Network

3y 1s network 1 - introduction

عن هذا التلخيص

1. في الملخص أحاول عدم الخروج عن محتوى المحاضرة إلا في الضرورة وفي هذه الحالة:
    1. الملاحظات المائلة *هكذا* تكون شرحا ليس مكتوبا في المحاضرة نفسها
    2. إذا هناك صفحة بكاملها أو جزء بكامله ليس في المحاضرة نفسها بل من فهمي سأوضح ذلك
2. الأمثلة أختصرها هنا فلا آتي بها كاملة إلا في الضرورة
3. غالبا لن أستخدم نفس عبارات المحاضرة فإذا كنت تريد نفس عبارات الحاضرة لكي تحفظها بالضبط كما هي يمكنك قراءة التلخيص ثم المرور على ملف المحاضرة سريعا
4. المحتوى أنا مضطر لجعله بالانجليزية حتى يتضمن المصطلحات التي يمكن أن تأتي فيها أسئلة ... هذا مع الأسف :(... ولغتنا الجميلة أولى بأن نعطي لها اهتماما

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chapter 1: introduction

roadmap (content) of this lecture

1. **what is the internet? what is a protocol ?**
2. **network edge**
    1. **hosts**
    2. **access network**
    3. **physical media**
3. **network core**
4. performance
    1. loss
    2. delay

    3. throughput
5. protocol layers, service models
6. security
7. history

Goal:

1. understanding the "feel" and "big picture" *بدون الدخول في تفاصيل كثيرة الصورة الكبيرة للمحتوى الخاص بالمادة كله*
2. introduction to terminology *المصطلحات الخاصة بالمادة*

هذا تلخيص حتى النقطة الرابعة network core
في نهاية التلخيص مفاجئة :)

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1. What is the internet ?

there are two views that we can discuss the meaning of the "internet" with ...

1. nuts and bolts view (what is its components ?) *الترجمة الحرفية المسامير والصماويل*
2. services view (what does it do ?)

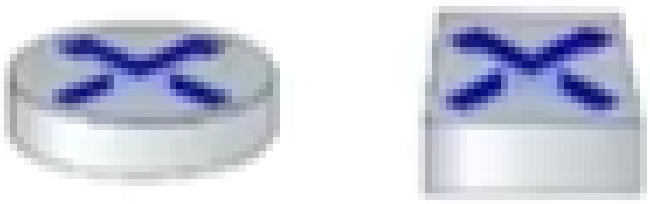
nuts and bolts view

- *let's start from the edges of the internet going to the middle*

1. first the edges are devices

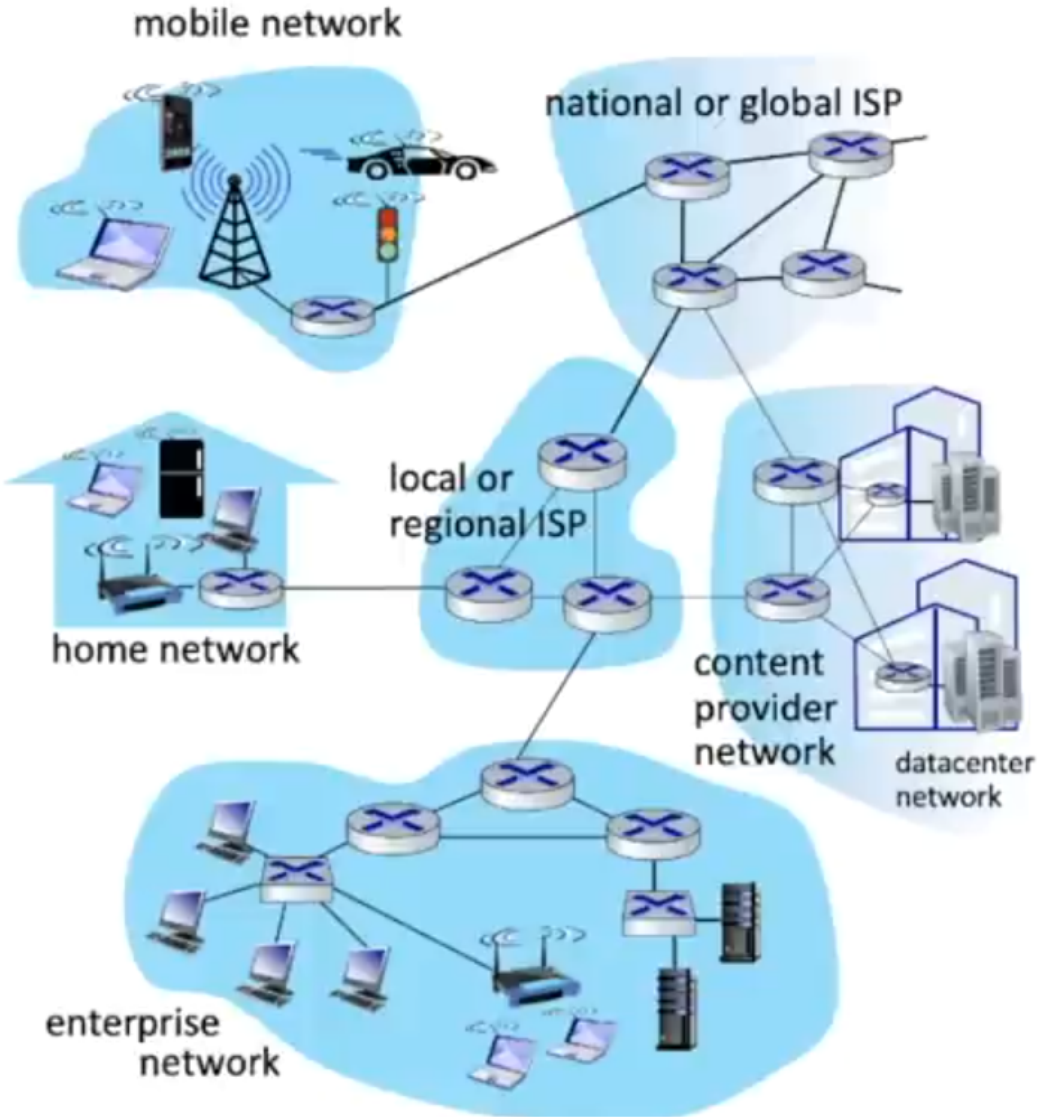
... called (hosts) or (end systems) and they are running network (apps) at the network **edge**

2. **packet switches** like this



forward packets (chucks of data) *تنقل مجموعة من البيانات*
   - *their types*: routers, switches
3. **communication links** *between hosts and packet switches have different types* (fiber, copper, radio, satellite)
4. **networks** are a collection of *all the previously mentioned components* devices, routers, links: managed by an organization

- *all represented in this picture*



- internet is a "network of networks"
  - in other words it's interconnected ISPs (مقدمي خدمة الانترنت) ... *معنى الكلمة سيتضح بعد ذلك*
- protocols (*تعريفها سيأتي بعد ذلك بالتفصيل*) are rules for controlling sending and receiving of messages like HTTP (web) and they are everywhere
  - *because protocols define the standard way of doing things there needs to an organization that define these things ... for the internet this organization is called*: IETF (internet Engineering Task) and their standards are called RFC: (request for comments)

services view

- internet is an infrastructure that provides services to applications like: web *for sending and receiving messages*
- internet provides (programming interfaces) for simplifying the process of transporting messages between distributed applications ... they are like "hooks" (*خطاطيف تربط شيئين ببعضهم*)
- The internet service is like the postal service (*خدمة البريد*)

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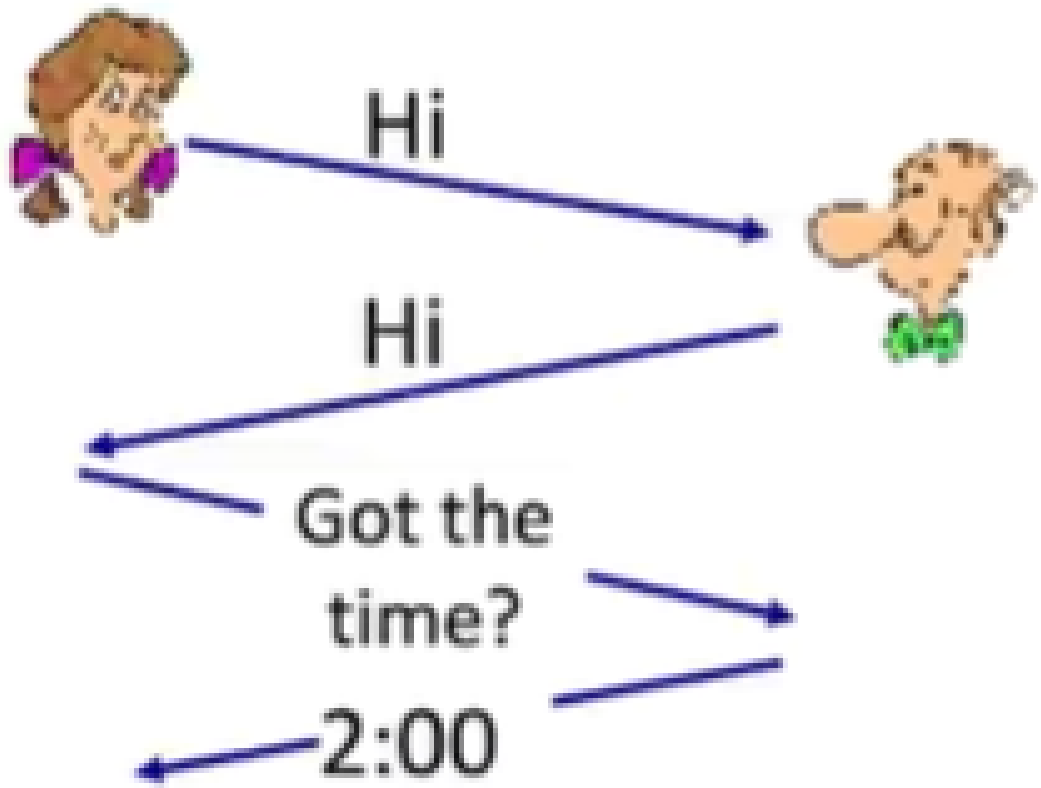
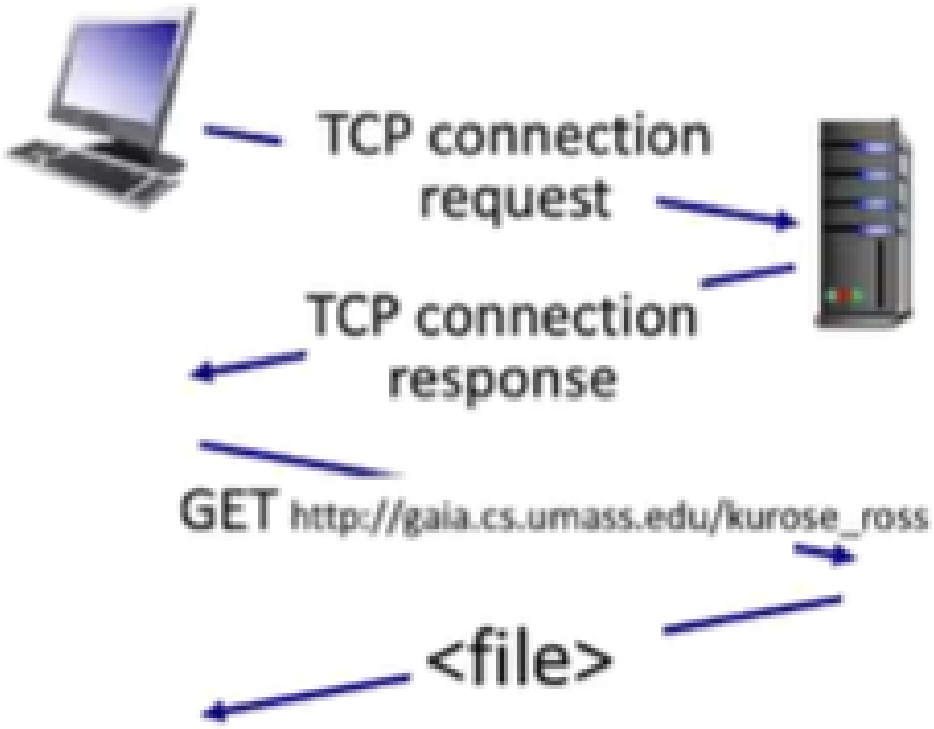
2. what's a protocol ?

- *to understand them, let's think of what's the similarity between human protocols and network protocols*
    1. we as humans have rules (protocols) that we follow when communicate like

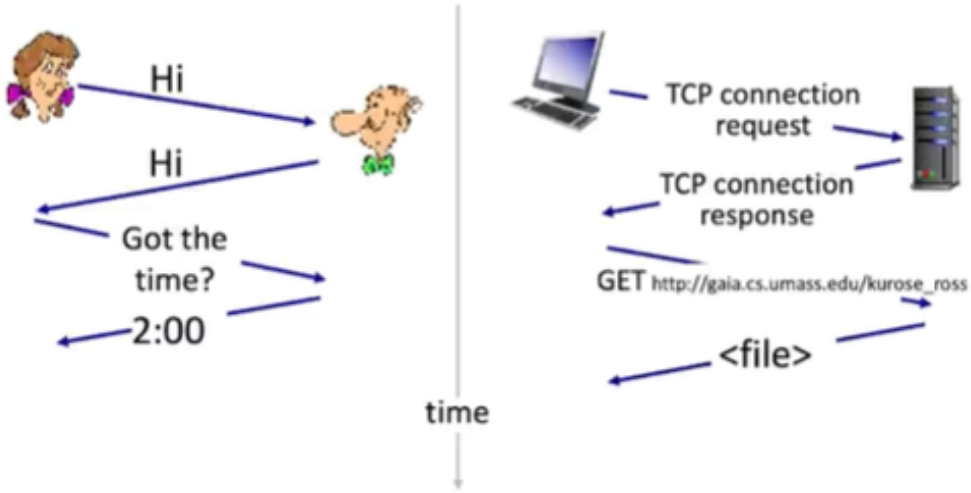


... you can notice from this example that we have two phases (request) and (response)

2. also computers works in the same way as they go into both those phases



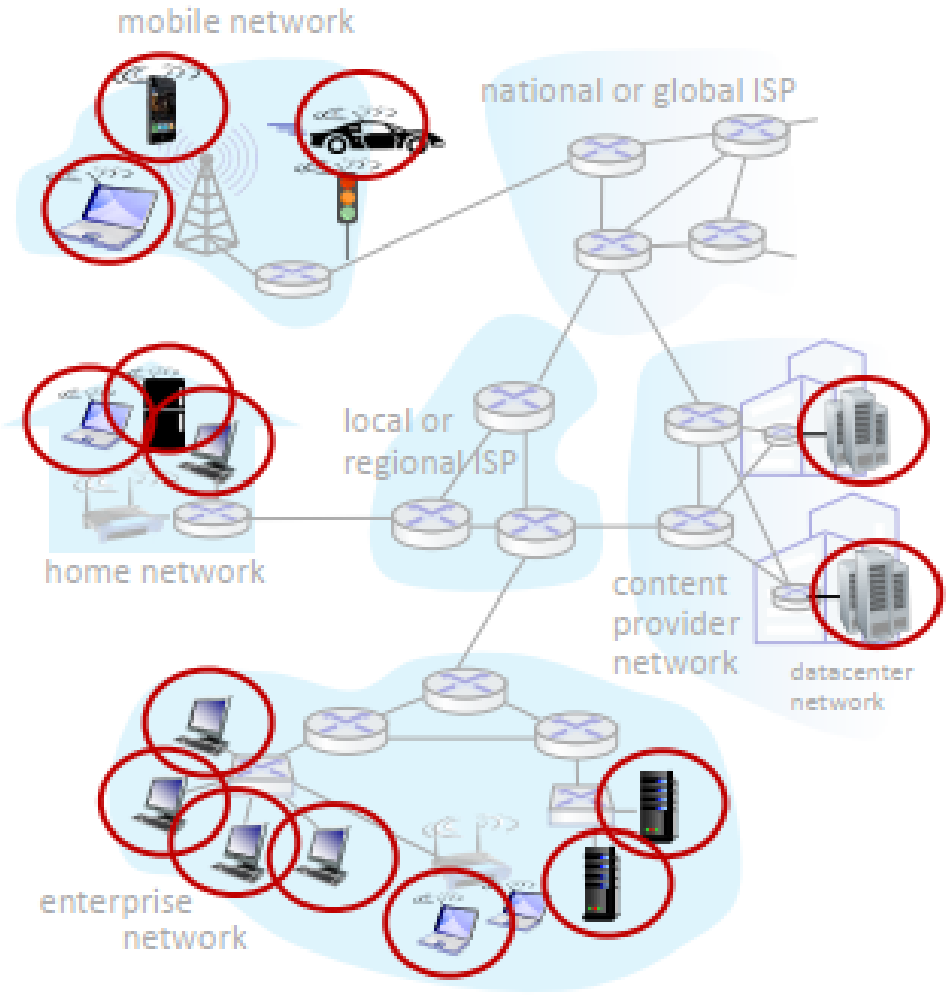
    - all communication activity in Internet is governed by protocols
- that's why human protocols are analogous (like) computer protocols



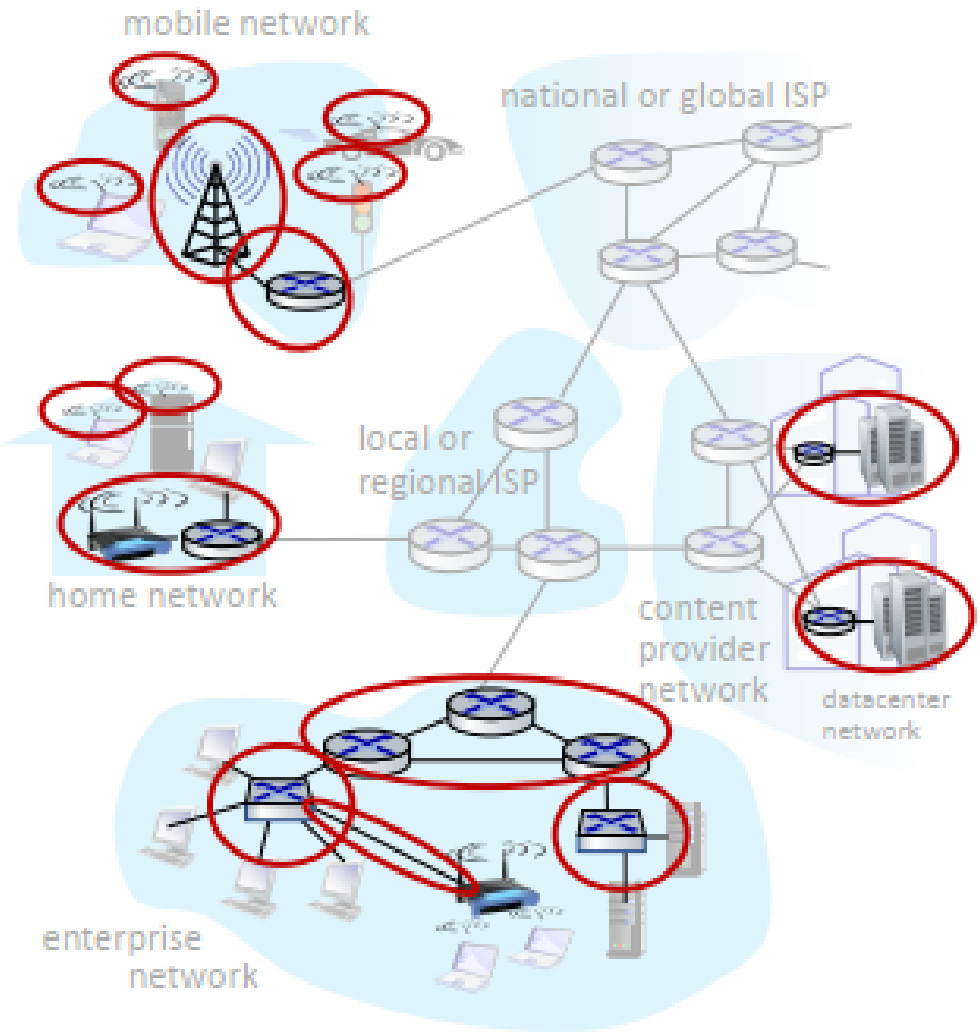
- Definition of protocols:
    - Protocols define the **format**, **order** of messages sent and received among network entities, and **actions** taken on msg transmission, receipt

3. Network edge: hosts, access network, physical media

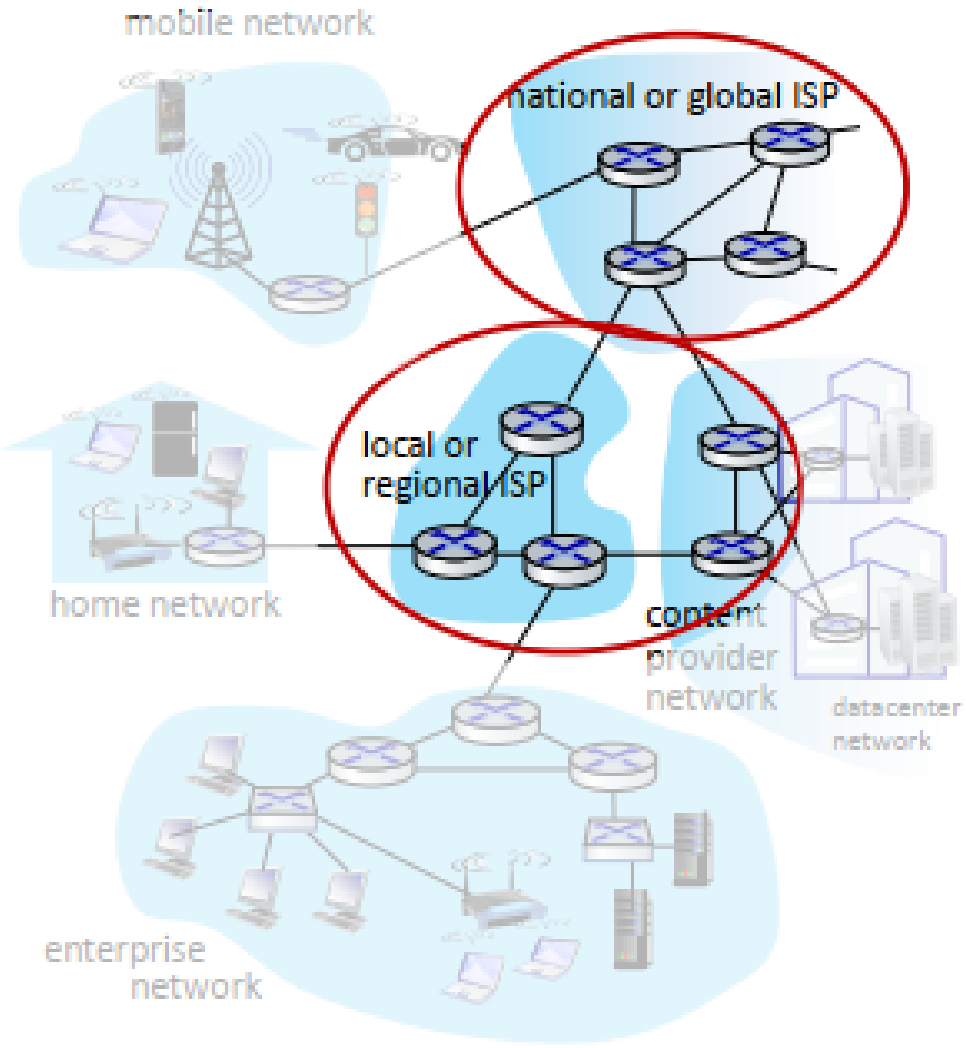
- overview of internet structure:
    1. network edge: hosts (clients and servers)
        - servers are often in data centers



    2. Access networks, physical media: wired and wireless communication links



3. Network core: interconnected routers forming a network of networks (*we will talk about this later*)



- the focus of this section is on **Access networks, physical media** specifically

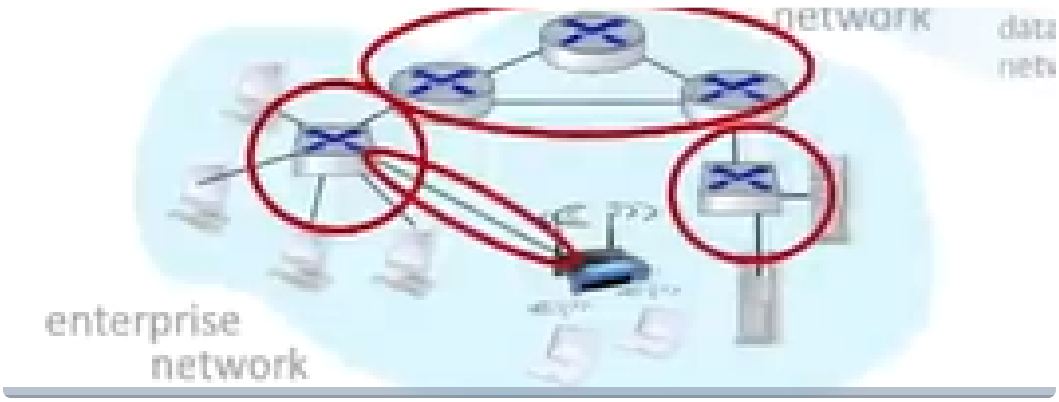
Access networks

- Q: how to connect end systems to edge router? *there are three types of access networks to this*
  1. residential access nets (*for homes*)

- *- inside the home*

- *- connecting multiple homes*

2. institutional access nets (*for companies*)



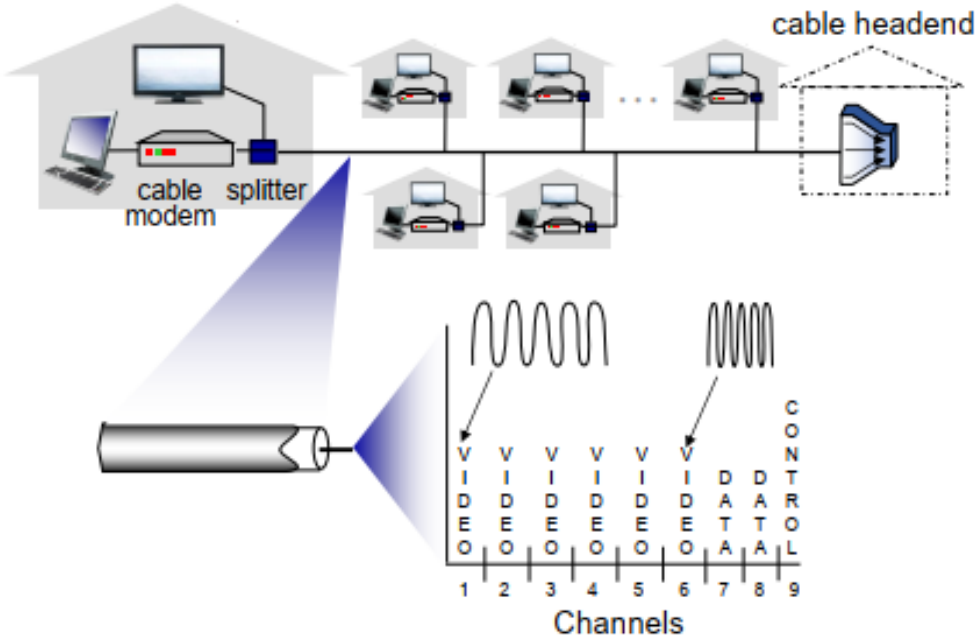
3. mobile access networks (WIFI, 4G/5G)

here we will cover some details of the first two types: residential and institutional access nets

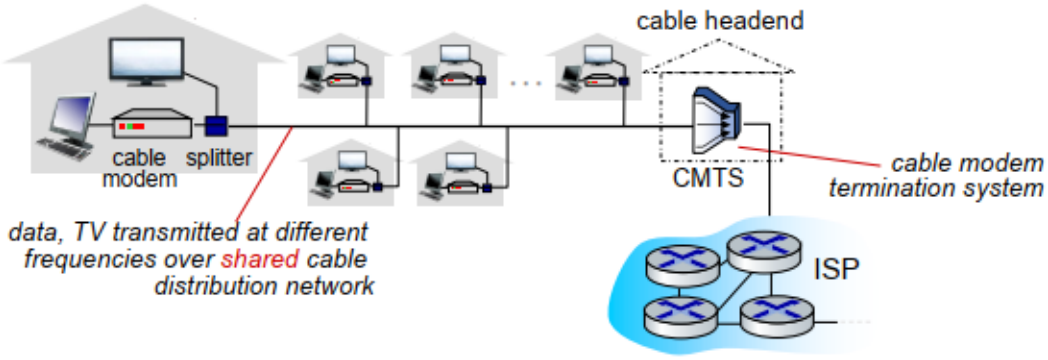
1. Residential access networks

(*connecting multiple homes together*) ... have more than one type

1. wired: cable-based access (*physical cable directly connected to the home*)



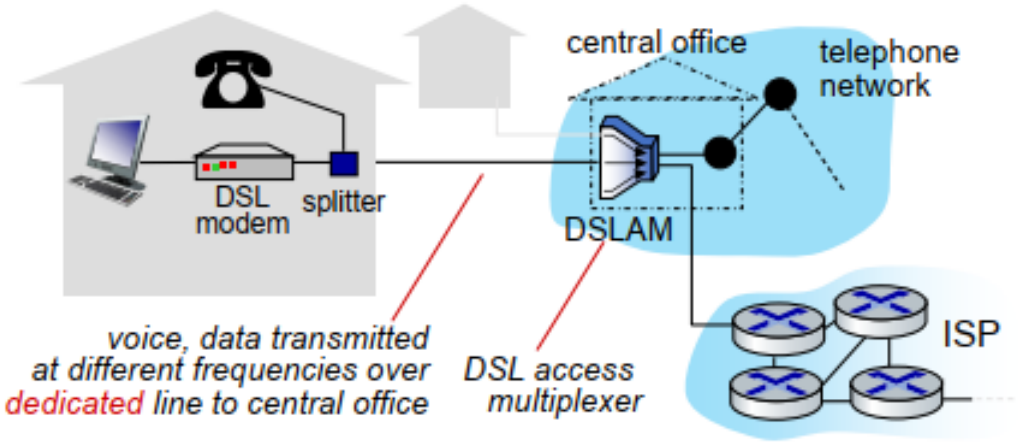
- *- as you can notice ... all the homes are connected with one line ... this line ends at the" cable headend" ... so how can we provide connect all those homes with one cable ??*



- - notice here that the "cable headend" is called "**CMTS**" or cable modem transmission system ... also notice that inside the home, the splitter connects to the **TV** and to the cable modem
- the technique used to allow all homes to send and receive messages using the same cable is called **FDM** (frequency division multiplexing) ... it depends on making different channels inside the cable ... each one transmits data in a different frequency band

- this type of residential access network uses: HFC (hybrid fiber coax) cables
  - those cables are "asymmetric" which means that they have different transmission rates for downstream transmission (to the home) and upstream transmission (from the home)
  - 40 Mbps – 1.2 Gbps downstream transmission rate, 30-100 Mbps upstream transmission rate
- To conclude, a network of cables and fiber attaches homes to ISP routers making homes **share access network** to cable headend

2. wired: digital subscriber line (DSL)



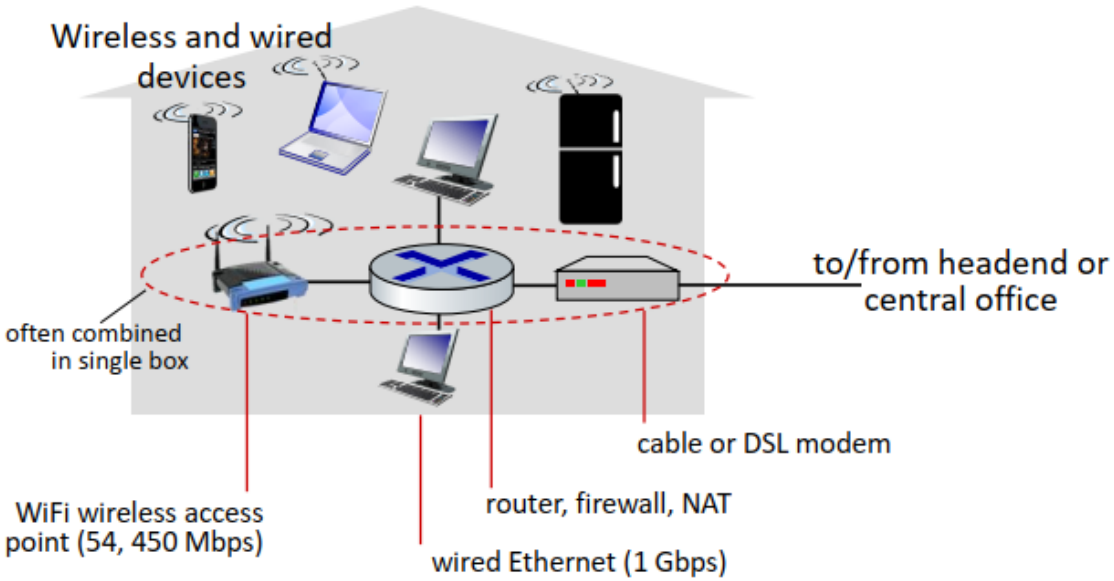
- this type of access network uses existing telephone line to central office DSLAM
  - *notice that the difference between this type and the (cable-based) mentioned above is that the (cable-based) uses a dedicated cable only for transmitting data ... on the other hand, (DSL) uses an existing telephone line that was already transmitting **voice** to transmit internet **data** with it*
  - *notice that in the illustration above the DSLAM (DSL access multiplexer) which distributes the service (DSL) is connected to*

both ISPs (for providing internet) and also with the telephone network

- **data** transmitted over DSL phone line goes to the **Internet** ... **voice** on the other hand goes to the **telephone net**

- transmission rates:
  - 24-52 Mbps dedicated downstream transmission rate
  - 3.5-16 Mbps dedicated upstream transmission rate
  - *notice that it's slower than the (cable-based) type mentioned above*

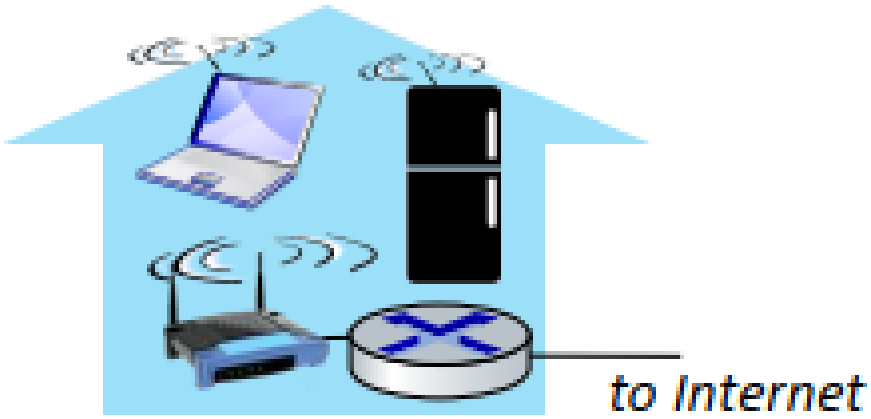
3. wireless and wired: home networks



- *notice the following:*
  1. WIFI (wireless access point), router, and (cable or DSL) modem are often combined together in a **single box**
  2. home networks contains both wireless (like the mobile) and wired devices (like the device below the router)
  3. the modem is connected to/from headend *(for cable-based access network)* or central office *(for DSL access network)*
  4. the bandwidth of WIFI is between 54, 450 Mbps

4. wireless access networks

1. Wireless local area networks (WLANs)



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    1. this network is typically within or around one building (~100 ft)
    2. the protocol used for WIFI is IEEE 802.11 but it have more than one type with different transmission rates:
        1. 802.11 b → 11 Mbps
        2. 802.11 g → 54 Mbps
        3. 802.11 n → 450 Mbps
2. Wide-area cellular access networks

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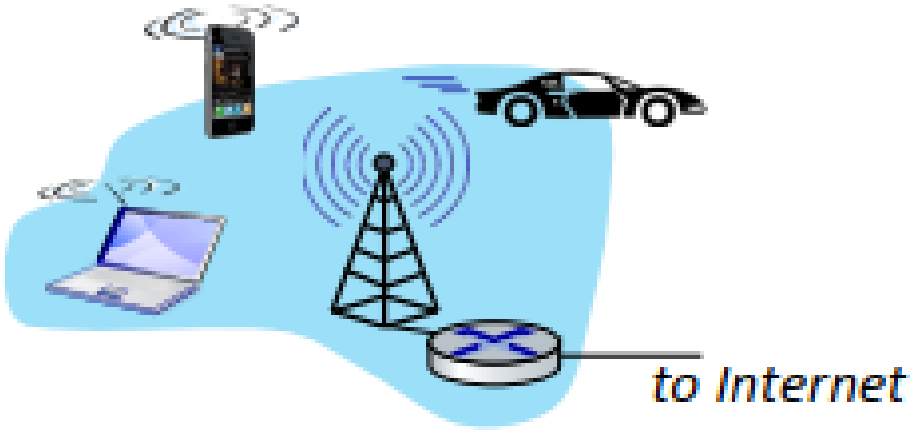
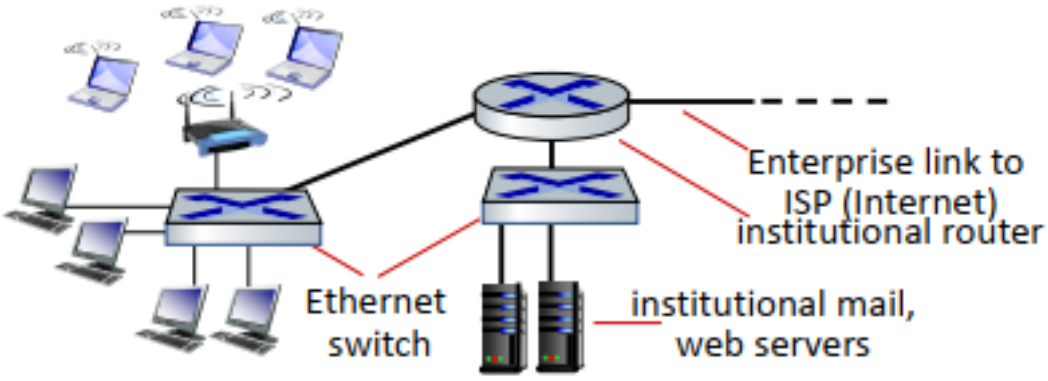


1. this network is provided by mobile, cellular network operator and it covers 10's of km (*which means 10 or 20 or 30 and so on*)

2. transmission rate: 10's of Mbps (*which means 10 or 20 or 30 and so on*)
3. uses 4G/5G cellular networks technology

2. Enterprise access networks

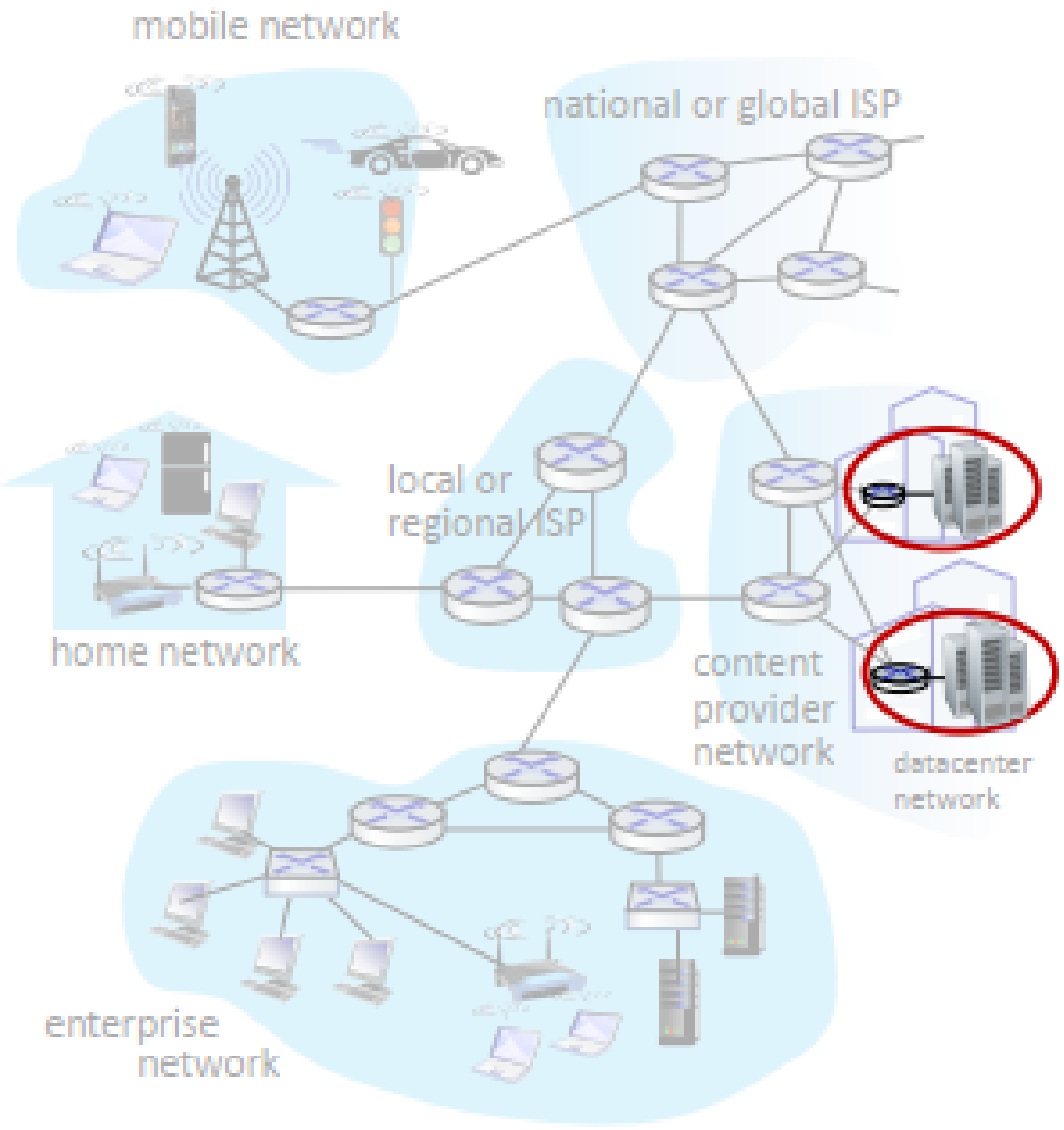
- where?: companies, universities, etc.
- consists of what? mix of wired, wireless link technologies, connecting a mix of switches and routers *(we'll cover differences between routers and switches in the following sections)*
- what is the rate of transmission for these networks?
  - Ethernet: wired access at 100Mbps, 1Gbps, 10Gbps
  - WIFI: wireless access points at 11, 54, 450 Mbps



physical media

Access networks: data centers networks

- *data centers contain* high-bandwidth links (10s to 100s Gbps) that connect hundreds to thousands of servers together, and to Internet.



Hosts: sends packets of data

what is the Packet transmission delay?

the computer "host" sends messages after breaking them into smaller **packets** of length **L** and at a transmission rate **R** ... the **time** needed to transmit these packets is the **packet transmission delay**

notices that **R** or transmission rate can also be called **link capacity** and **link bandwidth**

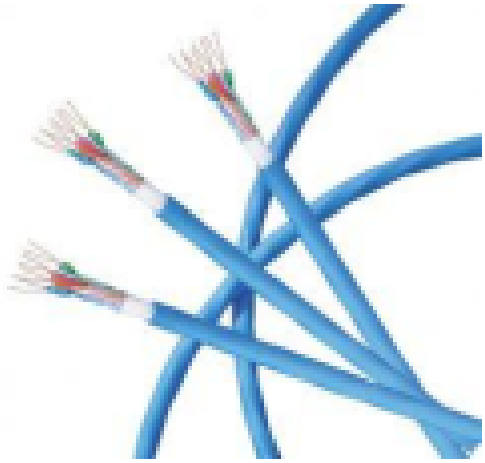
- *I think you should memorize this*

$$\text{packet transmission delay} = \text{time needed to transmit } L\text{-bit packet into link} = \frac{L \text{ (bits)}}{R \text{ (bits/sec)}}$$

Links: physical media

let's try summarizing this point in question and answer format

1. what propagates between transmitter/receiver pairs ? **the bit**
2. what lies between transmitter & receiver ? **physical link**
3. In what type of media do signals propagate in solid media: copper, fiber, coax? **guided media**
4. In what type of media do signals propagate freely, e.g., radio ? **unguided media**
5. "Twisted pair (TP)" cables consists of what ? **two insulated copper wires**
6. what is the transmission rate of "Category 5" and "Category 6" types of "Twisted pair" cables
    - **Category 5: 100 Mbps, 1 Gbps Ethernet**
    - **Category 6: 10Gbps Ethernet**



7. for the "Coaxial cable"
    1. what is it's components ? **it have two concentric copper conductors**
    2. is it unidirectional or bidirectional ? **bidirectional (*sends and receives data*)**
    3. what is it's bandwidth ? **it have multiple frequency channels in each cable ... each channel have 100's Mbps bandwidth**
8. for "Fiber optic"
    1. consists of what ? **It's a glass fiber carrying light pulses, each pulse is a bit**
    2. speed ? **high-speed point-to-point transmission (10's-100's Gbps)**
    3. error rate ? **it have low error rate because it's immune to electromagnetic noise ... because of that "repeaters" (which amplify the signal) are spaced far apart**
9. for the "wireless radio"
    1. how signals are carried ? **signal are carried in various "bands" in the electromagnetic spectrum**
    2. are radio waves broadcasted "half-duplex" or "full-duplex"? **it's half-duplex which means that one device sends a message**

at a time ... no more than one device

3. what are the effects of the environment on radio waves? reflection, obstruction by objects (عرقلة), and interference/noise
4. what are radio types ?
    1. Wireless LAN (WIFI)
        - 10-100’s Mbps; 10’s of meters
    2. wide-area (e.g., 4G/5G cellular)
        - 10’s Mbps (4G) over ~10 Km
    3. Bluetooth: cable replacement
        - short distances, limited rates
    4. terrestrial microwave
        - point-to-point; 45 Mbps channels
    5. satellite
        - up to < 100 Mbps (Starlink) downlink
        - 270 msec end-end delay (geostationary)

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4. The network core: packet/circuit switching, internet structure

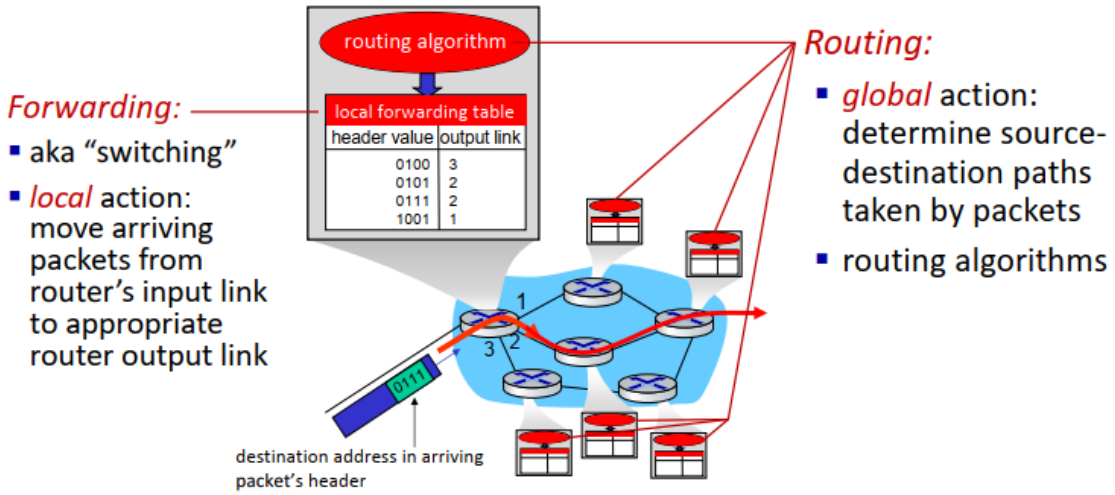
there are two types of switching ... packet switching is the default one for "networks" and circuit switching is the default for "telephones"

Packet switching

- as we already discussed, network is a mesh (شبكة) of interconnected routers .. using "packet switching" breaks

"application-layer" messages into Packets ... those packets are forwarded from one router to the next until it reaches its destination

- the network core do two functionalities
  1. Forwarding (aka switching) - this is the "local action"
     - move arriving packets from router's input link to appropriate router output link (*from a router to the next*)
  2. Routing - this is the "global action"
     - determine source-destination paths taken by packets (*from the source all the way to the destination*)
     - determine "routing algorithms"
  - *notice in this illustration that the router have an internal table of contents that makes it possible for the router to forward and rout messages*



  - routing (all the way from source to destination) **vs.** forwarding (from a router directly to the next one)

- 

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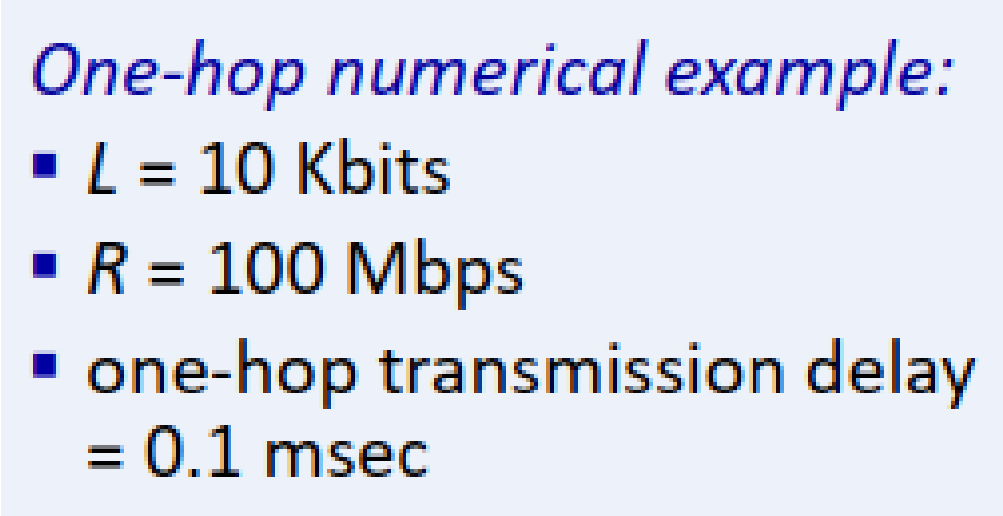
- packet-switching **store then forward** packets from one router to the other because they must all arrive completely to the router before they are forwarded to another.
    - the process of "store-and-forward" takes some time to be done ... this time is called "packet transmission delay" (*we have discussed this before*)

- that's an example of calculating the time:

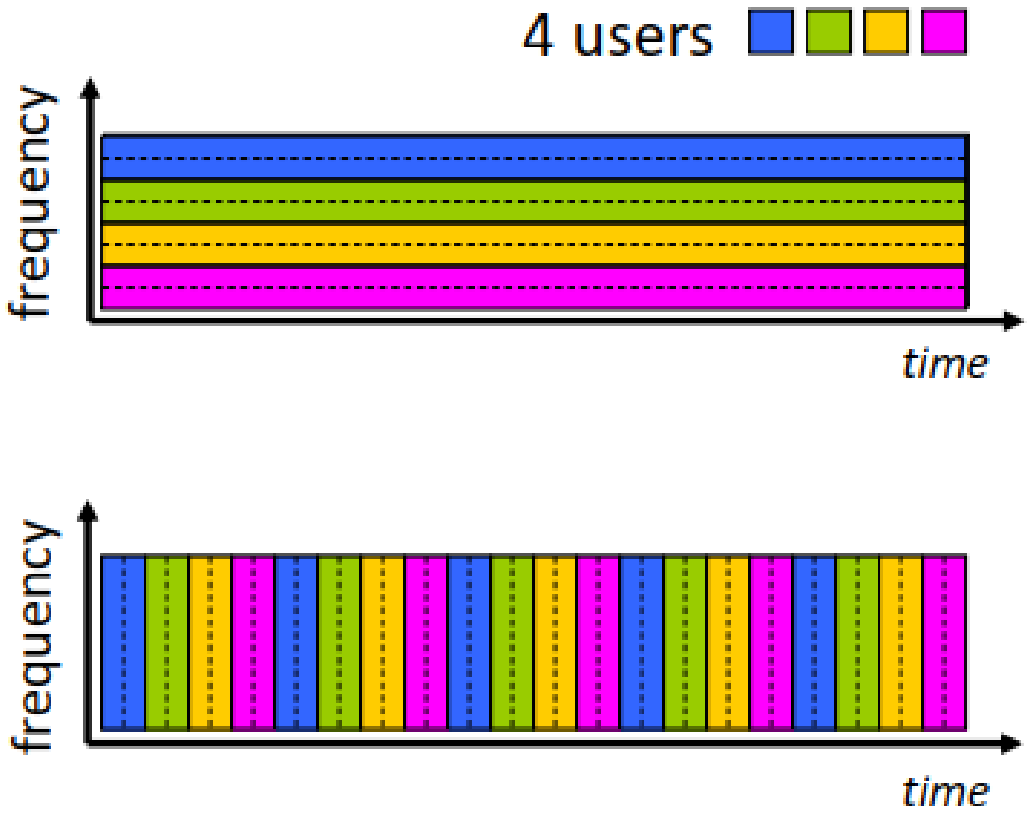


- In packet switching: routers **queue** packets in its internal memory (buffer) so that the **F**irst packet **A**rrived is the **F**irst to be **O**utputted (FIFO) ... but if the memory is full the coming packets are dropped (lost)

Circuit switching

- the basic idea of it is that you **reserve** a link ... so no one can share it with you ... and the performance is guaranteed (مضمون)
- this technique is used traditionally for telephone networks
- circuit switching have two types

- *this illustration is enough to understand them*



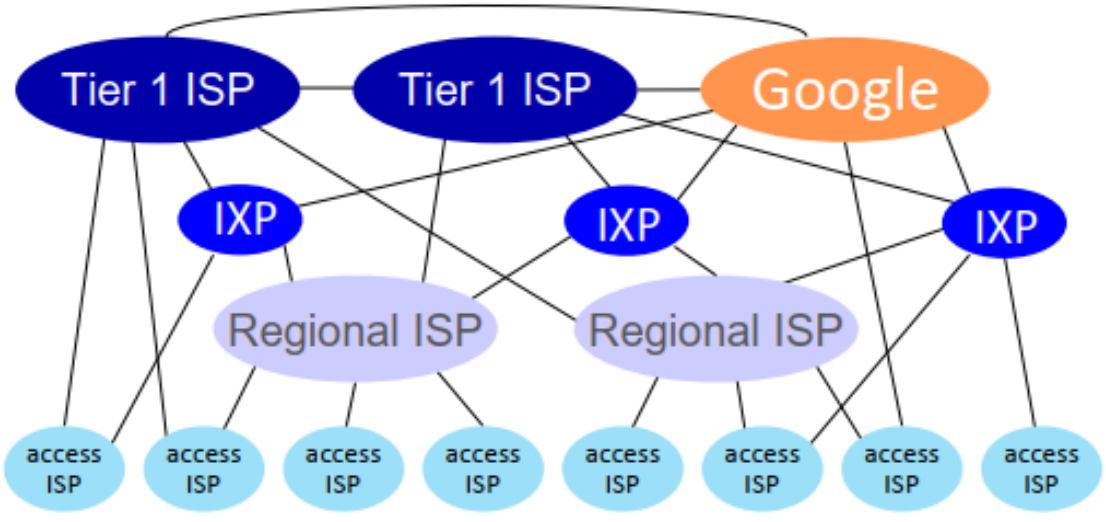
1. FDM - frequency division multiplexing
    - the idea of it is to divide **optical** and **electromagnetic** frequencies into (narrow) bands
    - each "call" from the telephone allocates its own "frequency" band ... and the call can transmit at max rate of that narrow band
2. TDM - time division multiplexing
    - time is divided into slots (*parts*)
    - each call can transmit at maximum rate in a specific time period ... but it takes all the frequencies available

packet vs. circuit switching

- packet switching have no limits on the number of users that can use the network at one time .... not like circuit switching which is limited
- packet switching have a possibility of **excessive congestion** (تكدس مفرط) of packets ... which may cause long delays and loss of data ... on the other hand, circuit switching is always reliable for the current users
- packet switching is the best for **bursty** data (مفاجئة ومتدفقة) that at sometimes have data to send and at other times it doesn't have data to send .... this type of data can accept **resource sharing** .. so packet switching is the best for it as it requires a simple setup

Internet structure

how to connect all the world together ?? ... this question have a beautiful step-by-step answer in the slides .. but here I'll give you just some notes on it
it's recommend to see the slides for this part ... from page 37 to 45



- in this illustration: **access ISPs** are connected together with **Regional ISPs** which is also connected to the **Tier 1 ISPs** (the top

level entity which provides internet) ....

- we also notice that **IXPs** (internet exchange points) connect **Tier 1 ISPs** together and also connects the **Regional ISPs** to them
- **Google** here is an example of "content provider networks" which are private networks connected to the internet through more than one **Tier 1 ISP** and **Regional ISPs**

إضافي ... هذا الجزء ليس في المحاضرة الأساسية

دونك رابط فيه شرح للمادة وجدته على الانترنت مطابق لمحتوى المحاضرة حتى أن شكل الشرائح (slides) هو واحد تقريبا .... هذا الشرح مقدم من مؤلف الكتاب (computer networking: A Top-Down Approach) الذي منه محتوى المادة كلها ... ويوجد عليه تطبيقات عملية وأسئلة وغيره

الرابط

Computer Networking: a Top Down Approach (umass.edu)

- من قسم Resources(for everyone) في أعلى الموقع اختر online course واستمتع :)