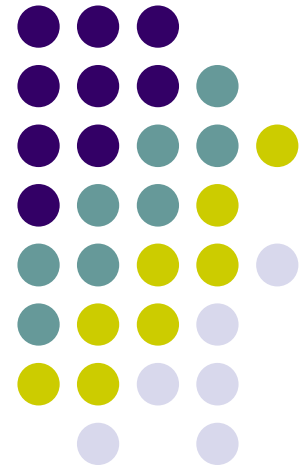


# Chapter 1

## Introduction

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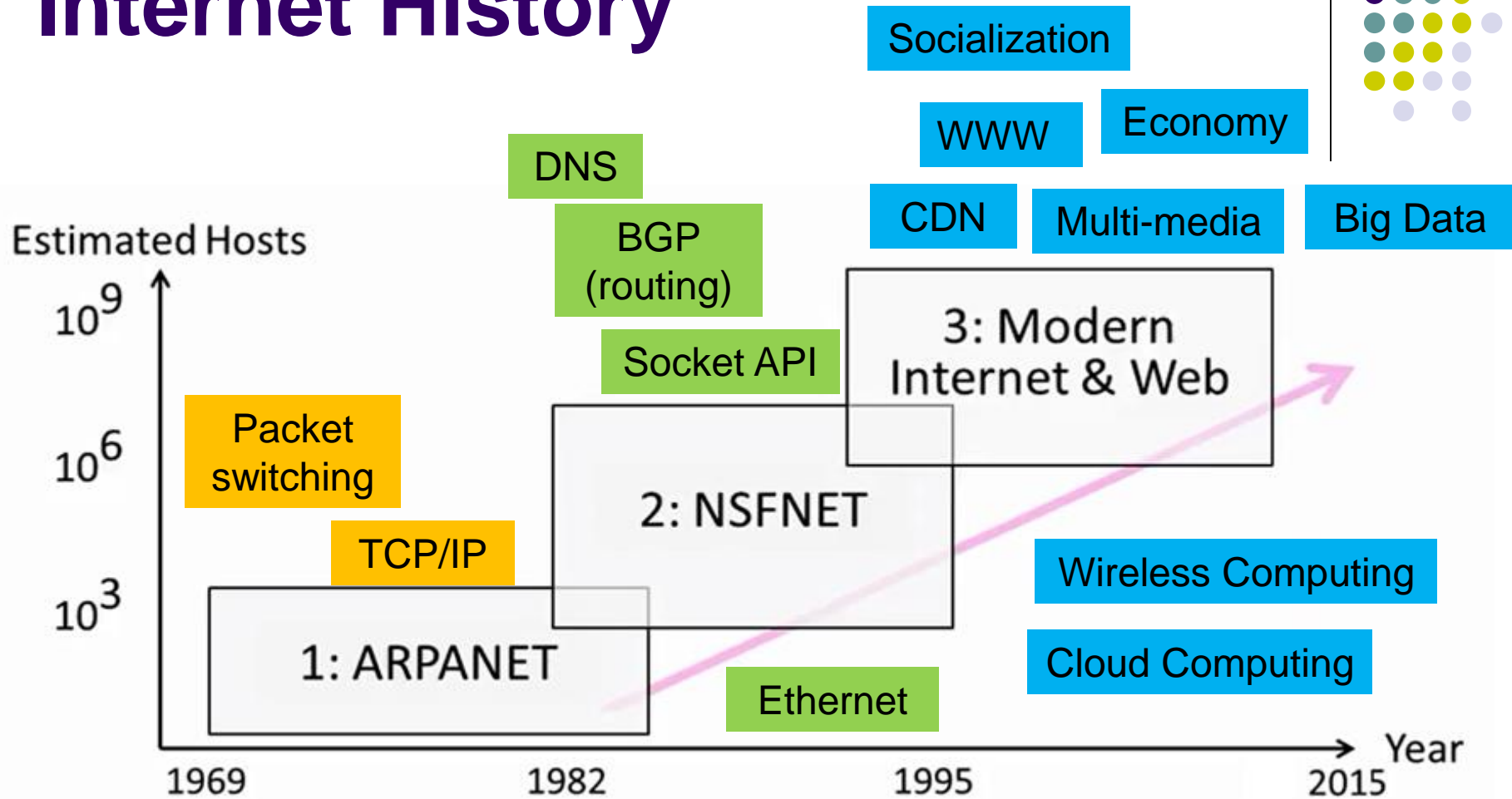




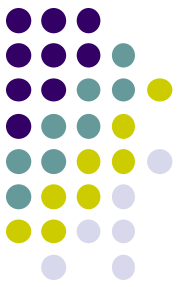
# Chapter 1: roadmap

- what's Computer Network?
- protocol layers, service models
- basic concepts of data transmission:
  - bandwidth, delay, throughput, multiplexing, switching
- what's the Internet?
- network edge:
  - hosts, access net, physical media
- network core:
  - packet/circuit switching, Internet structure

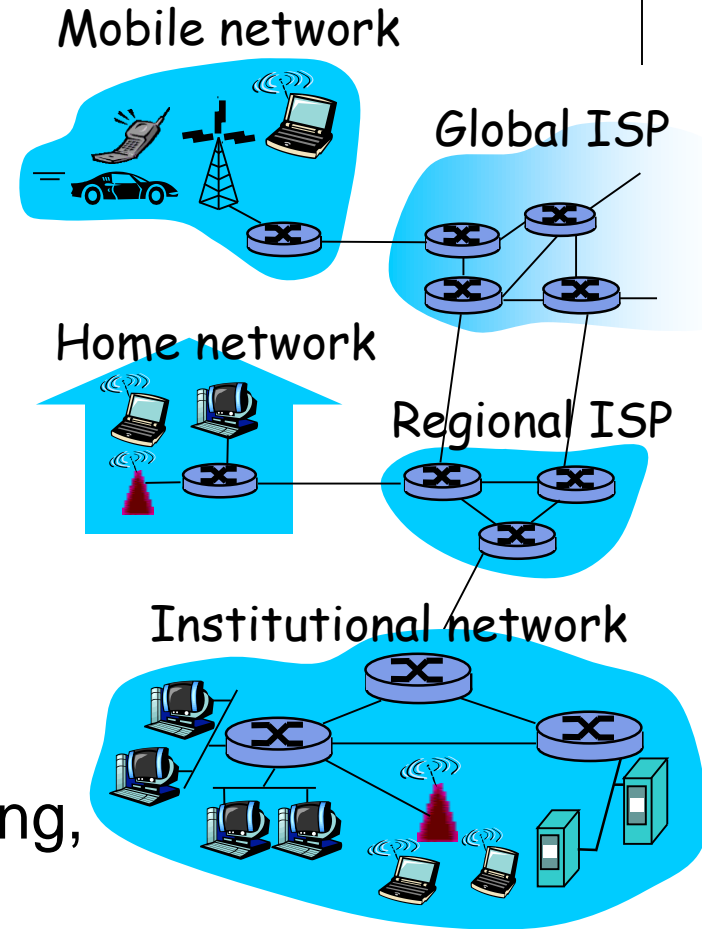
# Internet History



# What's the Internet: “nuts and bolts” view



- millions of connected computing devices:  
*hosts , end systems*
  - *communication links*
    - fiber, copper, radio, satellite
  - *routers*: forward packets (chunks of data)
  - *protocols* control sending, receiving of msgs
    - e.g., TCP, IP, HTTP
- PC
- server
- wireless laptop
- cellular handheld
- access points
- wired links
- router



# What's the Internet: a service view

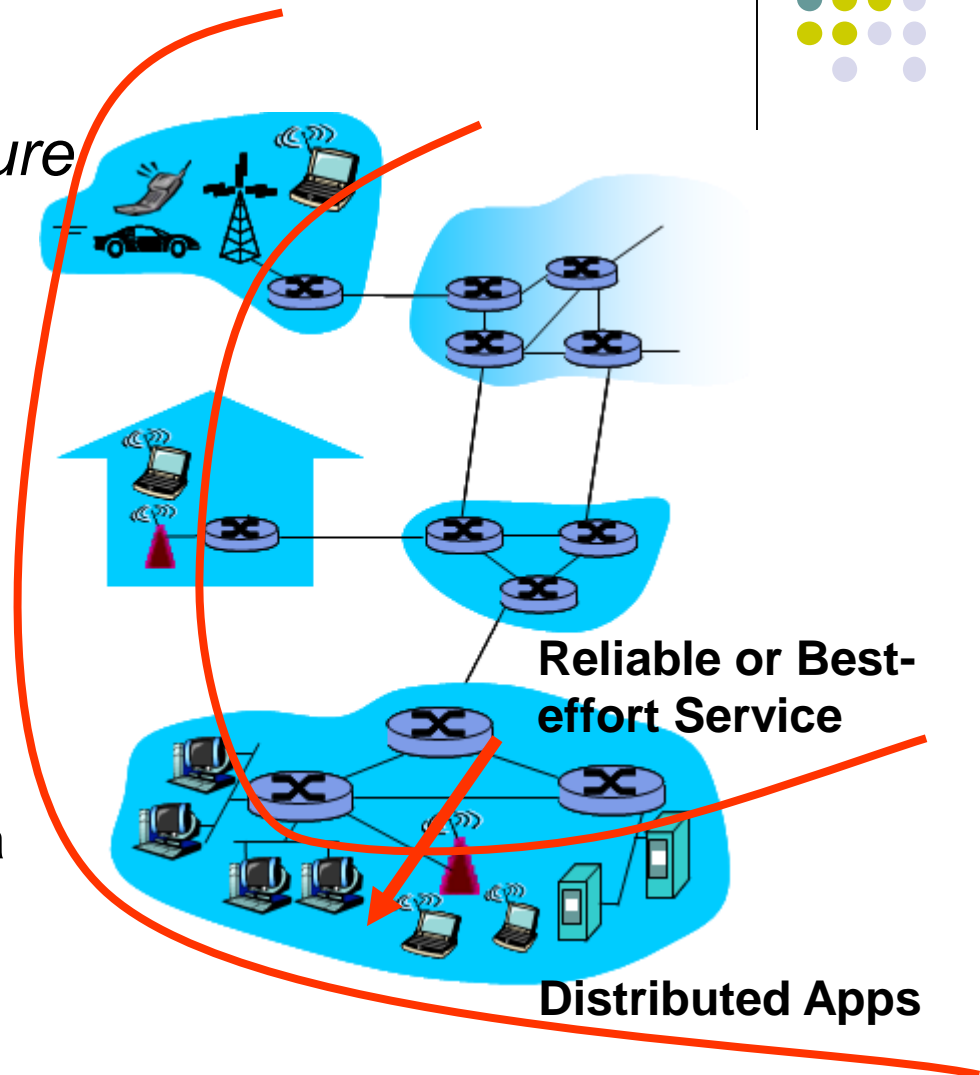


- communication *infrastructure* enables **distributed applications**:

- Web, VoIP, email, games, e-commerce, file sharing

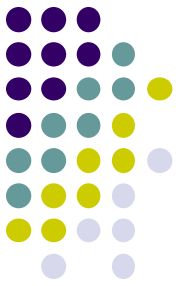
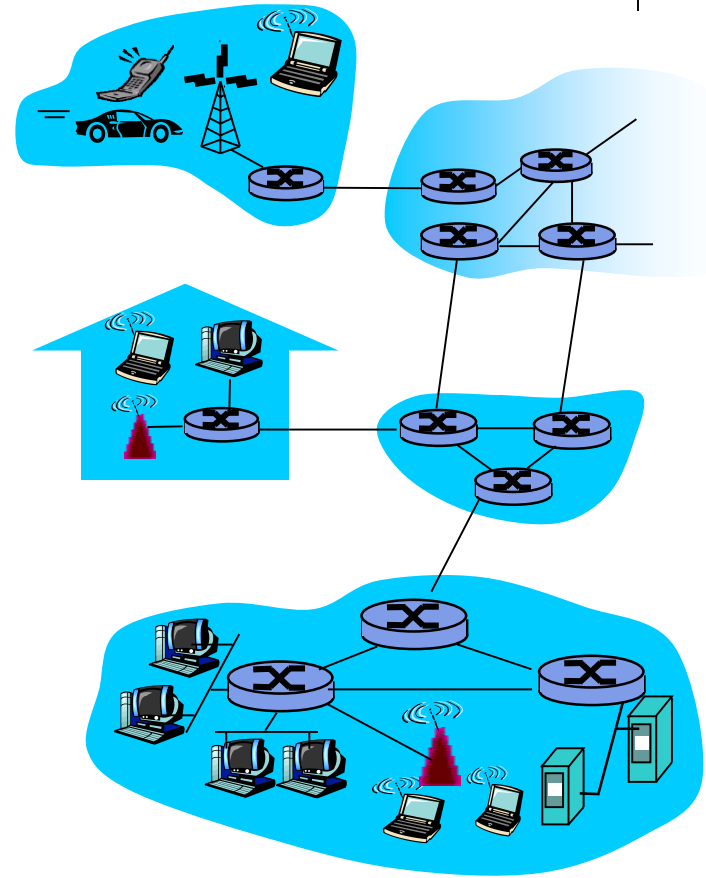
- communication services provided to apps**:

- reliable data delivery from source to destination
- “best effort” (unreliable) data delivery



# Internet Structure

- **network edge:**  
applications and hosts
- **access networks,**  
**physical media:** wired,  
wireless communication  
links
- **network core:**
  - ❖ interconnected  
routers
  - ❖ network of networks





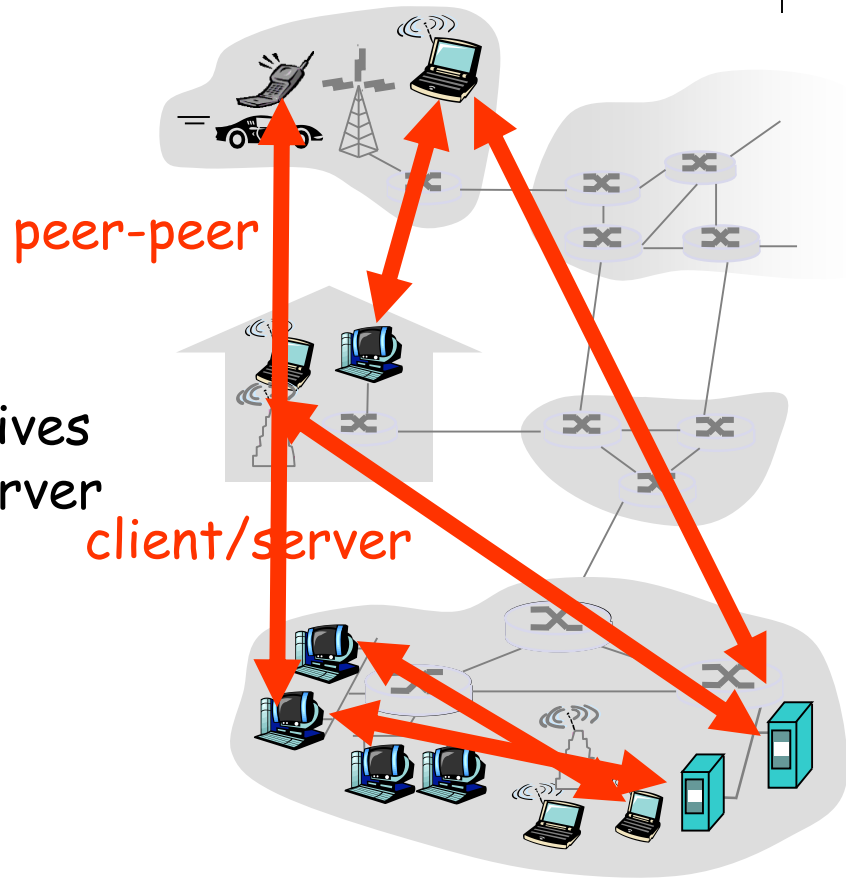
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# The network edge

- **end systems (hosts):**
  - run application programs
  - e.g. Web, email
  - at “edge of network”
- **client/server model**
  - ❖ client host requests, receives service from always-on server
  - ❖ e.g. Web browser/server; email client/server
- **peer-peer model:**
  - ❖ minimal (or no) use of dedicated servers
  - ❖ e.g. Skype, BitTorrent





# Access Networks

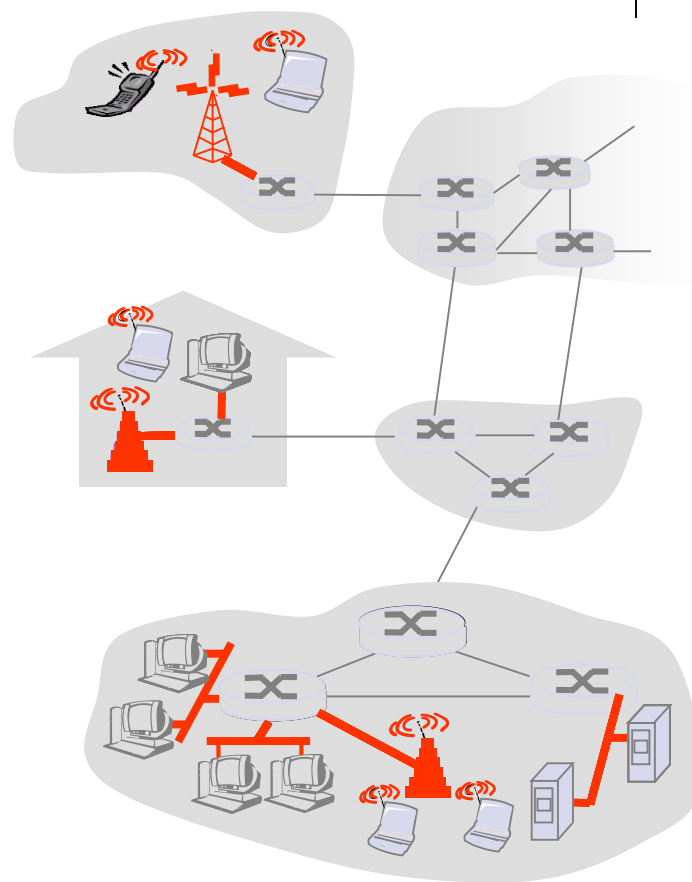


*Q: How to connect end systems to edge router?*

- residential access nets
- institutional access networks (school, company)
- mobile access networks

*Keep in mind:*

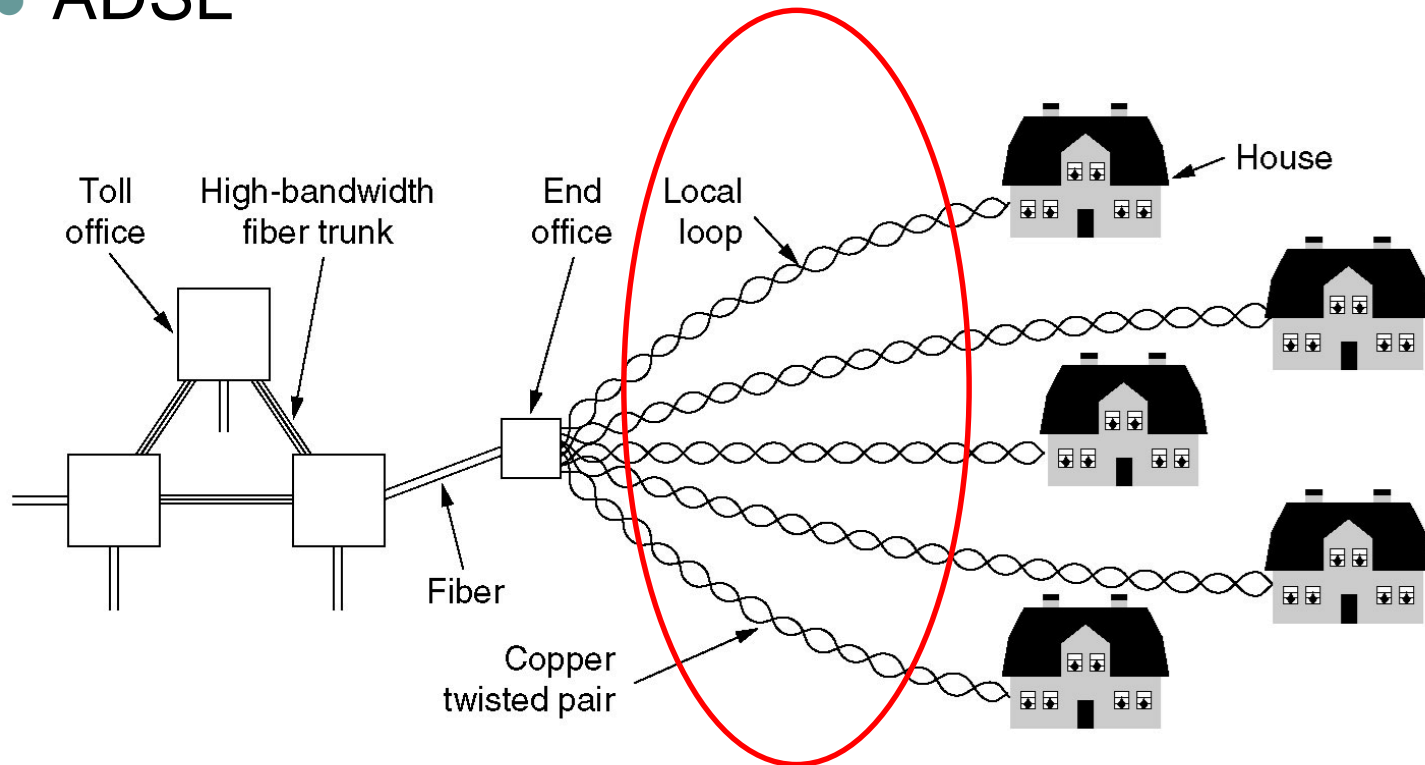
- bandwidth (bits per second) of access network?
- shared or dedicated?



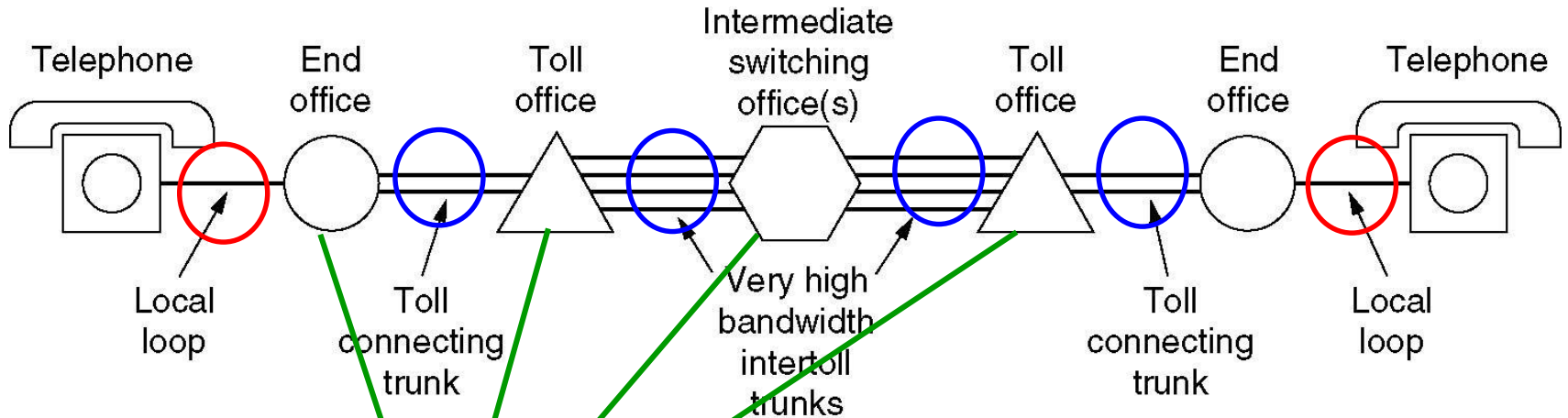
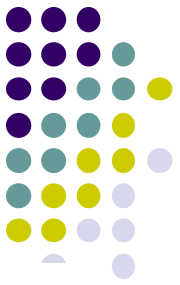
# Internet over PSTN



- Internet access through the Local Loop:
  - Modems
  - ADSL

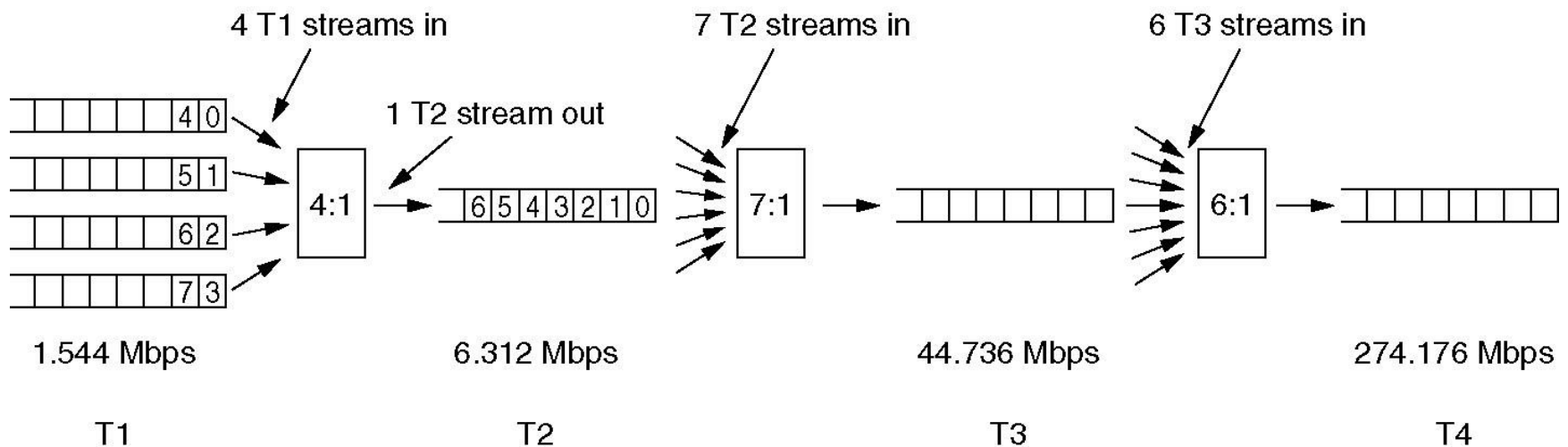
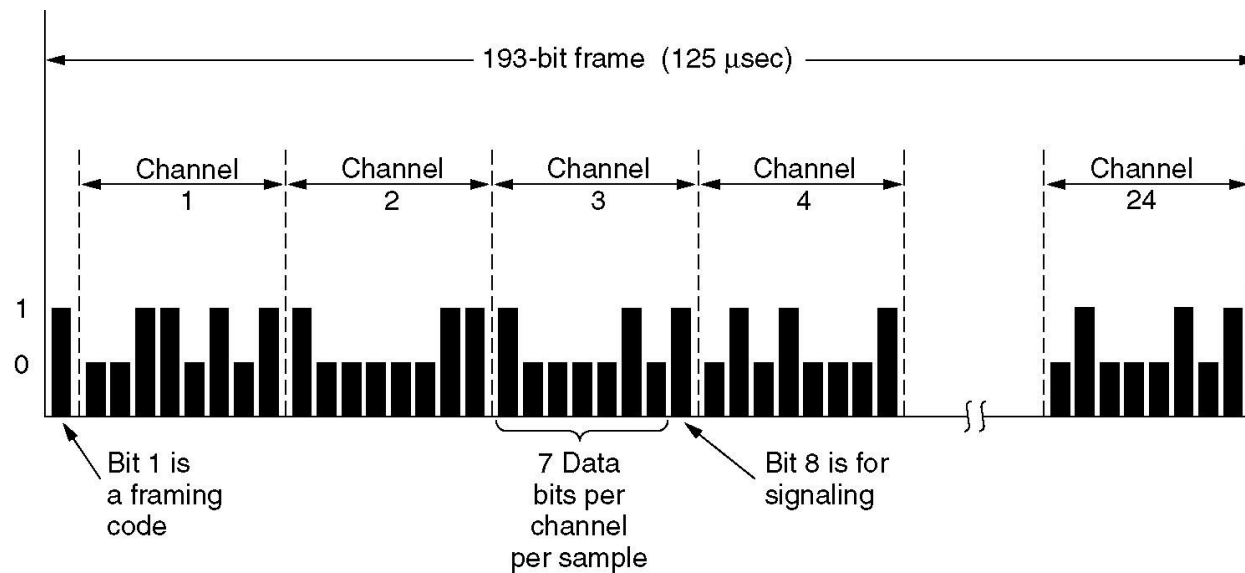
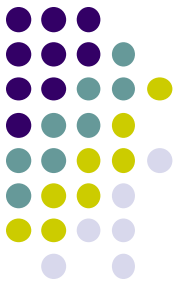


# Structure of the Telephone System

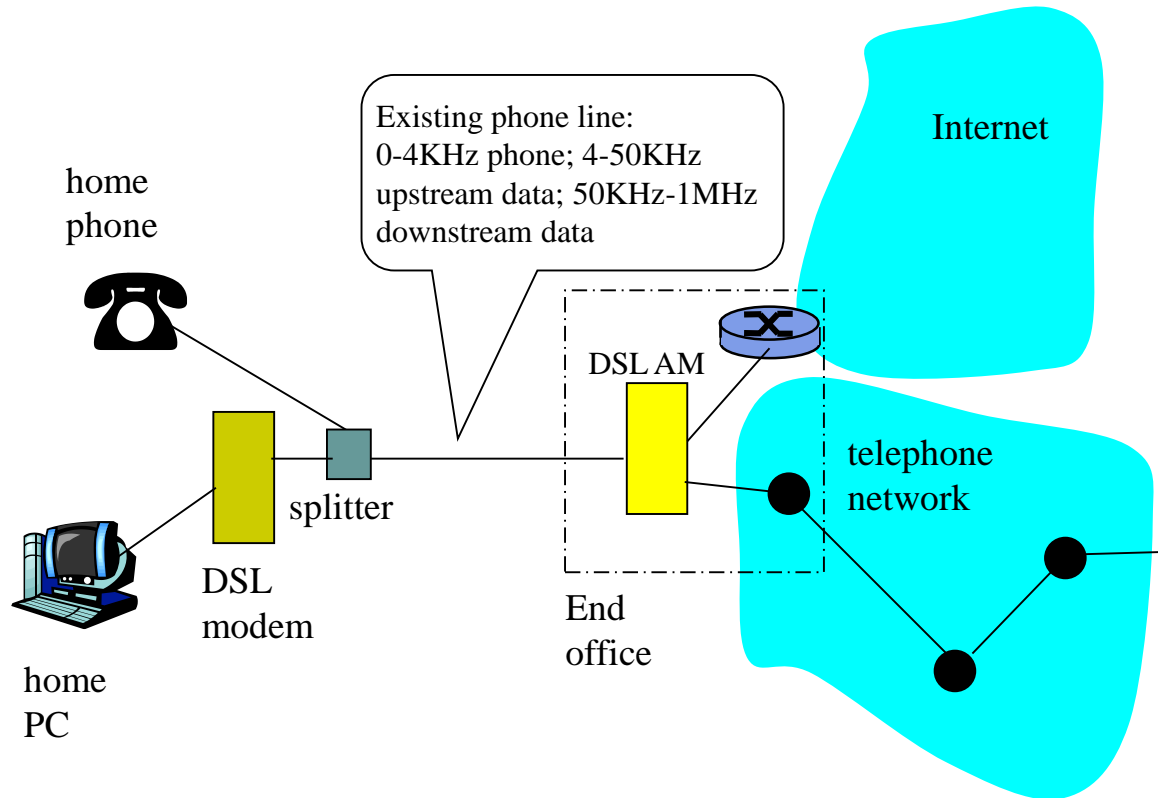


- **Local loop.** Analog twisted pairs going to houses and businesses.
- **Trunk:** Digital fiber optics connecting the switching offices.
- **Switching offices:** Where calls are moved from one trunk to another.
  - **End office:** Each telephone connects directly to the telephone company's nearest end office .The distance is typically 1 to 10 km.
  - **Toll office:** Each end office has a number of outgoing lines to one or more nearby switching centers, called toll offices
  - **Primary, sectional, and regional offices** form a network by which the toll offices are connected.

# TDM in Trunks



# Digital Subscriber Line (DSL)

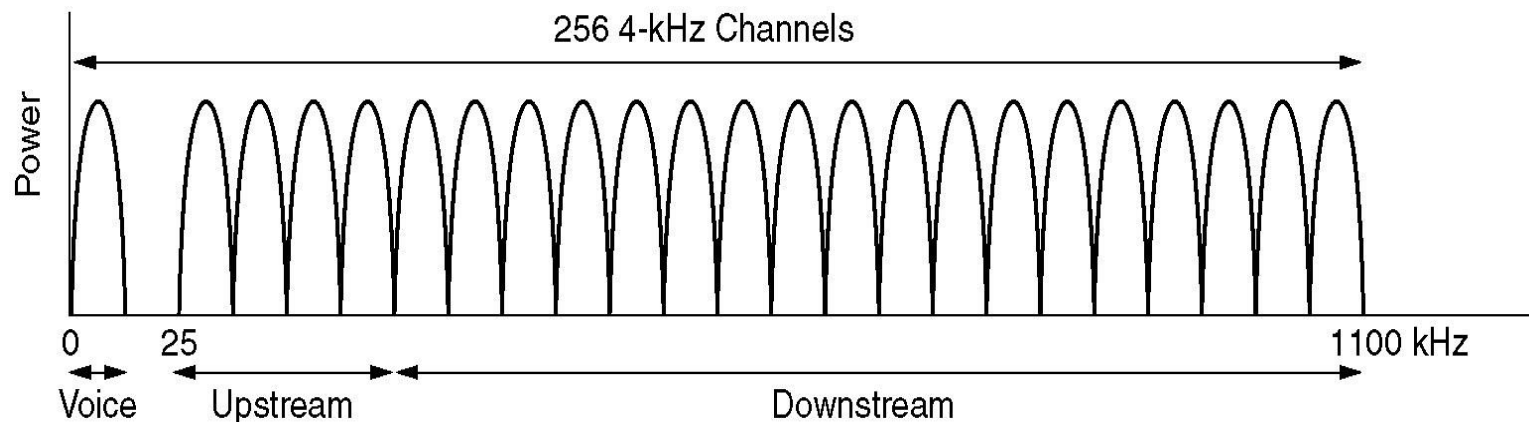


- up to 1 Mbps upstream
- up to 8 Mbps downstream
- Can surf and phone at same time: could be "always on"

# Digital Subscriber Line-FDM

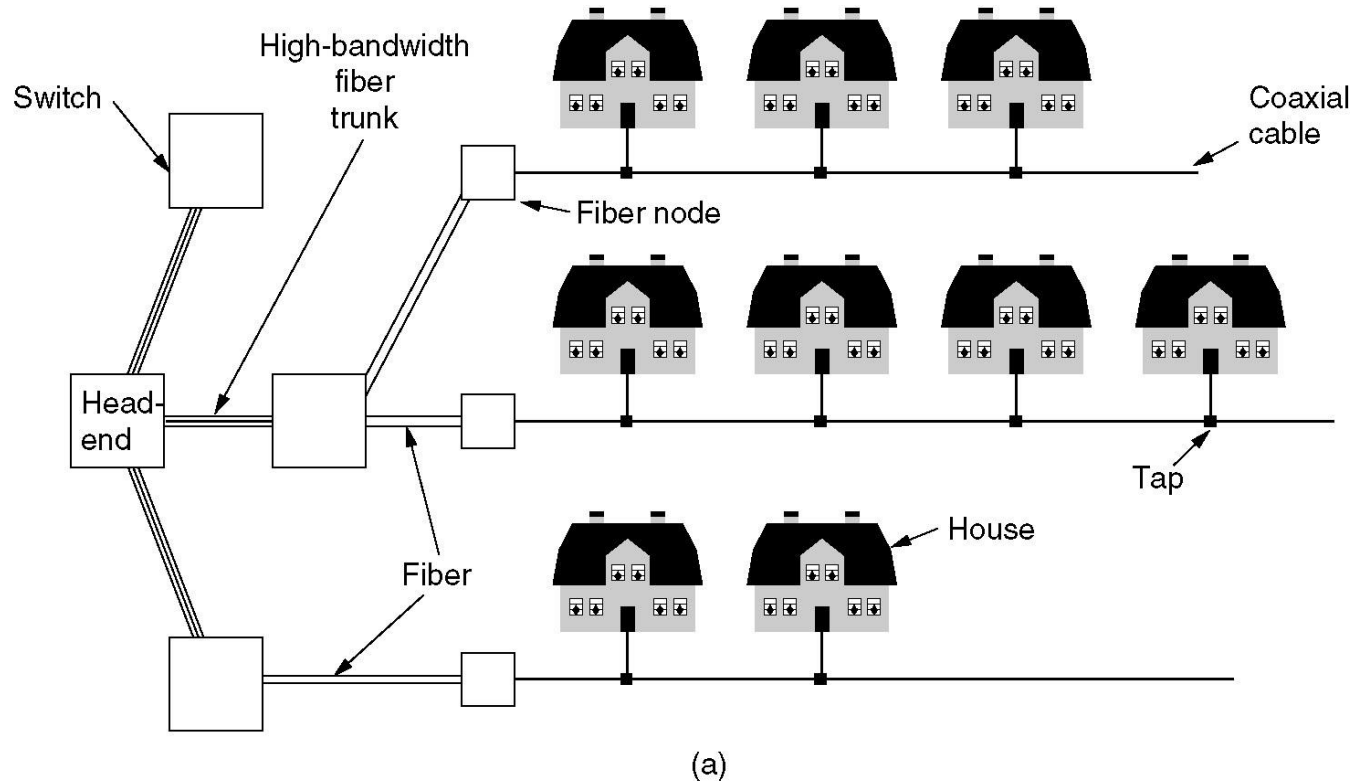


- DMT (Discrete MultiTone) : 1.1 MHz = 256x4kHz logical channels
- xDSL: It is up to the provider to decide how it will arrange its channels.
  - Asymmetric DSL: upstream 32 channels , downstream 200. sampling rate 4000 baud, up to 15 bits per baud QAM.
  - Symmetric DSL: 116 channels for both upstream and downstream
- Best-of-Effort service: different channels may have different data rates.



# Internet over Cable

## - Cable TV (Hybrid Fiber Coax)



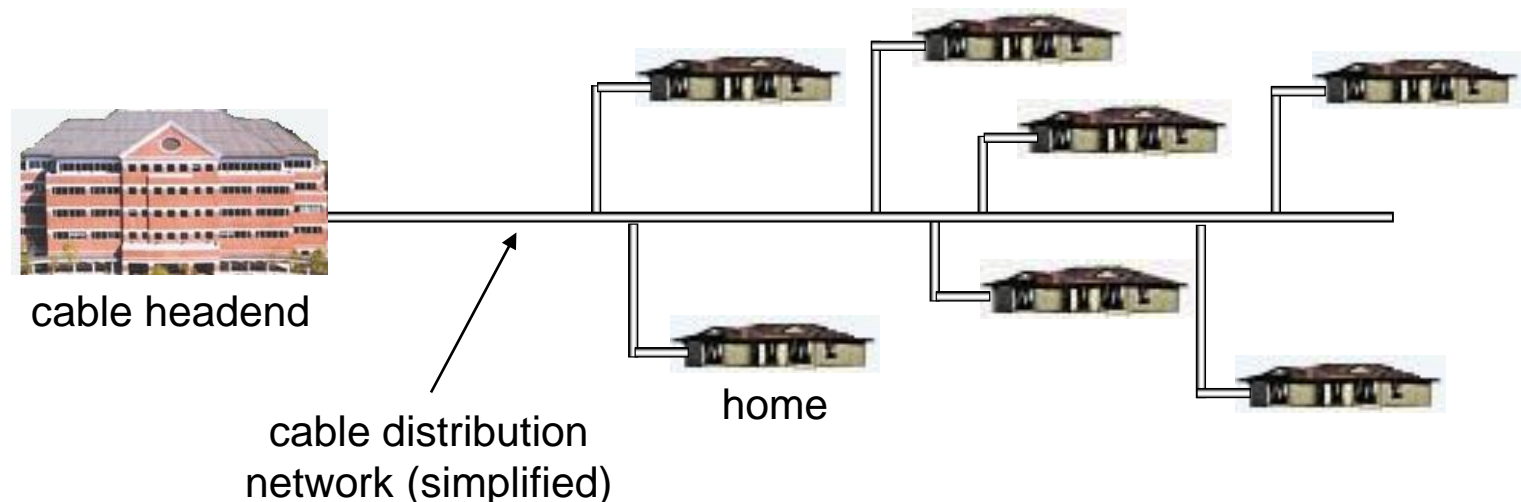
- Cable requires sharing whereas the telephone system does not.

# Internet over Cable



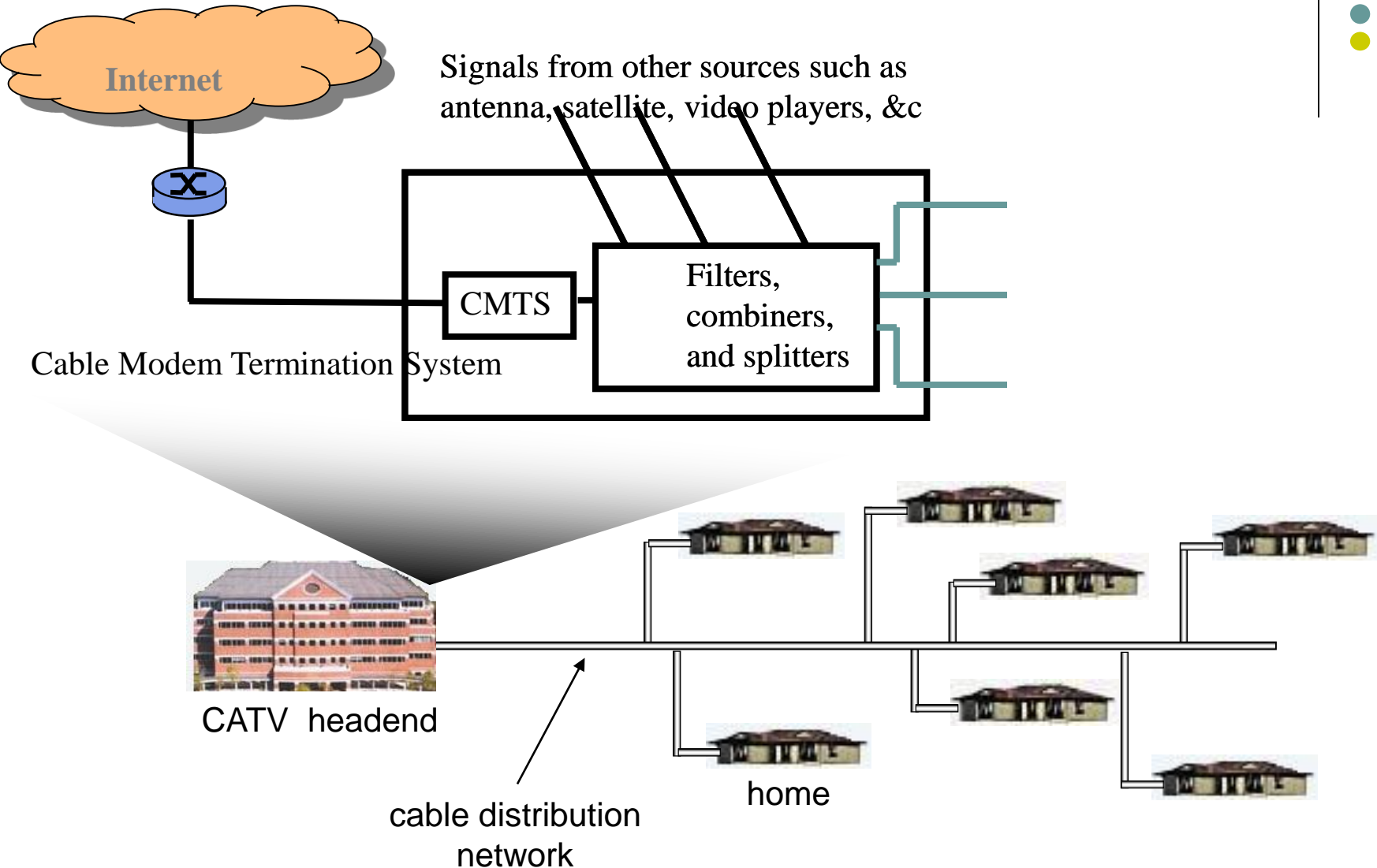
- up to 12 Mbps upstream
- up to 36 Mbps downstream
- Can surf and watch TV at same time: could be “always on”

Typically 500 to 5,000 homes

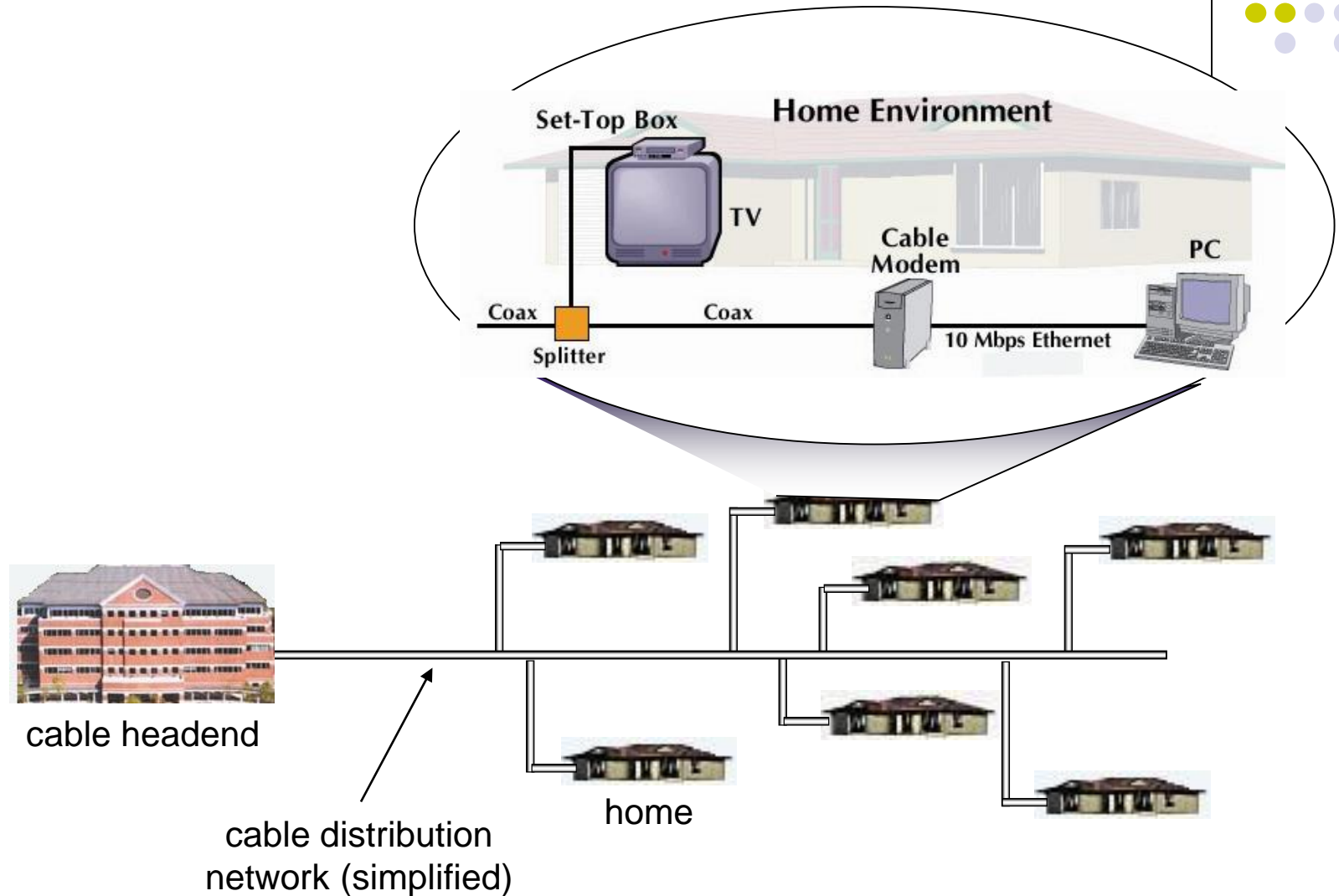




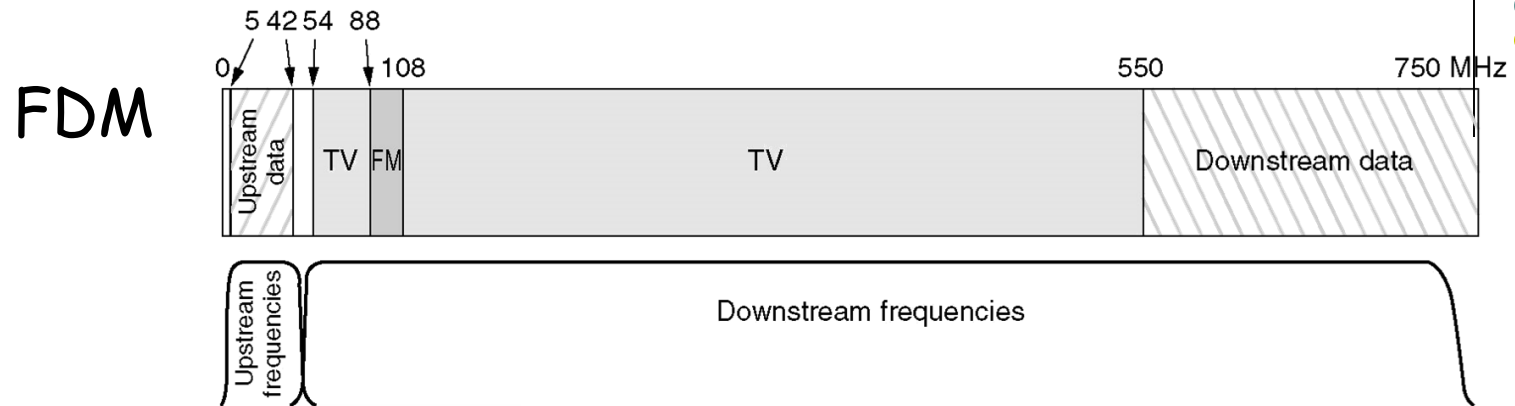
# Internet over Cable



# Internet over Cable



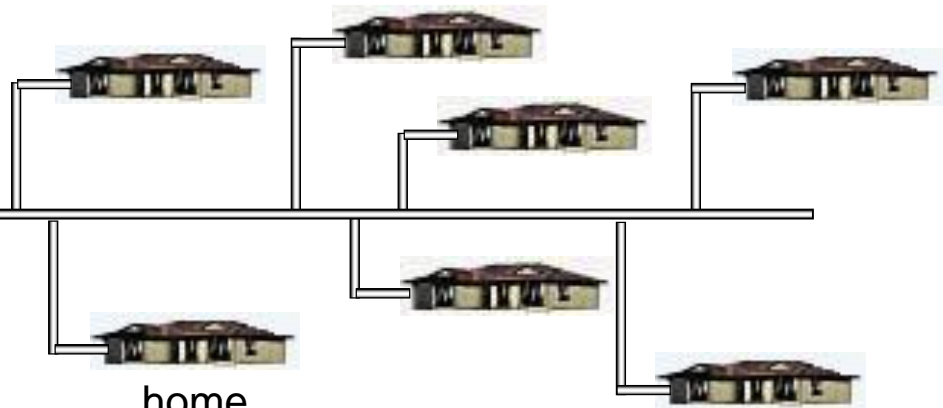
# Internet over Cable-FDM



cable headend

cable distribution network

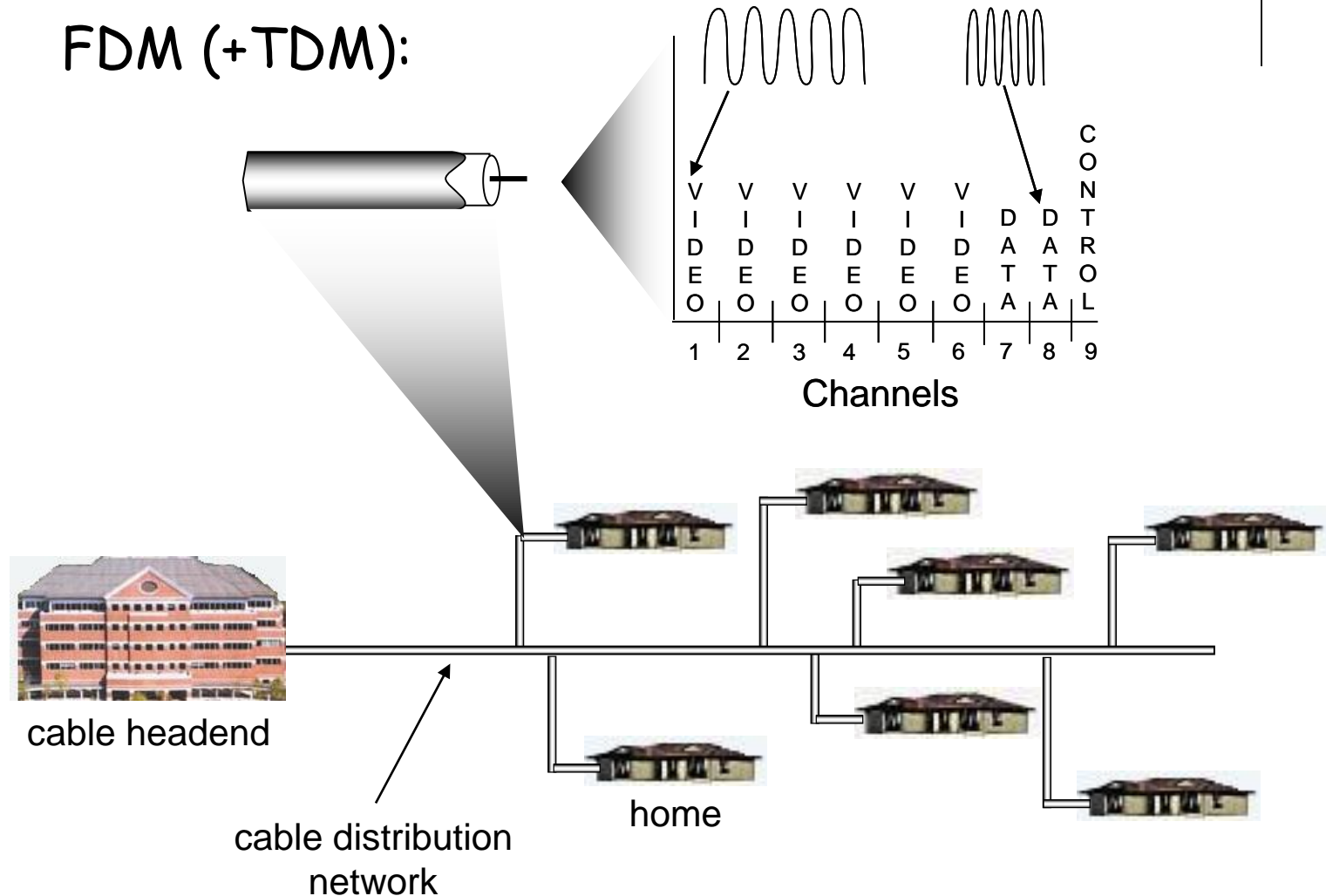
home



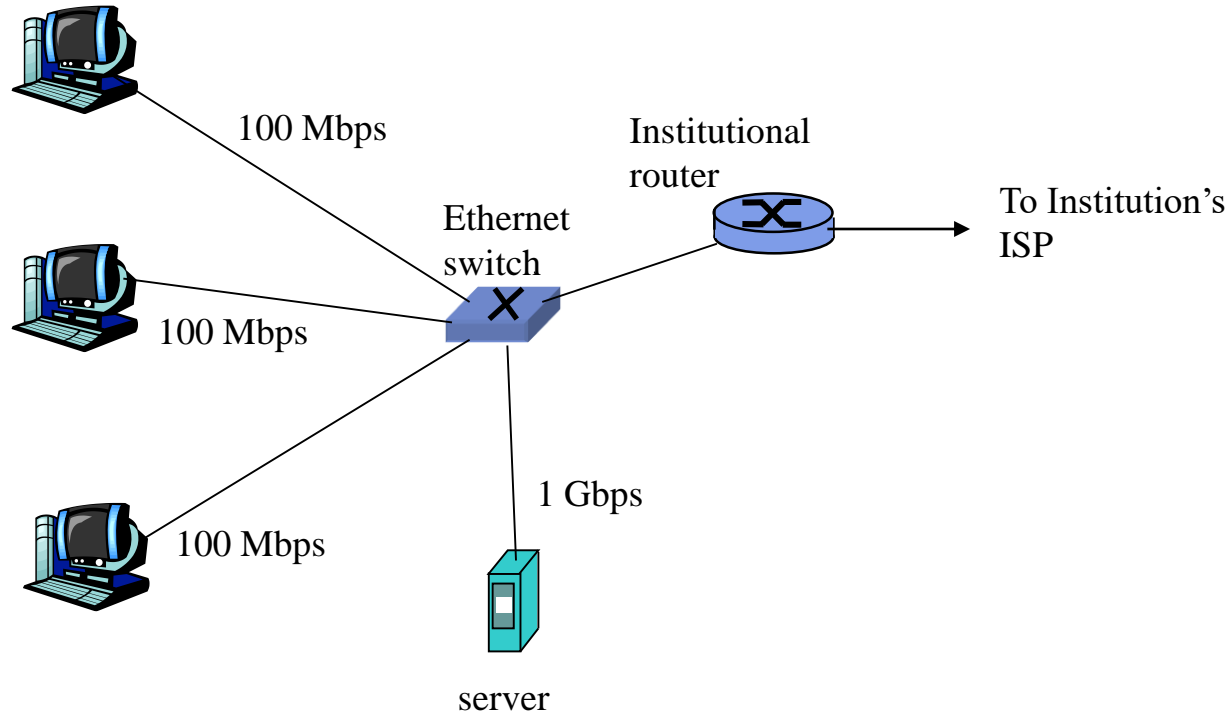
# Internet over Cable



FDM (+TDM):



# Ethernet Internet Access

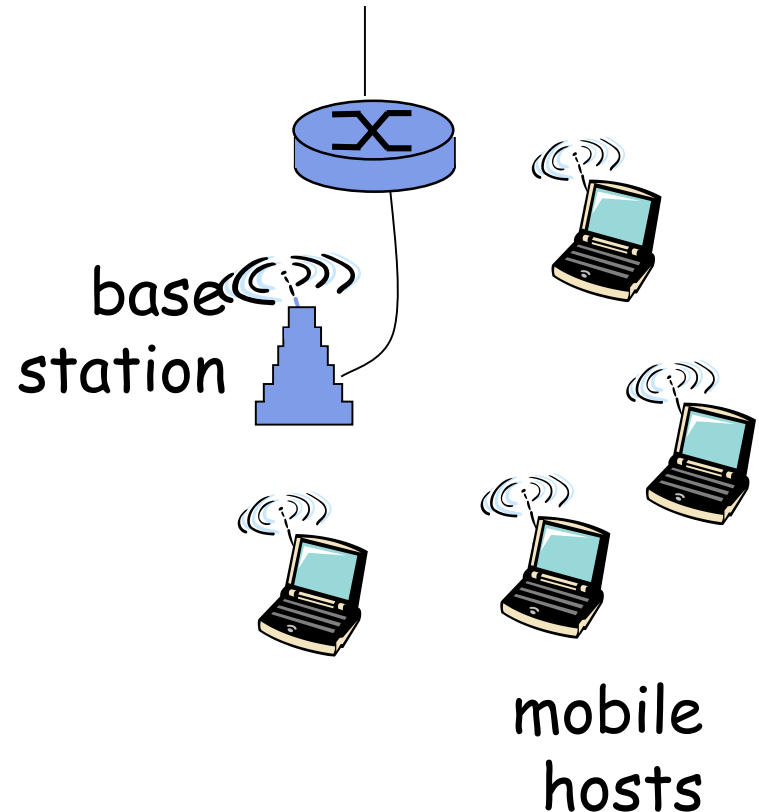


- Typically used in companies, universities, etc
- 10 Mbps, 100Mbps, 1Gbps, 10Gbps Ethernet

# Wireless Access Networks



- connect end system to router via base station/ access point
- **wireless LANs:** 802.11b/g (WiFi): 11 or 54 Mbps
- **wider-area wireless access**
  - ~1Mbps over 3G cellular system (GPRS, CDMA)
  - next up(100 Mbps): 4G(TD-LTE), WiMAX
  - Satellite communication

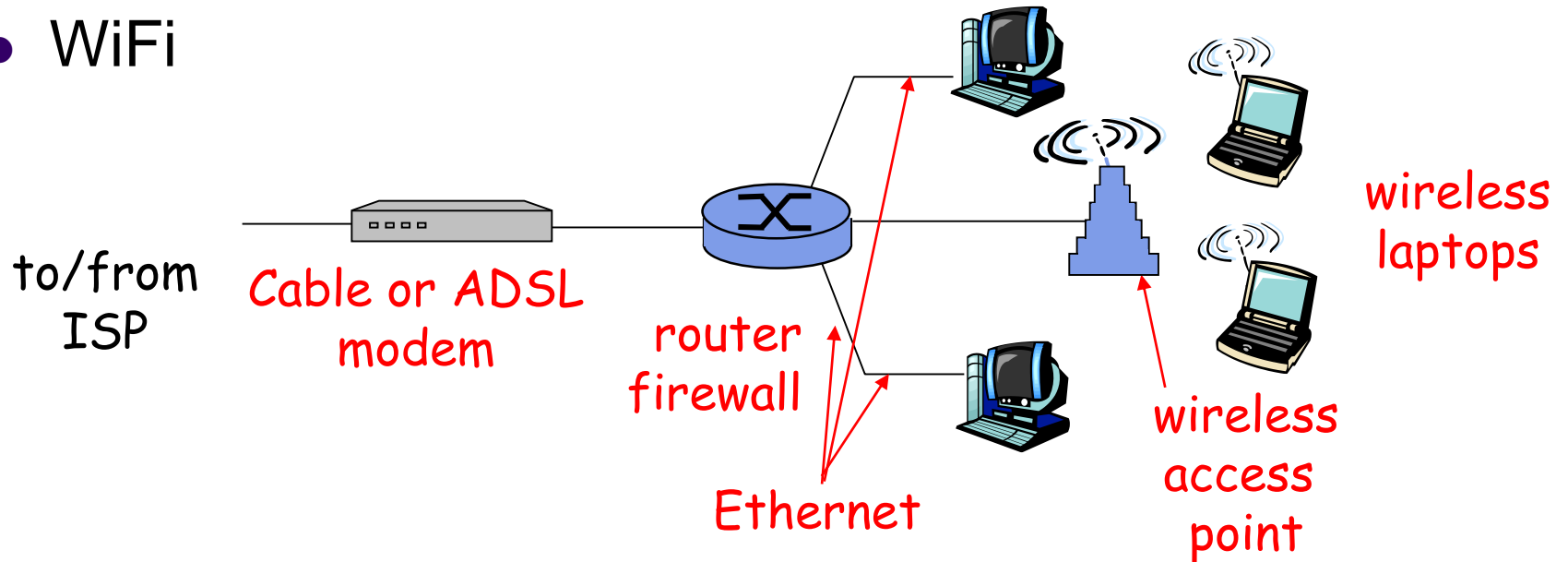


# Home Networks



## Typical home network components:

- DSL or cable modem
- router/firewall/NAT
- Ethernet
- WiFi





# Chapter 1: roadmap

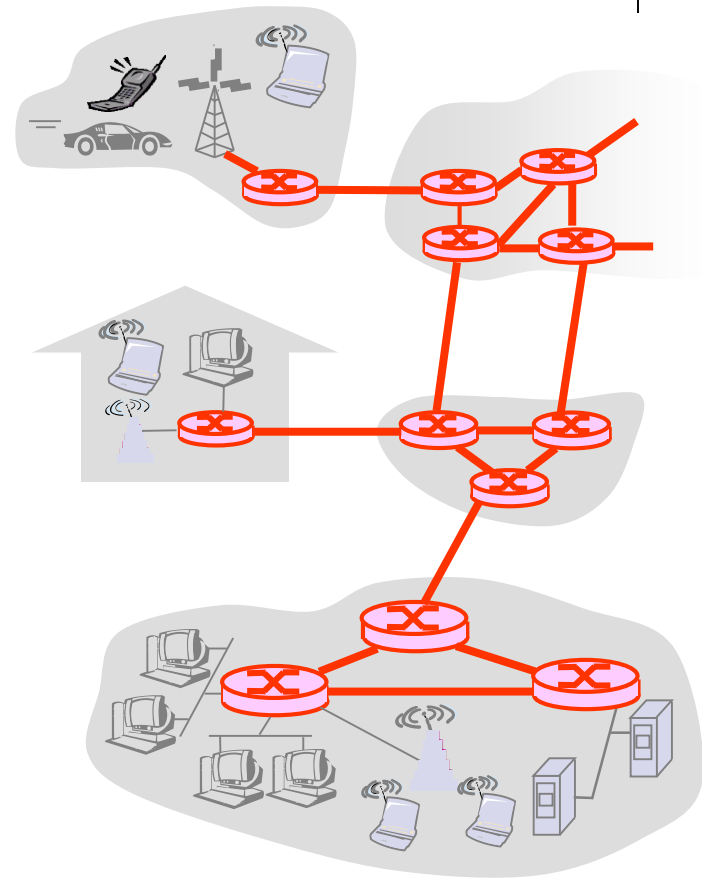
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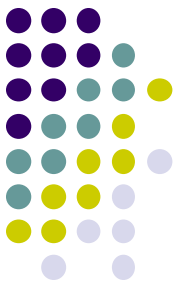


# The Network Core

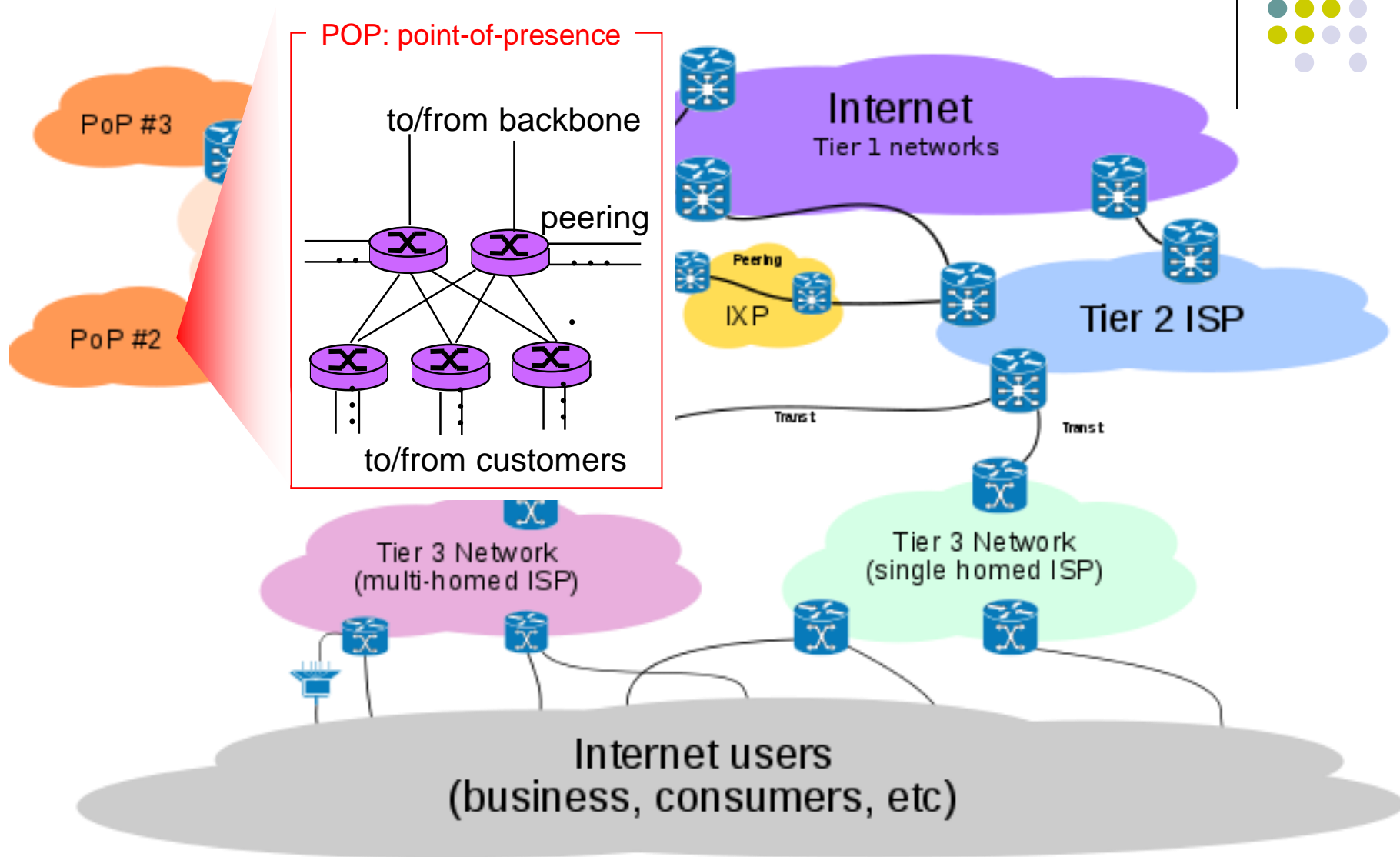


- mesh of interconnected routers
- *the fundamental question:* how is data transferred through net?
  - **circuit switching:** dedicated circuit per call
  - **packet-switching:** data sent thru net in discrete “chunks”





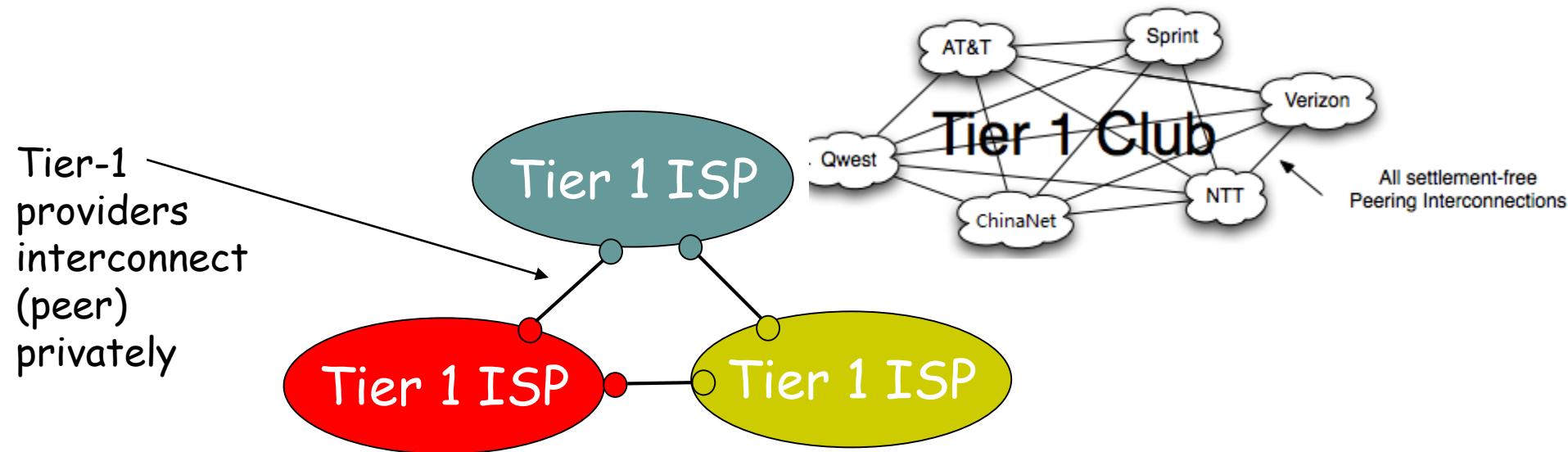
# network of networks



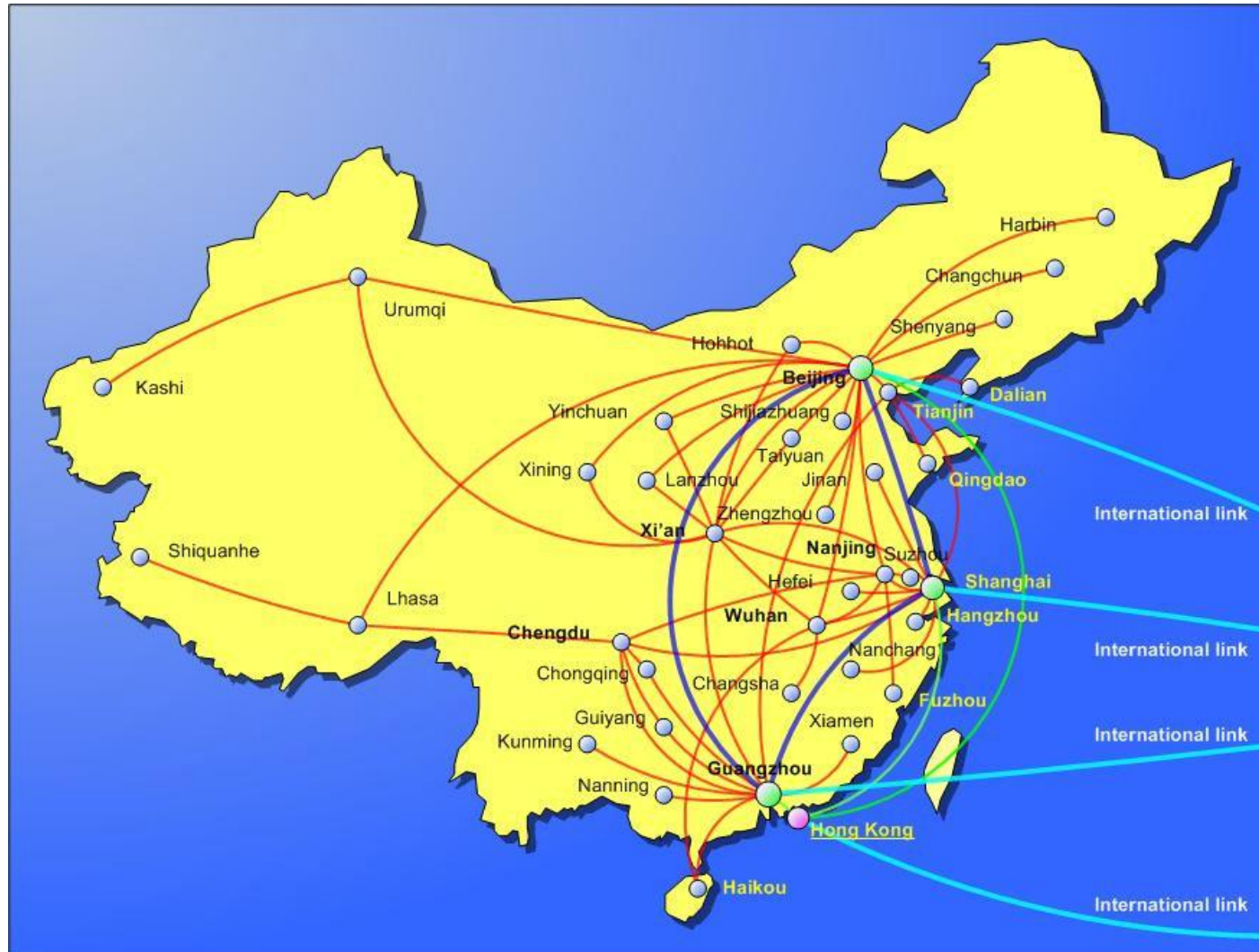
# Tier-1 ISP



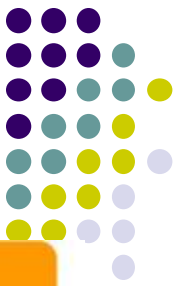
- can reach every other network on the Internet without purchasing IP transit or paying settlements.
- treat each other as equals
- national/international coverage (e.g., ChinaNet and ChinaGBN)



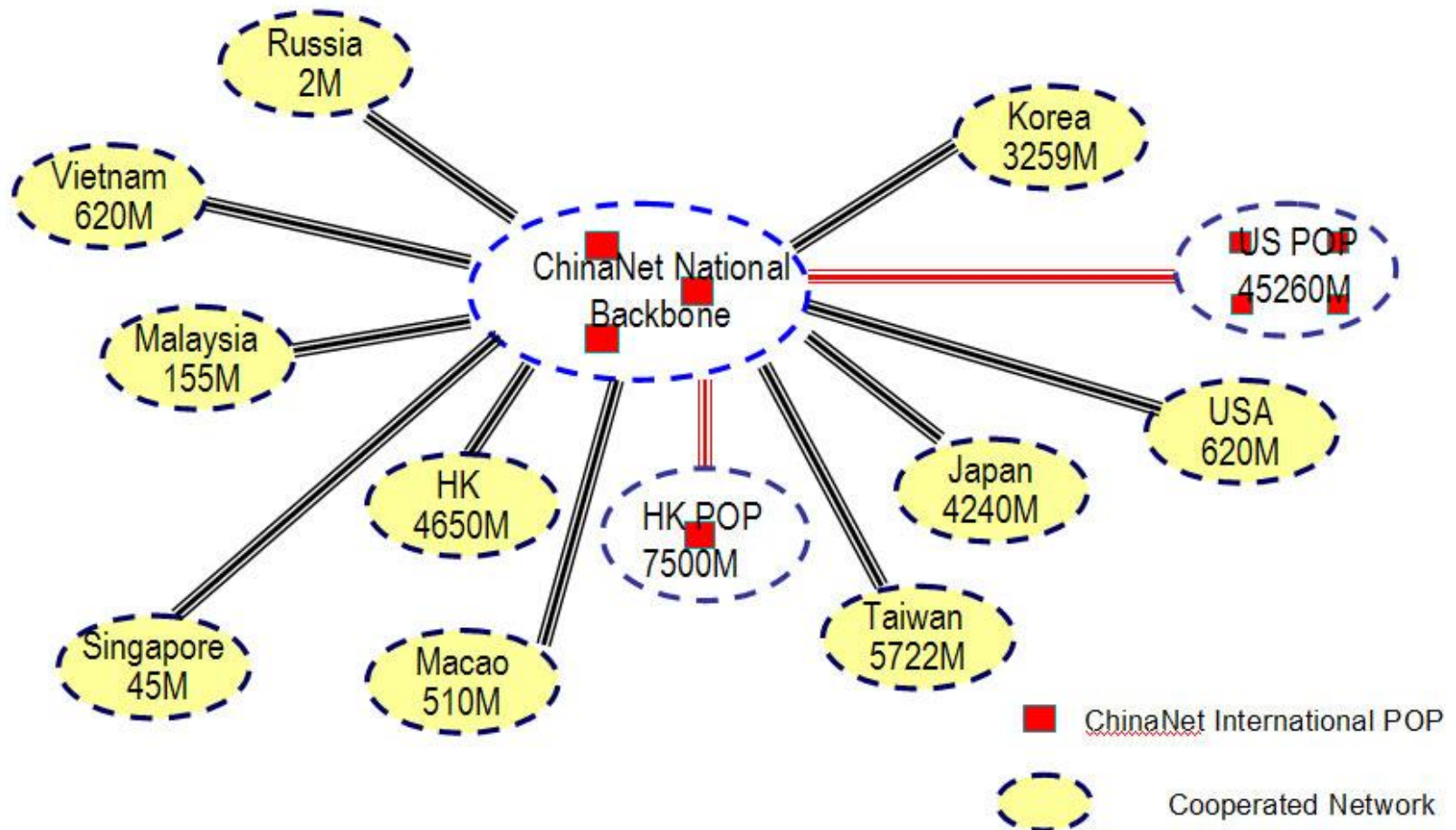
# Tier-1 ISP: e.g., ChinaNet



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## ChinaNet International Connectivity

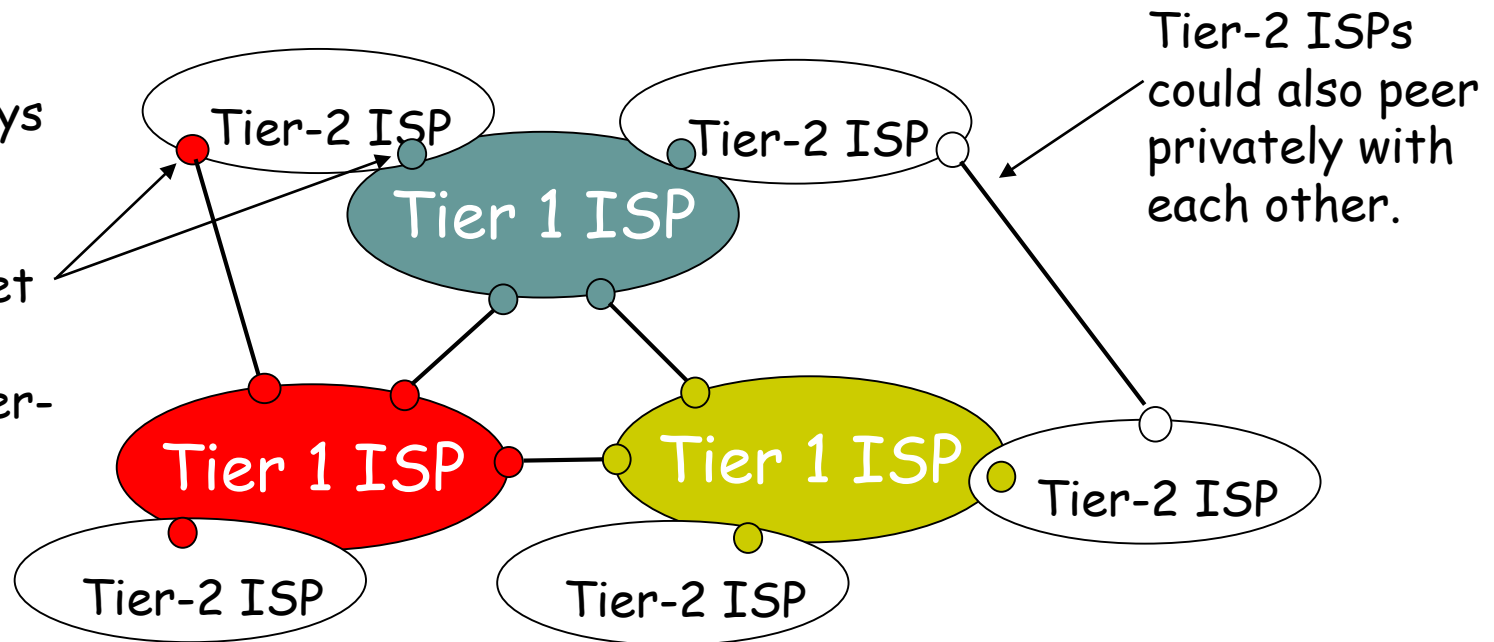


# Tier-2 ISPs



- **smaller (often regional) ISPs** Connect to one or more tier-1 ISPs, possibly other tier-2 ISPs

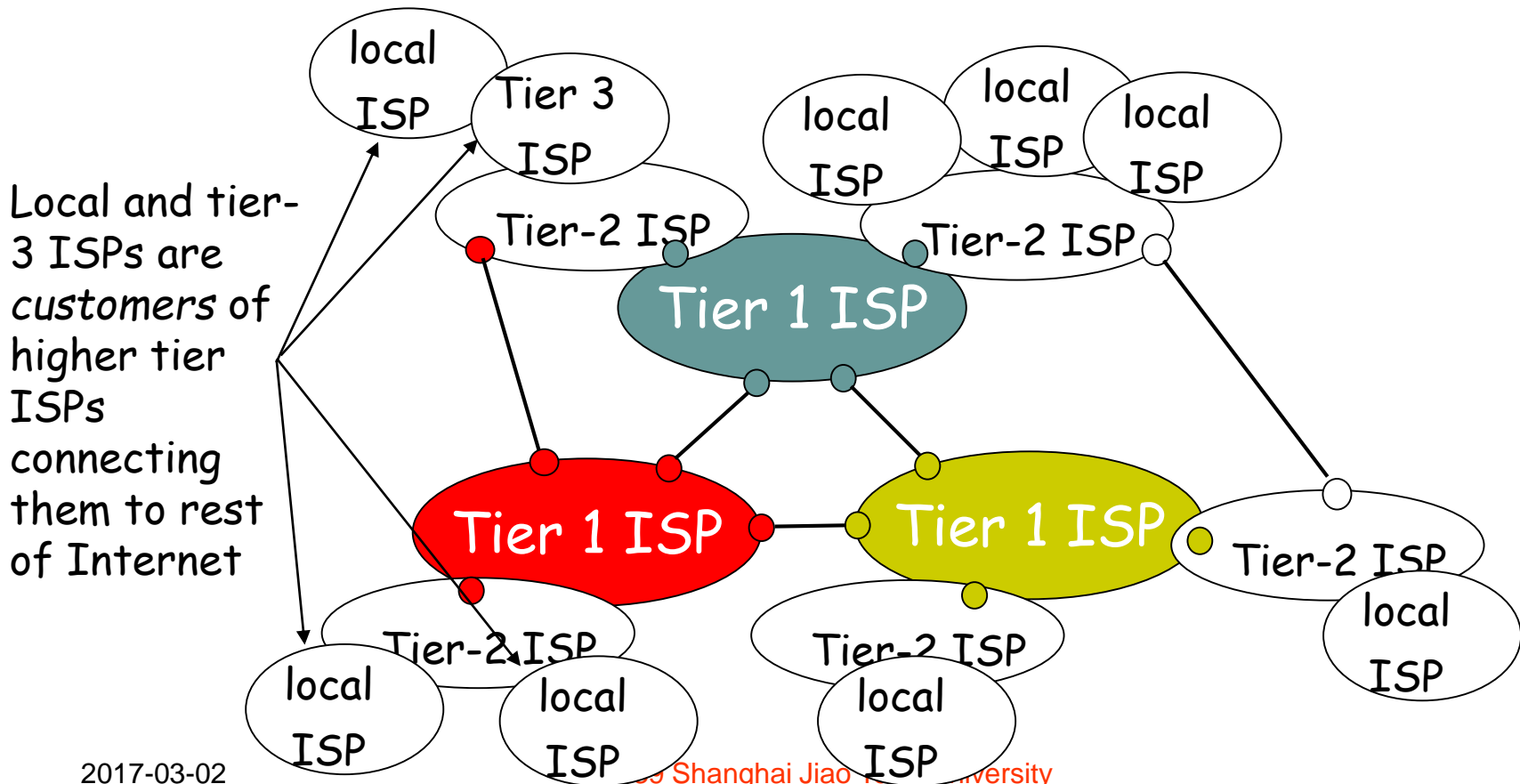
- Tier-2 ISP pays tier-1 ISP for connectivity to rest of Internet
- tier-2 ISP is customer of tier-1 provider





# Tier-3 ISP and Local ISP

- last hop (“access”) network (closest to end systems)

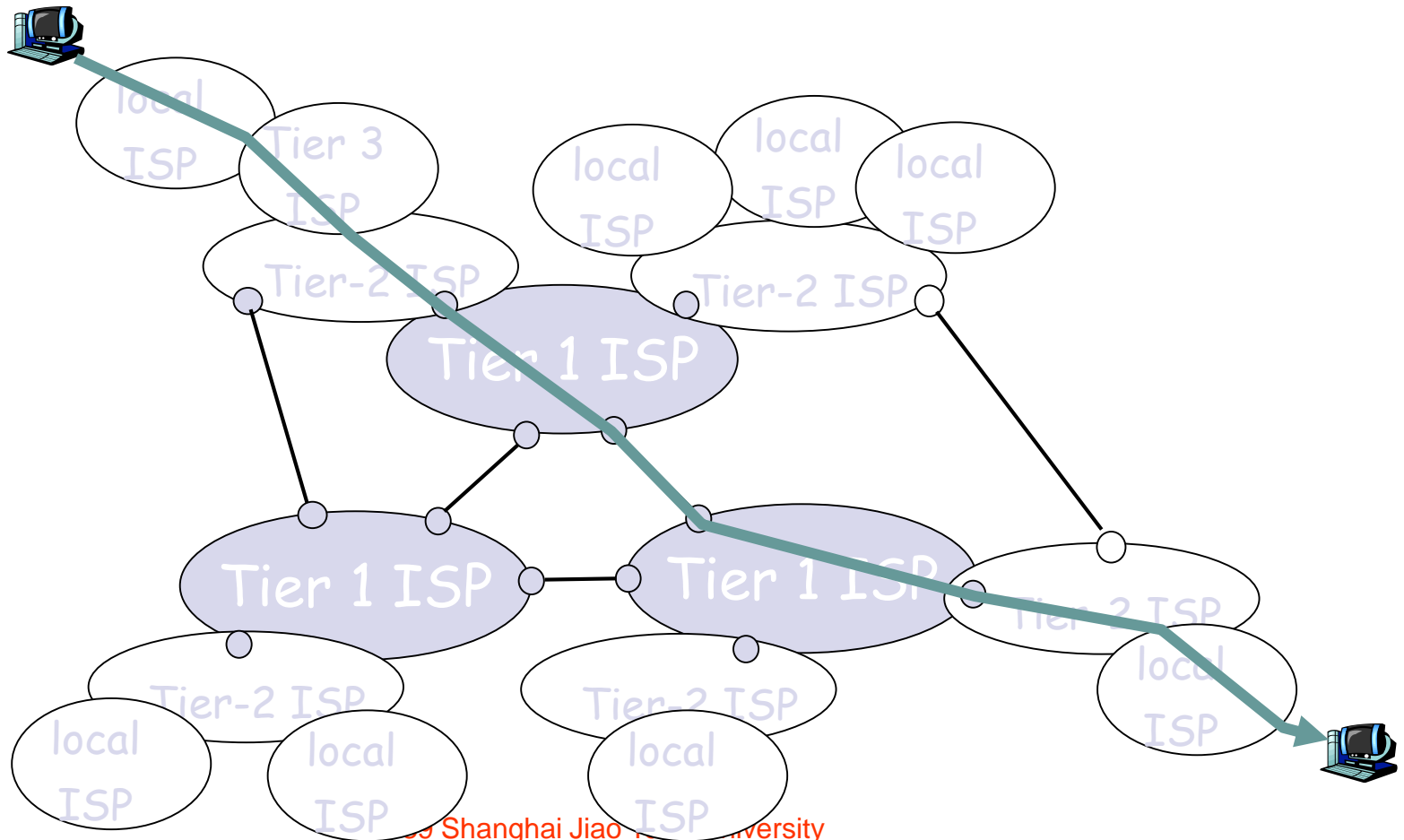




# network of networks



- a packet passes through many networks!





# Assignment 1



- Page 70: R11
- page 74: P6, P7, P24, P30
- additional problems
- page 79: D4
- Download/upload the assignment at:
  - <ftp://lpshen@public.sjtu.edu.cn>
- Due time: 24:00 next Thursday