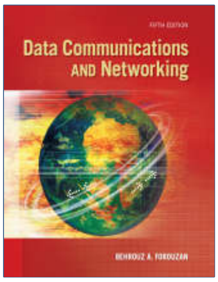


Computer Networks

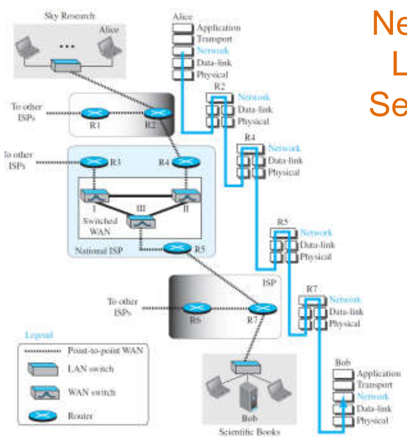
Lecturer: Dr. A.O. Aldhaibani

Lecture 3

Network Layer

2

Network Layer Services



3

Generating Packets

- **Encapsulating** the payload (data received from upper layer) in a network-layer packet at the source.
- **De-capsulating** the payload from the network-layer packet at the destination.

The network layer is doing the service of a carrier such as the postal office, which is responsible for delivery of packages from a sender to a receiver without changing or using the contents.
The source is not allowed to change the content of the payload unless it is too large for delivery and needs to be fragmented.
if a packet is fragmented, the header needs to be copied to all fragments and some changes are needed

4

Routing and Forwarding

– *Routing*

– The **network layer** is **responsible** for **routing** the packet from its source to the destination.

– The **network layer** is **responsible** for **finding** the **best** one among the **possible routes (or paths)**.

– Routers **build Routing Table** that contains **information** about **best paths** to all destinations.

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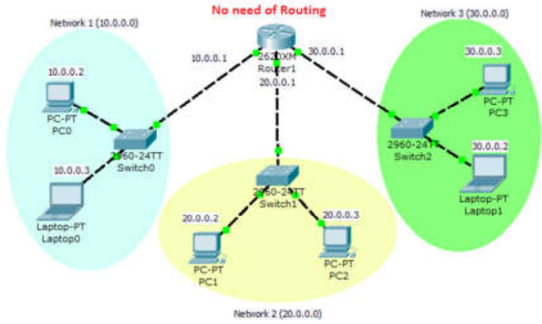
Routing



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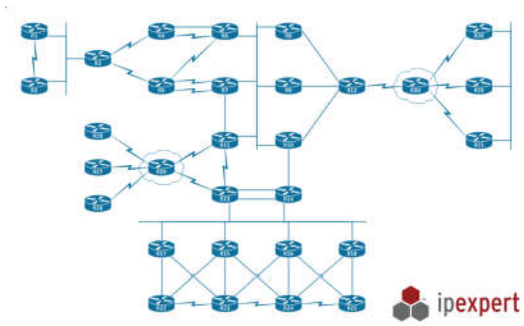
Routing



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Routing

– The **routing** is **done** using **two** methods:

– **Static Method**: **Building** the routing table manually **by** the network **admin**.

– **Dynamic Method**: **Building** the routing table using **routing protocols**.

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Forwarding

- **Forwarding** is: the **action** applied by each router when a packet **arrives** at one of its **interfaces**.
- **Lookup**: is the **searching** operation in the routing table.
- **Routing** Table = **Forwarding** Table

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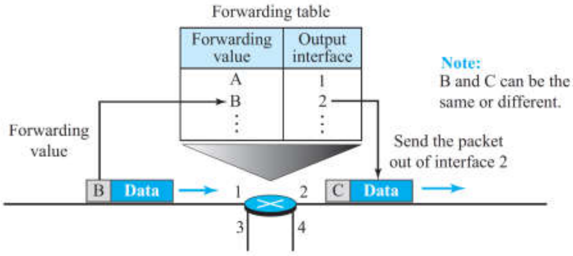
Forwarding Process



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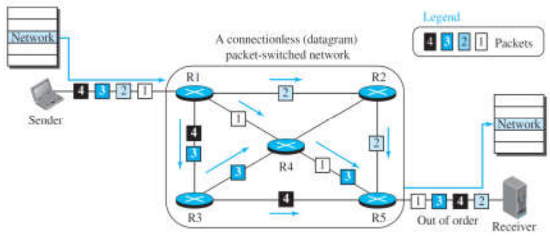
Datagram Approach: Connectionless Packet Switching

The network-layer protocol treats each packet independently, with each packet having no relationship to any other packet. The idea was that the *network layer is only responsible for delivery of packets from the source to the destination.* In this approach, the packets in a message may or may not travel the same path to their destination.



The router in this case routes the packet based only on the destination address. The source address may be used to send an error message to the source if the packet is discarded.

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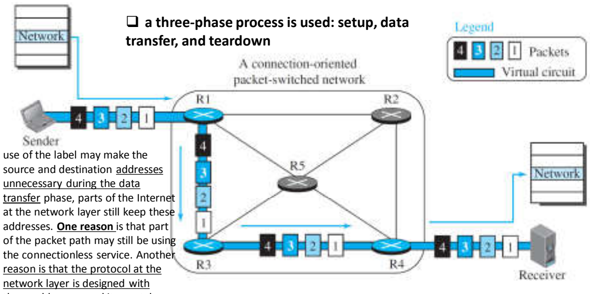
A virtual-circuit Packet-Switching

Before all datagrams in a message can be sent, a virtual connection should be set up to define the path for the datagrams. After connection setup, the datagrams can all follow the same path. In this type of service, not only must the packet contain the source and destination addresses, it must also contain a flow label, a virtual circuit identifier that defines the virtual path the packet should follow.

- **a three-phase process is used: setup, data transfer, and teardown**



use of the label may make the source and destination addresses unnecessary during the data transfer phase, parts of the Internet at the network layer still keep these addresses. **One reason** is that part of the packet path may still be using the connectionless service. Another reason is that the protocol at the network layer is designed with these addresses, and it may take a while before they can be changed

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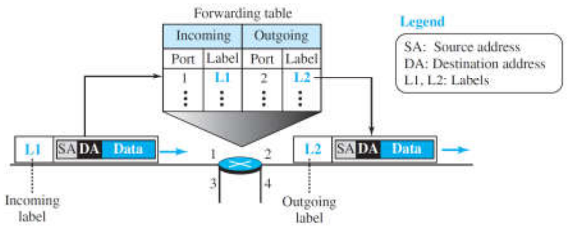
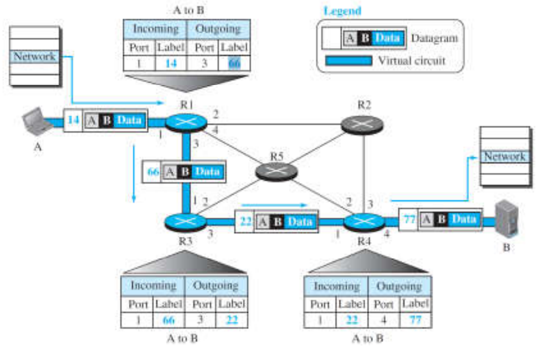
Forwarding in virtual-circuit networks



Flow of one packet in an established virtual circuit



Network Layer Performance (Delay)

– *Transmission Delay*
- If the first bit of the packet is put on the line at time t1 and the last bit is put on the line at time t2, then the transmission delay of the packet is (t2-t1).
- **Delay_{tr} = (Packet length) / (Transmission rate).**
- Delay_{tr} = 10,000,000bits / 10Mbps = 10,000,000/10,000,000 = 1second

Network Layer Performance (Delay)

– *Propagation Delay*
- The time it takes for a bit to travel from point A to point B in the transmission media.
- **Delay_{pg} = (Distance) / (Propagation speed).**
- Delay_{pg} = 2000 meters / 2×10^8 meters/second = 10 milliseconds.
- **Note**:
- 3×10^8 meters/second is the propagation speed of light
- 2×10^8 meters/second is the propagation speed of bit in the cable.

Network Layer Performance (Delay)

- *Processing Delay*
  - The time required to process a packet in a router or a destination host.
- *Queuing Delay*
  - The time a packet waits in input and output queues in a router.
- *Total Delay*
  - Total delay = $(n + 1)$ $(Delay_{tr} + Delay_{pg} + Delay_{pr})$ + (n) $(Delay_{qu})$

- Where *n = number of* routers

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Network Layer Performance (Throughput)

- The **number** of **bits passing** through the point in a **second**.
  - **Actually** the **transmission rate** of data at that point.
  - **Throughput = minimum {TR1, TR2, . . . TRn}.**

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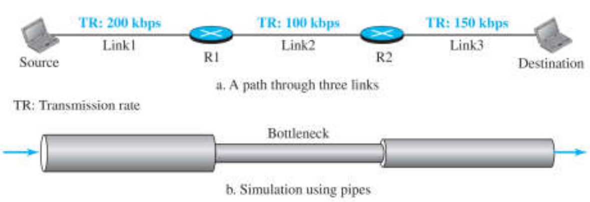
Throughput in a path with three links in a series

- The data **rate** for this path is **100** kbps, **i.e.** the **minimum** of the **three** different data rates.



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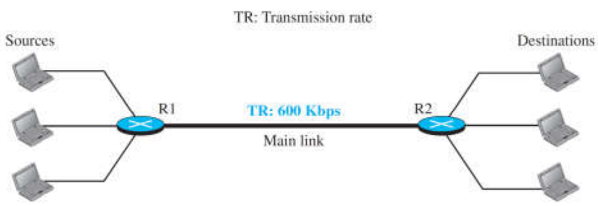
Throughput in shared links

- The **throughput** is only **200** kbps because the link is **shared** between **three** paths.



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IPv4 Addressing

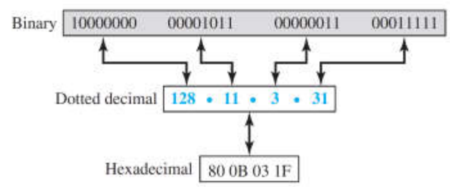
- **IP address identifies** the **connection** of each device to the **network** or **Internet**

- **IPv4** address is a **32-bit** address that **uniquely** and **universally** defines the connection of a **host** (client or server) or a **router** to the Internet.

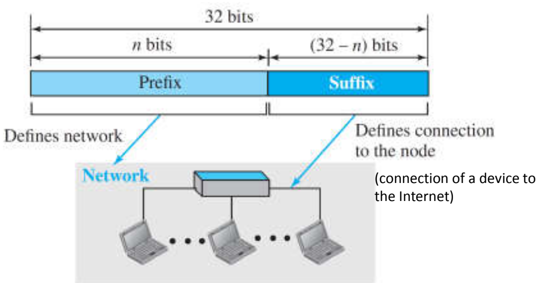
IP Address Space

- The **address space** is 2^{32} or **4,294,967,296**
- (the total number of addresses used by the protocol)

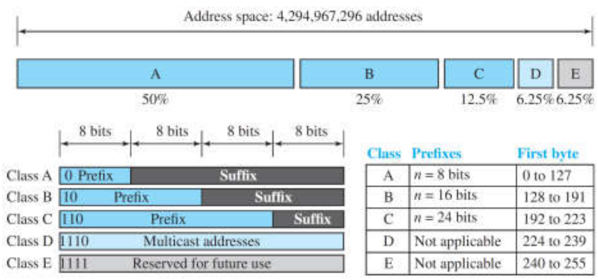
Three different notations in IPv4 addressing



Hierarchy in IP Addressing



Classful Addressing



Class	Prefixes	First byte
A	n = 8 bits	0 to 127
B	n = 16 bits	128 to 191
C	n = 24 bits	192 to 223
D	Not applicable	224 to 239
E	Not applicable	240 to 255

Classful Addressing

Class Name	Number of Networks	Number of Hosts	prefix
Class A	$2^7 = 128$	$2^{24} – 2 = 16,777,214$	8
Class B	2^{14} = ١٦،٣٨٤	$2^{16} – 2 = 65,534$	16
Class C	2^{21} = ٢،٠٩٧،١٥٢	$2^8 – 2 = 254$	24

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Classful Addressing

- 10.4.5.6 / 8
- 00001010.0000 ……
- 172.
- 10

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IP address Depletion

– The **reason** that classful addressing has become **obsolete** is address **depletion**.

– The **Internet** was **faced** with the **problem** of the **addresses** being rapidly **used up**, resulting in **no more** addresses **available** for **organizations** and **individuals** that needed to be connected to the Internet.

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Advantage of Classful Addressing

– **Classful** Addressing had **one advantage**.

- we can **easily find** the **class** of the address and, since the **prefix length** for each class is **fixed**.

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Problems with Classful IP Addressing

- Class A – 16,777,214 Hosts
- Class B – 65,534 Hosts
- Class C – 254 Hosts

- What do you do if you have 2,000 hosts?
  - Pick Class B and waste 63,000+ addresses.

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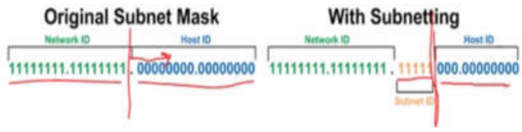
classless interdomain routing

- If we start with 255.255.0.0, but want to divide into smaller networks we need to take bits from the Host ID and move them into the Network ID.



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Classless Addressing

– In 1996, the **Internet authorities** announced a new architecture called **classless addressing.**

– In **classless** addressing, **variable-length** blocks are used that **belong** to **no classes**.

– the **prefix length** in **classless** addressing is **variable**.

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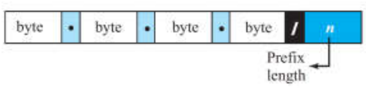
Prefix Length: Slash Notation

– Since the **prefix** length is **not inherent** in the address, how to find the prefix length if an address is given?

– In this case, the **prefix length**, *n*, is **added** to the **address**, separated by a **slash**.



Examples:
12.24.76.8/8
23.14.67.92/12
220.8.24.255/25

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Formulas

- **Number of Subnets:**
  - 2^n
  - n = Number of 1's in the Subnet ID
- **Number of available host addresses:**
  - $2^n - 2$
  - n = Number of 0's in the Host ID
  - Host ID cannot be all 0's or all 1's
- **Example:**
  - 11111111.11111111.11111000.00000000
  - $2^5 = 32$ Subnets
  - $2^{11} - 2 = 2046$ Available hosts in each subnet

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CIDR = **Classless Inter-Domain Routing**

192.168.0.0 /30

255.255.255.252

00000000 --→ 11111100

Host 2^2 - 2 = 4 – 2 = 2

Net 2^6 = 64

△ 256 – 252 = 4

Net	0	4	8	12	16	...	...	244	248	252
Frist host	1	5	9	13	17	...	...	245	249	253
Lost host	2	6	10	14	18	...	...	246	250	254
Broad cast	3	7	11	15	19	...	...	247	251	255

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Activities

- 192.168.10.11/26
- 10.0.0.0/9

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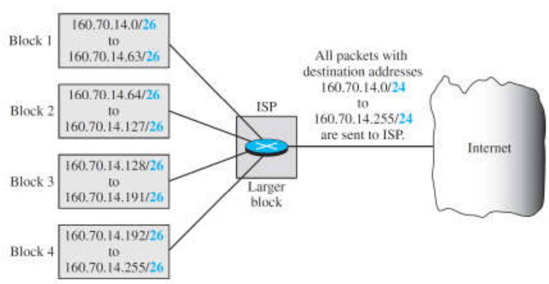
Address Aggregation



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Special Addresses

– *This-host Address:*

0.0.0.0/32

It is used whenever a host needs to send an IP datagram but it does not know its own address to use as the source address

– *Limited-broadcast Address:*

255.255.255.255/32

It is used whenever a router or a host needs to send a datagram to all devices in a network

– *Loopback Address:*

127.0.0.0/8

- A packet with one of the addresses in this block as the destination address never leaves the host; it will remain in the host. Any address in the block is used to test a piece of software in the machine.

Special Addresses

– *Private Addresses*

10.0.0.0/8 ،172.16.0.0/12 ،192.168.0.0/16 and 169.254.0.0/16

Four blocks are assigned as private addresses. use a set of private addresses for internal communication

– *Multicast Addresses*

224.0.0.0/4

is reserved for multicast addresses

- لمعرفة عنوان شبكه من Ip معين
- 192.168.0.109/28
- 255.255.0.240
- 01101101=109
- 11110000=240
- 01100000 =96
- Net.ID 192.168.0.96

Discussion