

# Challenges to the Internet Protocol (IP)

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# The Internet Protocol (IP)

Principles of Network Switching:

**Circuit-Switching** : Provides a dedicated path between source and destination for the duration of the call.

**Packet-Switching** : Creates an independent path for each packet as it transverse the network.

How do computers communicate ?

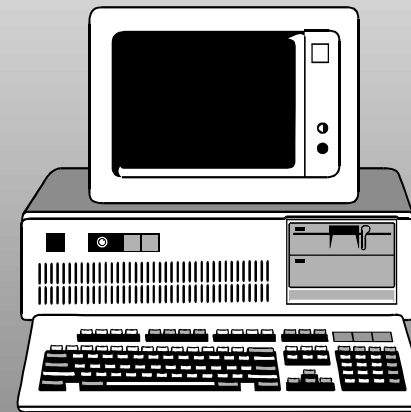
# Principles of Computer Communications

**The two computers must be connected to some form of physical medium. A number of issues have to be resolved to enable computers talk to each other.**

**If one speaks ASCII and the other speaks EBCDIC, they wont understand each other would they ?**

# Computers Application Programs

- **Application programs: files, E-Mail, Video, Audio, Multimedia, etc.**



# 7-layer Open System Interface

- **Protocol layers**

Application

Presentation

Session

Transport

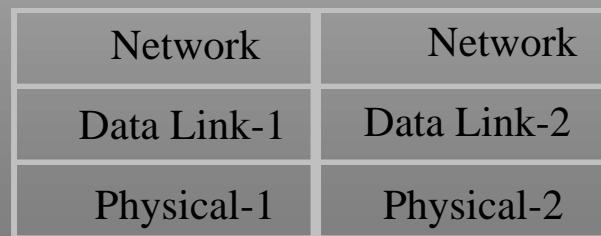
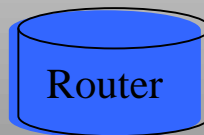
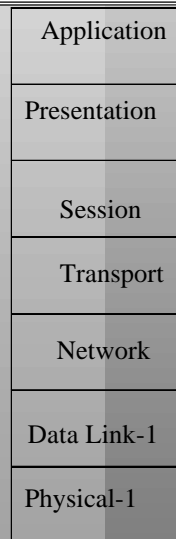
Network

Data Link

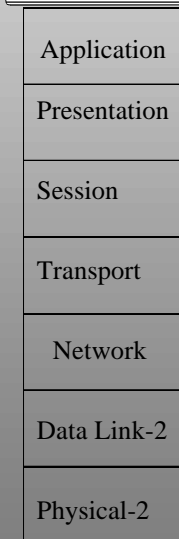
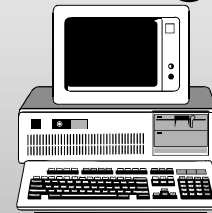
Physical

# Computer Communications & Networking

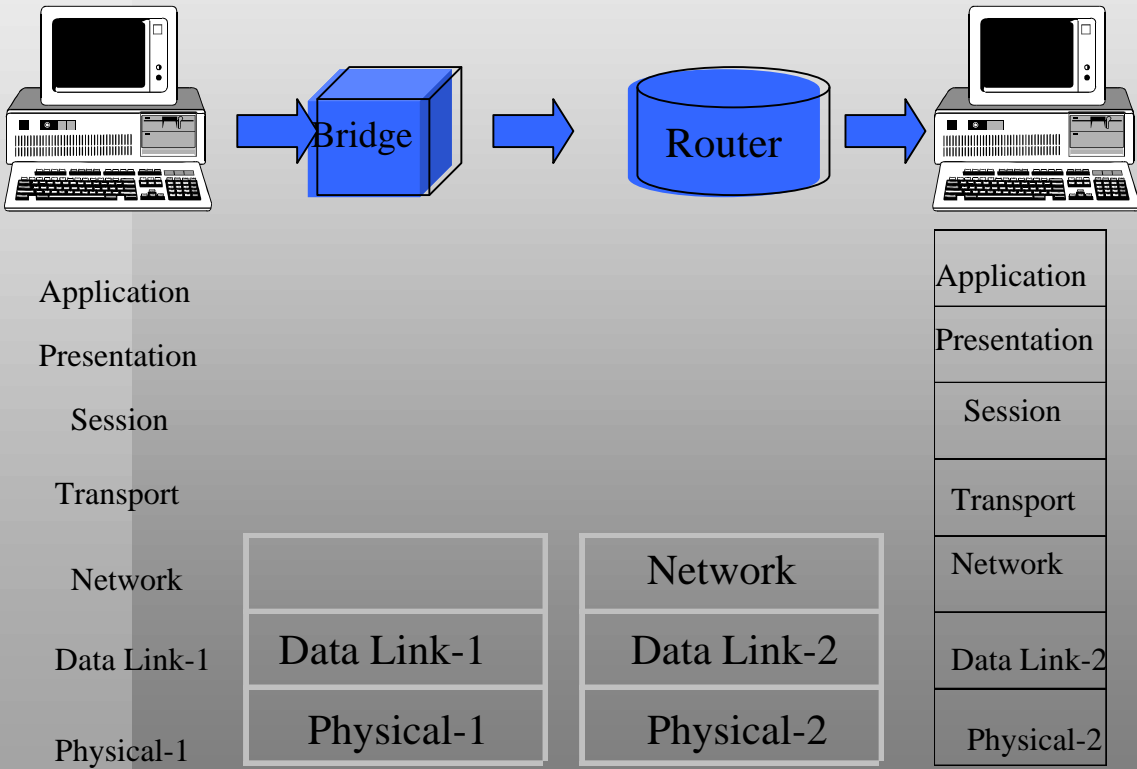
## Computer A



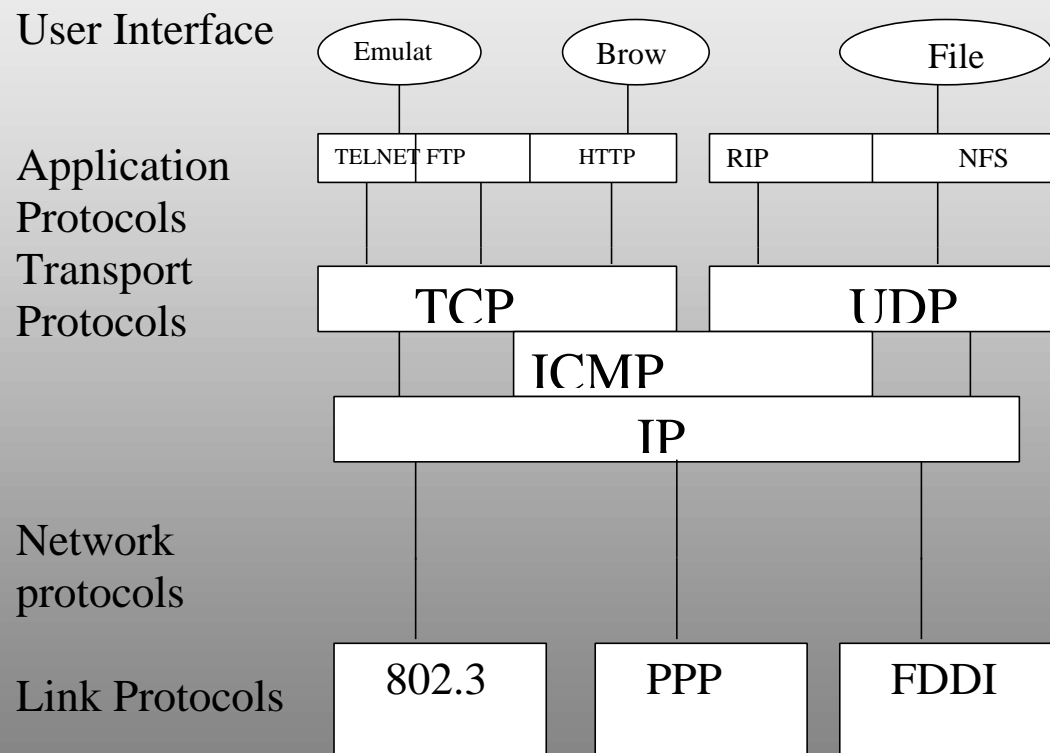
## Computer B



# Computer Communications



# Internet Reference Model



# Internet Protocol Packet

- **IP4 Packet**

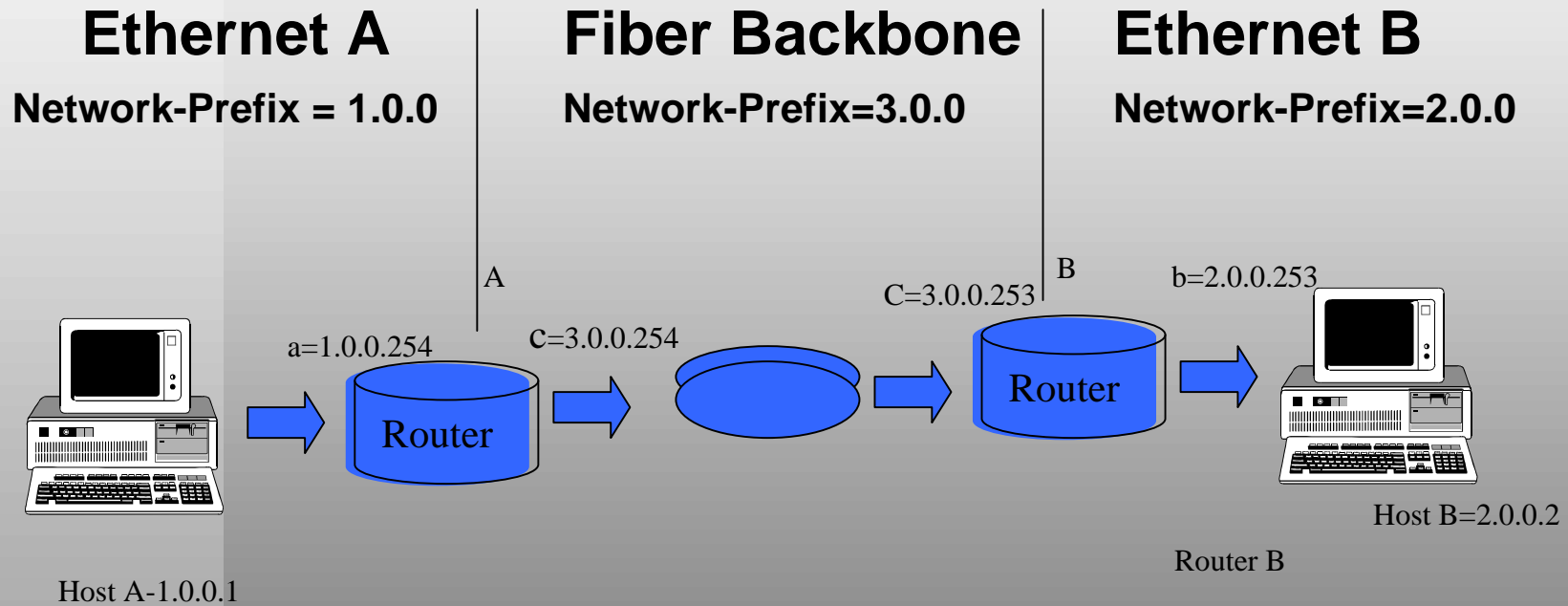
Vers=4	IHL	Type of Service	Total Length	
Identification		Flags	Fragment offset	
Time to live	Protocol		Header Checksum	
Source Address				
Destination Address				
Options				
Transport Header				
Application Header				
Application data				

**IP Header**

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**Payload**

# Internet Protocol (IP) Networks



Target	Next Hop	Interface
1.0.0/24	Direct	a
0.0.0/0	1.0.0.254	a

Target	Next Hop	Interface
1.0.0/24	3.0.0.254	c
2.0.0/24	Direct	b
3.0.0/24	Direct	c

# Internet Protocol (IP)

## IP Overview

- **Limitations of IPv4**
- **How many addresses do we need ?**
- **Features of IPv6**

# Internet Protocol (IP) v4

- **IPv4 Addresses**

- **Example : 156.85.123.45**

**= 1001 1100:0101 0101:0111 1011:0010  
1101**

**= 9C : 55 : 7B : 2D**

- **Max. Number of address = 4.3  
Billion**

# IP Network classes

## Network classes:

- **Class A Networks : 16 million nodes**
- **Class B Networks : 64 K nodes or less**
- **Class C networks : 250 nodes or less**

# IP Networks Addresses

## Class A:



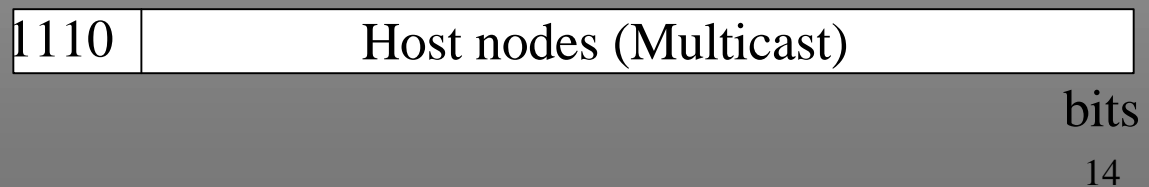
## Class B:



## Class C:

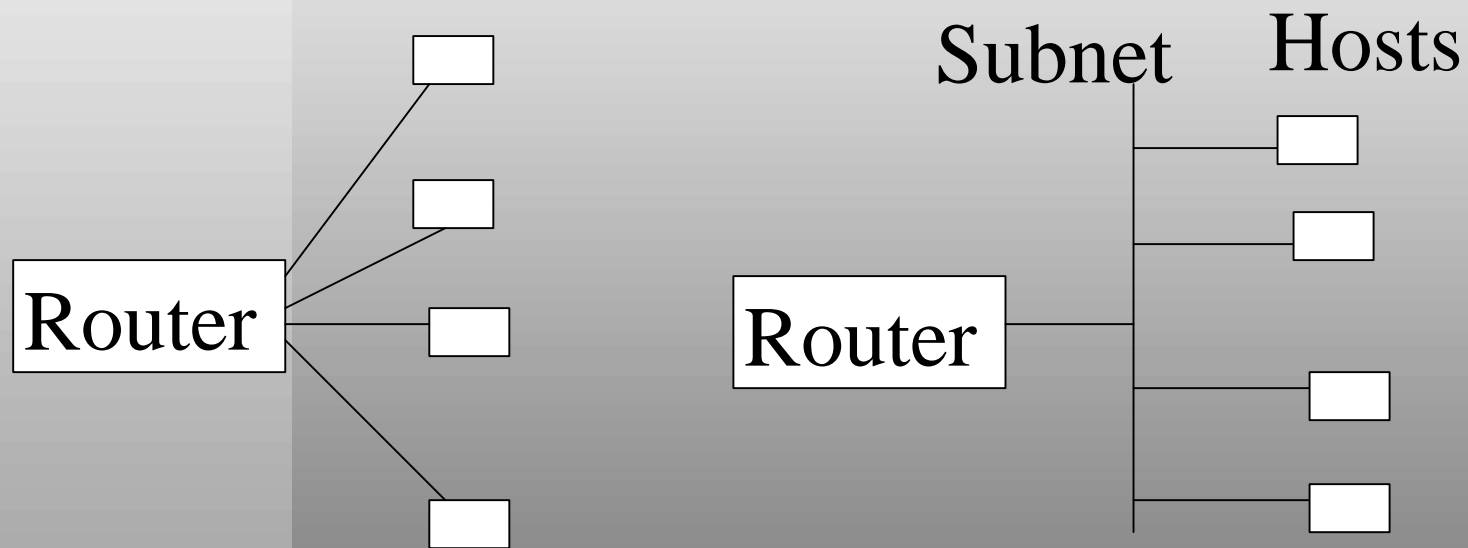


## Class D:



# Router - Subnet connection

**Local = Subnet + Host Node**



# IP Networks

- **All-zero network numbers are reserved**
- **127 Class A + 16,383 Class B + 2,097,151 Class C = 2,113,662 Networks total**
- **Class C is too small. Class B is most popular.**

# IP Addresses

- ? **Allow network to have multiple Class C addresses. Multiple addresses = long routing tables = Long routing update messages.**
- ? **• Subdivide one Class A among providers.**
- ? **• Address Space will be exhausted by 2008.**

# Challenges to Internet Protocol (IP)

## Three Possible Threats for IPv4:

- No more addresses
- No more Network numbers
- Too big routing tables

# Challenges to Internet Protocol (IP)

## Addresses we need for 21st Century:

- **Estimated 10 Billion people by 2020**
- **Each person will be served by more than one computer, Say 100 computers =1000 Billion computers**
- **Multiple interfaces/node and multiple addresses /interface**

# Internet Protocol v 6

## IPv6 Addresses:

- 128-bit long =  $2^{128} = 3.4 \times 10^{38}$  addresses  
= 670 x  $10^{21}$  addresses per sq..m of earth surface !!  
If assigned at the rate of  $10^{15}$  addresses per sec, it would take 20 years !!
- Allows multiple interfaces per host, multiple addresses per interface. unicast, multicast, anycast.

# IP Address Notation

- **IPv4: 4 bytes**

**Decimal-Dot: 123.56.45.77**

**Length of address : 7 to 15 characters**

- **IPv6:16 bytes**

**Length of address : 31 to 63 characters**

**Preferred form: x:x:x:x:x:x:x:x**

**where x is Hex values of 16 bits**

# IPv6 Address Notation

- IPv6:

**Binary 1111 1110 1101 1100: 1011  
1010 1001 1000: 0111 0110 0101  
0100: 0011 0010 0001 0000: 1111  
1110 1101 1100: 1011 1010 1001  
1000: 0111 0110 0101 0100: 0011  
0010 0001 0000**

**Hex=FEDC:BA98:7654:3210:FEDC:BA9  
8:7654:3210**

# IPv6 Address Notation

- IPv6

Skip one sequence of zero words, e.g.

FEDC:0000:0000:0000:9876:0000:0000:ABCD

=FEDC::9876:0000:0000:ABCD

0000:0000:0000:0000:0000:0000:0000:0001

=::0001

0000:0000:0000:0000:0000:0000:0000:0000

=::

## IPv6 Address Notation

- **Mixed IPv4 and IPv6 nodes**

**x:x:x:x:x:d:d:d:d** 'd' for decimal of  
8 bits.

**Leave the last 32 bits in dot-decimal**

**FEDC:0000:0000:0000:9876:0000:6789:ABC**

**D**

**=FEDC::9876:0000:0000:103:137:171:6**

**1**

# IP V6 Address Architecture

**Format Prefix indicates the type of address.**

<b>Allocation</b>	<b>Prefix (Binary)</b>
<b>Provider-based</b>	<b>010</b>
<b>Link-Local use</b>	<b>1111 1110 10</b>
<b>Site-Local use</b>	<b>1111 1110 11</b>
<b>Multicast</b>	<b>1111 1111</b>
<b>Reserved(unspecified, Loop back, IPv6 with Embedded IPv4 Addresses)</b>	<b>0000 0000</b>

# Provider-based Global Unicast

- **Unicast**

3	5	16	8	24	8	16	48
010	Registry ID	Provider ID	0	Subscriber ID	0	Subnet ID	Interface ID

- Variable size partitions
- 5-bit registry, 11111  IANA

# Local-Use addresses

- **Link Local: FE:80::xxx**

<b>10 bits</b>	<b>n bits</b>	<b>118 - n bits</b>
1111 1110 10	0	Interface ID

# Local-Use Addresses


- **Site Local: FE:C0::xxx**

<b>10 bits</b>	<b>n bits</b>	<b>118 - n bits</b>
1111 1110 11	0	Interface ID

# Multicast addresses

8 bits	4 bits	4 bits	112 bits
1111 1111	Flags	Scope	Group ID

0	0	0	T
---	---	---	---



T = 0  Permanent address, 1  Transient address

- **Scope:**
- = 1 Node-Local , 2 Link-Local, 5 Site-Local, 8 Org.-Local, E Global

# Multicast Addresses

## Pre-Defined Multicast Addresses

- Reserved Addresses

FF00::, FF01::,  FF09::, FF0A,   
FF0F::

- All Nodes Addresses

FF01::1, FF02::1

- All Routers Addresses

FF01::2, FF02::2

# IPv6

- **Advantages of IPv6 over IPv4**
- **Expanded addressing capabilities**
- **Simplified header Format:**
  - **Some IPv4 fields are dropped or made optional**
    - **Reduction in processing cost**
    - **Less BW cost**

# IPv6

- **Flow labeling**
- **Support authentication and privacy**
- **Support for improved options and extensions**

# IPv6 Headers

- IPv6 Header = 40 bytes

Version (4 bits)	Priority (4 bits)	Flow Label (24 bits)	
Payload Length (16 bits)	Next Header (8 bits)	Hop Limit (8 bits)	
Source Address ( 128 bits)			
Destination address (128 bits)			

# IPv6 Vs IPv4

- **1995 Vs 1975**
- **IPv6 is only double the size of IPv4 Header**
- **Only 'Version' is common in the Headers**
- **IPv6 has no optional fields. Replaced by extension headers.**
- **Hop limit = 8 bits = 255 hops max.**
- **Next Header = 6 (TCP), 17 (UDP)**

# IPv6 Header types

- Hop-by-Hop = 0
- Routing Header = 43
- Fragment Header = 44
- Authentication Header = 51
- Encrypted Payload = 52
- TCP = 6
- UDP = 17

# IPv6 Extension Headers

IPv6 header Next header=TCP	TCP header + Data
--------------------------------	-------------------

IPv6 header Next header = Routing	Routing header Next header = TCP	TCP header + Data
--------------------------------------	-------------------------------------	----------------------

IPv6 header Next header = Routing	Routing header Next header = Fragment	Fragment header Next header = TCP	
--------------------------------------	--	--------------------------------------	--

# IPv6 Extension Headers

- **Extension Headers ( Except Hop-by-Hop options Header) are examined only at the destination node, and in the order they appear in the packet.**
- **Routing : Loose / tight source routing**
- **Fragment: MTU = 576 bytes, 536 payload**
- **Destination options**
- **Authentication**
- **Encapsulation security payload**

# Hop-by-Hop Options Header

- **Header Format**

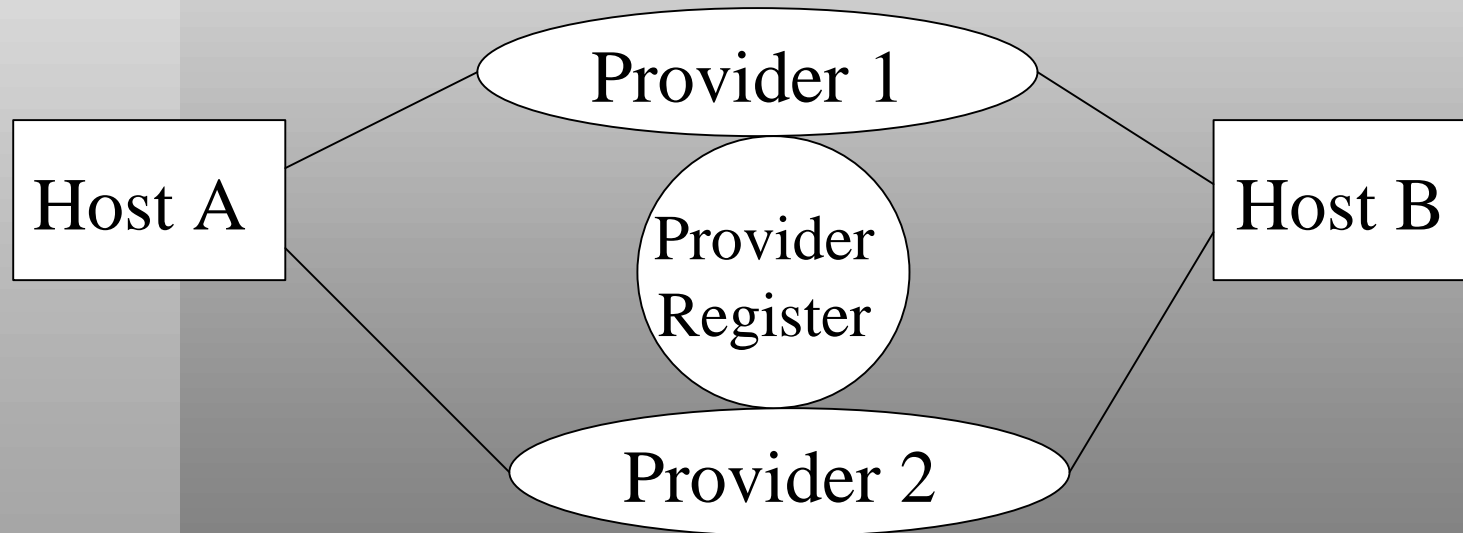
Next header ( 8-bit)	Header Length (8-bit)
<p>Options : pad1 + padN + Jumbo Payload</p> <p>Jumbo Payload Length= Length of packet in Bytes &gt; 64 K</p>	

# Routing Header

Next header	Routing type=0	Number Addresses	Next address
Reserved	Strict / Loss bit mask		
Address 1			
Address 2			
Address n			

# Routing Header

- **Strict**  Discard if Next address  $\neq$  Neighbor
- New Functionality : Provider selection, Host Mobility



# Flow Labels

- A flow is a sequence of packets sent from source to destination. Flow label indicates that packets need special handling at routers, e.g. Real-time service, special quality of service etc..
- All packets with the same flow must be sent with same source & destination addresses, priority and flow label.

# Priority in IPv6

- **4-bit priority field**
- **Enables source to identify the desired delivery priority of its packets relative to other packets from the same source.**
- **Two ranges: 0 through 7 specify priority of traffic (non-real time).**
- **8 through 15 specify priority of real-time packets.**

# Mobile IP

- **Proposed 1996 to enable node mobility in the Internet. Documents: RFC 2002, 2003, 2004, 2004, 2005, and RFC 2006**
- **provides a mechanism for routing IP packets to mobile nodes connected to any foreign links using their permanent IP address.**

# Mobile IP

- **Mobile IP provides scalable, robust and secure solution for mobility on the Internet.**
- **Host-specific routing and changing node IP address are not acceptable solutions for node mobility.**
- **Mobile IP is a network-layer solution works in connection with routing protocols such as OSPF, RIP and BGP.**

# Mobile IP

- **A mobile node communicates using its Home IP address.**
- **A mobile node communicates with other nodes that do not implement Mobile IP.**
- **A mobile node security must be over above those of fixed node.**

# Mobile IP

- **Heterogeneous mobility in addition to homogenous mobility.**
- **Mobile node functional entities:**
  - **Mobile node**
  - **Home agent**
  - **Foreign agent**

# Home Agent (Router)

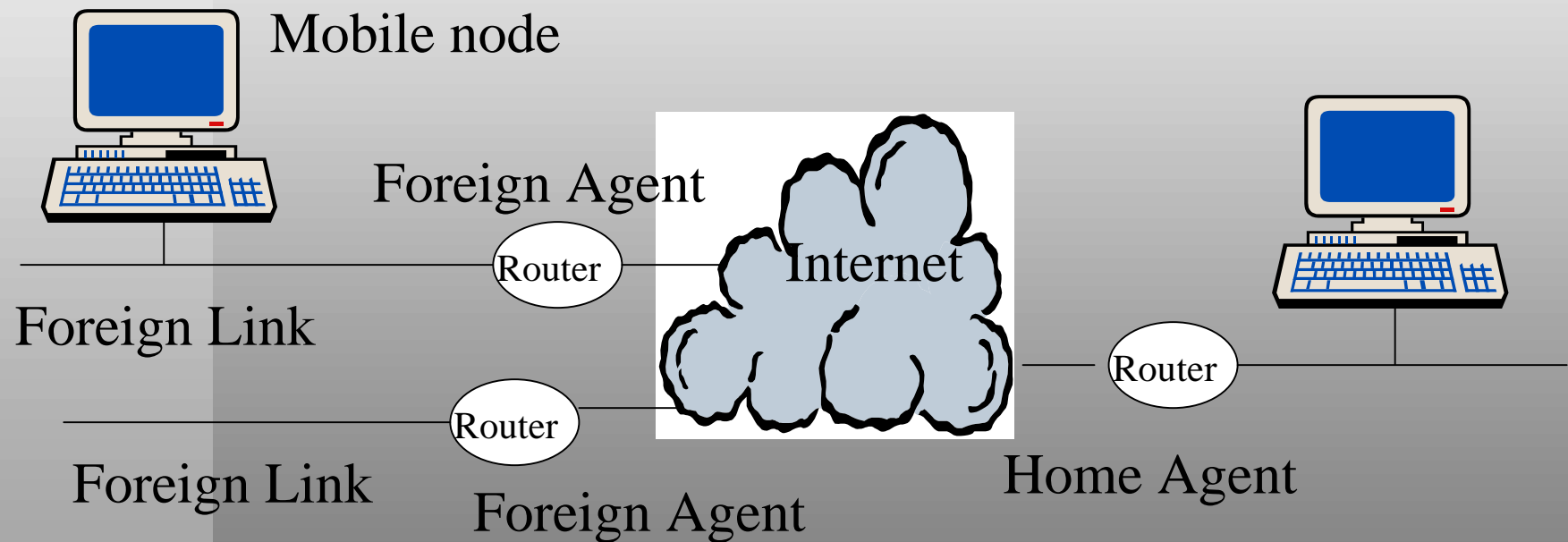
- **Keep update of the mobile current location through care-of-address.**
- **Attract packets destined to mobile node home address.**
- **Tunnel packets to mobile node care-of-address.**

# Foreign Agent (Router)

- **Inform home agent of the current mobile node care-of-address.**
- **Provides, in some cases, care-of-address**
- **Acts as default router for packets generated by the mobile node.**

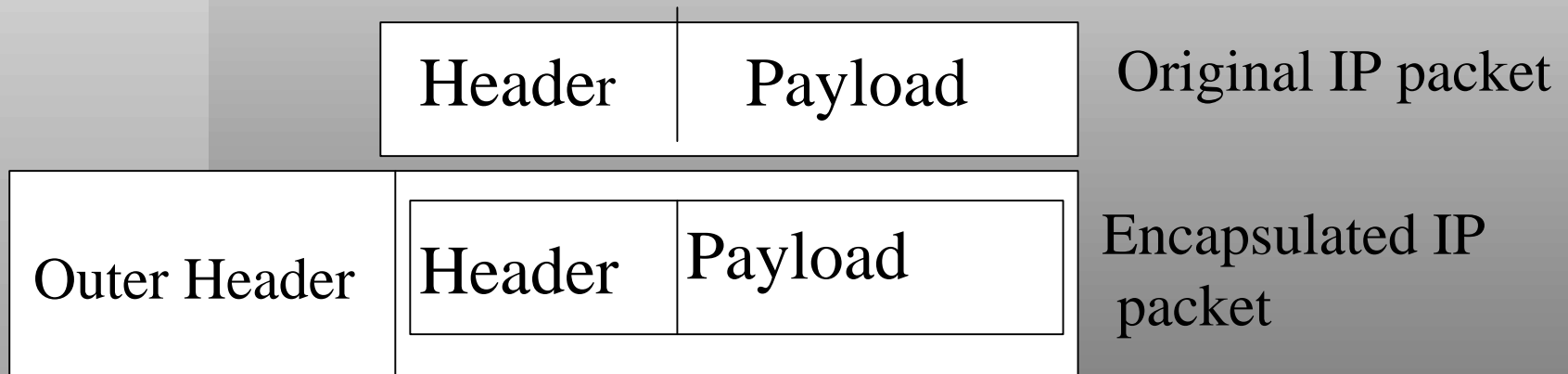
# Mobile IP entities

- **Typical entities**



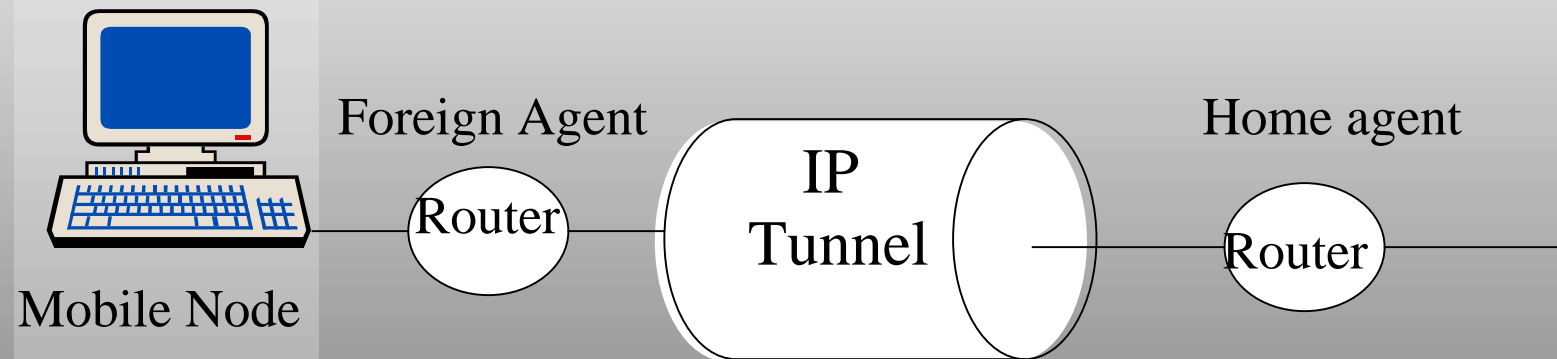
# Mobile IP Tunneling

- **Mobile IP Tunnel is a path followed by an IP packet encapsulated within the payload of a second IP packet.**



# Mobile IP Tunneling

- IP Tunneling

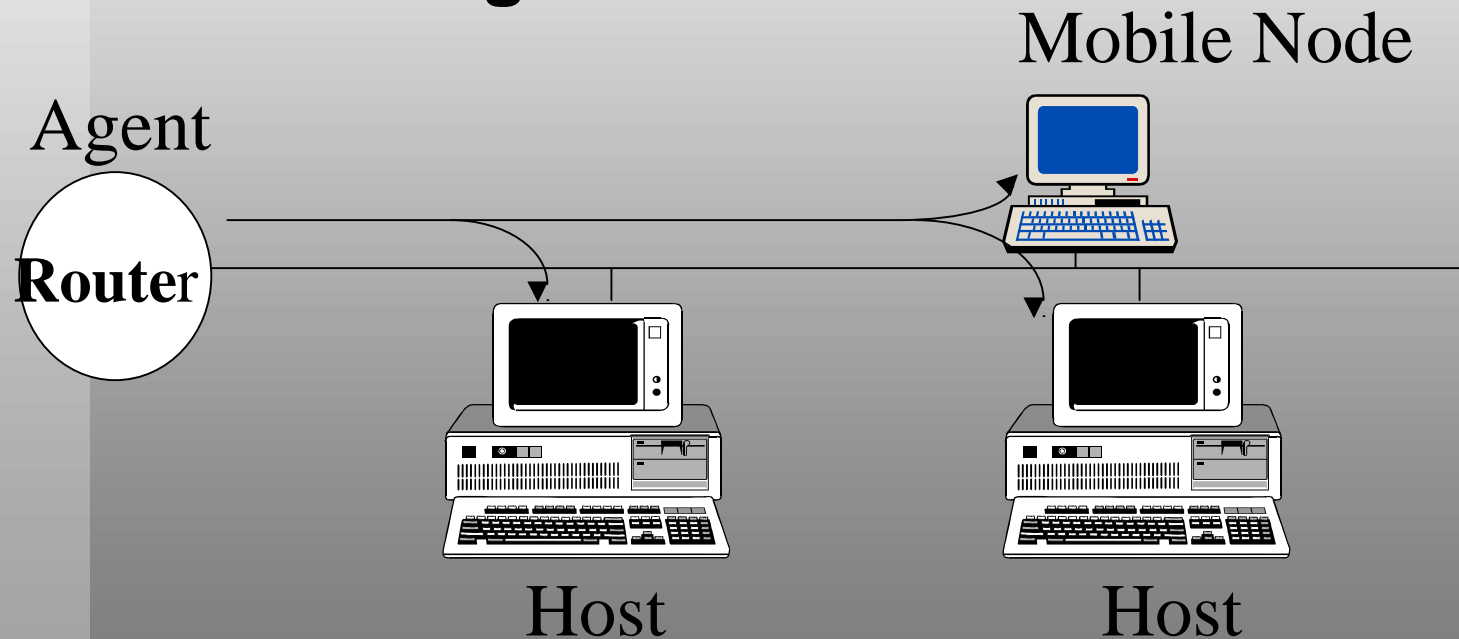


# Care-of-Address

- **Foreign agent or collocated care-of-address.**
- **Must be at most one hop away from foreign link.**
- **It is the exist point of IP tunnel.**

# How does Mobile IP work ?

- 1 . Home and Foreign agents periodically broadcast agent adverts.



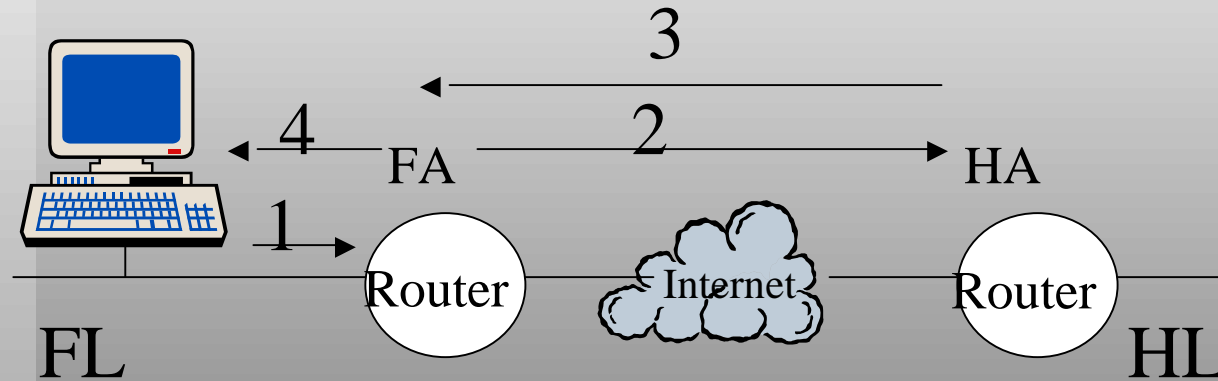
# How does Mobile IP work ?

- 2 . Mobile Node examine agent advert to determine whether itself is connected to HA or FA. If connected to FA, obtain Care-of-address.



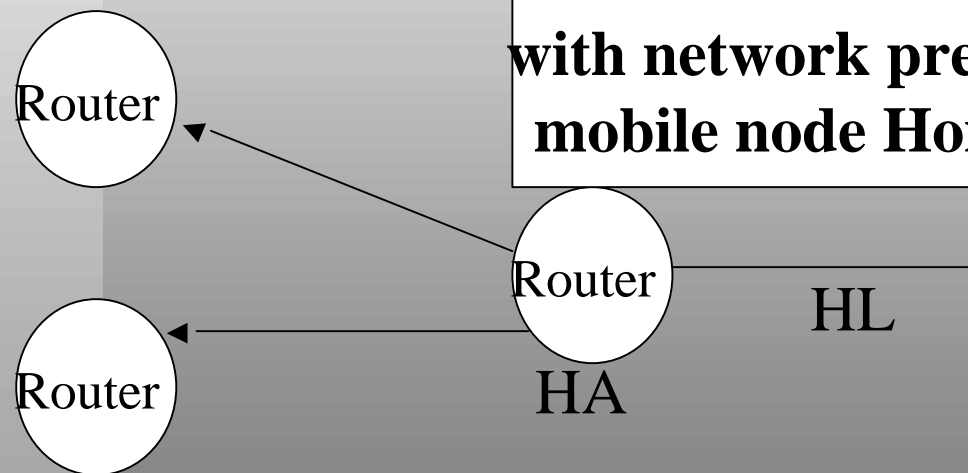
# How does Mobile IP work ?

## 3 Mobile node register its care-of-address with its HA



# How does Mobile IP work ?

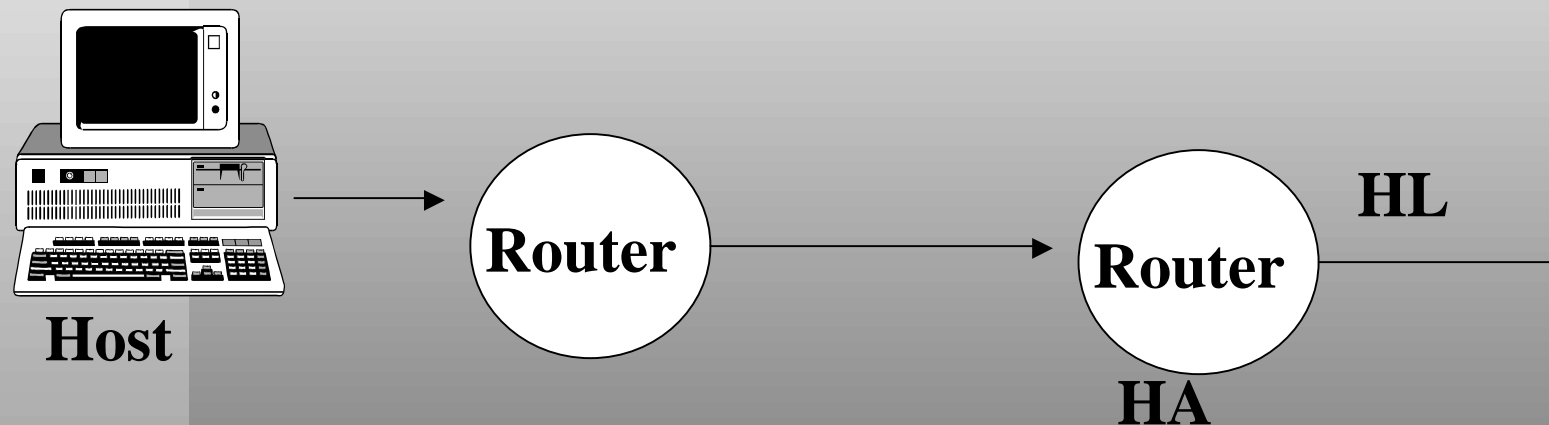
## 4 HA advertises reachability to Mobile node Home address



**Routing update:  
'I can reach all destinations  
with network prefix equal to  
mobile node Home address**

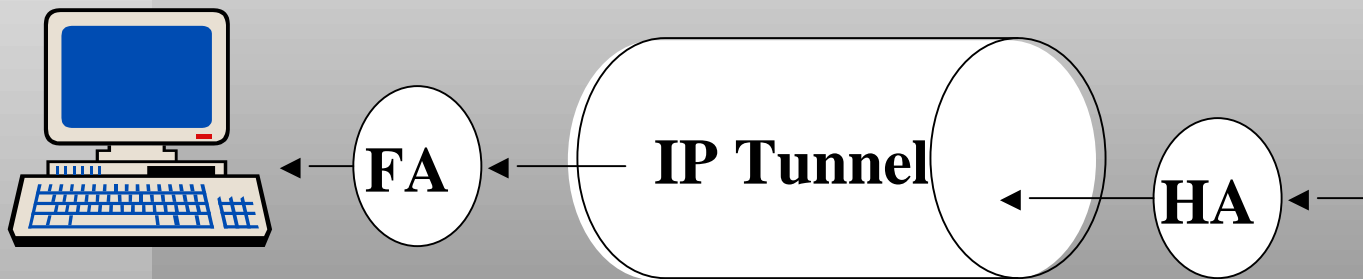
# How does Mobile IP work ?

- 5 HA attracts packets destined to Mobile node Home address.



# How does Mobile IP work ?

- 6 HA intercepts packets destined to Mobile Node Home address and tunnel them to Mobile Node care-of-address.



## Mobile Node

- FA removes original packet from tunnel and delivers packet to Mobile Node over Foreign Link

# IP Telephony

- **Real-Time transmission of voice over the Internet.**
- **Significantly reduces the cost of long distance calls.**
- **Facilitates value added services e.g. Video conferences.**

# Internet Telephony Vs. PSTN

- **PSTN:**
  - **A full-duplex 64K circuit is established until the call ends even though parties are speaking or silent.**
  - **Cost is based on distance and time.**
  - **PSTN offers guaranteed QoS.**

# Internet Telephony Vs. PSTN

- **Internet:**

- Voice is divided into packets that contain source & destination addresses, sequence number, etc...
- Routers and servers direct these packets over the Internet to their destination.
- At destination, packets are recomposed into their original order.
- Delay degrades voice quality and makes QoS variable.
- Cost is based on bandwidth usage.

# QoS of IP Telephony

- **Factors determine QoS:**
  - **Latency:** delay between when one speaks and the other is able to hear what is spoken.
  - **Lost packets are replaced by new ones generated by interpolation.** Too many lost packets makes voice unintelligible or at best voice doesn't match the speaker's natural voice.
  - **RSVP reserve enough bandwidth for required QoS.**

# IP Telephony requirements

- **Software : Ms Netmeeting, VocalTel etc.**
- **Hardware :**
  - **multimedia PC**
  - **Internet Interface Card : Interface standard telephone to internet, Provide DSP-based echo cancellation and audio compression.**
  - **Gateways : Takes voice / Fax from PSTN and places it on internet and vice versa.**

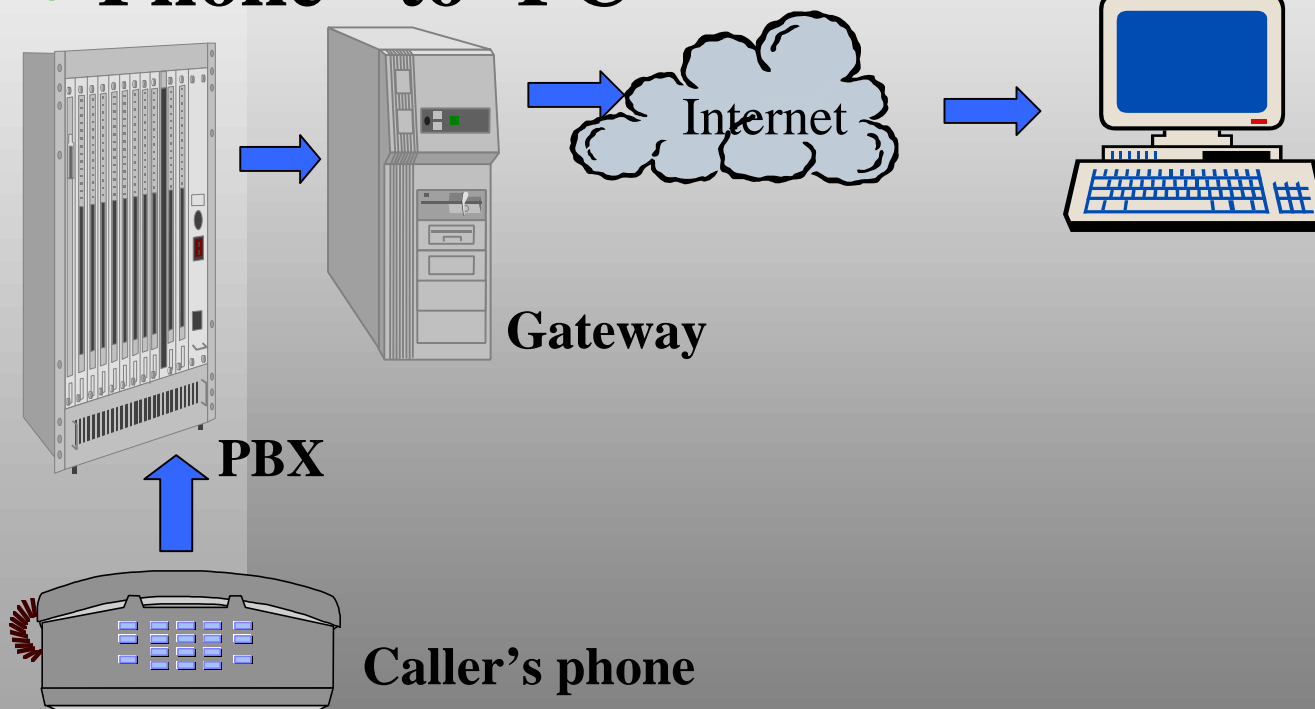
# IP Telephone calls

- Phone - to- Phone



# IP Telephone calls

- **Phone - to- PC**



# Phone - to - Phone Connection

- **The callers contact nearest gateway over the PSTN.**
- **Gateway prompts the callers to enter the phone # of the party they wish to call.**
- **Gateway looks for another gateway local to the called party.**
- **Second gateway locates the called party and Place a local PSTN call.**