COMPUTER COMMUNICATION NETWORKS

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Application Layer

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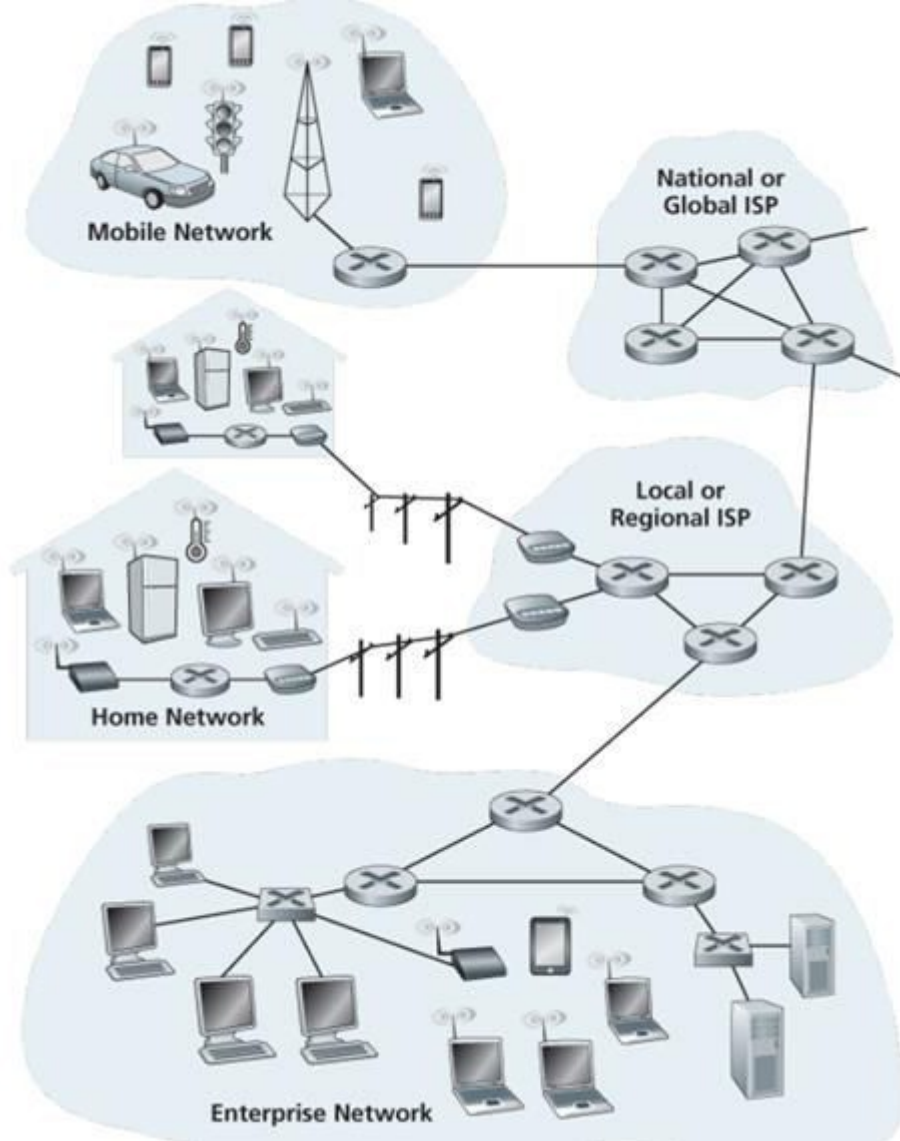
Application Layer
Important Terminologies

- **End systems** (e.g. : PC, laptop, mobile, Devices, tablet etc) are connected by a network of **communication links** and **switches and routers**.
- There are many types of communication links, which are made up of **different types of physical media**, including coaxial cable, copper wire, optical fiber, and radio spectrum.(e.g. Cat-V/ Cat-VI UTP, Multi-mode fiber, Wi-Fi, 4G, etc.)
- Different links can transmit data at different rates, with the **transmission rate (R)** of a link measured in **bits/second.** (e.g., Ethernet -1Gbps, 4G- 100Mbps etc.)
- When one end system has data to send to another end system, the sending end system **segments** the data and adds **header bytes** to each segment **(packets)**.

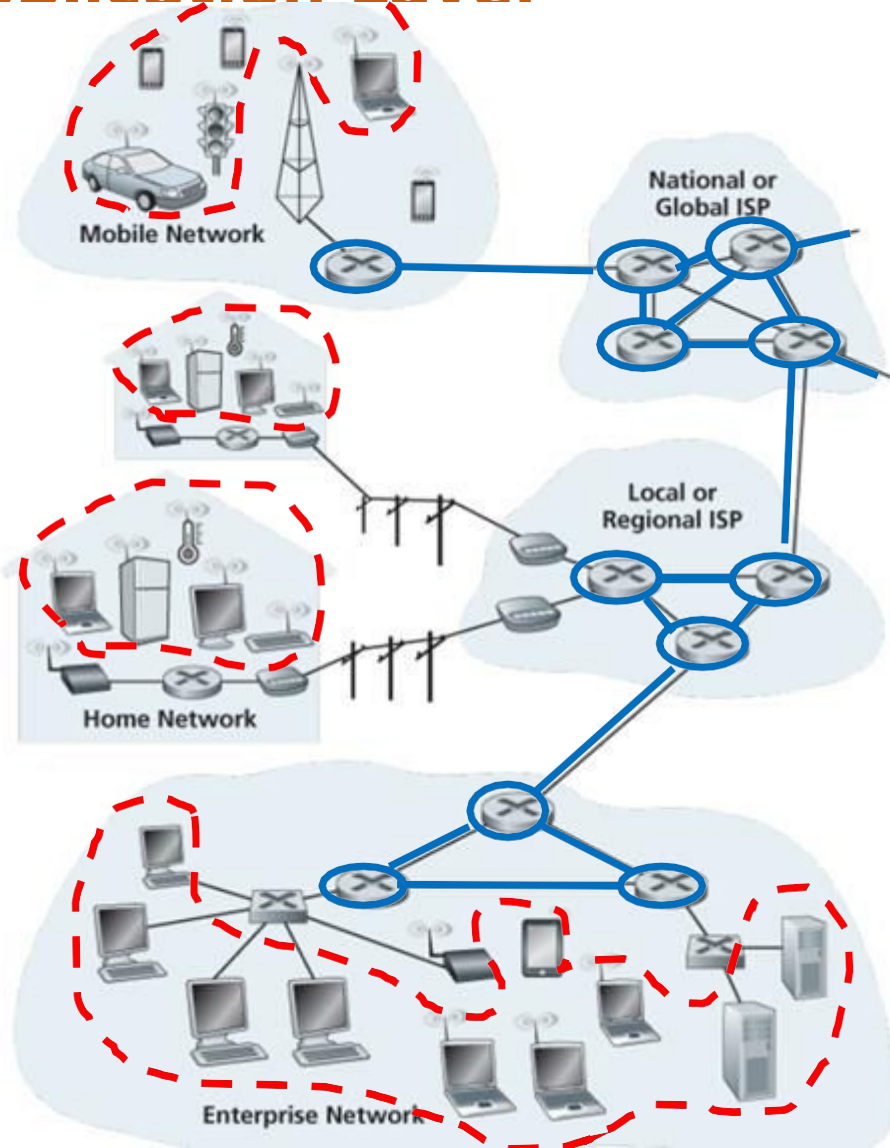# COMPUTER COMMUNICATION NETWORKS

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- **Internet** is viewed as a graphical network which provides **services to distributed applications.**
- **End systems** are referred to as **hosts** because they host (that is, run) application programs.
- End systems are at the **edge of the network.**
- Hosts are further divided into two categories: **clients and servers**

Network edges are depicted as shaded regions

Network core is highlighted in dark blue

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Application Layer

Network edges are depicted as shaded regions

Network core is highlighted in dark blue

Host or End Systems

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Application Layer

- A **packet switch** takes a packet arriving on one of its incoming communication links and forwards that packet on one of its outgoing communication links.
- A **packet switch** may have multiple incoming – outgoing ports.
- Packet switches in Internet are either **routers** (used in network core) or **link-layer switches** (used in access networks) which forward packets toward their ultimate destinations.
- The sequence of communication links and packet switches traversed by a packet from the sending end system to the receiving end system is known as a **route** or **path** through the network.
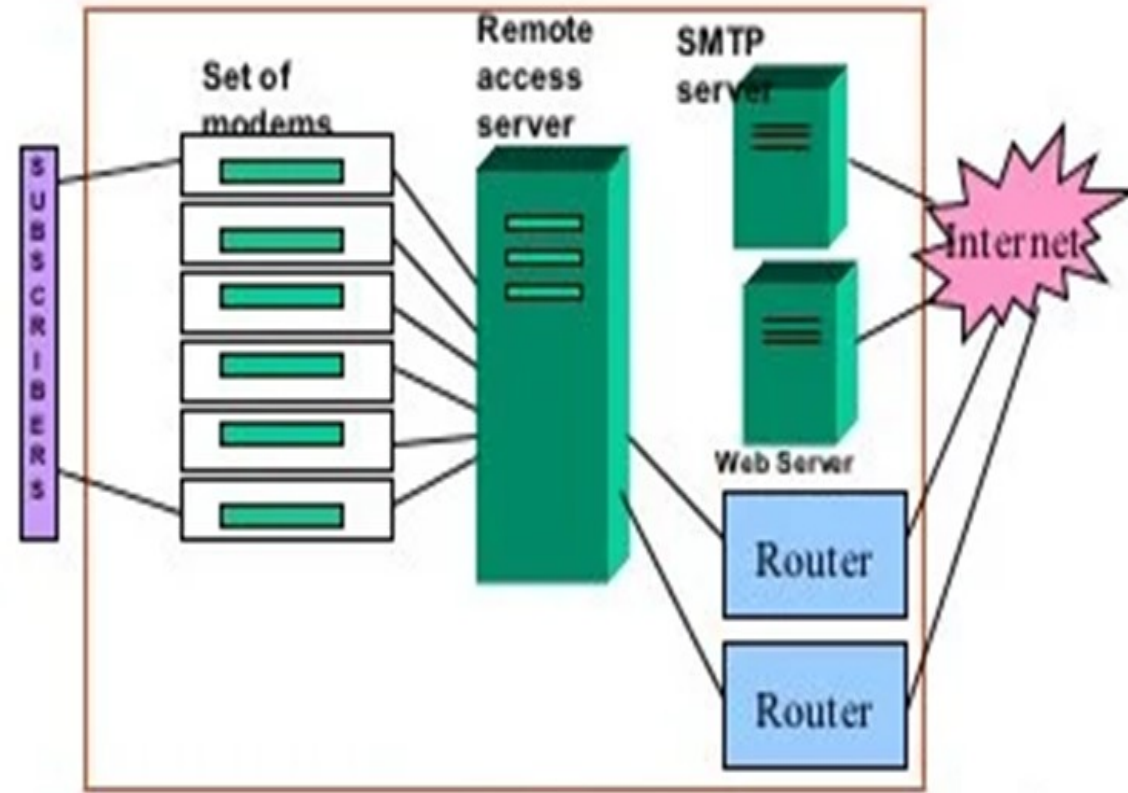
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ISP Architecture

ISP architecture of wired network (copper, fibre) is shown here.

Subscribers can be anyone of the following:
- Home,
- Enterprise,
- Community,
- Business

The ISP architecture based on wireless networks like GSM, 4G etc. will be relatively
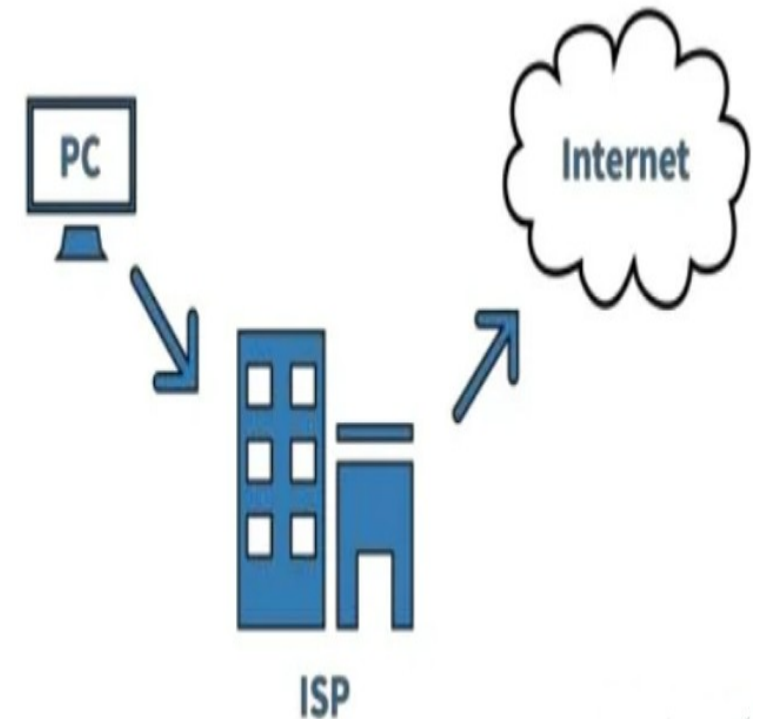
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Internet Service Provider (ISP)

- End systems access the Internet through **Internet Service Providers (ISPs).** Different types of ISPs are given as **:**
  - **Residential ISPs** such as local cable or telephone companies
  - **Corporate ISPs**
  - **University ISPs**
  - **ISPs** that provide Wi-Fi access in airports, hotels, coffee shops, and other public places
  - **Cellular data ISPs** providing mobile access to our smartphones and other devices
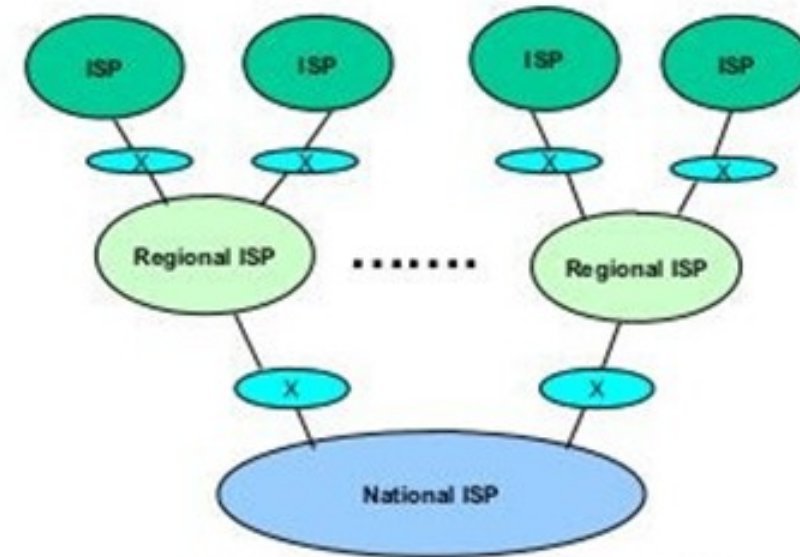- The place where end users or access

Application Layer
Types of ISPs

Regional ISP- usually provides internet access to a specific geographic area

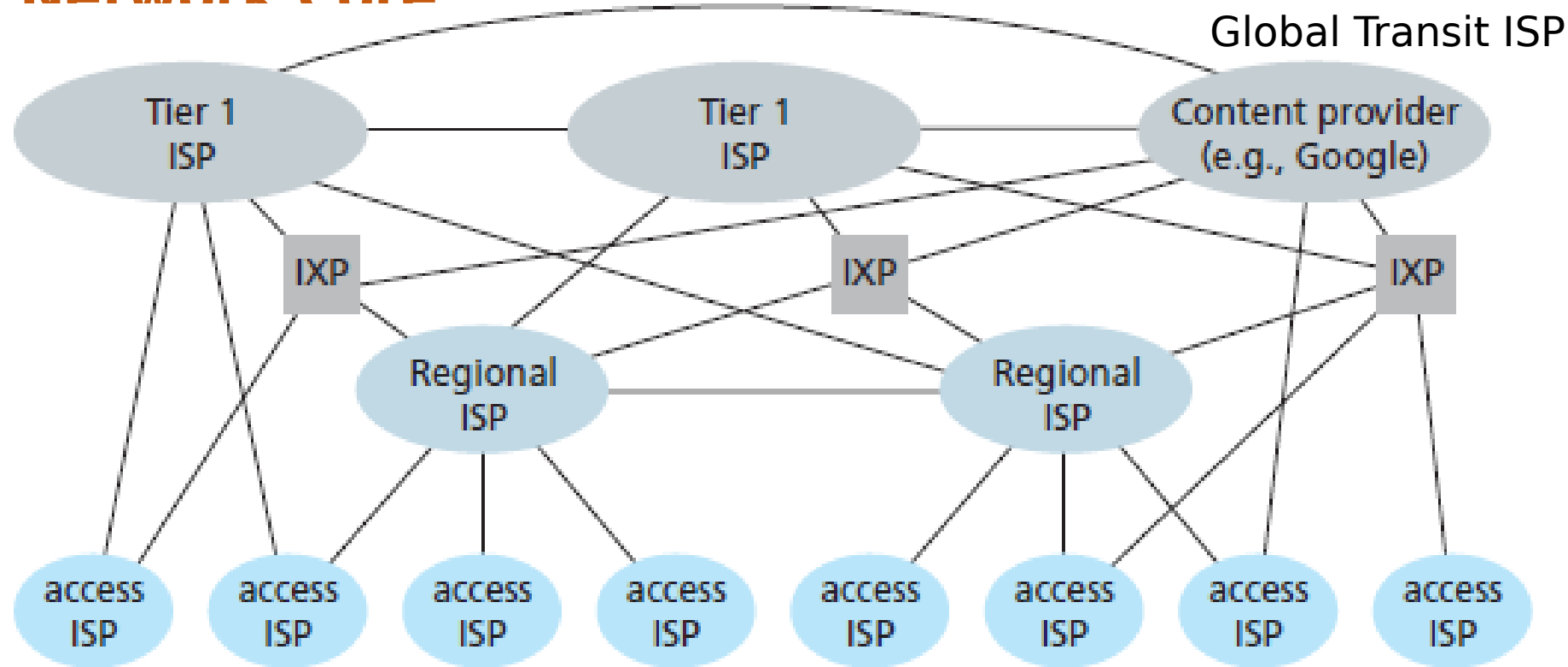**National ISP-** It is a business that provides internet access nation wide

Structure of a national ISP

Network Core

Global Transit ISP

Customer

Examples of Tier 1 ISPs: AT&T, Sprint, Verizon etc. in the US. Bharti, Reliance, Tata and VSNL are Tier-1 ISPs in India

Examples of Regional ISPs: BSNL, Airtel, Vodafone, Reliance communications, etc.

Organization of Network Core:

ISP hierarchy

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PoPs of various ISPs in the hierarchy may be interconnected using **multi- homing, peering, and Internet exchange points (IXPs) .**

Multihoming :

- Any ISP (except for Tier-1 ISPs) may choose to **multi-home**, that is, to connect to two or more provider ISPs.
- For   example,   an access   ISP may multi-home with two   regional ISPs, or it may multi-home with two regional ISPs and also with a tier-1 ISP.
- Similarly, a regional ISP may multi-home with multiple tier-1 ISPs.

Network Core

Peering:
- ISPs at the same level of the hierarchy can **peer,** that is, they can directly connect their networks together so that all the traffic between them passes over the direct connection rather than via upstream intermediaries.

Internet Exchange Point (IXP):
- A third-party company can create an **Internet Exchange Point (IXP)** (typically in a stand-alone building with its own switches), which is a meeting point where multiple ISPs can peer together.

Application Layer

Services Provided by ISP

- ISPs provide a variety of types of network access to the end systems.
- ISPs provide Internet access to content providers.
- ISPs that provide access to end systems must be interconnected:

Lower-tier ISPs are interconnected through national and international upper-tier ISPs.

Upper-tier ISPs consists of high-speed routers interconnected with high-speed fiber-optic links

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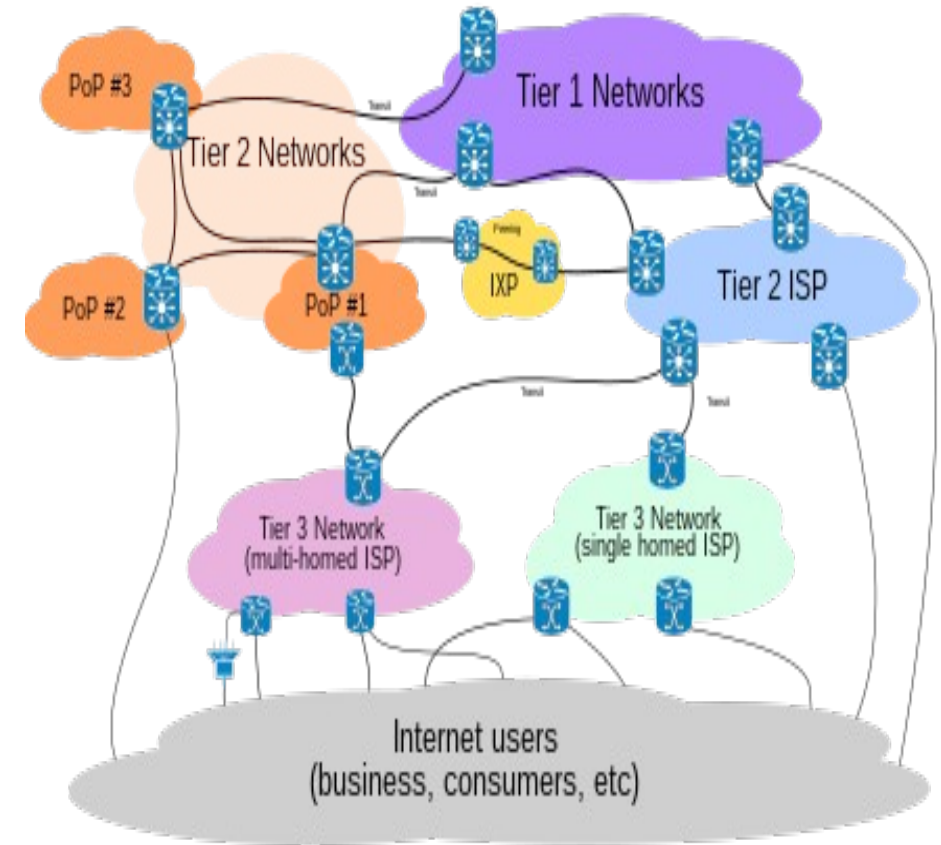
End systems, packet switches, and other pieces of the Internet run **protocols** that control the sending and receiving of information within the Internet. The two major protocols are as follows:

1. **Transmission Control Protocol (TCP)**
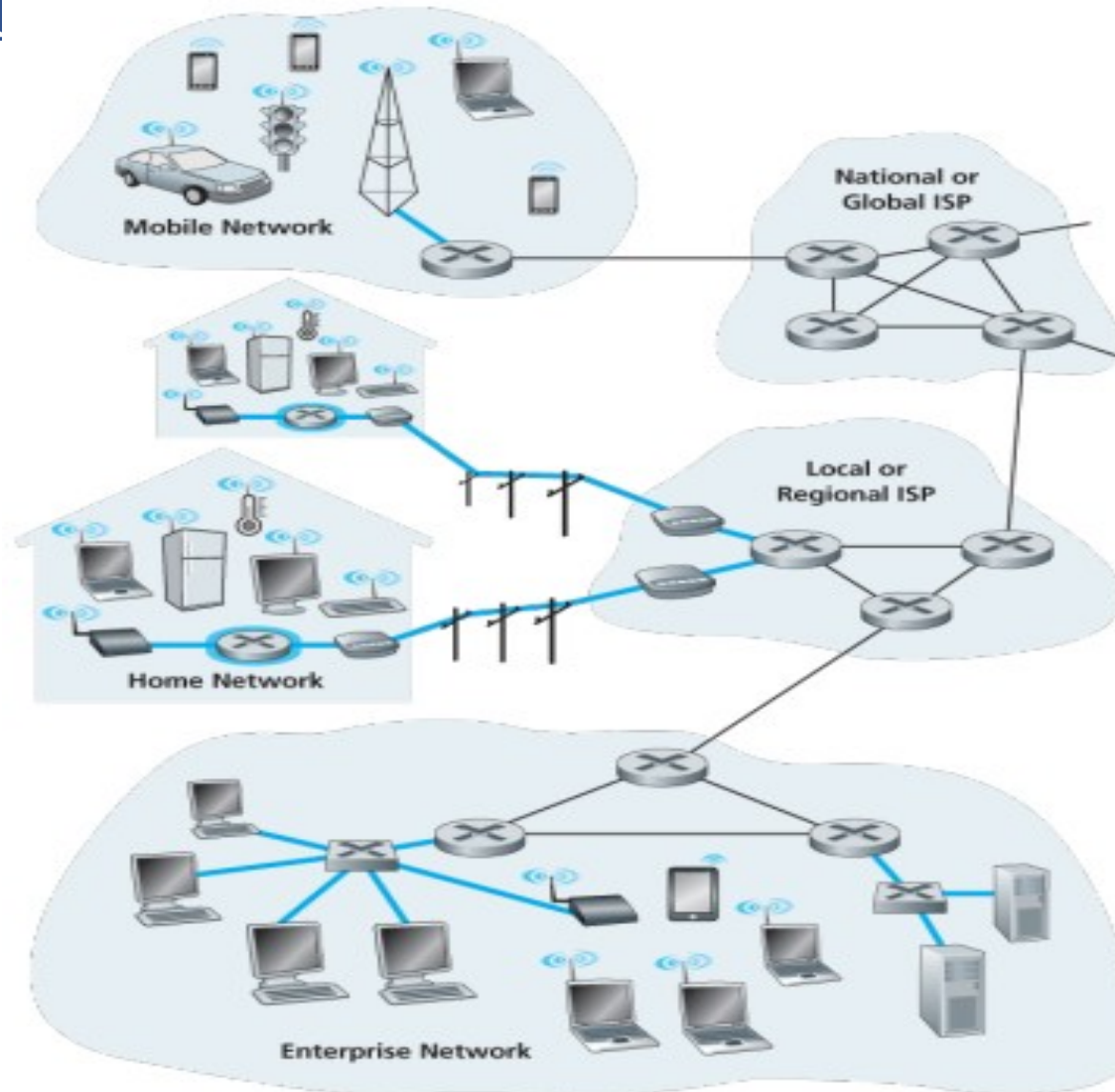2. **Internet Protocol (IP)**

The **IP protocol** specifies the **format of the packets** that are sent and received among routers and end systems.

The Internet's principal protocols are collectively known as **TCP/IP.**
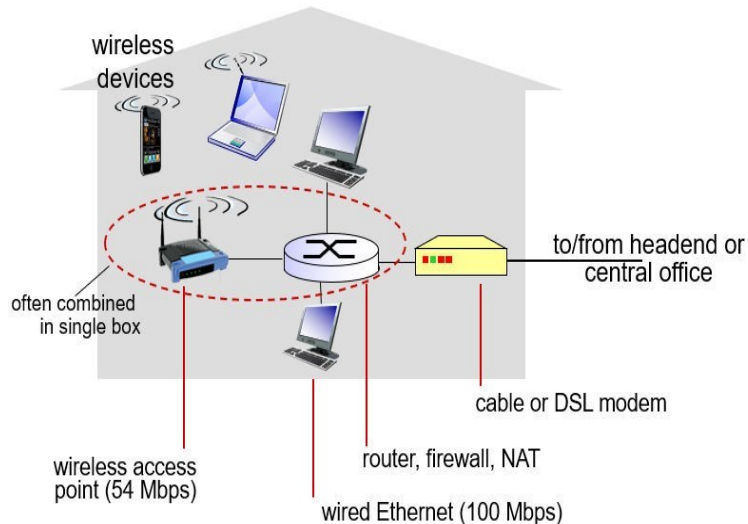
Access networks

Application Layer

- **Access network**—the network that physically connects an end system to the **first router** (also known as the **"edge router"**)
- Routers which connect the access network to an ISP are referred to as **gateways**.
- Access networks can be classified based on various features
  - **Mobility**: Static or dynamic
  - **Span or size**: Local area networks, home networks, wide area networks, etc.
  - **Topologies**: Tree, star, ring, bus, point-to-point.
  - **Physical media**: Wired or wireless
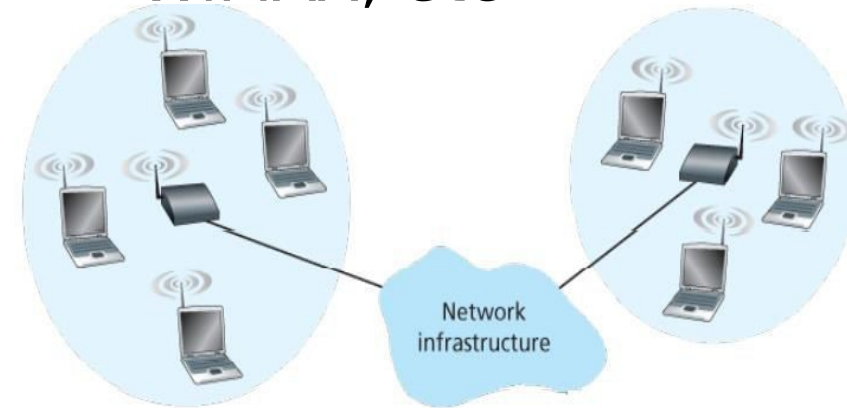   - Speed of data transfer to the regional ISP

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Examples of PHY media in access networks

- **Home access networks**
  - DSL, Cable, Fiber to the home (FTTH), Dial-up and Satellite

- **Mobile access networks**
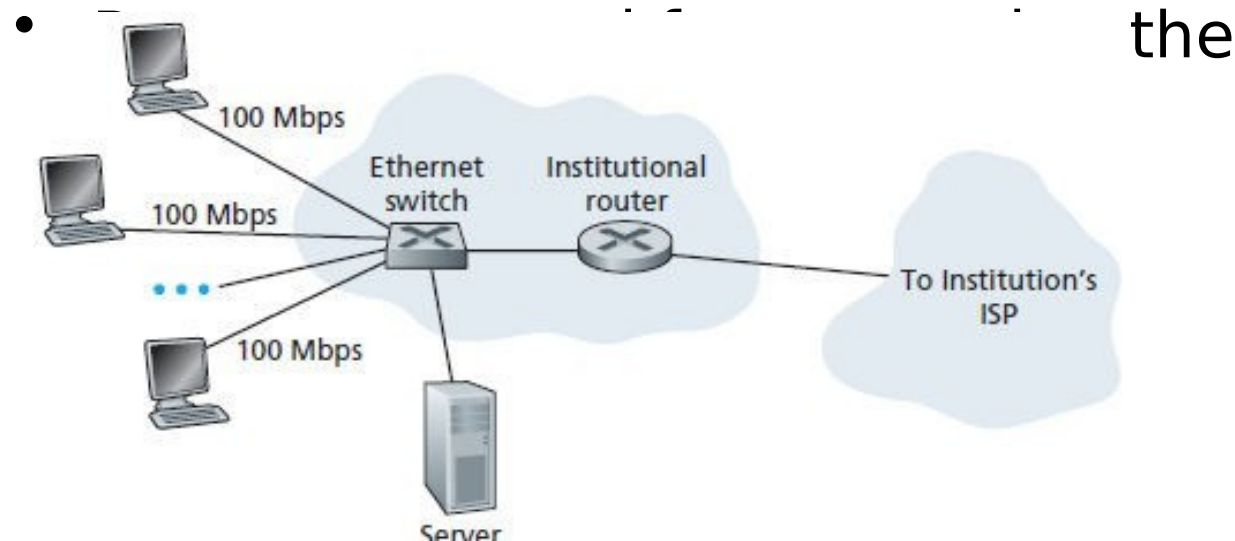 - 3G, LTE, 4G, WiMAX, etc.

Enterprise access network

- ISP can be a telecom operator
- Built using Ethernet cables, switches and hubs
- Ethernet switches are preferred over routers in a LAN
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Nomenclature under different access networks

Feature	DSL based access network	Cable TV based access network	FTTH based access network
Modem	DSL modem	Cable modem	Optical modem
Local multiplexer	Splitter	Fiber node	Optical network terminator
Central office (CO)	DSL access multiplexer (DSLAM)	Cable modem terminating system (CMTS)	Optical line terminator (OLT)
Downlink rates	12 Mbps [ITU 1999] and 24 Mbps [ITU 2003]	DOCSIS 2.0 standard 42.8 Mbps	100 Mbps (cable length based)
Uplink rates	1.8 Mbps [ITU 1999] and 2.5 Mbps [ITU	DOCSIS 2.0 standard 30.7 Mbps	30 Mbps (cable length based)

THANK YOU

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