Using Telephone and Cable Networks for Data Transmission

DSL, Cable Modem

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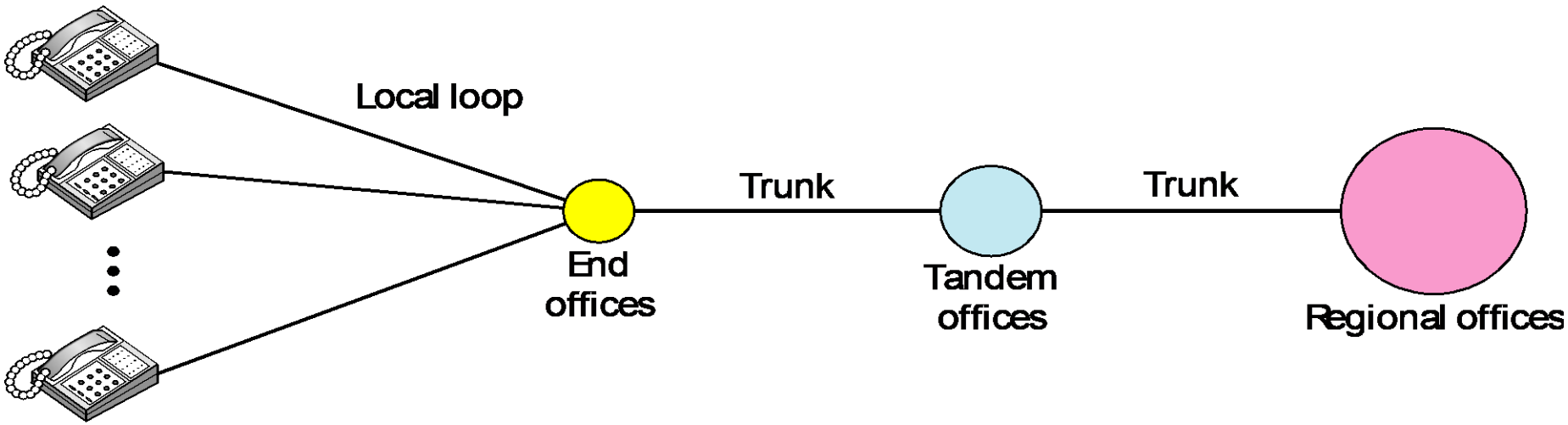
Reading Material for this discussion

- DATA COMMUNICATIONS AND NETWORKING, Fourth Edition by Behrouz A. Forouzan, Tata McGraw-Hill
  - Chapter 9, Topic 9.1, 9.4, 9.5

DIGITAL SUBSCRIBER LINE (DSL)

- to provide higher-speed access to Internet.
- supporting high-speed digital communication over the existing local loops
- a set of technologies xDSL
- x = A, V, H, or S.

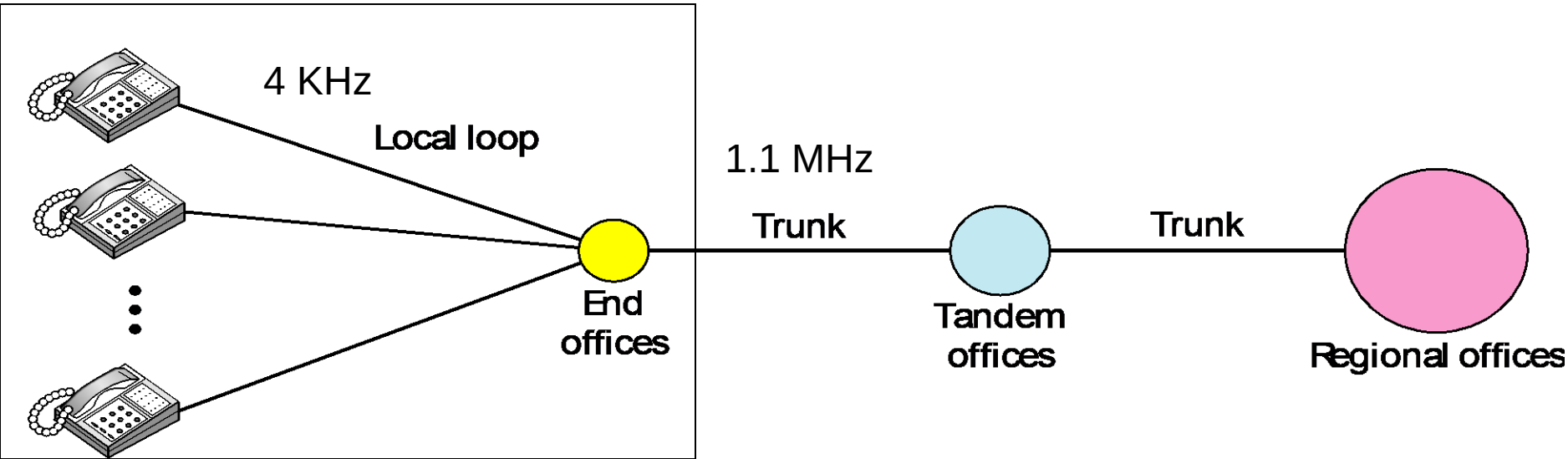


ADSL (Asymmetric DSL)

- first technology in the set
- asymmetric = provides higher bit rate in downstream direction than in upstream
- *technology designed for residential users*
- *it is not suitable for businesses (Why?)*

Using Existing Local Loops

- ADSL uses existing local loops
- BW of twisted-pair local loop = 1.1 MHz
- Filter at end office of telephone company where each local loop terminates limits BW to 4 kHz
- sufficient for voice communication
- Helps in multiplexing
- If filter is removed, 1.1 MHz is available for data and voice communications



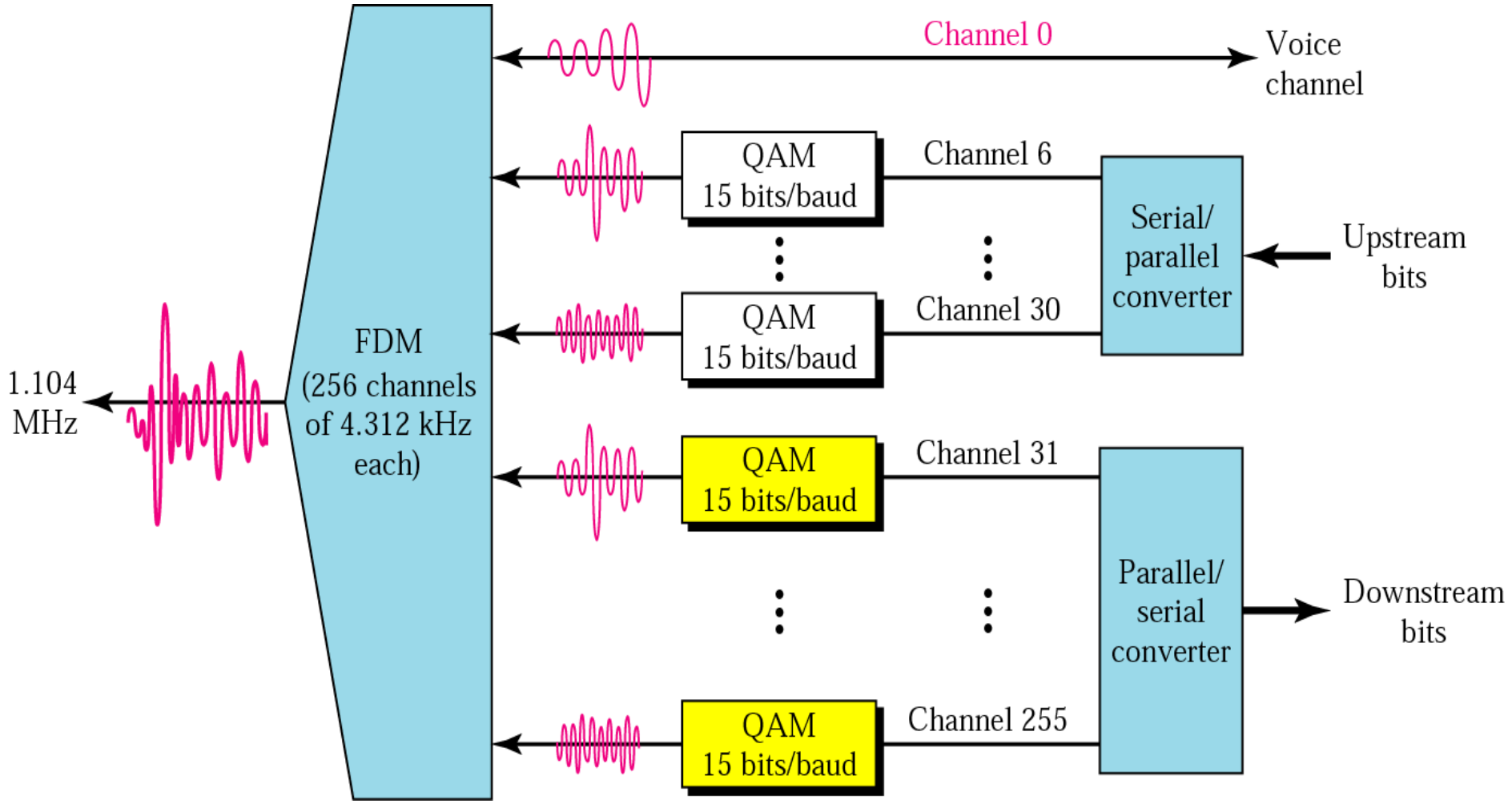
Adaptive Technology

- 1.1 MHz is theoretical BW of local loop
- Factors affecting BW
  - distance between residence and switching office
  - size of cable
  - signaling used
- Designers test condition and bandwidth availability of line before settling on a data rate
- ADSL data rate changes based on condition and type of local loop cable

Discrete Multitone Technique

- The modulation technique in ADSL
- combines QAM and FDM.
- Typically, 1.104 MHz is divided in 256 channels
- Each channel uses BW of 4.312 kHz

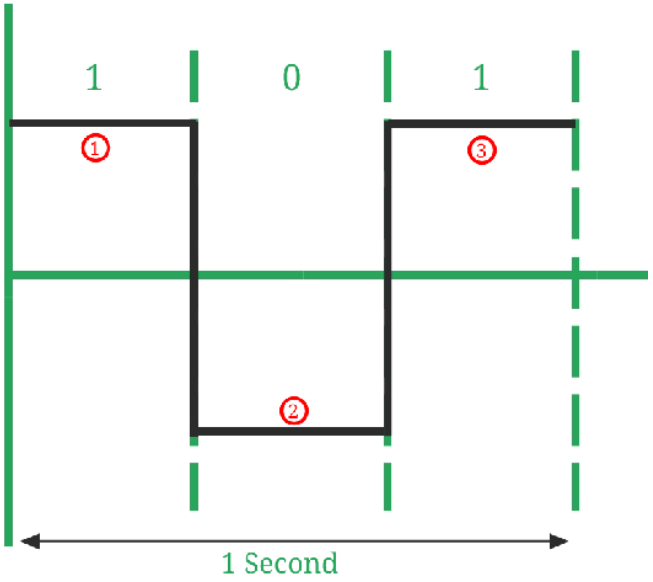
Discrete Multitone Technique



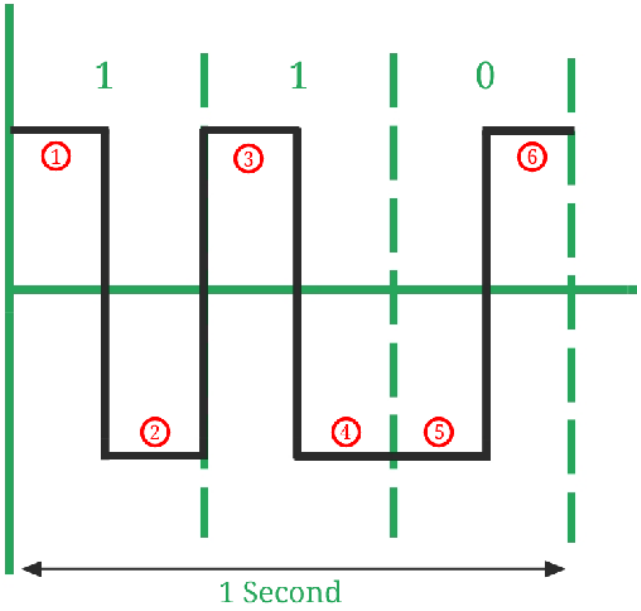
Channel 1 to 5 are not used - To provide gap between voice and data

Bit Rate and Baud Rate

- Bit rate = number of bits per second
- Baud rate = number of signal elements per second



- In 1 sec
  - Number of signal elements (red) = 3
  - Number of bits transmitted (green) = 3
- Baud rate = 3/1 = 3 baud
- Bit rate = 3/1 = 3 bps



- In 1 sec
  - Number of signal elements (red) = 6
  - Number of bits transmitted (green) = 3
- Baud rate = 6/1 = 6 baud
- Bit rate = 3/1 = 3 bps

Upstream data and control

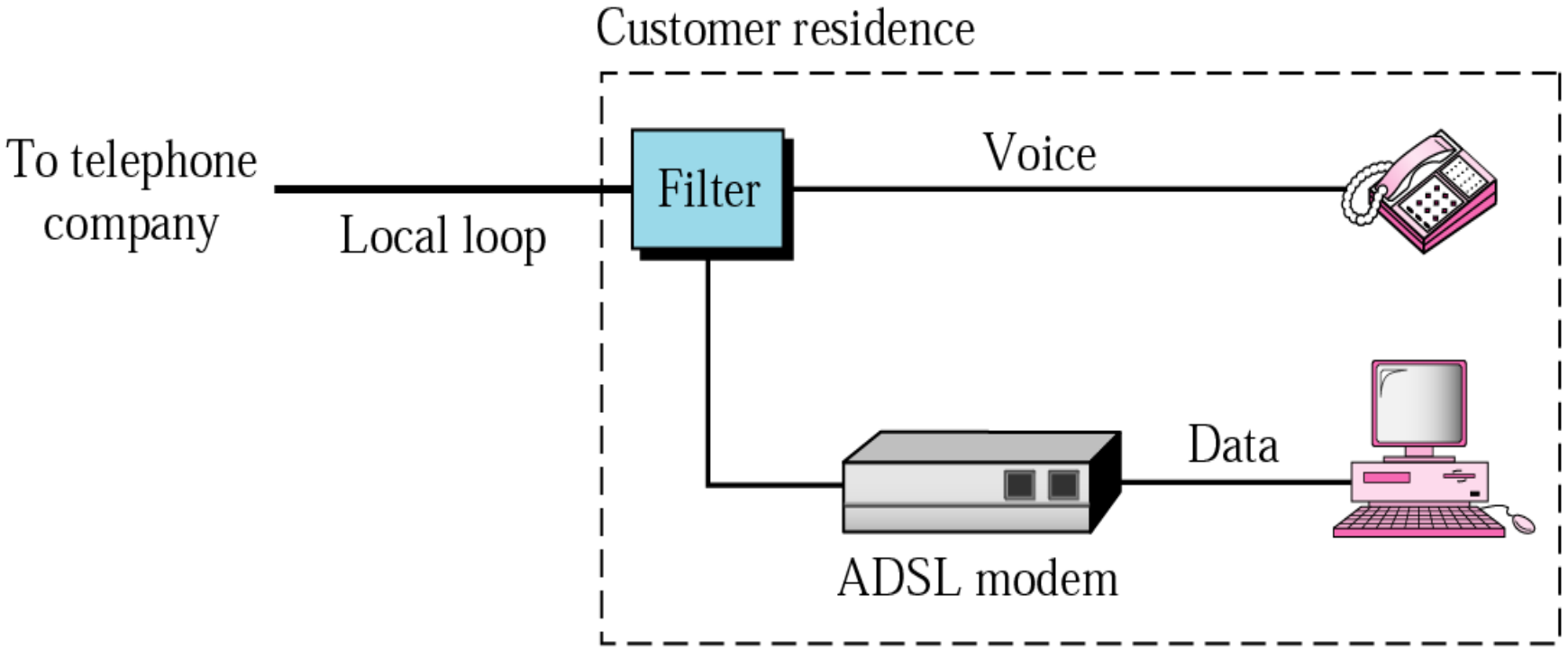
- Channel No. 6 to 30
- Upstream data transfer - (24) and control - (1)
- 24 chs, each using 4 kHz (from 4.312 kHz available)
- BW = with QAM, 24 (chs) x 4000 (Hz) x 15 (bits/baud) = 1.44-Mbps
- Actual data rate < 500 kbps as some carriers are deleted at frequencies where noise is large, thus some channels are unused

Downstream Data and Control

- Channels = 31 to 255 (225 channels)
- Control = 1 ch
- Data = 224 chs
- BW = 224 x 4000 x 15 = 13.4 Mbps
- Actual data rate < 8 Mbps
- As some of the carriers are deleted at frequencies where the noise level is large

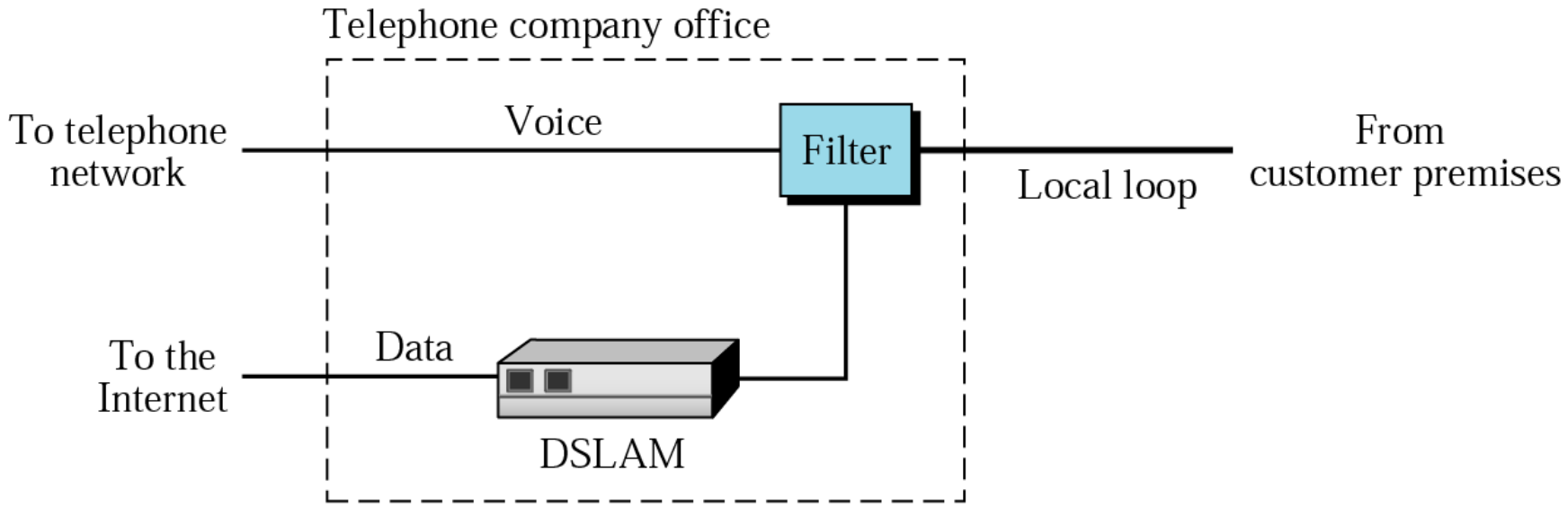
Customer Site

- local loop connects to a splitter which separates voice and data communications
- ADSL Modem Modulates/Demodulates data using DMT and Creates downstream/upstream



Telephone Company Site

- DSLAM (digital subscriber line access multiplexer) functions as ADSL
- In addition, it packetizes the data to be sent to the Internet (ISP server)



High-bit-rate digital subscriber line

- HDSL uses 2B 1Q encoding which is less susceptible to attenuation.
- A data rate of 1.544 Mbps (up to 2 Mbps) can be achieved without repeaters
- up to a distance of 12,000 ft (3.86 km).
- HDSL uses two twisted pairs (one pair for each direction) to achieve full-duplex transmission.

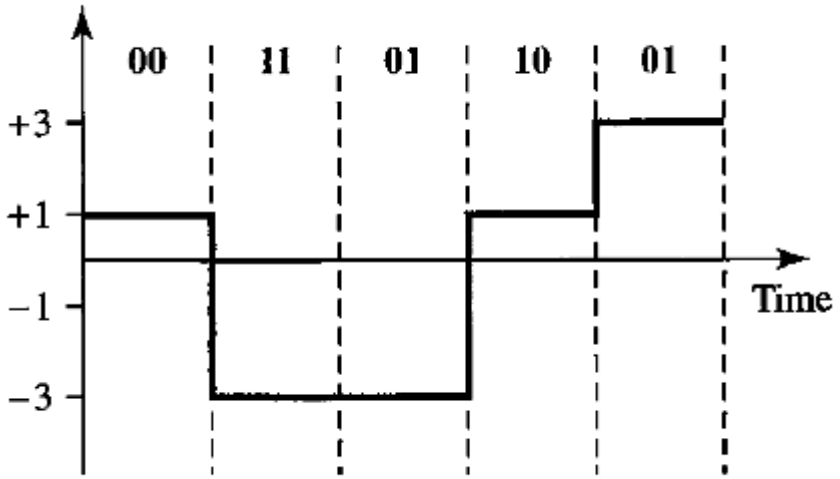
2B1Q scheme
two binary, one quaternary

- L=4
- High BW as per

Nyquist Criteria

	Previous level: positive	Previous level: negative
Next bits	Next level	Next level
00	+1	−1
01	+3	−3
10	−1	+1
11	−3	+3

Transition table



Assuming positive original level

Symmetric Digital Subscriber Line

- SDSL is a one twisted-pair version of HDSL.
- provides full-duplex symmetric communication supporting up to 768 kbps in each direction.
- suitable for businesses that send and receive data in large volumes in both directions.

Very high-bit-rate digital subscriber line

- VDSL, uses coaxial, fiber-optic, or twisted-pair cable for short distances.
- modulating technique is DMT.
- Provides range of bit rates (25-55 Mbps) for upstream comm. at dis. of 3000 to 10,000 ft.
- The downstream rate is normally 3.2 Mbps.

Summary of DSL technologies

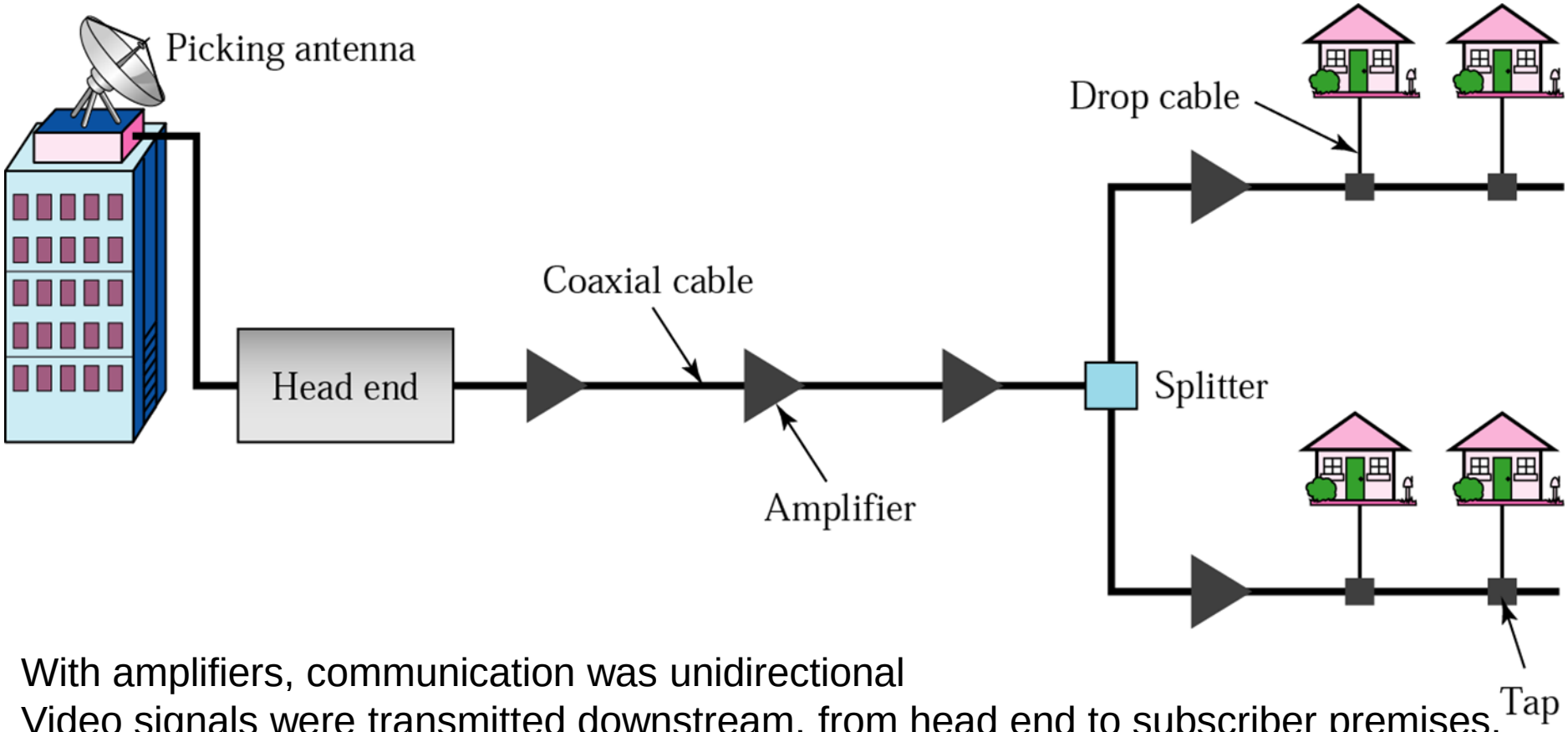
Technology	*Downstream Rate*	*Upstream Rate*	*Distance (ft)*	*Twisted Pairs*	*Line Code*
ADSL	1.5–6.1 Mbps	16–640 kbps	12,000	1	DMT
ADSL Lite	1.5 Mbps	500 kbps	18,000	1	DMT
HDSL	1.5–2.0 Mbps	1.5–2.0 Mbps	12,000	2	2B1Q
SDSL	768 kbps	768 kbps	12,000	1	2B1Q
VDSL	25–55 Mbps	3.2 Mbps	3000–10,000	1	DMT

CABLE TV NETWORKS

- Started as a video service provider, but it has moved to the business of Internet access.
- How this network can be used to provide high-speed access to the Internet

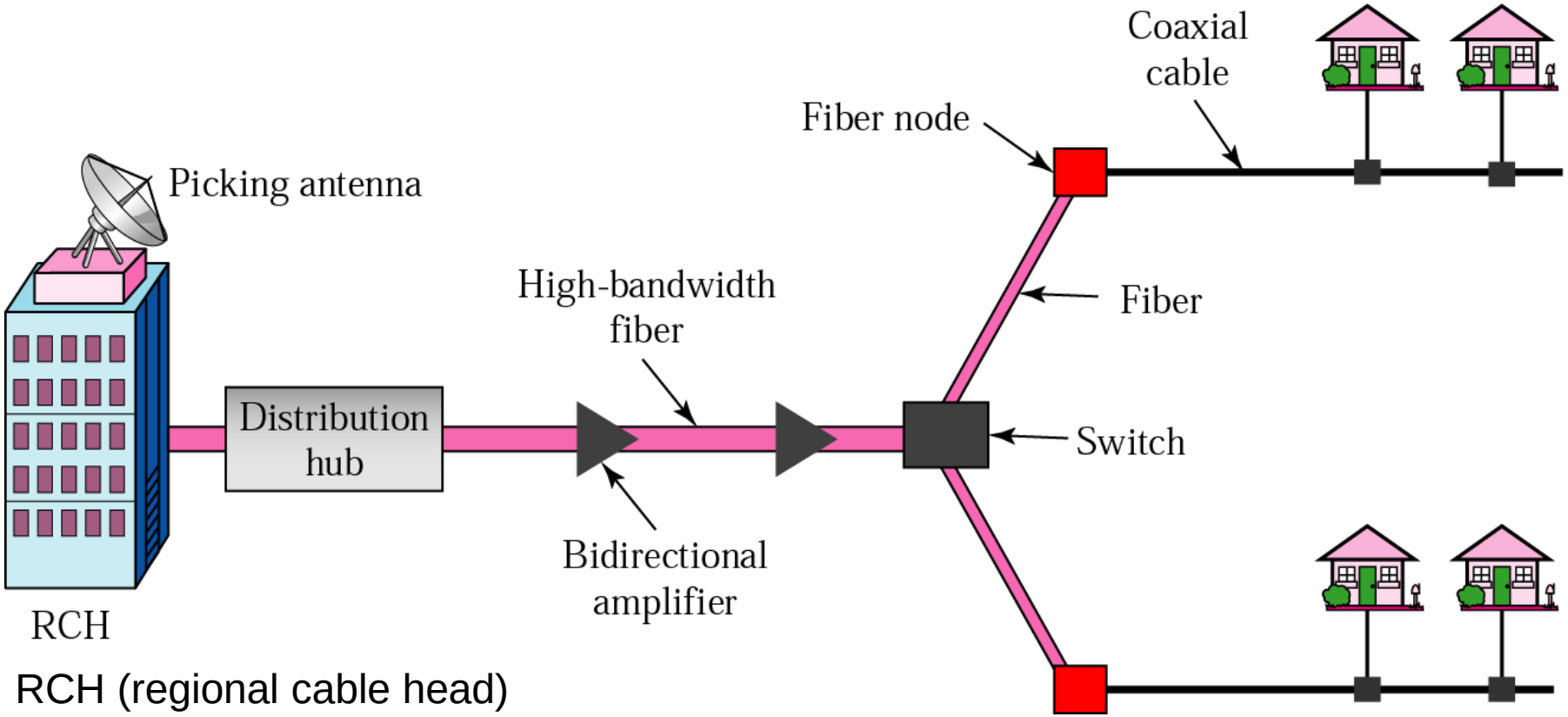
Traditional Cable Networks [Community antenna TV (CATV)]

- Cable TV broadcast video signals to locations with poor/no reception
- An antenna at the top of a hill/building received the signals from TV stations
- Distributed them, via coaxial cables, to the community



With amplifiers, communication was unidirectional
Video signals were transmitted downstream, from head end to subscriber premises.

Hybrid Fiber-Coaxial (HFC) Network (2nd Generation)



RCH (regional cable head)

- Serves 4,00,000 subscribers

Distribution Hub

- Modulation and distribution of signals

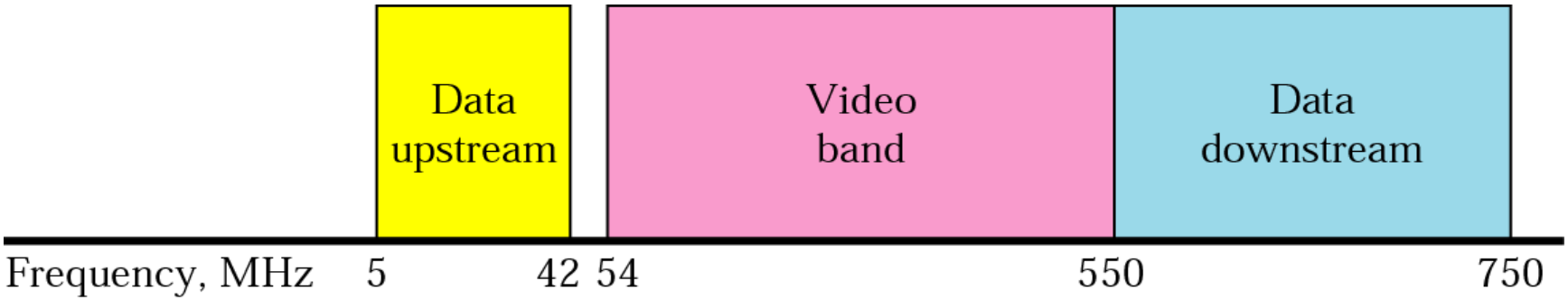
Fiber node

- Splits analog signals (video) so same signal is sent to each coaxial cable.

- Each coaxial cable serves up to 1000 subscribers.
- Network is now bi-directional and reduces need for amplifiers

Bandwidth in HFC

- Last part of network is a coaxial cable.
- Coaxial cable BW is from 5 - 750 MHz
- To provide Internet access, it is divided into
  - video, downstream data, upstream data



Coaxial cable bands

- Downstream Video Band
  - occupies frequencies from 54 to 550 MHz.
  - each TV channel occupies 6 MHz,
  - this can accommodate more than 80 channels.
- Downstream Data Band
  - Occupies band, from 550 to 750 MHz.
  - band is divided into 6-MHz channels.
  - Uses 64-QAM (or 256-QAM)
- Data Rate
  - 6 bits/baud in 64-QAM.
  - One bit is used for FEC, → 5 bits of data per baud
  - standard specifies 1 Hz for each baud;
  - downstream data rate = 30 Mbps (5 bits/Hz (signal element) x 6 x 10^6 Hz (channel)).
  - standard specifies only 27 Mbps.
  - Cable Modem is connected to PC through 10Base-T cable→ limits data rate to 10 Mbps

Upstream Data Band

- occupies lower band, from 5 to 42 MHz.
- divided into 6-MHz channels.
- lower frequencies are more susceptible to noise and interference
- Hence QAM technique is not suitable for this band
- better solution is QPSK
- Data Rate
  - 2 bits/baud in QPSK.
  - standard specifies 1 Hz for each baud;
  - upstream data = 12 Mbps (2 bits/Hz x 6 MHz).
  - data rate is usually < 12 Mbps.

Upstream Sharing by subscribers

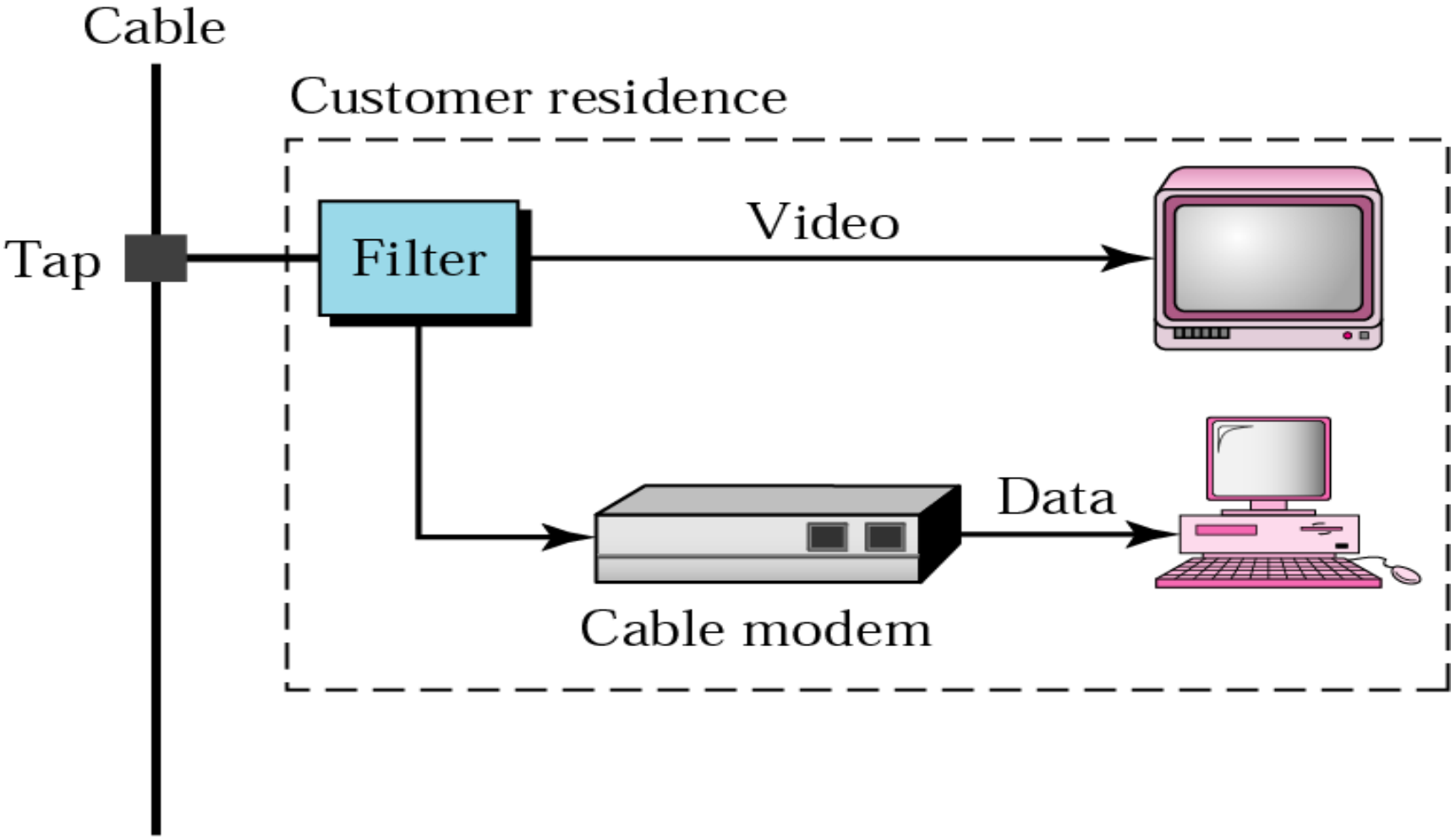
- upstream data BW = 37 MHz, ch size=6 MHz
- six 6-MHz (37/6) channels available in upstream
- subscriber needs to use one channel to send data in upstream direction.
- 6 channels shared in area with 1000, 2000, or 100,000 subscribers by timesharing
- Cable provider allocates one channel for a group of subscribers.
- Subscribers has to contend for the channel with others who want access

Downstream Sharing

- band has 33 channels of 6 MHz.
- cable provider has more than 33 subscribers
- each channel shared between group of subscribers
- There is a multicasting situation in downstream
- Data for any of the subscribers in the group, is sent to shared channel
- Each subscriber gets the data.
- subscriber ‘s Cable Modem matches address carried with data to address assigned by provider.
- If it matches data are kept otherwise discarded

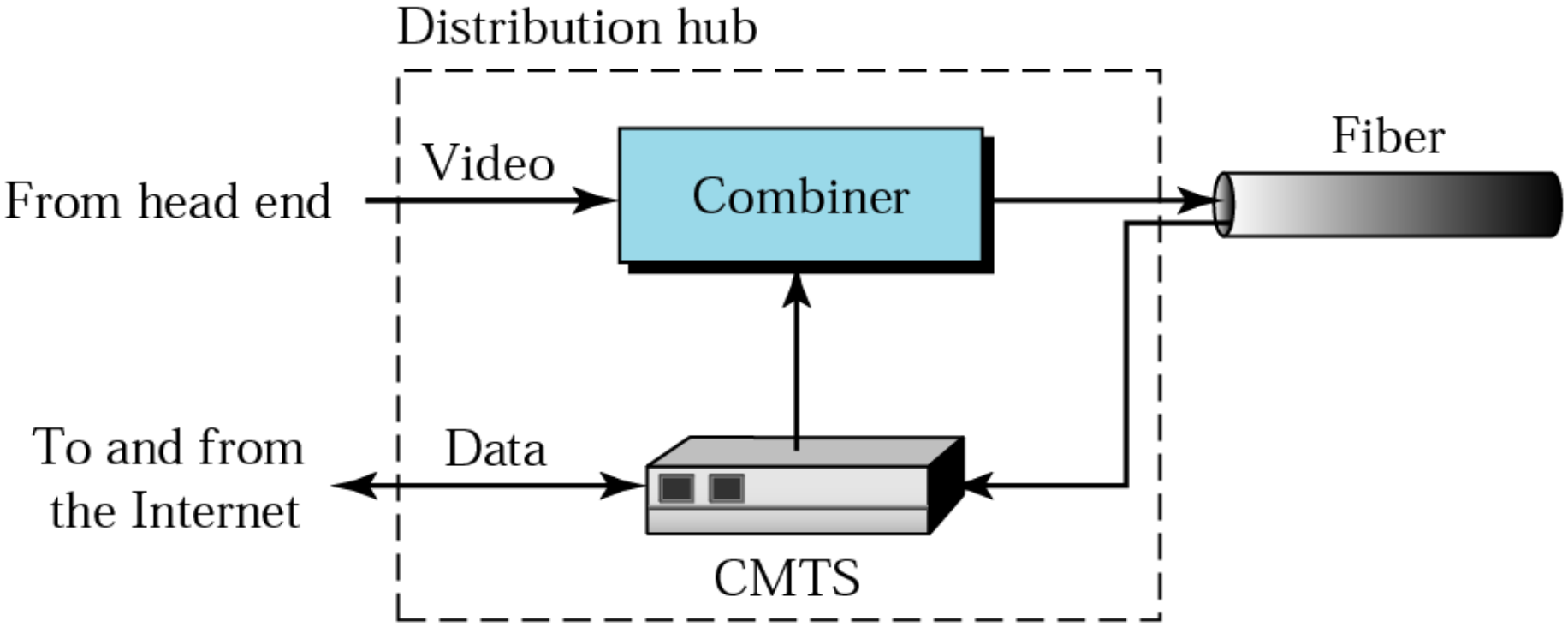
Cable Modem (CM)

- installed on subscriber premises.
- similar to an ADSL modem



Cable Modem Transmission System (CMTS)

- installed inside distribution hub by cable company.
- receives data from Internet and passes them to combiner, which sends them to subscriber.
- Also receives data from subscriber and passes them to Internet



Thank You