Lesson 1.1: Introduction & Foundation

CSC450 – COMPUTER NETWORKS | WINTER 2019-20

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OUTLINE

- Applications.
  - World Wide Web.
  - Audio/video applications.
- General requirements.
- Foundation.
  - Direct links.
  - Indirect links.
  - Classification by scale.
  - Concept of Internet.
  - Protocols.
- Network edge.
  - Components.
  - Access network.

INTRO

- What is a network?
  - Definition 0: Collection of **nodes** and **links** that connect them.
    - Examples?
- How is computer network different from other types of networks?
  - **Generality!**

APPLICATIONS (1)

- Key computer network **actors**:
  - **Users.**
    - Interact with networks through applications.
  - **App developers.**
    - Create network applications.
  - **Administrators.**
    - Operate and manage networks.
      - Growing overlap between users and admins.
  - **Designers.**
    - Design and build network devices and rules for communication.

APPLICATIONS (2)

- Manifold of computer network **applications**:
  - **World Wide Web (WWW).**
  - Email clients.
  - Social networks.
  - **Audio / video streaming services.**
  - Instant messaging.
  - File sharing.

APPLICATIONS: WORLD WIDE WEB (1)

- World Wide Web (WWW or simply "**web**").
  - Internet "*killer app*".
    - More precisely – suite (**platform**) of applications.
- Web allows user to **view pages** with (*selectable*) textual and graphical objects.
  - Each selectable object is bound to a **Uniform Resource Locator** (**URL**).
    - URL is an **identifier** to the **next** page / object to be viewed.

APPLICATIONS: WORLD WIDE WEB (2)

- Example:
  - URL of CS curriculum: https://coes.latech.edu/documents/2018/06/2018_compsci.pdf
    - "*http*" - HyperText Transfer Protocol will be used to download the object.
    - "*coes.latech.edu*" - the name of the server that stores the object.
    - "*/documents/2018/06/2018_compsci.pdf*" - uniquely identifies the object at the site.
  - 17 messages are involved to process single page (object) request:
    - 6 messages to translate the server name into IP address;
      - coes.latech.edu -> 138.47.28.18
    - 3 messages to set up TCP connection;
    - 4 messages for HTTP request and acknowledgment;
    - 4 messages to tear down TCP connection.

APPLICATIONS: AUDIO/VIDEO

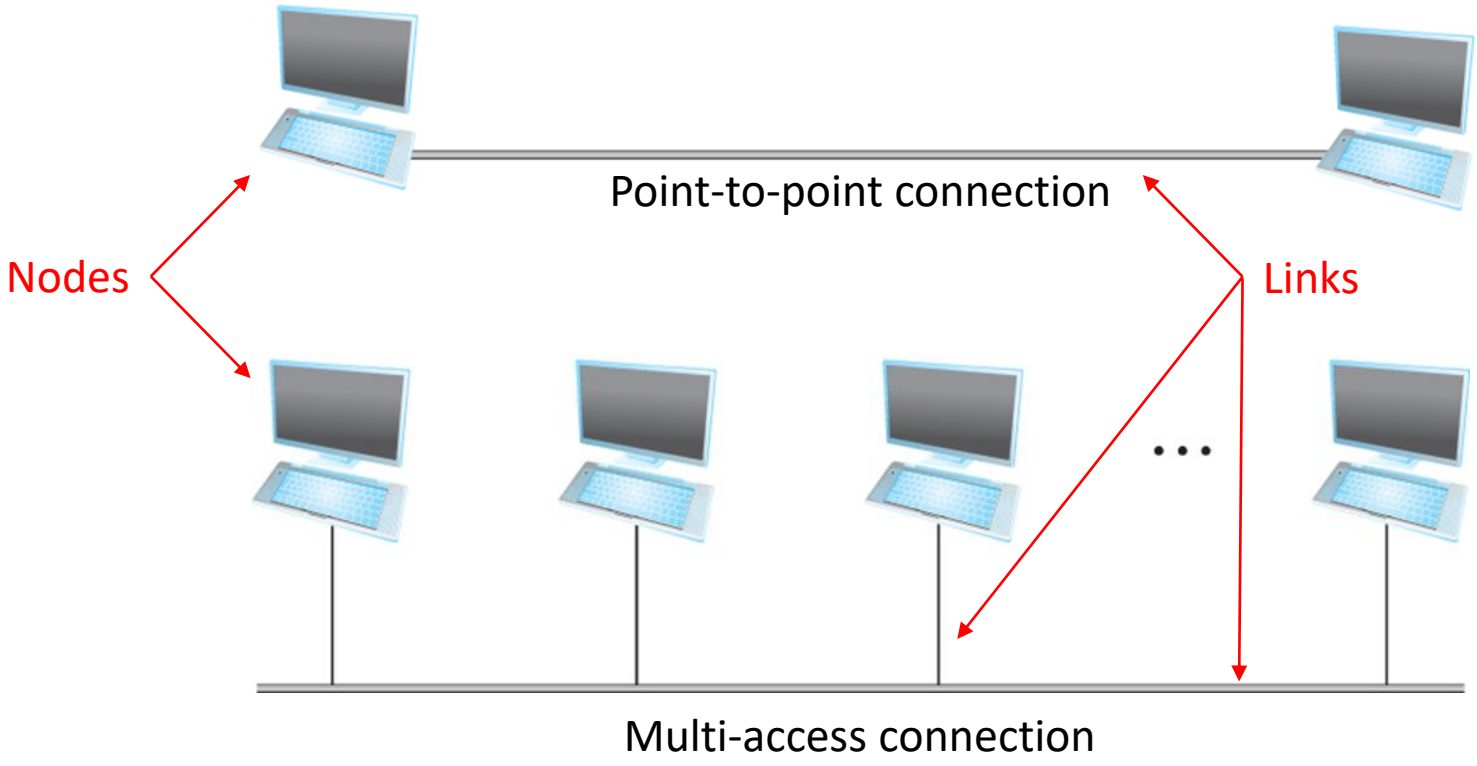
- **Streaming** audio/video.
  - Video on demand, internet radio.
  - Delivery of streaming content is different from fetching a webpage or an object.
- **Real-time** audio/video.
  - Telecommunication, VoIP.
  - Delivery of real-time content is different from processing of streaming data.
- **Diversity** of requirements drives how network **supports** different types of applications.

GENERAL REQUIREMENTS

- General network **requirements**:
  - **Scalability**.
    - Adding more nodes to network.
    - Node addressing and messages routing.
  - **Efficiency**.
    - All nodes sharing the network.
    - Several nodes sharing a link.
  - **Support of services**.
    - App-to-app communication through channels.
    - Reliability issues.
  - **Manageability**.
    - Automating network management.
    - Stability vs. feature velocity.

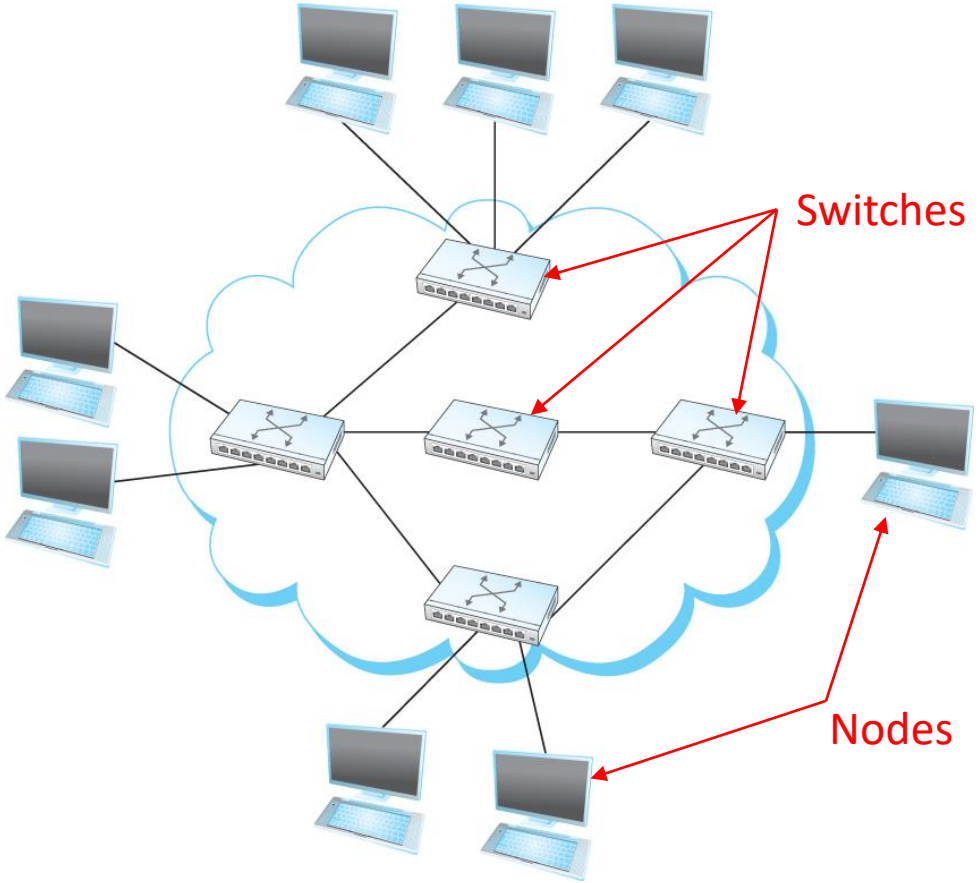
FOUNDATION: DIRECT LINKS

- What is a **computer network**?
  - Group of *computer systems* that are **linked** together through *communication channels*.
    - Courtesy of technopedia.com
- *Computer systems* – **nodes**.
  - **End points**.
    - Hosts, servers.
  - **Redistribution points**.
    - Hubs, switches, routers.
- *Communication channels* – **links**.
  - **Wired** links.
  - **Wireless** links.

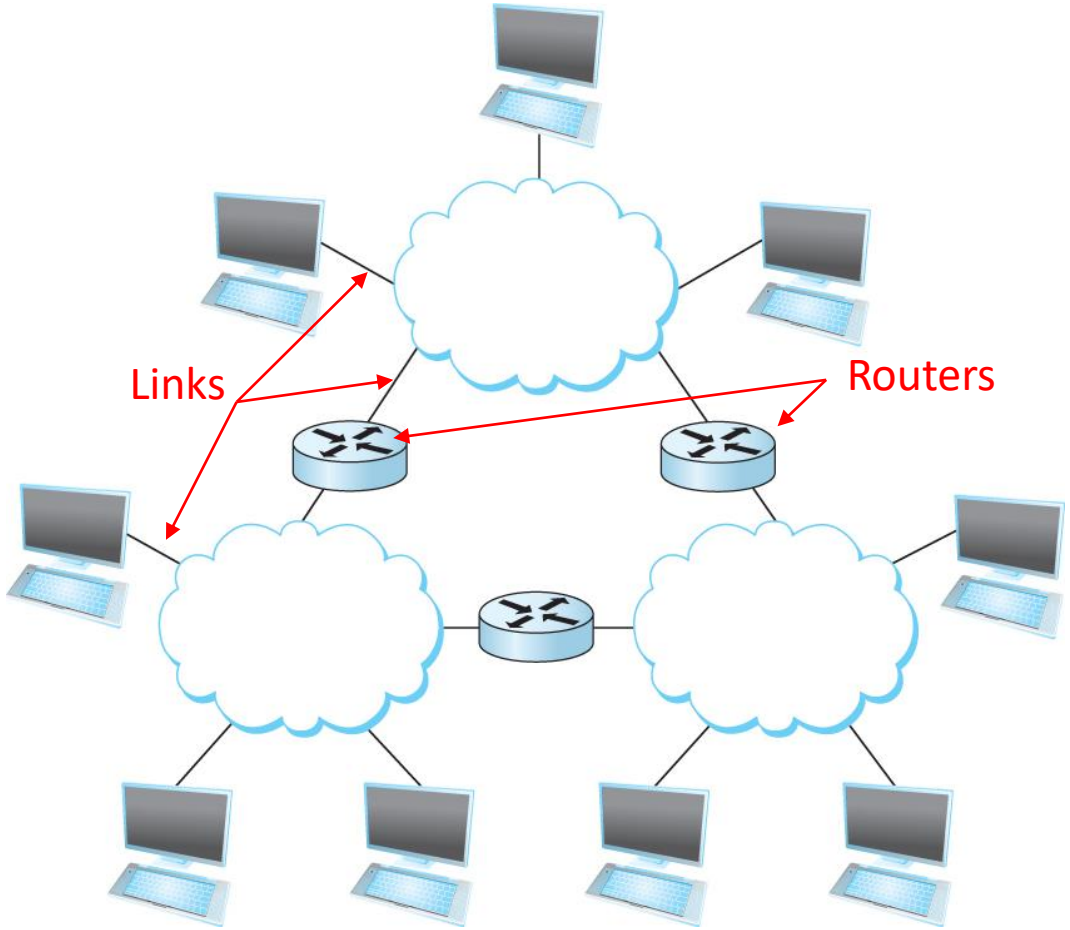


FOUNDATION: INDIRECT LINKS

- **Switched network** and **network of networks** (*internetwork*) can be arranged with **indirect links**.



Switched network



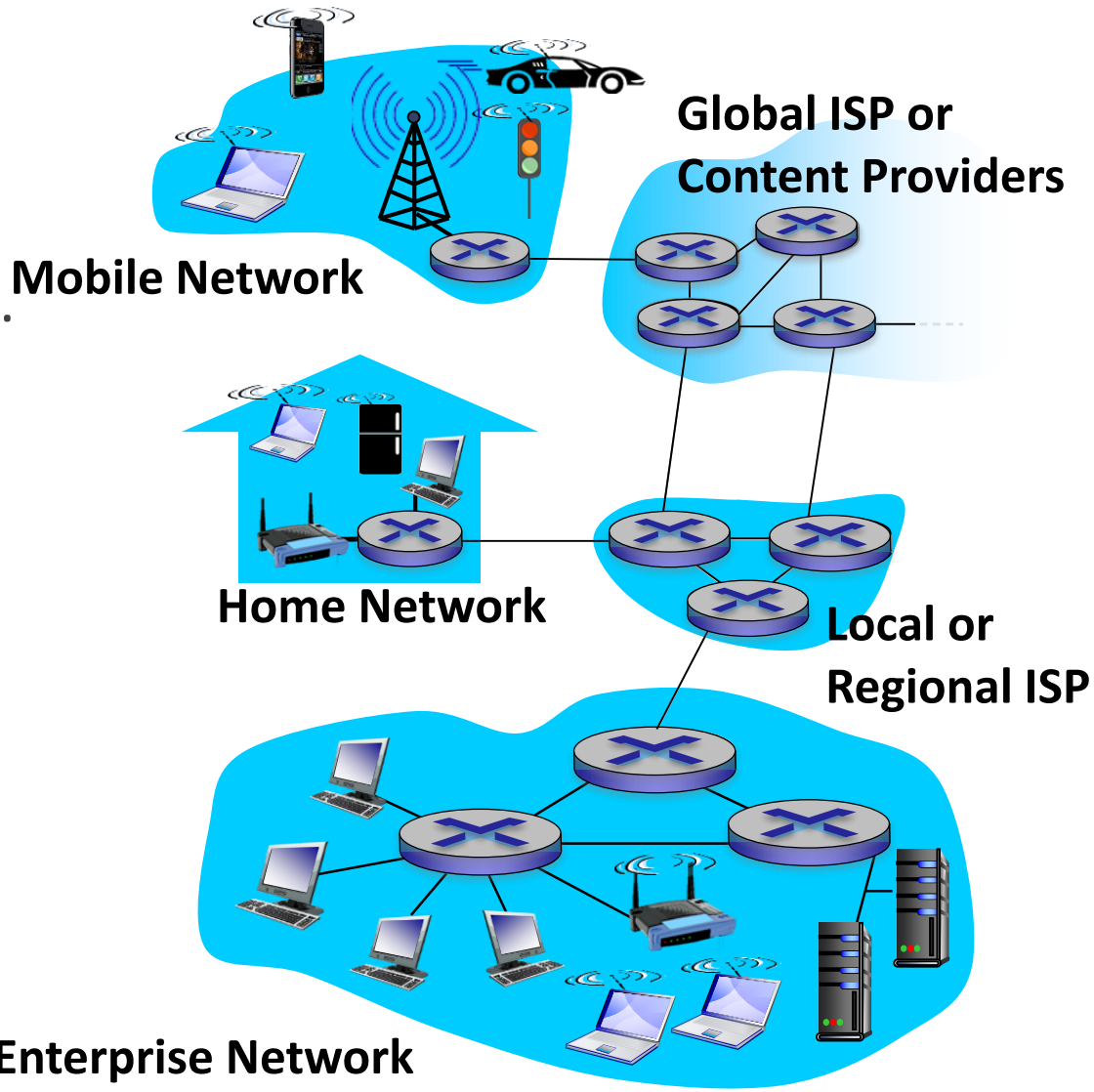
Interconnection of networks

FOUNDATION: CLASSIFICATION BY SCALE

- Networks are frequently **classified** by their **scale**:
  - Wired.
    - Local area network (**LAN**).
    - Metropolitan area network (**MAN**).
    - Wide area network (**WAN**).
  - Wireless.
    - **System networks**.
    - Wireless LAN (**WLAN**).
    - Wireless WAN (**WWAN**).
  - Internet.

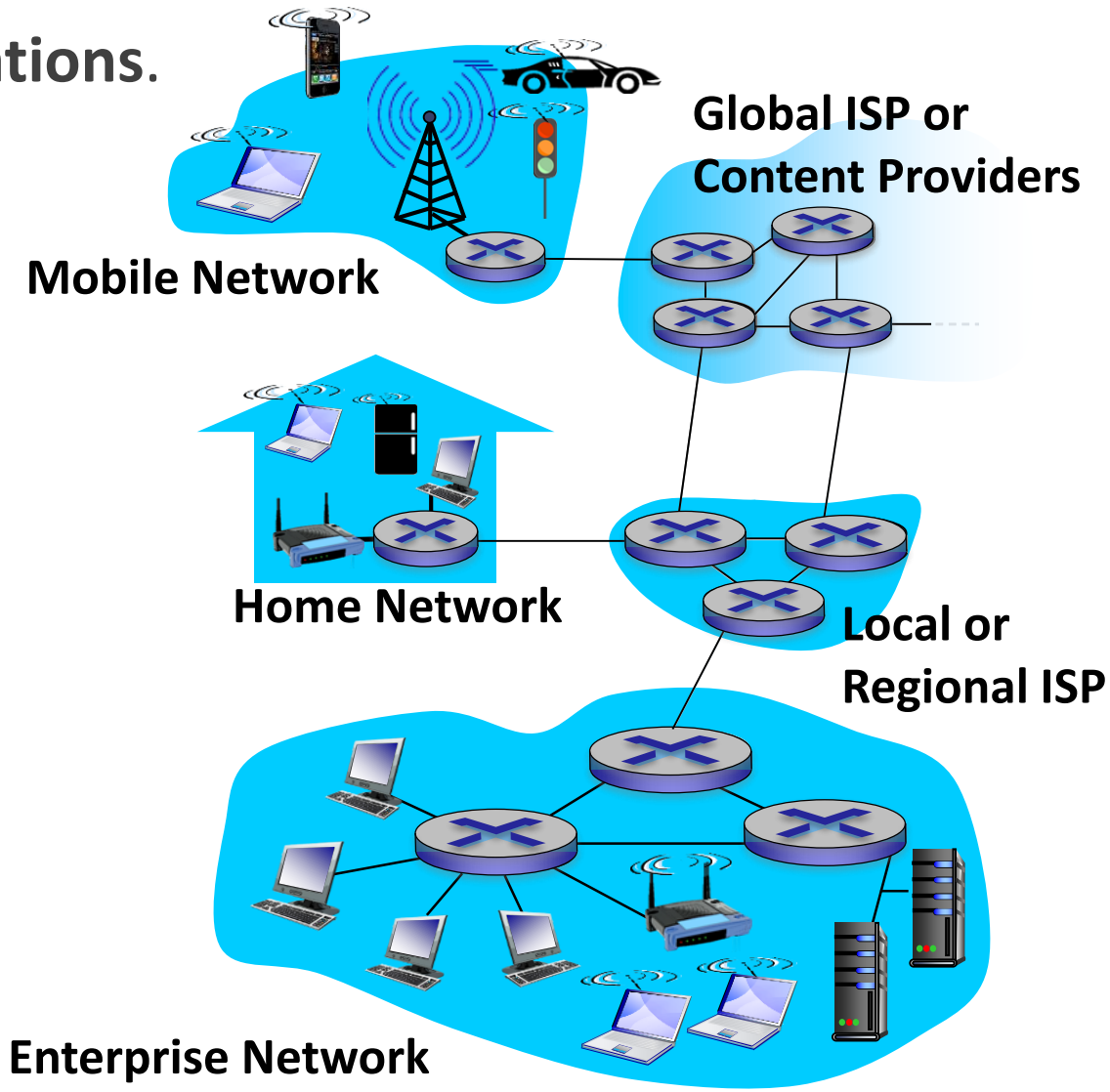
FOUNDATION: CONCEPT OF INTERNET (1)

- Internet is a "**network of networks**".
  - Billions of **hosts** (*nodes*) and communication **links**.
    - Data is being **transmitted** by **routers** and **switches**.
  - **Protocols** control **sending** & **receiving** of messages.
    - TCP, UDP, IP, HTTP.
  - **Standards** govern protocols **operations**.
    - Request For Comments (RFC).
    - Internet Engineering Task Force (IEFT).



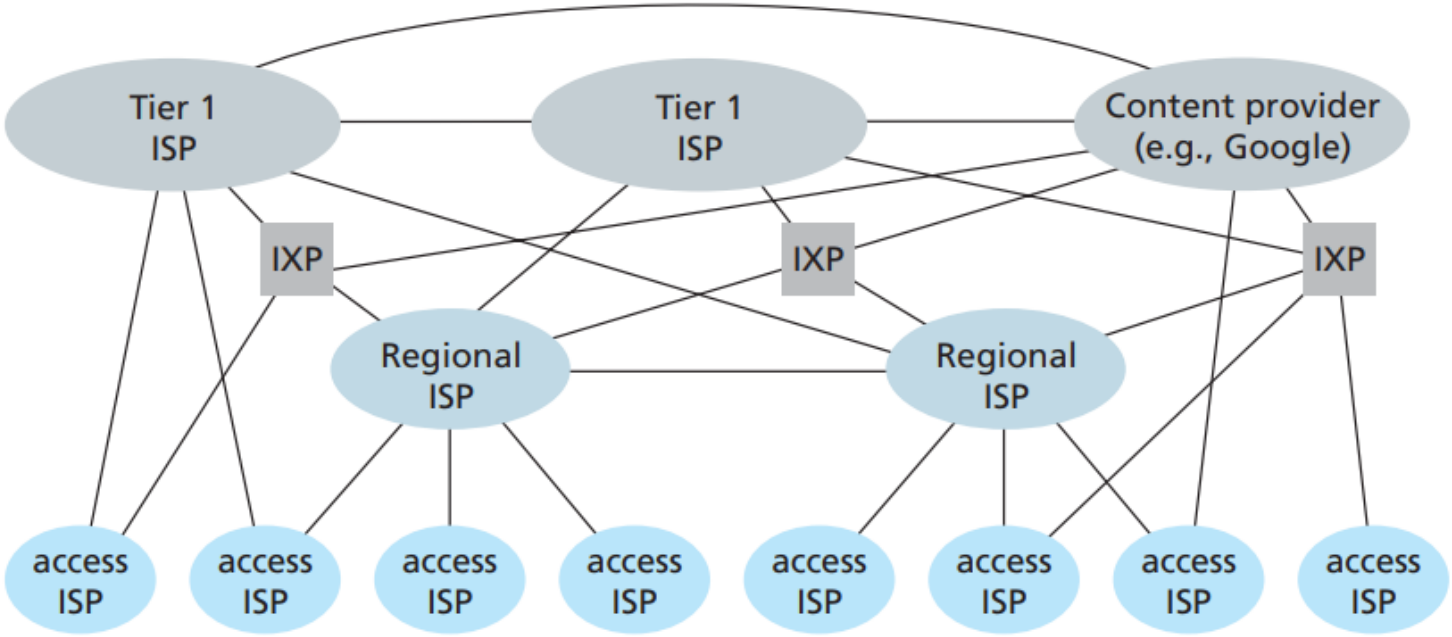
FOUNDATION: CONCEPT OF INTERNET (2)

- Internet is an **infrastructure** for **network applications**.
  - Provides **services** and **rules** of how to use them.
    - **Services** – communication between applications.
    - **Rules** – application programming interfaces (APIs).



FOUNDATION: INTERNET STRUCTURE

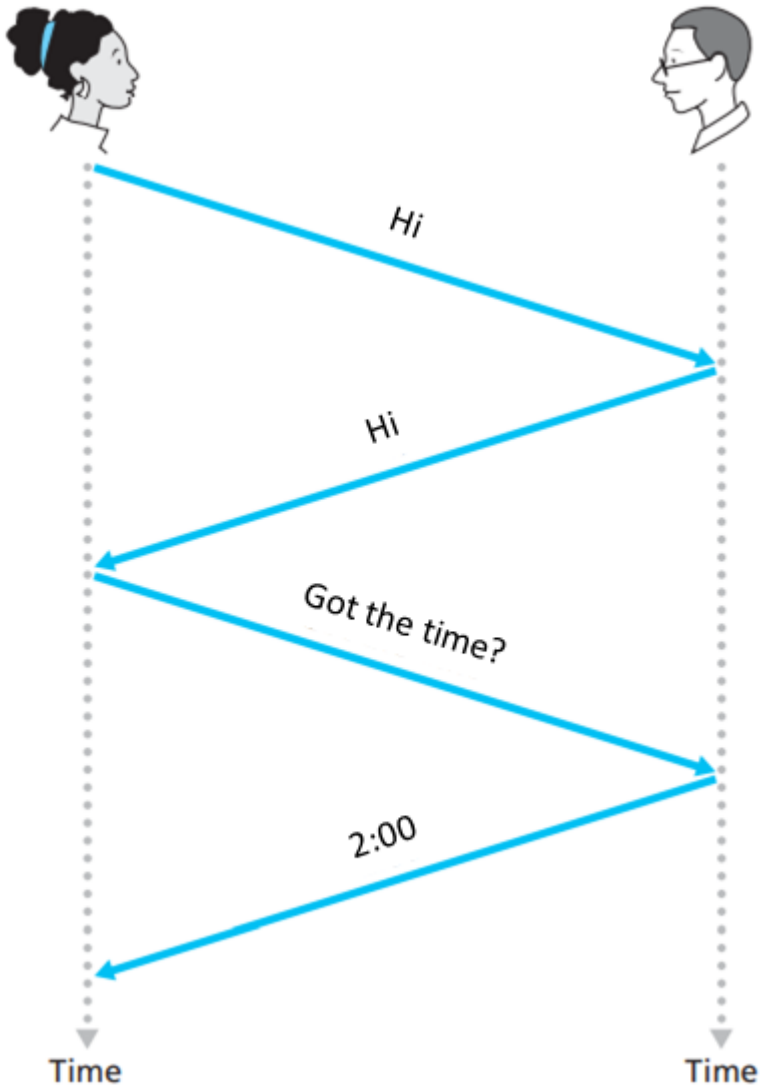
- **End nodes** connect to **Internet** via **access** Internet Service Providers (**ISPs**).
- Access ISPs must be **interconnected** so hosts can **exchange** data.
  - Connecting access ISPs to each other is not feasible.
- **Solution** - regional, global and Tier-1 ISPs, Internet Exchange Points (IXP), and Content Providers form complex "**Internet hierarchy**".



Interconnection of ISPs

FOUNDATION: PROTOCOLS (1)

- **Protocol** (*set of rules*) defines:
  - **Format** of network messages;
  - **Order** of messages sent and received among nodes;
  - **Actions** taken on message transmission and receipt.



Human protocol

FOUNDATION: PROTOCOLS (2)

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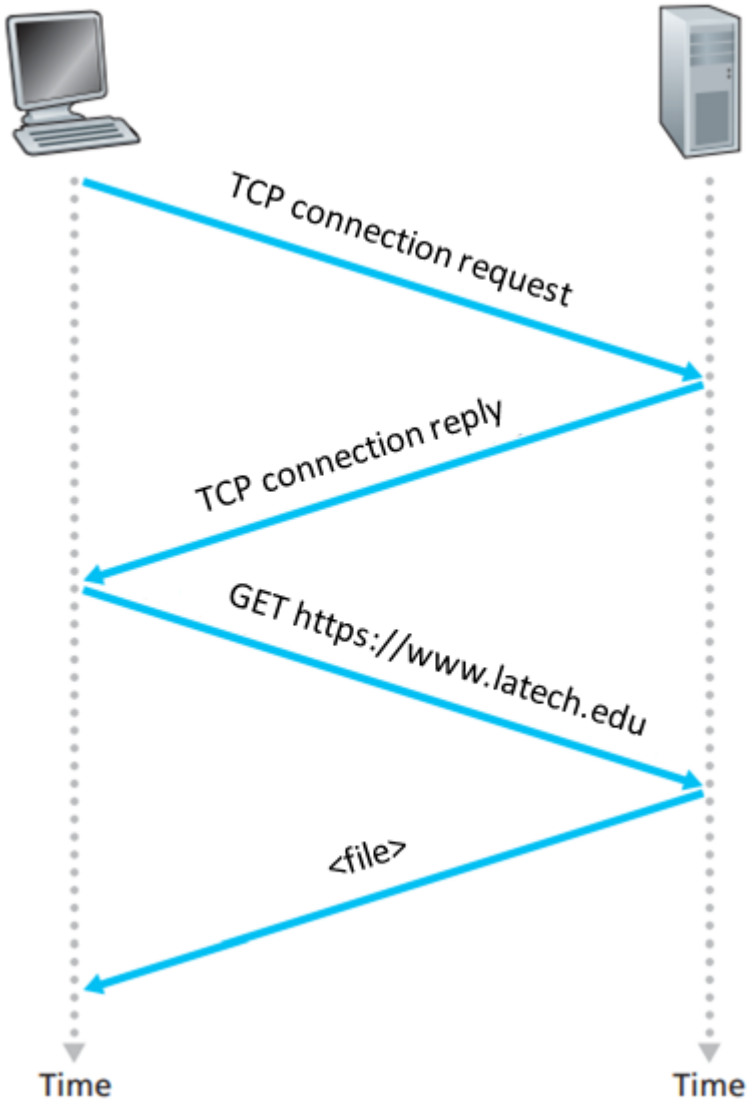
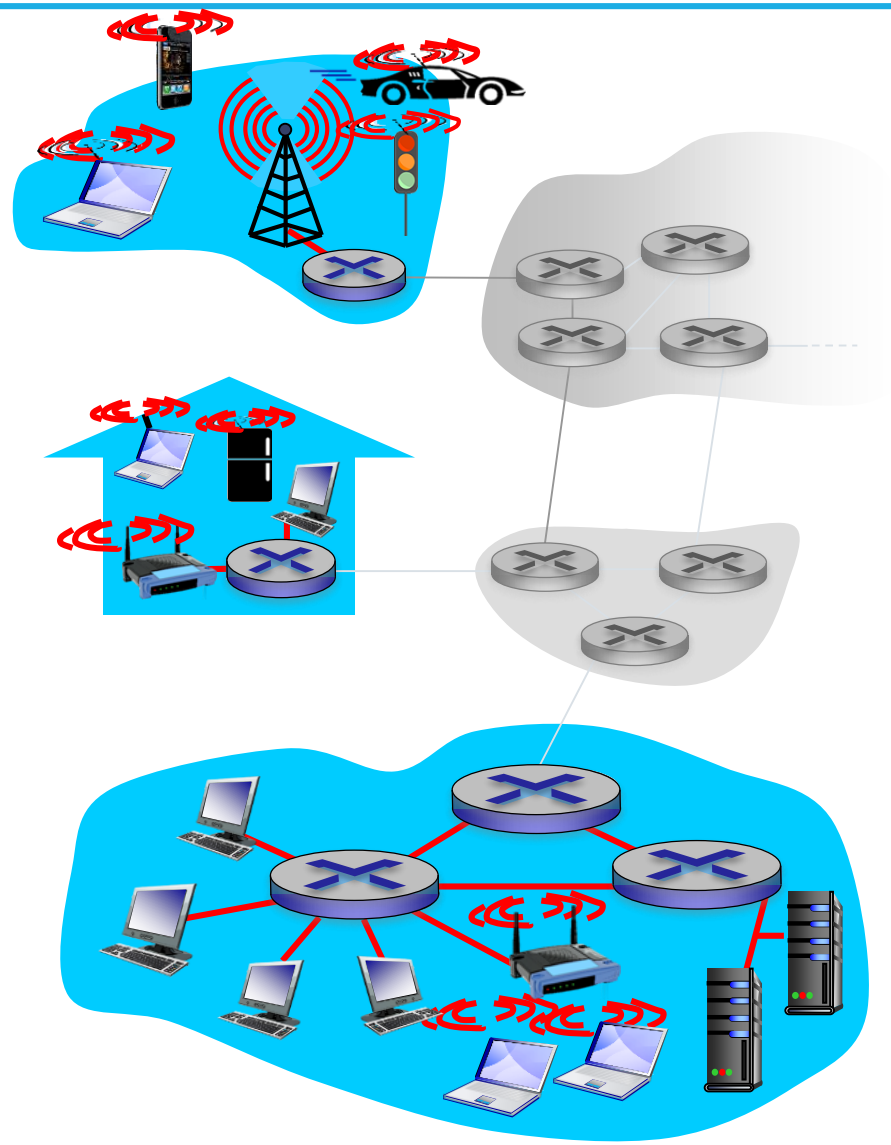


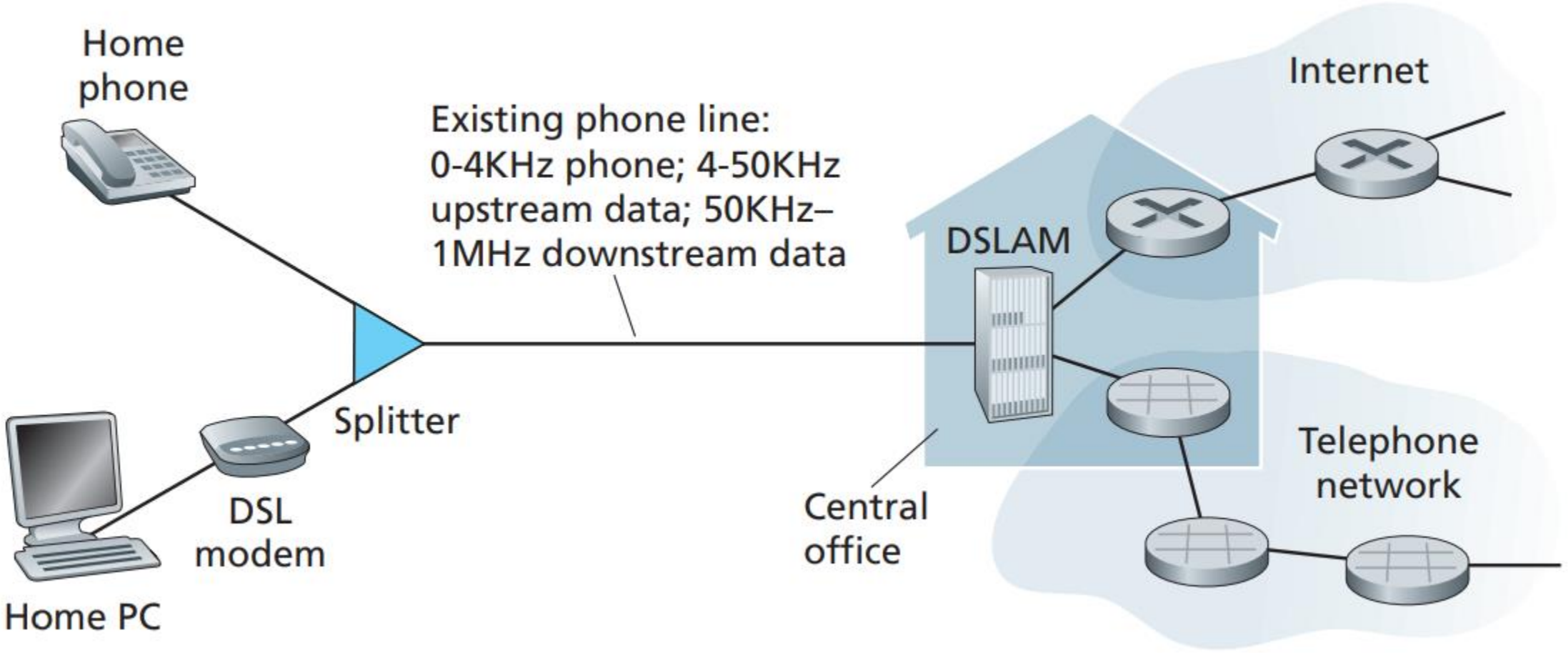
NETWORK EDGE: COMPONENTS

- **Components** at the network edge:
  - **Hosts** (end points).
    - **Client**.
    - **Server**.
      - Often in data centers / clouds.
  - **Access networks**.
    - **Wired** / **wireless** communication links.
    - Physically **connect** hosts to edge router.



ACCESS NETWORKS: DSL (1)

- Digital subscriber line (**DSL**).



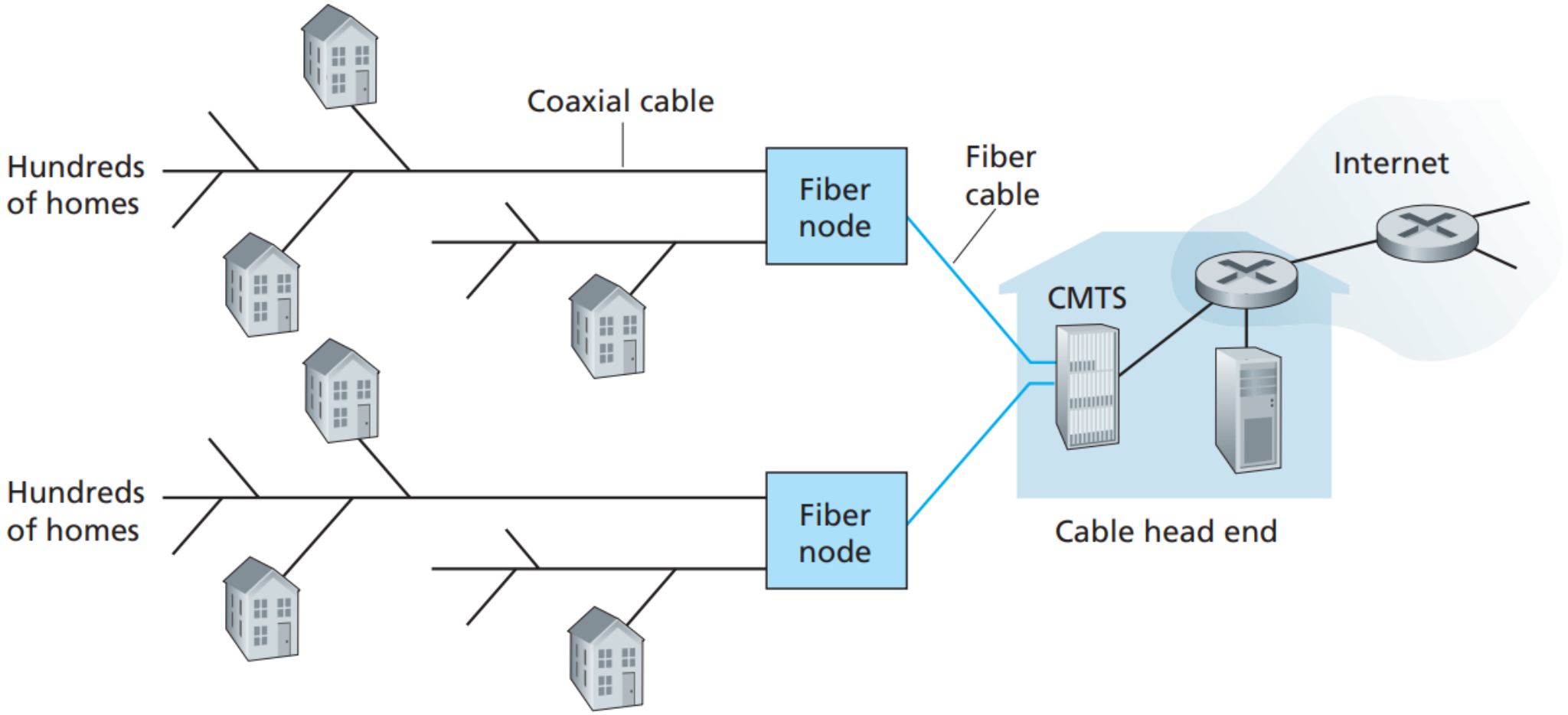
DSL Internet access

ACCESS NETWORKS: DSL (2)

- Digital subscriber line (DSL).
  - Utilizing existing **telephone** lines.
    - **Voice** and **data** are encoded at different **frequencies**.
    - **Splitter** separates data and telephone frequencies.
  - DSL access multiplexer (**DSLAM**) provides **conversion** between analog and digital signals.
  - **Twisted-pair** copper wire used as a medium.

ACCESS NETWORKS: CABLE (1)

- **Cable** network.



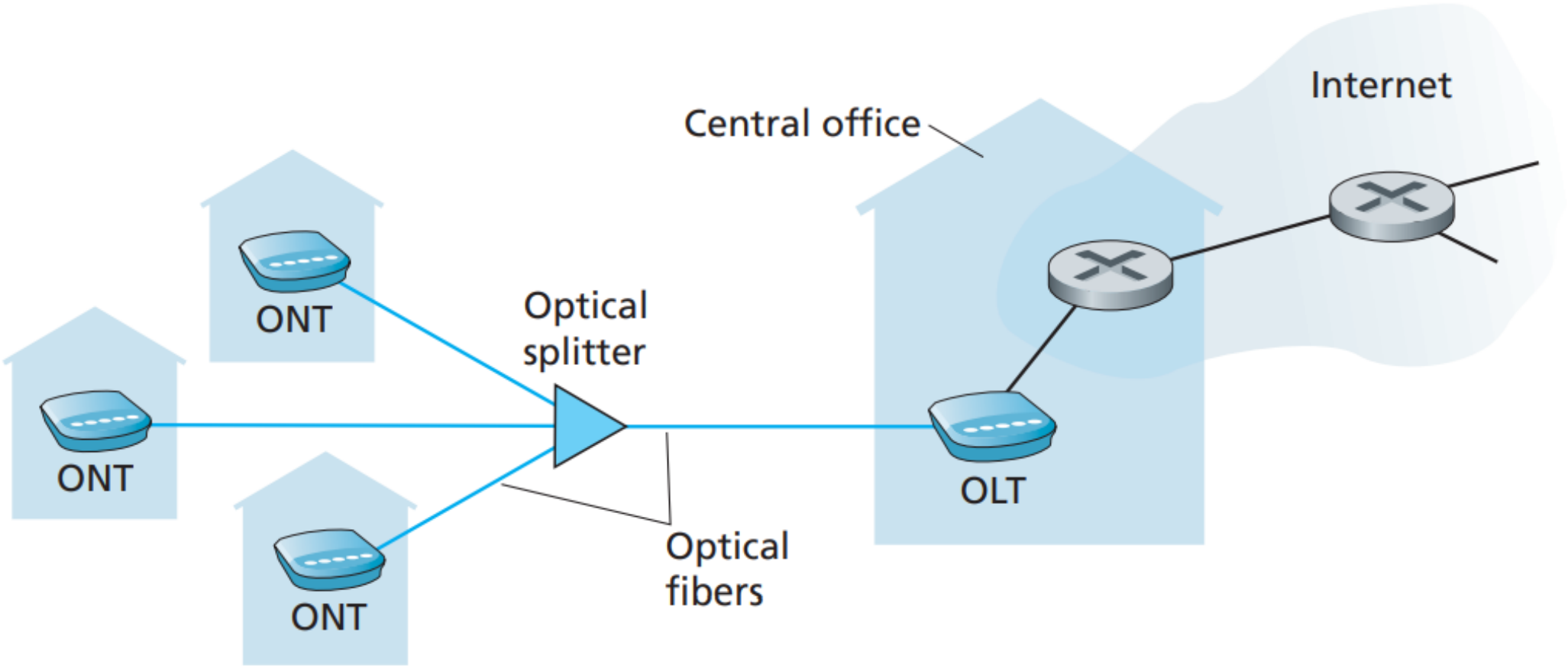
Hybrid fiber-coaxial access network

ACCESS NETWORKS: CABLE (2)

- **Cable** network.
  - Utilizing existing cable **television** lines.
  - Cable modem termination system (**CMTS**) provides **conversion** between analog and digitals signals.
  - Hybrid **fiber coax** network.
    - **Fiber-optics** cable from **ISP** to neighborhood fiber **nodes**.
    - **Coaxial** cable from neighborhood fiber **nodes** to **customers**.

ACCESS NETWORKS: FIBER-OPTICS (1)

- **Fiber**-to-the-home (FTTH) network.



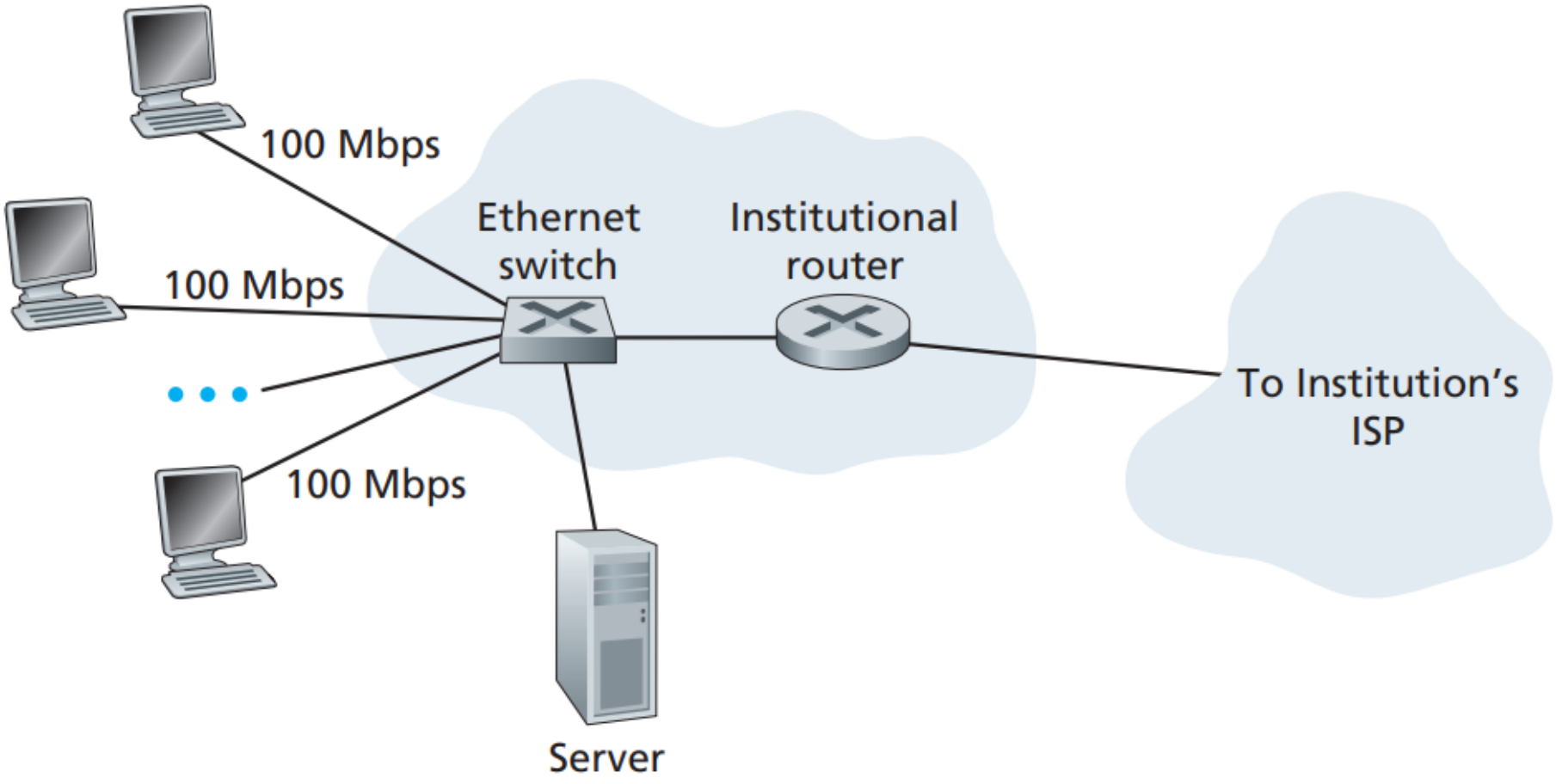
Fiber-to-the-home Internet access

ACCESS NETWORKS: FIBER-OPTICS (2)

- **Fiber**-to-the-home (FTTH) network.
  - Optical network terminator (**ONT**) connects customer to neighborhood **splitter**.
  - **Splitter** combines homes into a **shared** optical **fiber**.
  - Optical line terminator (**OLT**) provides **conversion** between optical and electrical signals.
  - **Fiber-optics** cable used as a medium.

ACCESS NETWORKS: ETHERNET (1)

- **Enterprise** network.



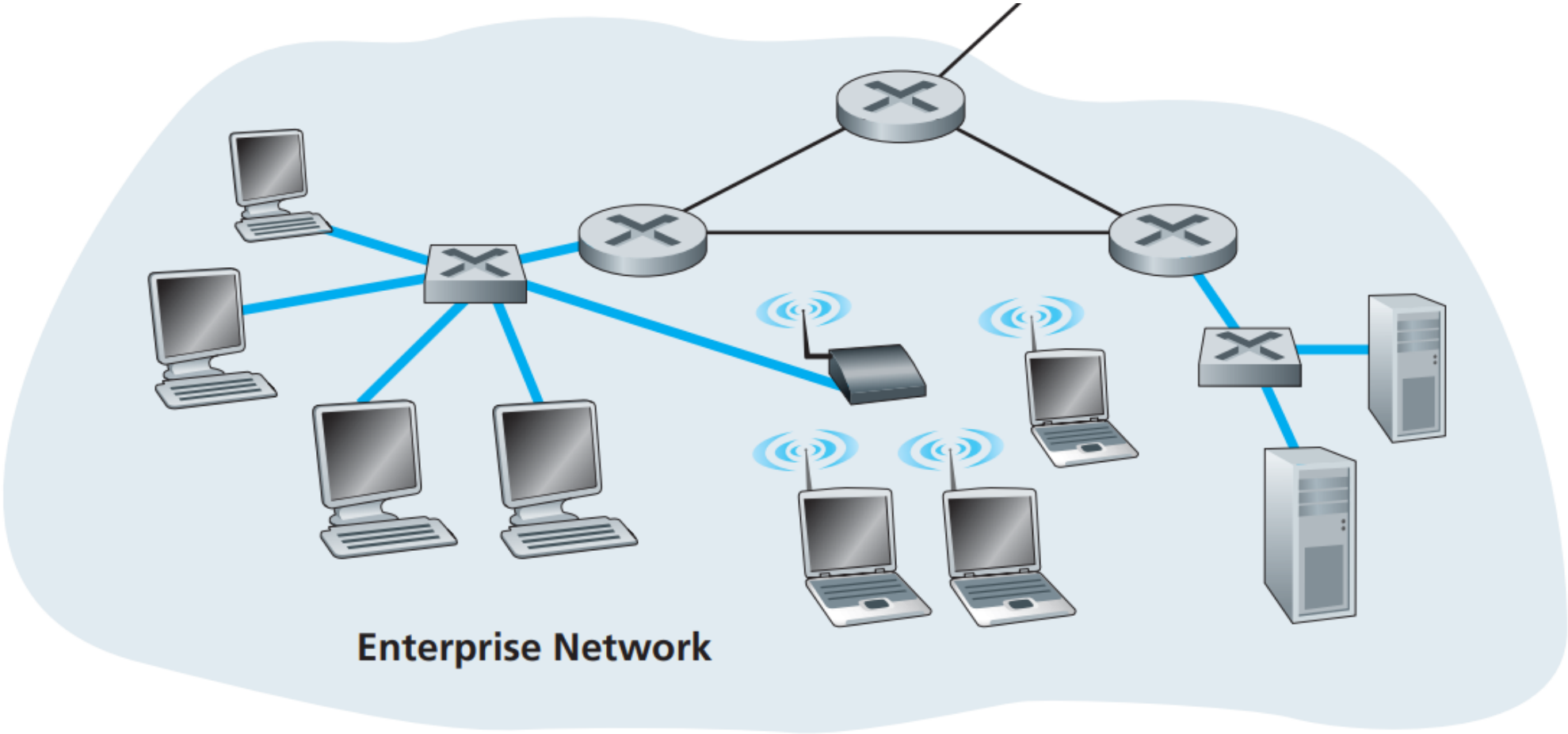
Ethernet Internet access

ACCESS NETWORKS: ETHERNET (2)

- **Enterprise** network.
  - **Ethernet** (IEEE 802.3) LAN technology.
  - **Twisted-pair** copper wire used to connect **hosts** to **Ethernet switch**.
  - **Ethernet switch** is connected to a **router** providing connection to ISP.

ACCESS NETWORKS: WLAN (1)

- **Wireless** LAN.



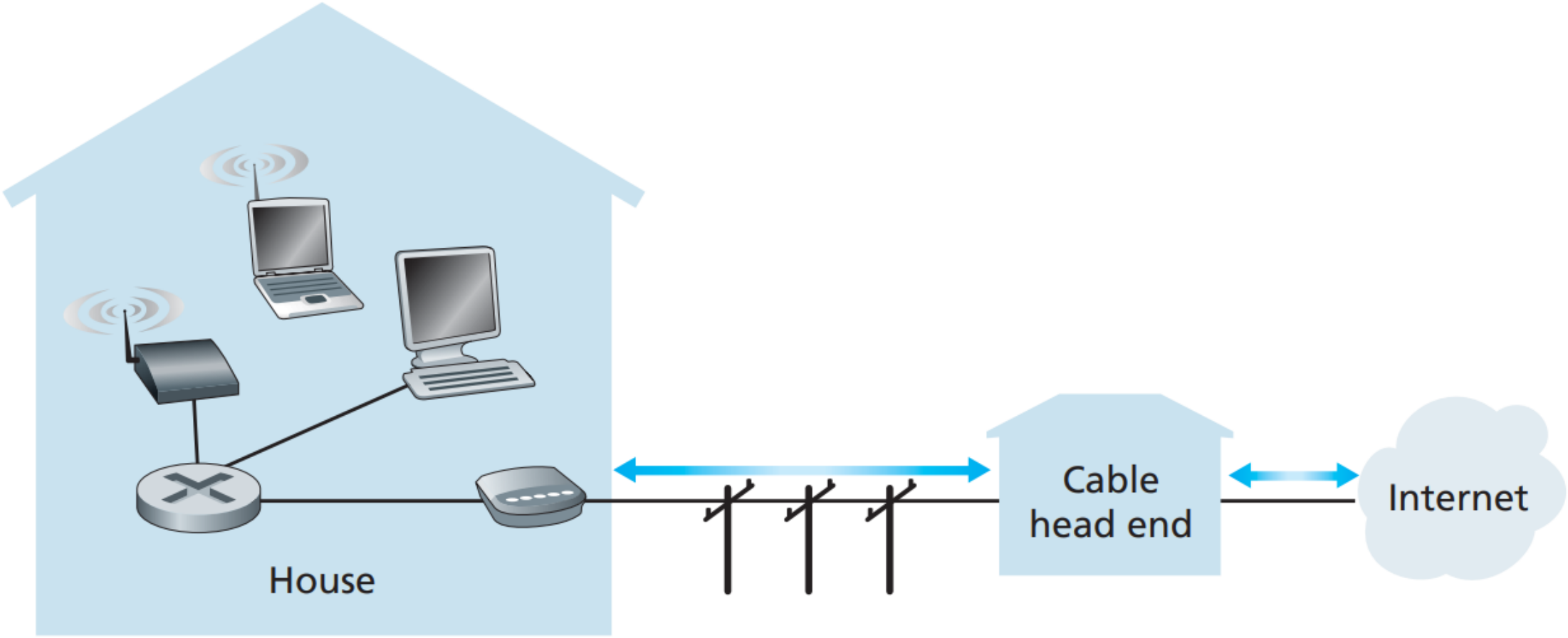
Wireless LAN Internet access

ACCESS NETWORKS: WLAN (2)

- **Wireless** LAN.
  - **Wi-Fi** technology (IEEE 802.11).
  - **Mid-distance** radio spectrum channels are used to connect **hosts** to **wireless access points**.
    - **Coverage** area ~300 ft.
  - **Access points** are connected to wired **Ethernet switches**.

ACCESS NETWORKS: ETHERNET + WLAN

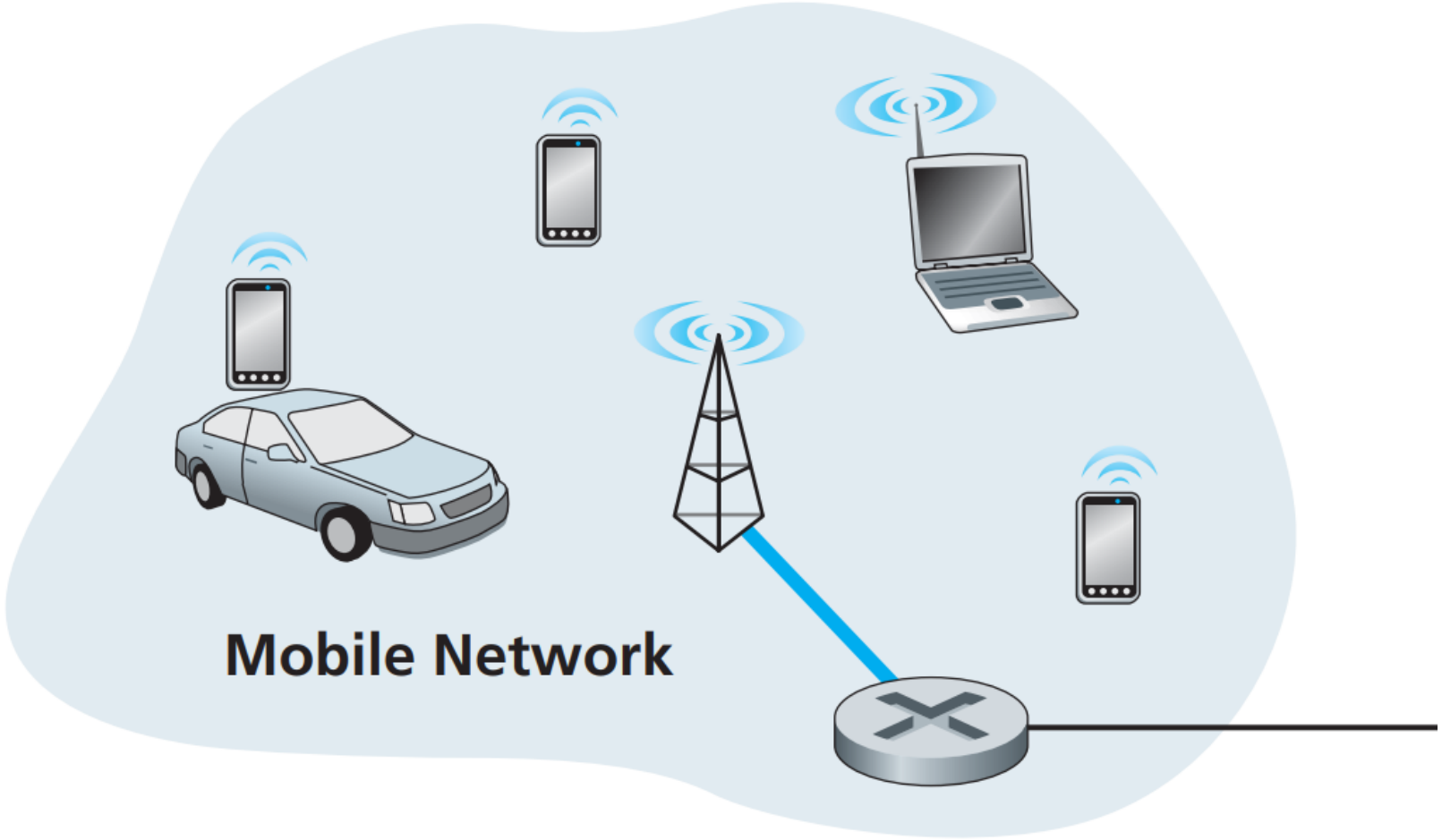
- Modern home network.



WLAN + Ethernet Internet access

ACCESS NETWORKS: WWAN (1)

- **Wireless** WAN.



Wireless WAN Internet access

ACCESS NETWORKS: WWAN (2)

- **Wireless** WAN.
  - Utilizing **wireless infrastructure** of **cellular** network providers.
  - **Long-distance** radio spectrum channels are used to connect **hosts** to **base stations**.
    - **Coverage** area ~30 miles.
  - **Base stations** are connected to **routers** providing connection to ISP.
  - **4G: LTE**, **5G** technologies.

SUMMARY

- General network requirements.
- Computer networks.
- Nodes / links.
- Internet.
- Protocols.
- Access networks.