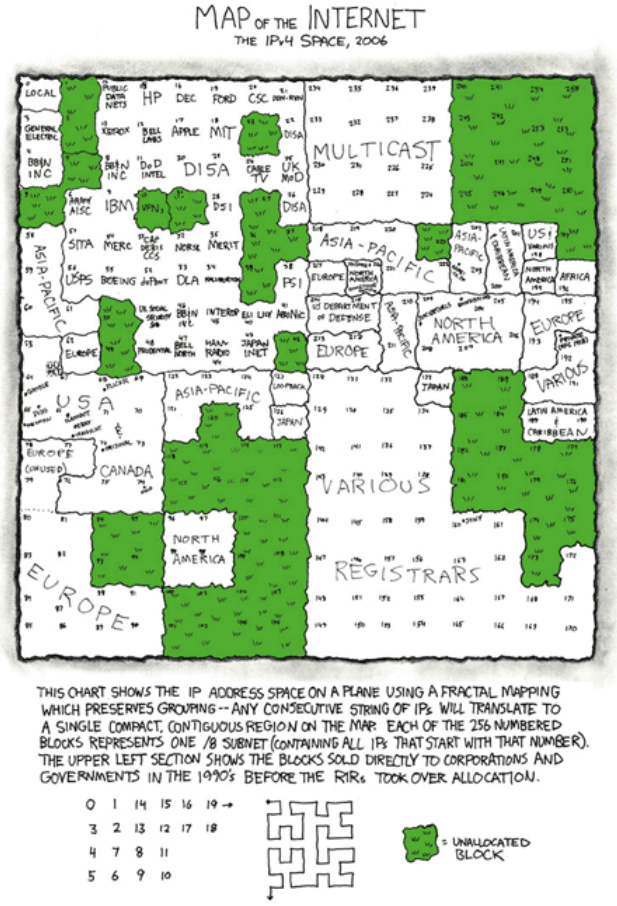
- The Network ID cannot be 127
  - Reserved for the loop-back interface
- The host ID cannot be 255
  - 255 a broadcast address
- The host ID cannot be 0
  - 0 means „this network”
- The host ID has to unique on the given network

Problems with Classful IP Addresses

- The original classful address scheme had a number of problems

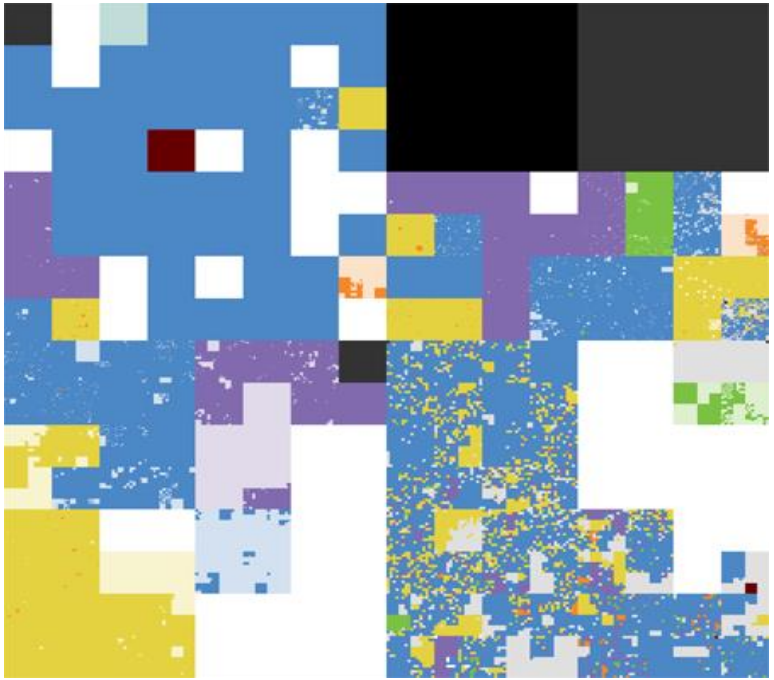
Problem 1. Too few network addresses for large networks

- Class A and Class B addresses are gone
- Initially given to institutions
  - Upper left corner
  - HP, Apple, MIT, IBM, Ford, etc
- Later RIRs are created
  - Regional Internet Registrar



IPv4 addresses (2006)

- Blue: ARIN – North America
- Yellow: RIPE NCC – Europe
- Magenta: APNIC – Asia-Pacific
- Green: LACNIC – Latin-America
- Orange: AfriNIC – Africa
- Black: Multicast
- Grey: Special addresses
  - Loopback, private, class E, etc.
- White: free



Problems with Classful IP Addresses

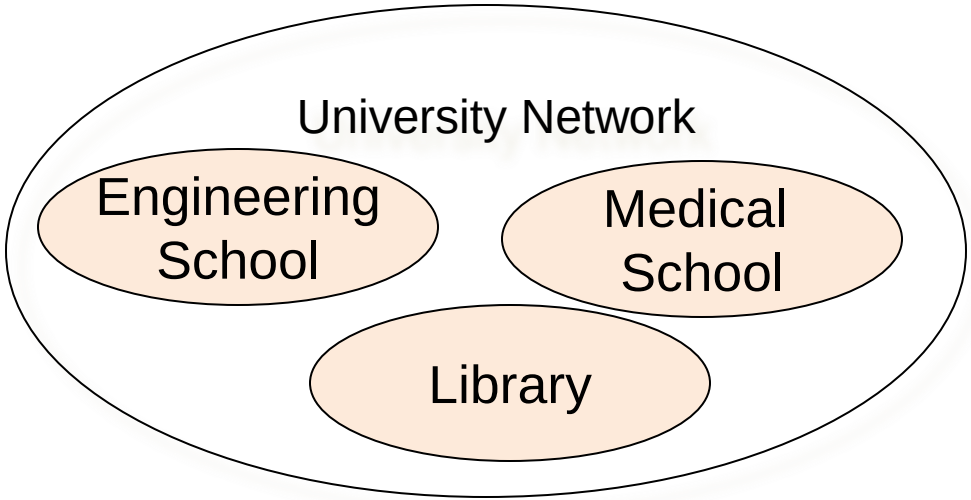
- The original classful address scheme had a number of problems

Problem 2. Two-layer hierarchy is not appropriate for large networks with Class A and Class B addresses.

  - **Fix #1: Subnetting**

Subnetting

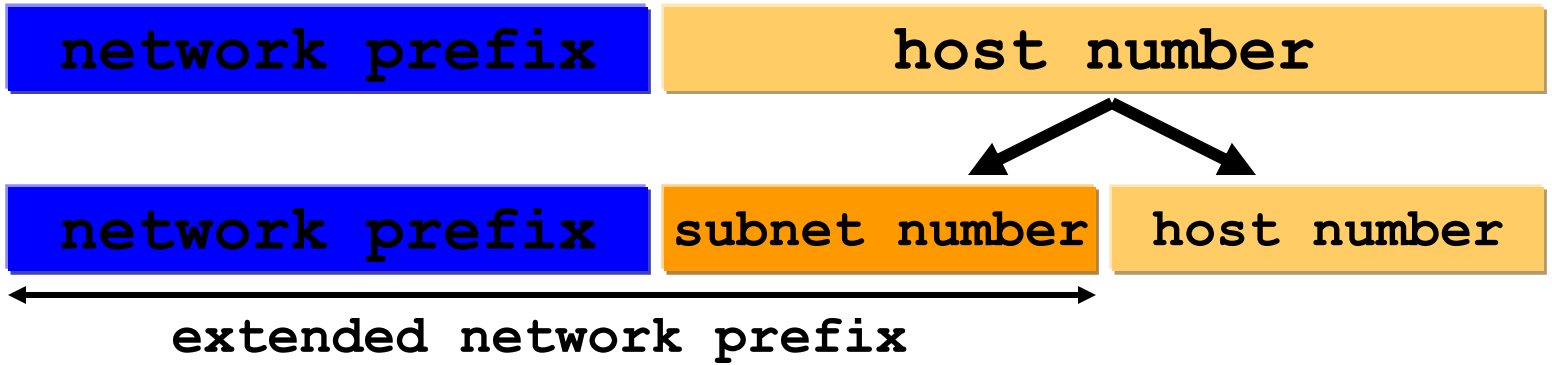
- **Problem**: Organizations have multiple networks which are independently managed
  - **Solution 1:** Allocate an address for each network
    - Difficult to manage
    - From the outside of the organization, each network must be addressable, must have an identifiable address.
  - **Solution 2:** Add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



→ **Subnetting**

Basic Idea of Subnetting

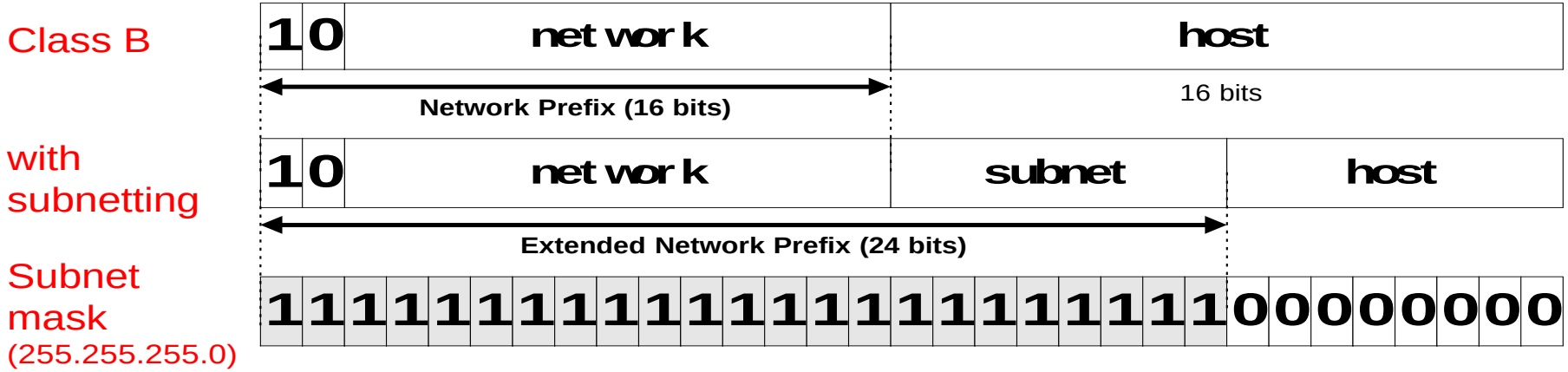
- Split the host number portion of an IP address into a **subnet number** and a (smaller) **host number**.
- Result is a 3-layer hierarchy



- 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

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

- 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)