IP Addresses

- An *internet* must operate like any other network:
  - It must allow hosts to send and receive data to each other
  - To facilitate this some type of *addressing scheme* is required
    - i.e. all hosts require a unique address
- So *addressing* is a critical component of the *internet abstraction*
- The *Internet Protocol* (IP) defines such an addressing scheme
  - IP addressing is independent of the underlying physical addressing schemes

IP Address Hierarchy

- Each host/router *interface* is assigned a unique 32-bit *IP address*
  - This address is used in packets that are sent across an internet
- Each IP address consists of two parts: a *prefix* and a *suffix*
  - Each physical network is assigned a unique *network number* which forms the ***network prefix*** part of a host's IP address.
    - It uniquely identifies the physical network to which the host is attached
  - The ***host suffix*** uniquely identifies the *host* on that network.
- *Network numbers/prefixes* are assigned globally, *host suffixes* are assigned locally

Dotted Decimal Notation

- Representing IP addresses in 32-bit binary form is only suitable for computers.
- A human-friendly version of IP addresses is known as *dotted-decimal notation.*
- Here each octet of the IP address is represented as a decimal value separated by a dot '.'
  - Examples include: 129.52.6.0, 128.10.2.3 and 128.128.255.0
  - Each decimal value represents 8-bits,
  - Consequently, the range of decimal numbers extends from 0 - 255

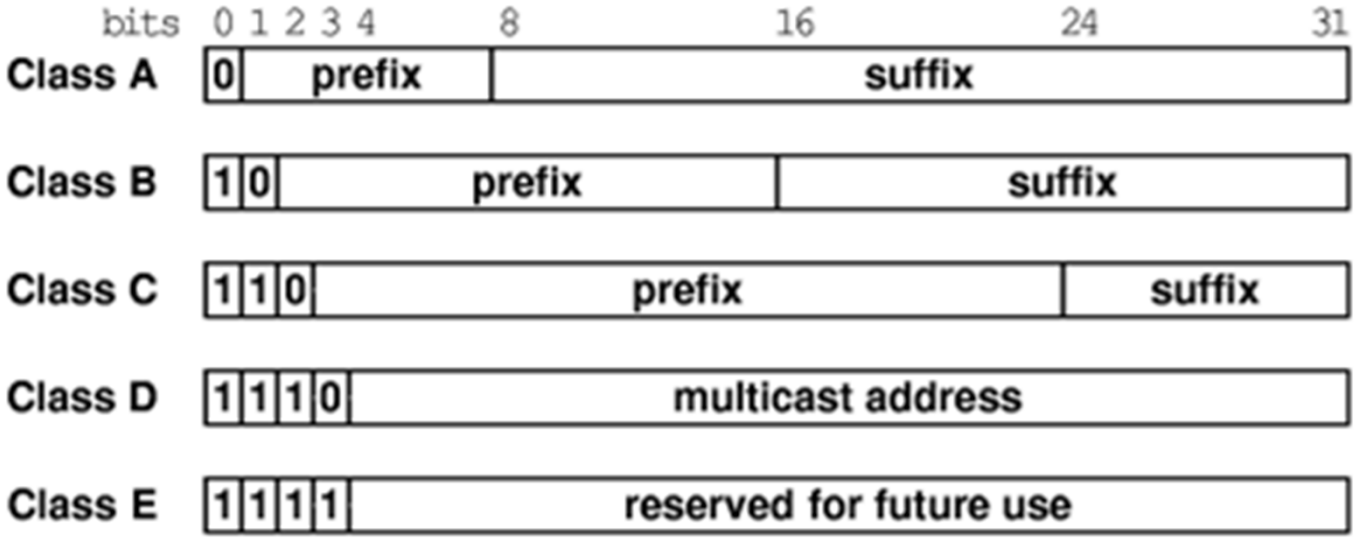
IP Address Hierarchy

- The IP addressing scheme must accommodate large and small internets:
  - This was originally achieved using *classful IP addressing*
- Classful Addressing was the first attempt to organize the IP address space.

Original *Classful* IP Addressing

- Here the IP address space was divided into **five** *classes:*
  - Each class had different size *prefix* and *suffix* portions to accommodate large and small networks.
  - The first four bits identify the *class* to which the address belongs (see next slide).
  - **Classes A, B and C** are known as the *primary classes* because they are used for *host addressing.*
  - Class D addresses are used for *multicasting*
  - Class E was reserved for future use.

Classful IP Addressing Scheme



- Note the different sizes of the *prefix* and *suffix* portions for each class:
  - For Class A addresses the first octet is the ***network prefix*** and the last three octets are the **host suffix.**
  - Notice also the split between *network prefix* and *host suffix* for Classes B and C.

Routing of IP Packets

- Q: Why is the separation of prefix and suffix important?
- A: Routers are responsible for directing datagrams/packets onto their final destination.
  - This is called *routing.*
  - The router needs to look at the address to make a decision about where to route a packet.
  - This is similar to the Post Office delivering letters.
  -

Routing of ‘Letters’

- Letters are routed through *National* and *Local* sorting offices.
- National Sorting Offices tend to be far away from the destination.
- They only need to examine the County/Town to route the letter towards a sorting office closest to the destination.

Routing of ‘Letters’

- The Local Sorting Office closest to the destination examines the Street Name and House Number to make the final delivery.
- This Post Office analogy is similar to the way Routers route incoming IP packets.

Back to routing of ‘Packets’

- Routers far away from the Destination router can be considered *National* Sorting Offices:
  - They only need to examine *network prefixes* (similar to *County/Town*) in an attempt to route the packet towards the final destination router.
- The Router closest to the destination station can be considered a *Local Sorting* Office
  - They examine the entire destination IP address including the *host suffix*.

Routing of IP Packets using Classful Addressing

- Classful IP addresses are *self-identifying* as the *network prefix* portion of an IP address can be computed from the address itself:
  - The first four bits will determine the class and hence the *network prefix*.
  - Refer to the next slide to see how the bits relate to the classes.
- This makes it easy for “far away” routers to route packets towards the destination router.

Classful IP address values

First Four Bits Of Address	Table Index (in decimal)	Class of Address
0000	0	A
0001	1	A
0010	2	A
0011	3	A
0100	4	A
0101	5	A
0110	6	A
0111	7	A
1000	8	B
1001	9	B
1010	10	B
1011	11	B
1100	12	C
1101	13	C
1110	14	D
1111	15	E

Routing of IP Packets using Classful Addressing

- Whilst *dotted-decimal notation* represents IP addressing in a simple form it does hide the first four bits:
  - Instead, we humans have to rely on range values to determine the Class of the address:
    - For Class A addresses the **first** octet is in the range 0-126,
    - For Class B addresses the range is 128-191, and,
    - For Class C addresses the range is 193-223.

A *classful* addressing example