제3강 : 네트워크 에지

Computer Networking: A Top Down Approach

컴퓨터 네트워크
(2019년 1학기)

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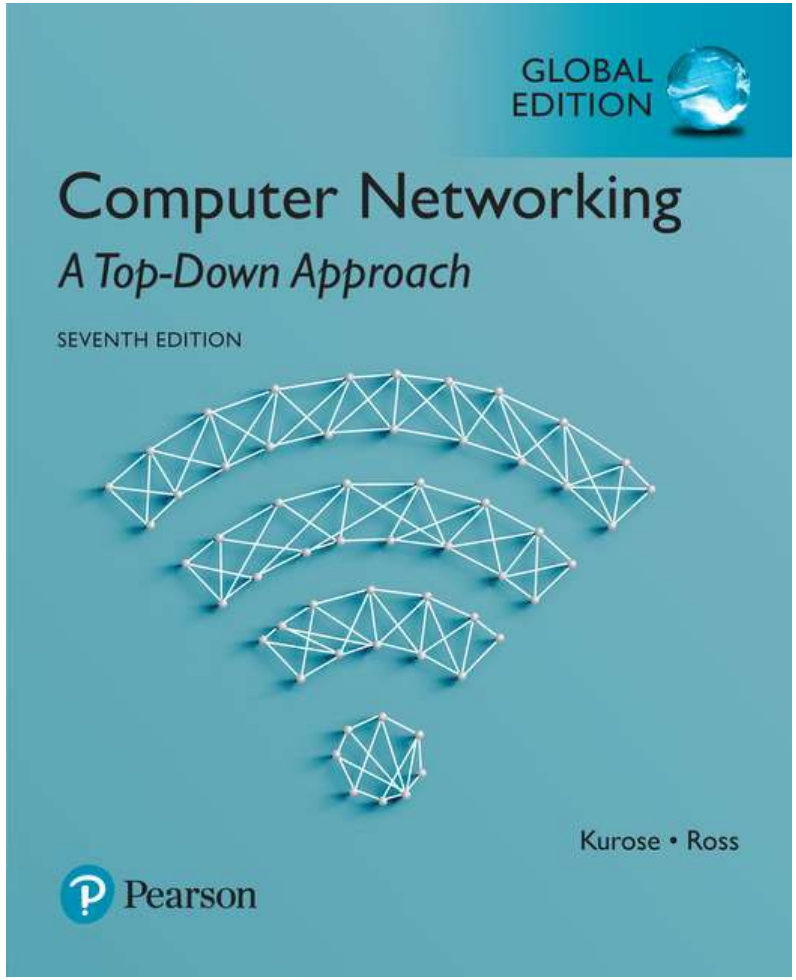


Chapter 1: introduction

overview:

- what's the Internet?
- what's a protocol?
- network edge; hosts, access net, physical media
- network core: packet/circuit switching, Internet structure
- performance: loss, delay, throughput
- security
- protocol layers, service models
- history

Pre-study Test :

1) 인터넷에 연결되는 데스크탑, 스마트폰, 그리고 서버 등과 같은 컴퓨팅 장치를 무엇이라 부르는가?
(How are the computing devices such as desktop, smartphone, and server connected to the Internet called?)

① switch
② router
③ host
④ hub

2) 다음 중 전화선을 사용하는 접속망 솔루션은 무엇인가?
(Which of the following access network solutions is using telephone line?)

① Cable modem
② DSL modem
③ Ethernet
④ FTTH

3) 와이파이 표준의 이름은 무엇인가?
(What is the standard for WiFi?)

① IEEE 802.3
② IEEE 802.5
③ IEEE 802.11
④ IEEE 802.15

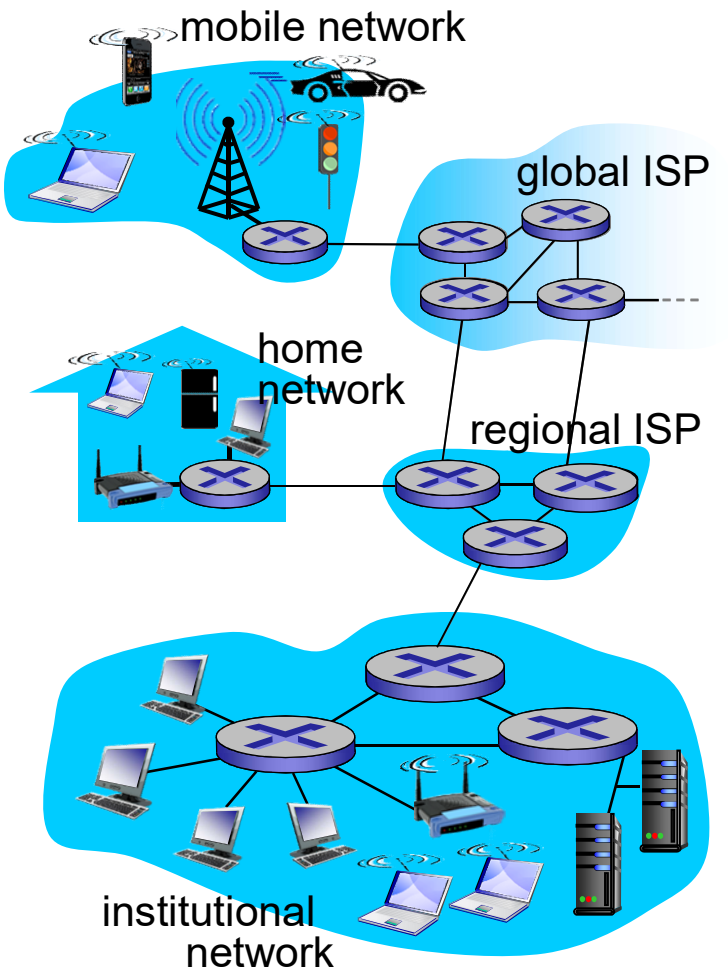
4) 인터넷에서 네트워크를 연결하는 장치는 무엇인가?
(What is the device which is used to connect networks in the Internet?)
① router
② switch
③ link
④ server

5) 우리나라에서 가장 많이 사용되는 접속망 솔루션은 무엇인가?
(Which of the following access network solutions is most widely used in Korea?)
① Cable modem
② DSL modem
③ Ethernet
④ FTTH

6) 다음 중 성격이 다른 매체를 하나만 고르시오.
(Please select one medium different from others?)
① UTP
② Coaxial Cable
③ Microwave
④ Fiber optics

A closer look at network structure:

- *network edge:*
  - hosts: clients and servers
  - servers often in data centers
- *access networks, physical media:* wired, wireless communication links
- *network core:*
  - interconnected routers
  - network of networks



Access networks and physical media

Q: How to connect end systems to edge router?

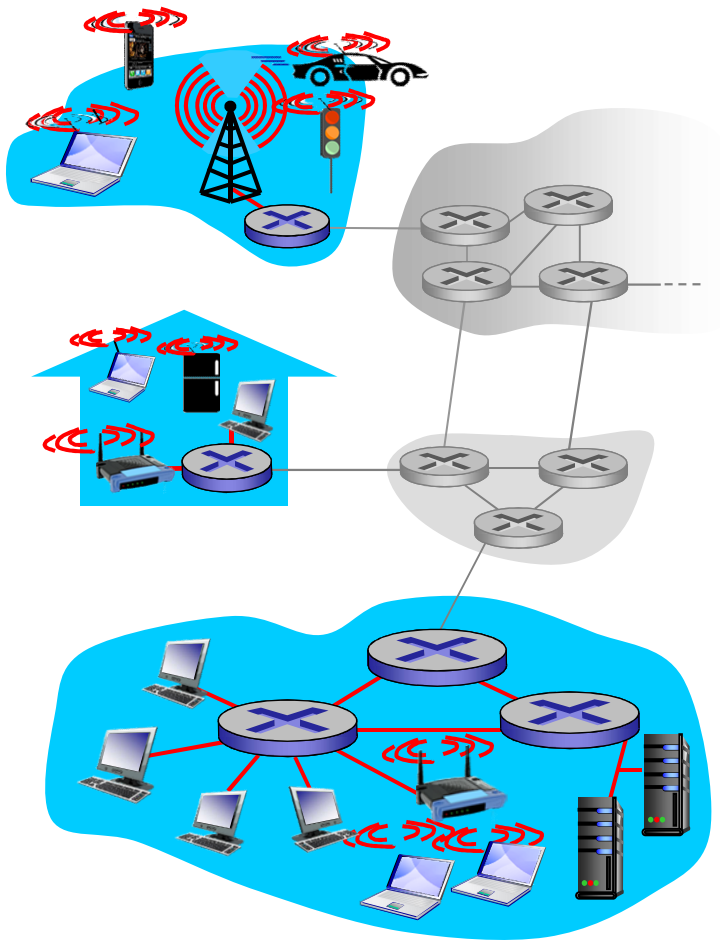
① residential access nets

② institutional access networks (school, company)

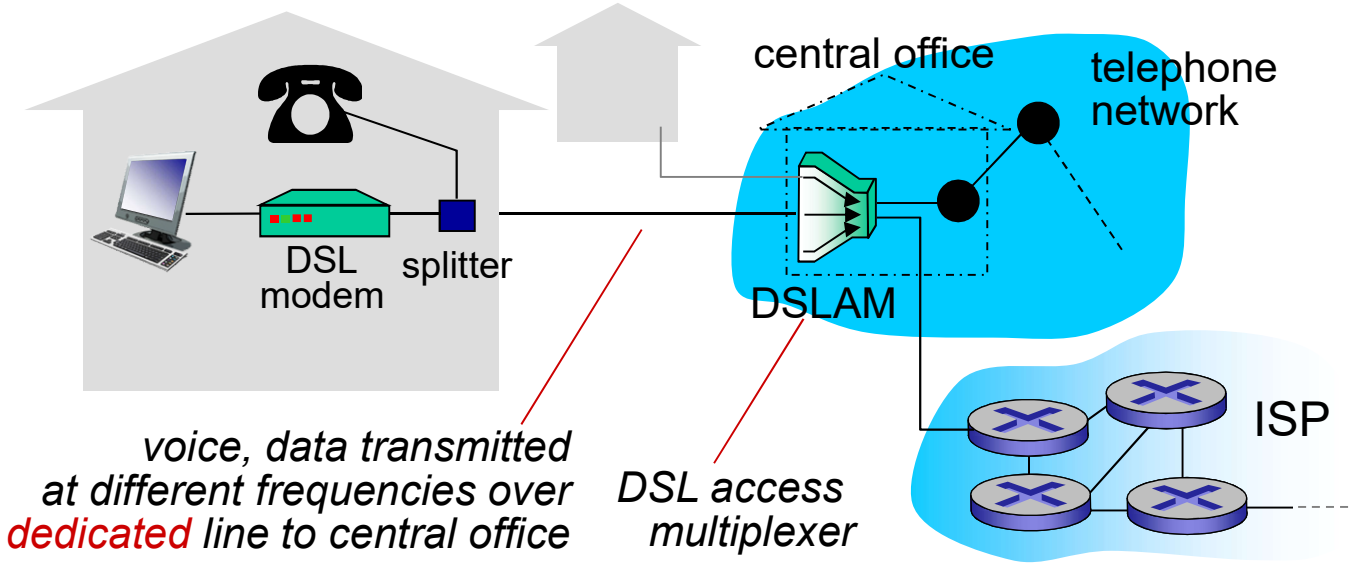
③ mobile access networks

keep in mind:

- bandwidth (bits per second) of access network?
- shared or dedicated?

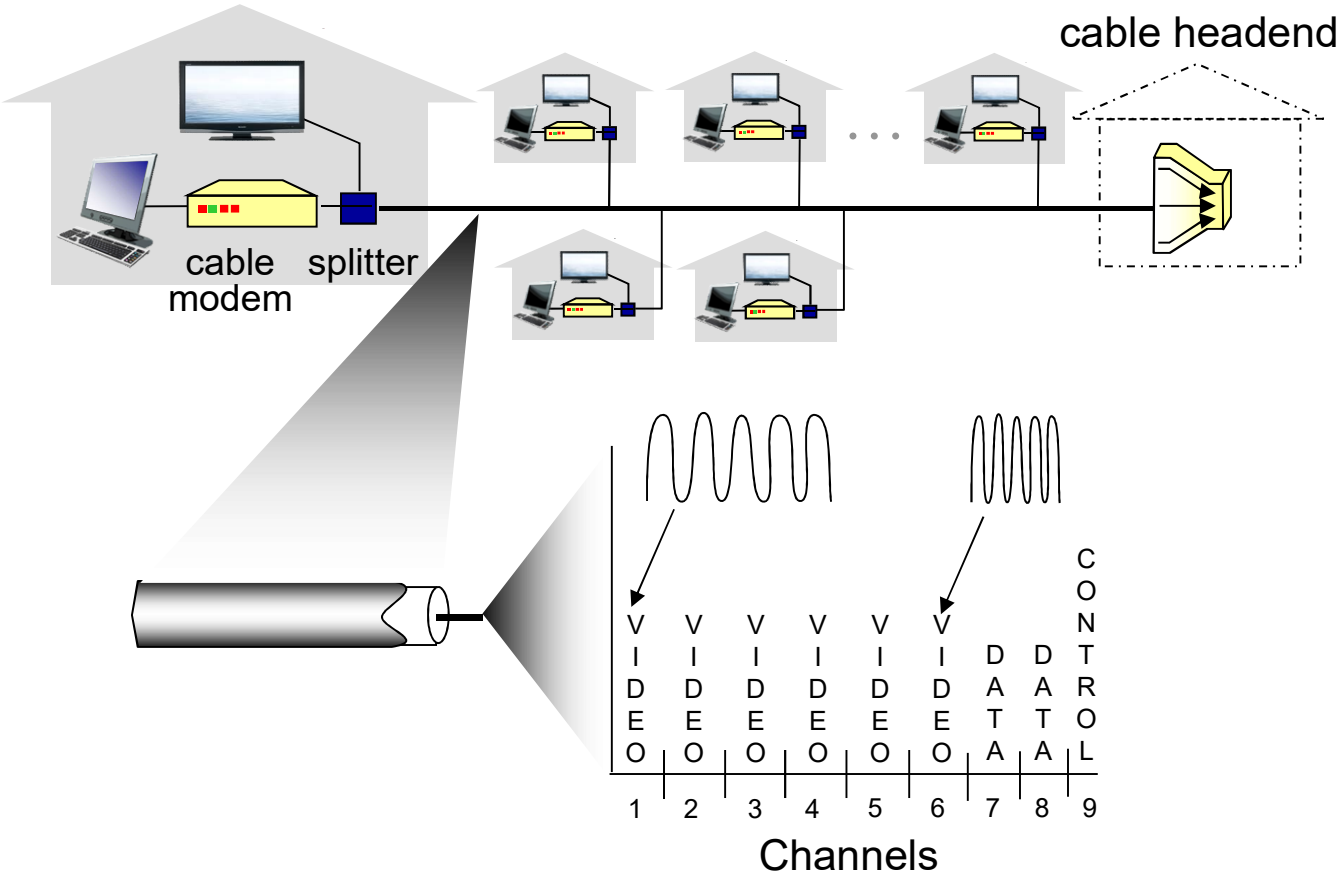


Access network: digital subscriber line (DSL)



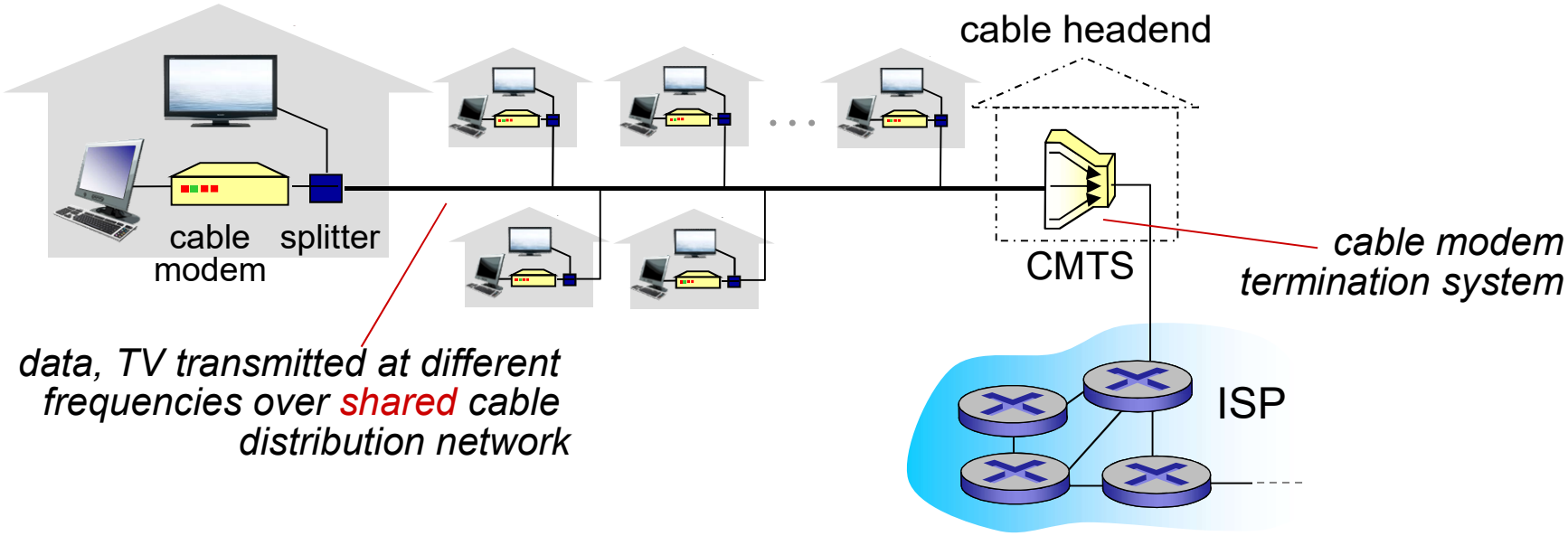
- use *existing* telephone line to central office DSLAM
  - data over DSL phone line goes to Internet
  - voice over DSL phone line goes to telephone net
- < 2.5 Mbps upstream transmission rate (typically < 1 Mbps)
- < 24 Mbps downstream transmission rate (typically < 10 Mbps)

Access network: cable network



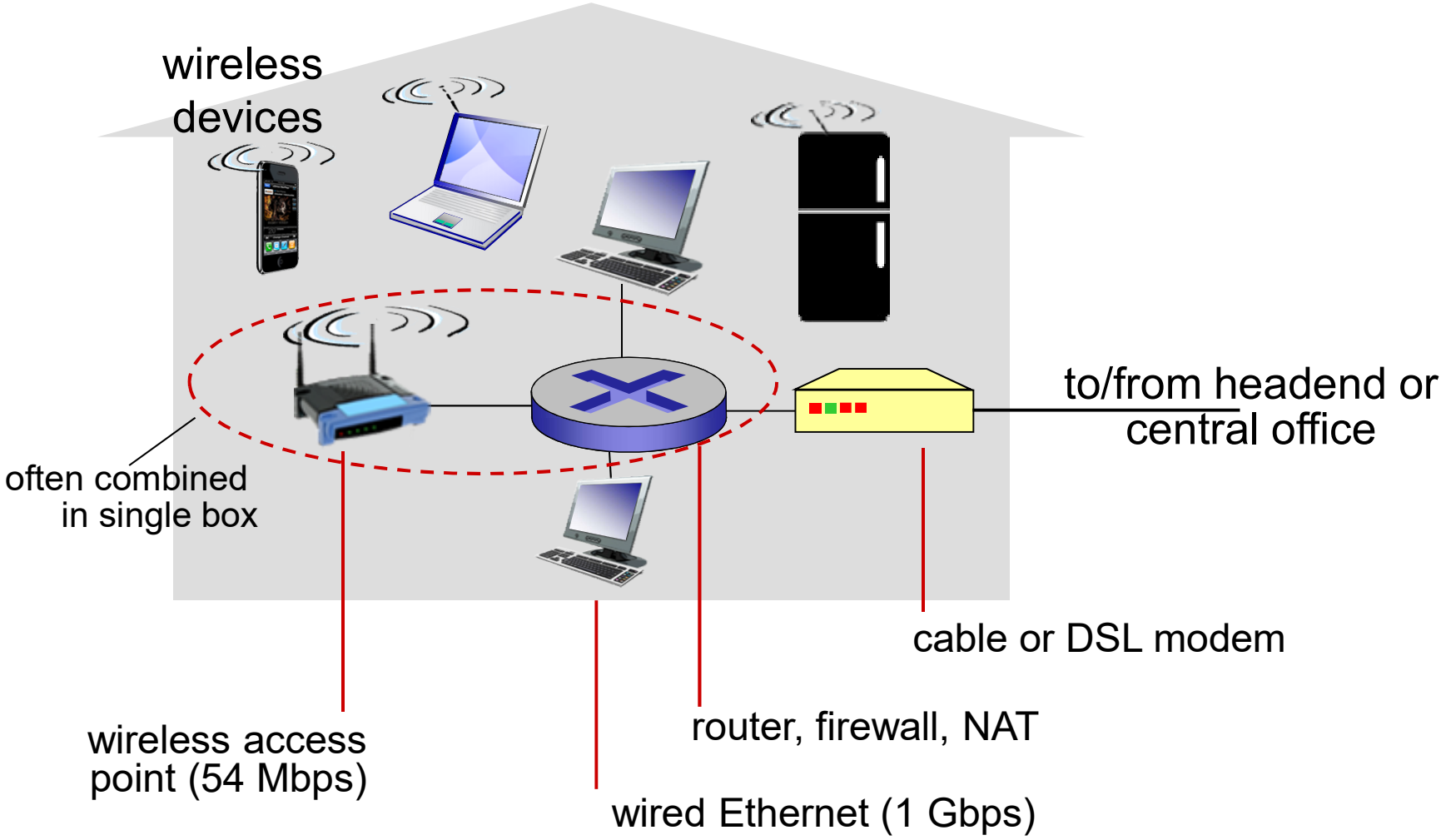
frequency division multiplexing: different channels transmitted in different frequency bands

Access network: cable network

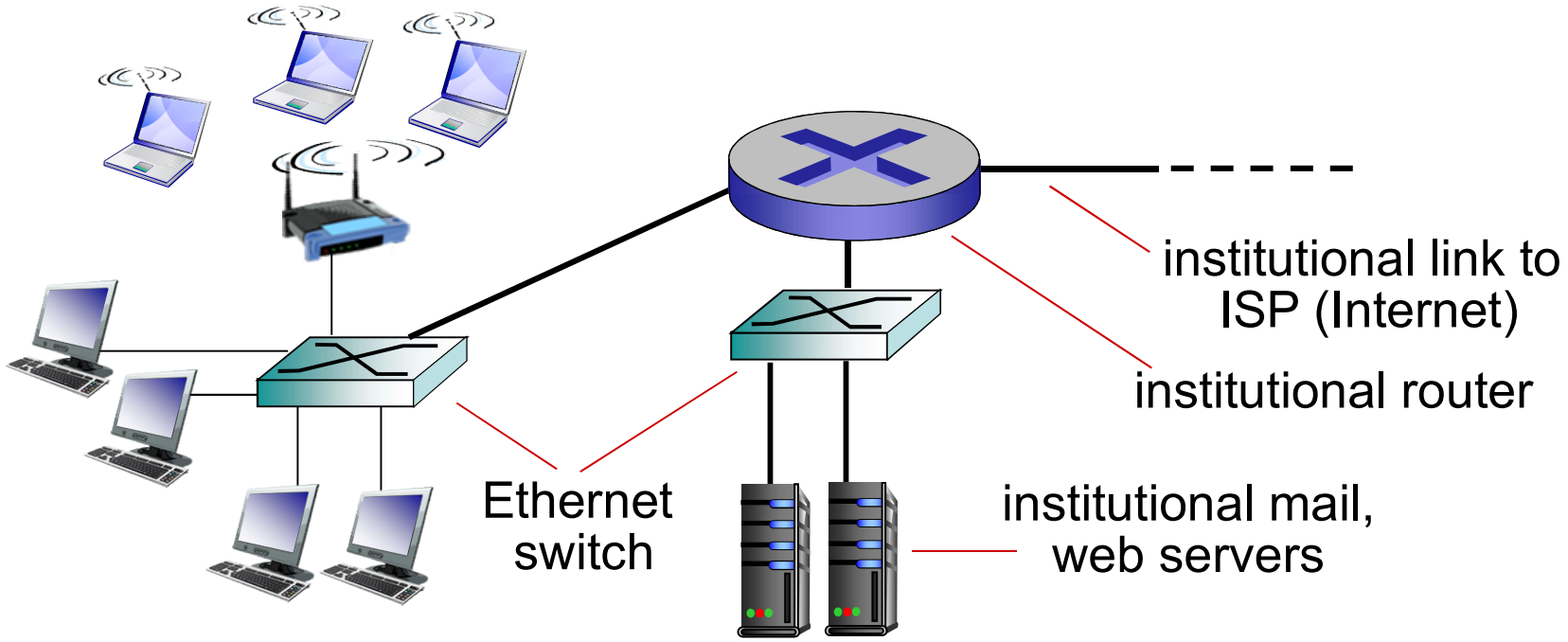


- HFC: hybrid fiber coax
  - asymmetric: up to 30Mbps downstream transmission rate, 2 Mbps upstream transmission rate
- network of cable, fiber attaches homes to ISP router
  - homes *share access network* to cable headend
  - unlike DSL, which has dedicated access to central office

Access network: home network



Enterprise access networks (Ethernet)



- typically used in companies, universities, etc.
- 10 Mbps, 100Mbps, 1Gbps, 10Gbps transmission rates
- today, end systems typically connect into Ethernet switch

Wireless access networks

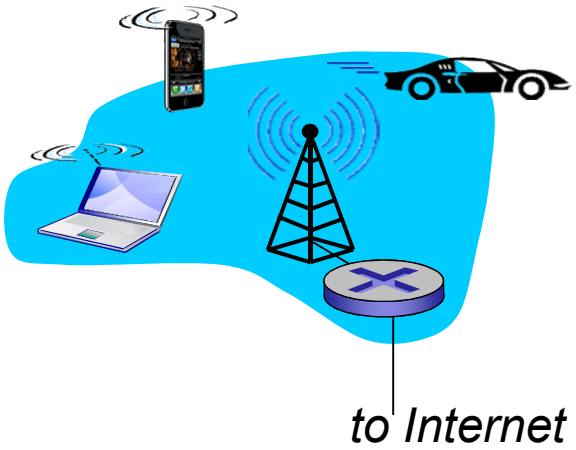
- shared *wireless* access network connects end system to router
  - via base station aka "access point"

wireless LANs:

- within building (100 ft.)
- 802.11b/g/n (WiFi): 11, 54, 450 Mbps transmission rate

wide-area wireless access

- provided by telco (cellular) operator 10's km
- between 1 and 10 Mbps
- 3G, 4G: LTE



Residential Access networks of Korea ?

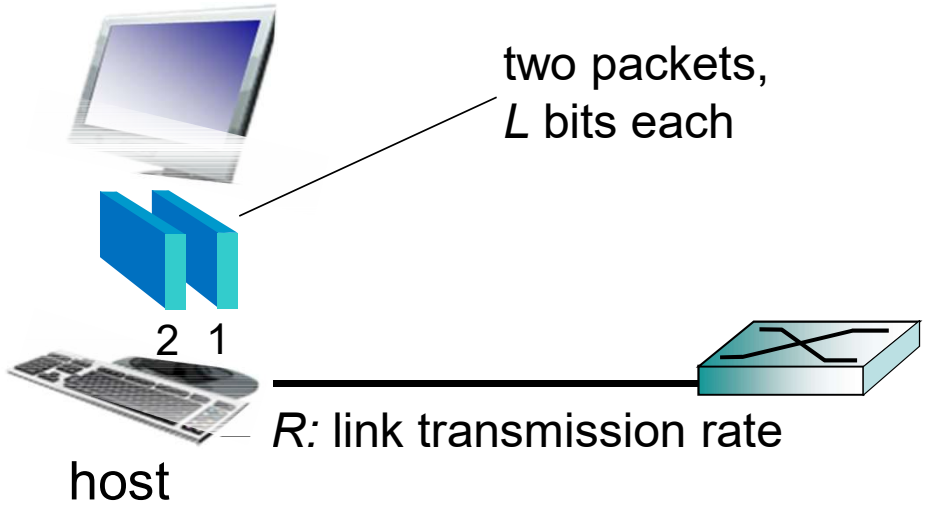
2017년 12월 서비스별 초고속인터넷 가입자수(과학기술정보통신부)

구분	XDSL	HFC (케이블모뎀)	LAN (아파트 LAN)	FTTH	위성	합계
KT	664,831	-	3,208,156	4,885,438	-	8,758,425
종합유선방송	22,947	2,073,582	925,475	140,579	-	3,162,583
SK브로드밴드	115,313	570,091	1,151,087	916,202	-	2,752,693
기타	1,053	3,077	12,958	3,077	-	20,165
SKT(재판매)	140,732	414,271	1,301,788	829,788	-	2,686,579
LGU+	-	913,056	1,973,668	928,749	-	3,815,473
합 계	944,876	3,974,077	8,573,132	7,703,833	-	21,195,918

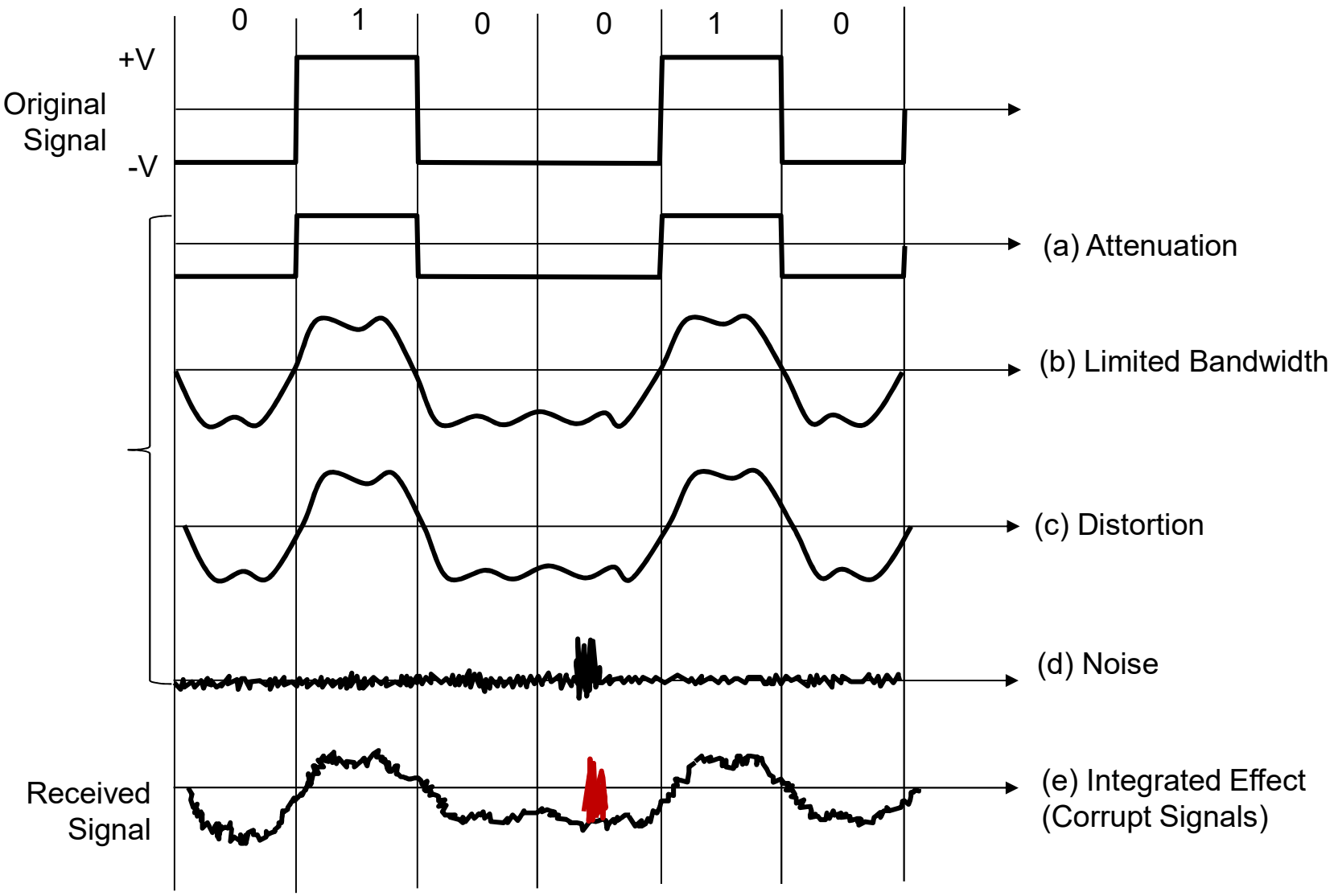
Host: sends *packets* of data

host sending function:

- takes application message
- breaks into smaller chunks, known as *packets*, of length *L* bits
- transmits packet into access network at *transmission rate R*
  - link transmission rate, aka link *capacity, aka link bandwidth*



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

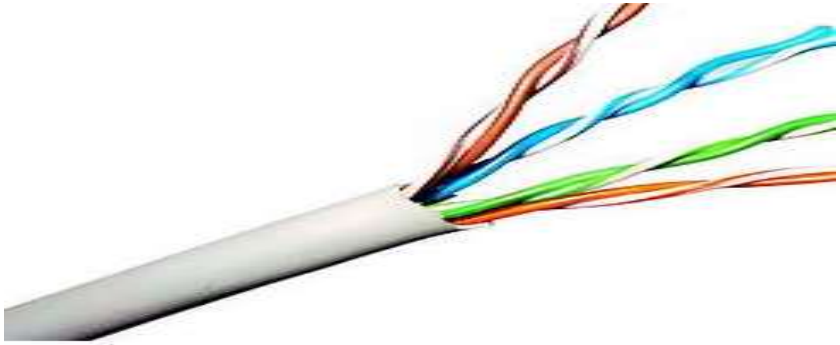

0
1
0
0
1
0
+V
Original
Signal
-V
(a) Attenuation
(b) Limited Bandwidth
(c) Distortion
(d) Noise
Received
Signal
(e) Integrated Effect
(Corrupt Signals)

Physical media

- bit: propagates between transmitter/receiver pairs
- physical link: what lies between transmitter & receiver
- guided media:
  - signals propagate in solid media: copper, fiber, coax
- unguided media:
  - signals propagate freely, e.g., radio

twisted pair (TP)

- two insulated copper wires
  - Category 5: 100 Mbps, 1 Gbps Ethernet
  - Category 6: 10Gbps



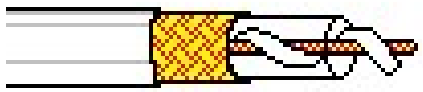
(a) UTP5e Cable

(b) RJ45 Connector

Physical media: coax, fiber

coaxial cable:

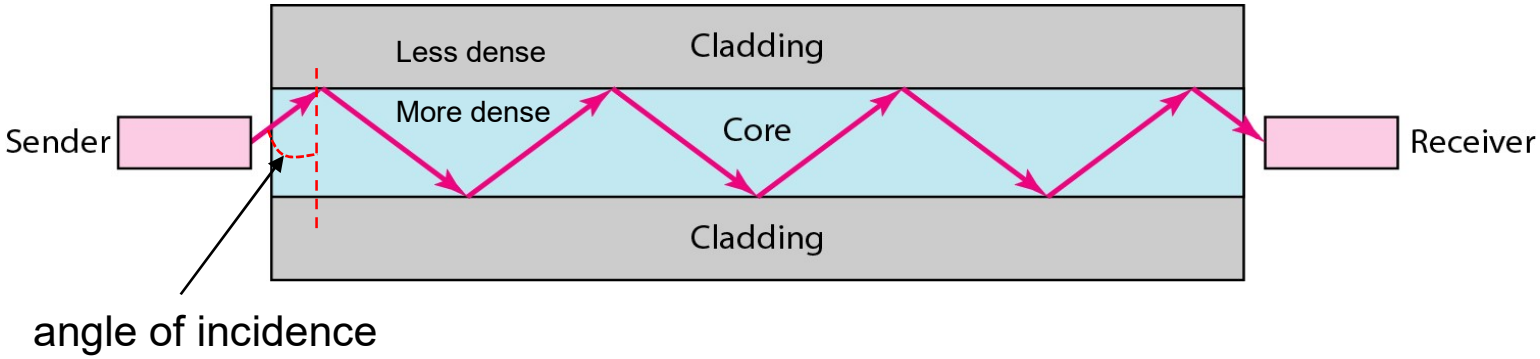
- two concentric copper conductors
- bidirectional
- broadband:
  - multiple channels on cable
  - HFC



fiber optic cable:

- glass fiber carrying light pulses, each pulse a bit
- high-speed operation:
  - high-speed point-to-point transmission (e.g., 10' s-100' s Gbps transmission rate)
- low error rate:
  - repeaters spaced far apart
  - immune to electromagnetic noise

- Optical Cable Structure
  - A Glass or Plastic Core is Surrounded by a Cladding of Less Dense Glass or Plastic

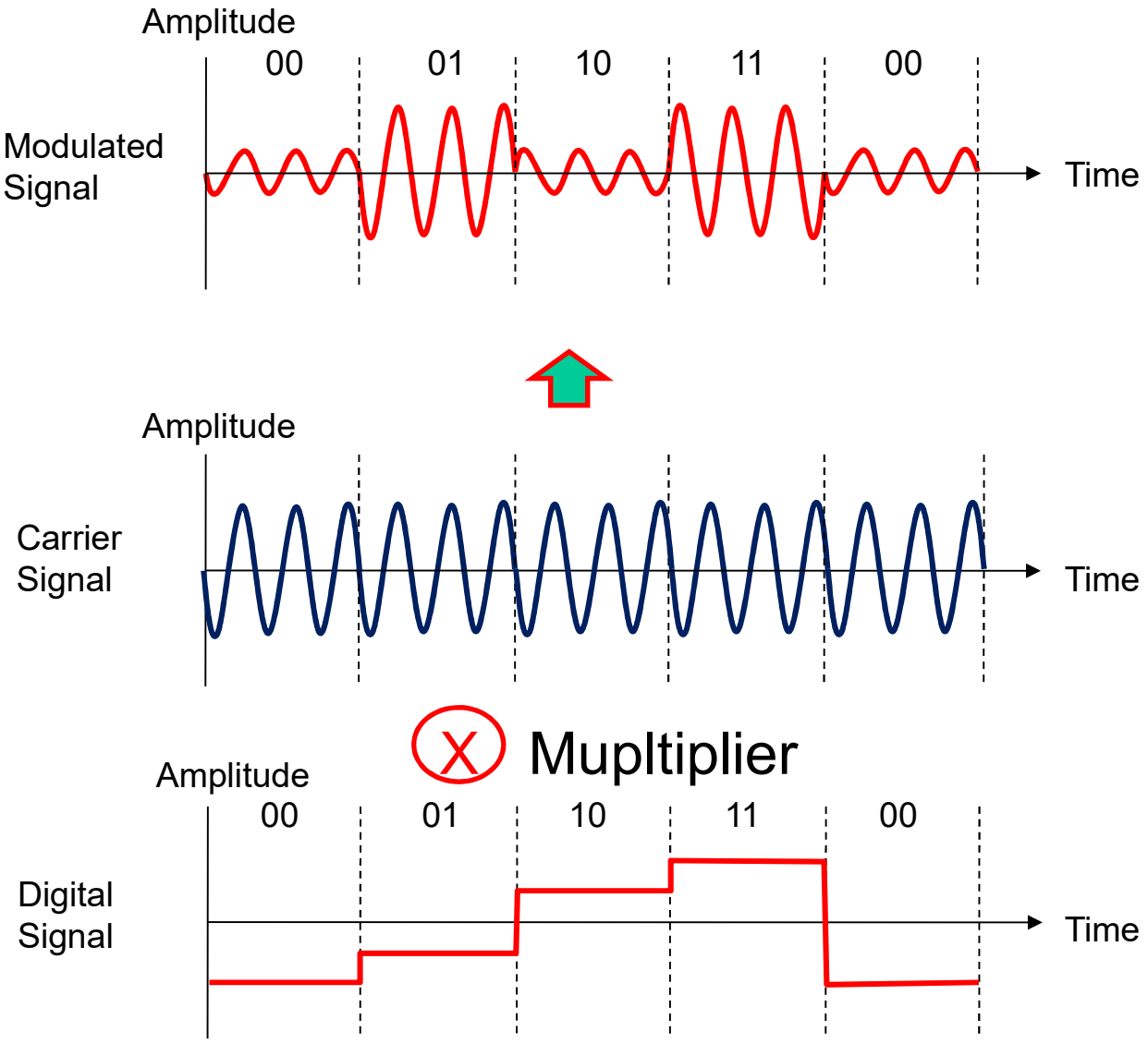


Physical media: radio

- signal carried in electromagnetic spectrum
- no physical "wire"
- bidirectional
- propagation environment effects:
  - reflection
  - obstruction by objects
  - interference

radio link types:

- terrestrial microwave
  - e.g. up to 45 Mbps channels
- LAN (e.g., WiFi)
  - 54 Mbps
- wide-area (e.g., cellular)
  - 4G cellular: ~ 10 Mbps
- satellite
  - Kbps to 45Mbps channel (or multiple smaller channels)
  - 270 msec end-end delay
  - geosynchronous versus low altitude


Amplitude
00
01
10
11
00
Modulated Signal
Time
Amplitude
Carrier Signal
Time
X
Mupltiplier
Amplitude
00
01
10
11
00
Digital Signal
Time

After-study Test :

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