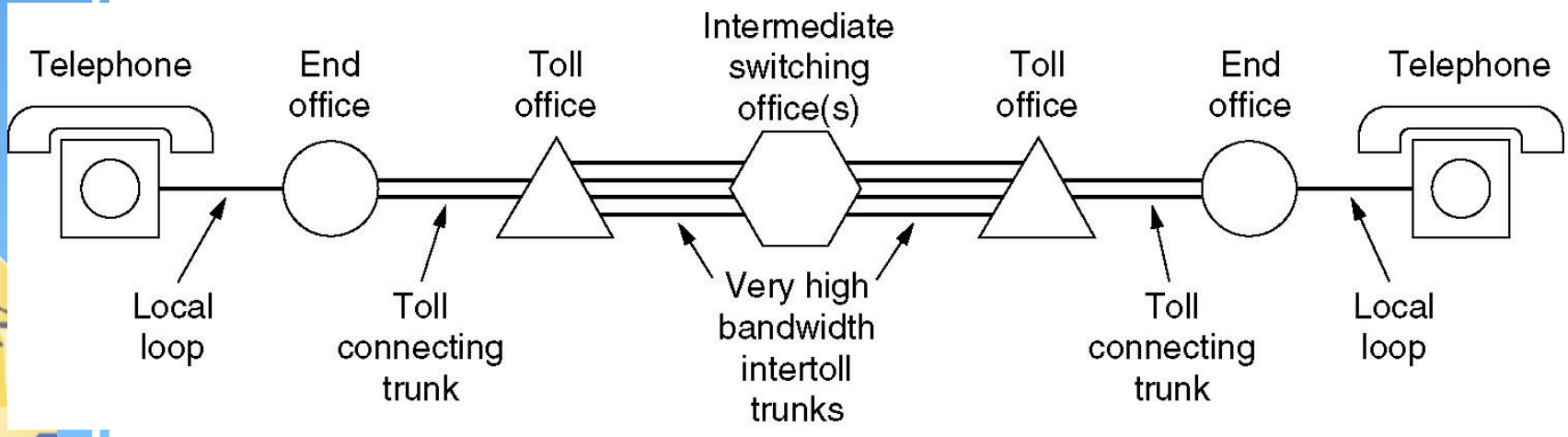
Overview

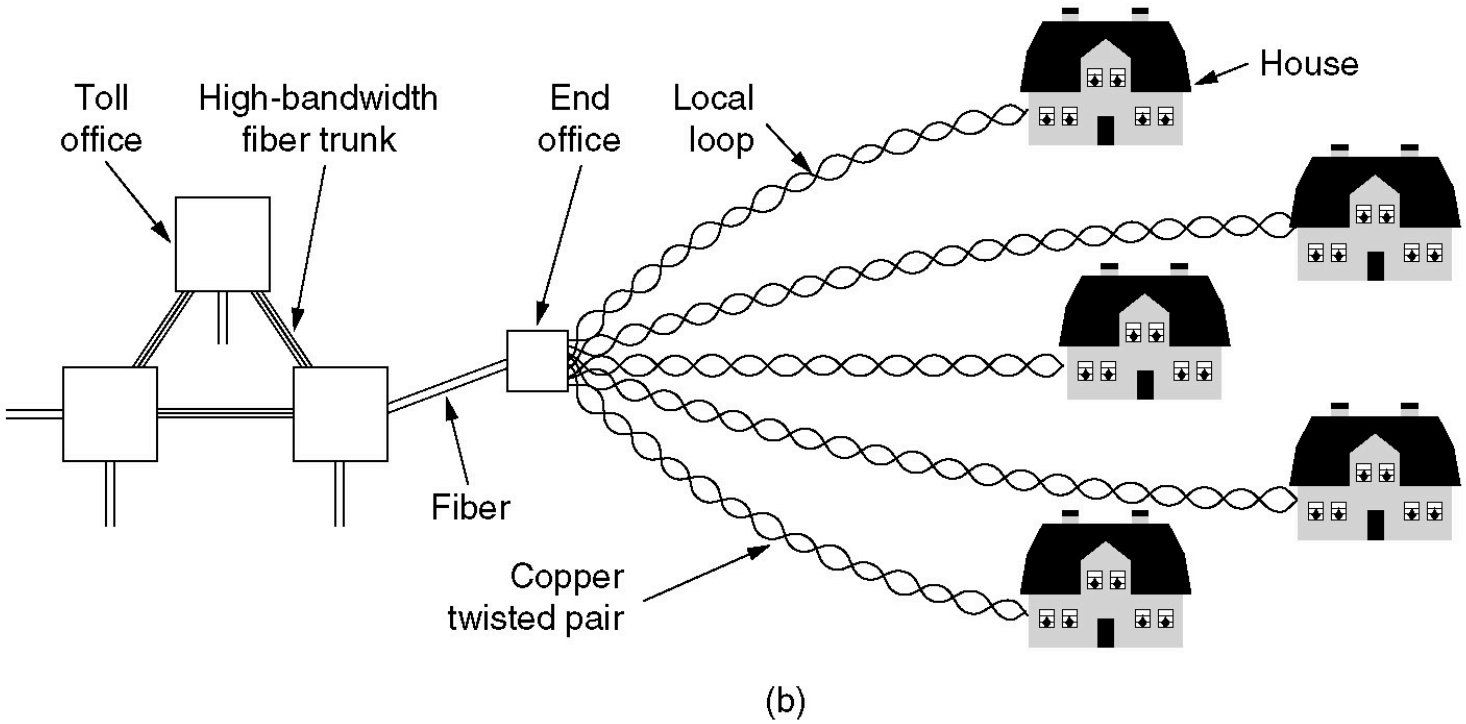
- We were looking at technologies to connect a bunch of nodes
  - Broadcast based networks: Ethernet, wireless etc.
  - Cell switched type: token ring, atm etc.
- Today we will look at point to point type of networks, connecting home with a ISP
- Material from Computer Networks - Andrew Tanenbaum (4 ed.)

Telephone network

- Local loop: analog link connecting your home to the toll offices
- Trunks: Digital fiber optics connecting these toll offices/switching offices etc.
- Switching offices: calls are moved from one trunk to another to connect the users
- Except for the local loop, all others are digital



Telephone setup



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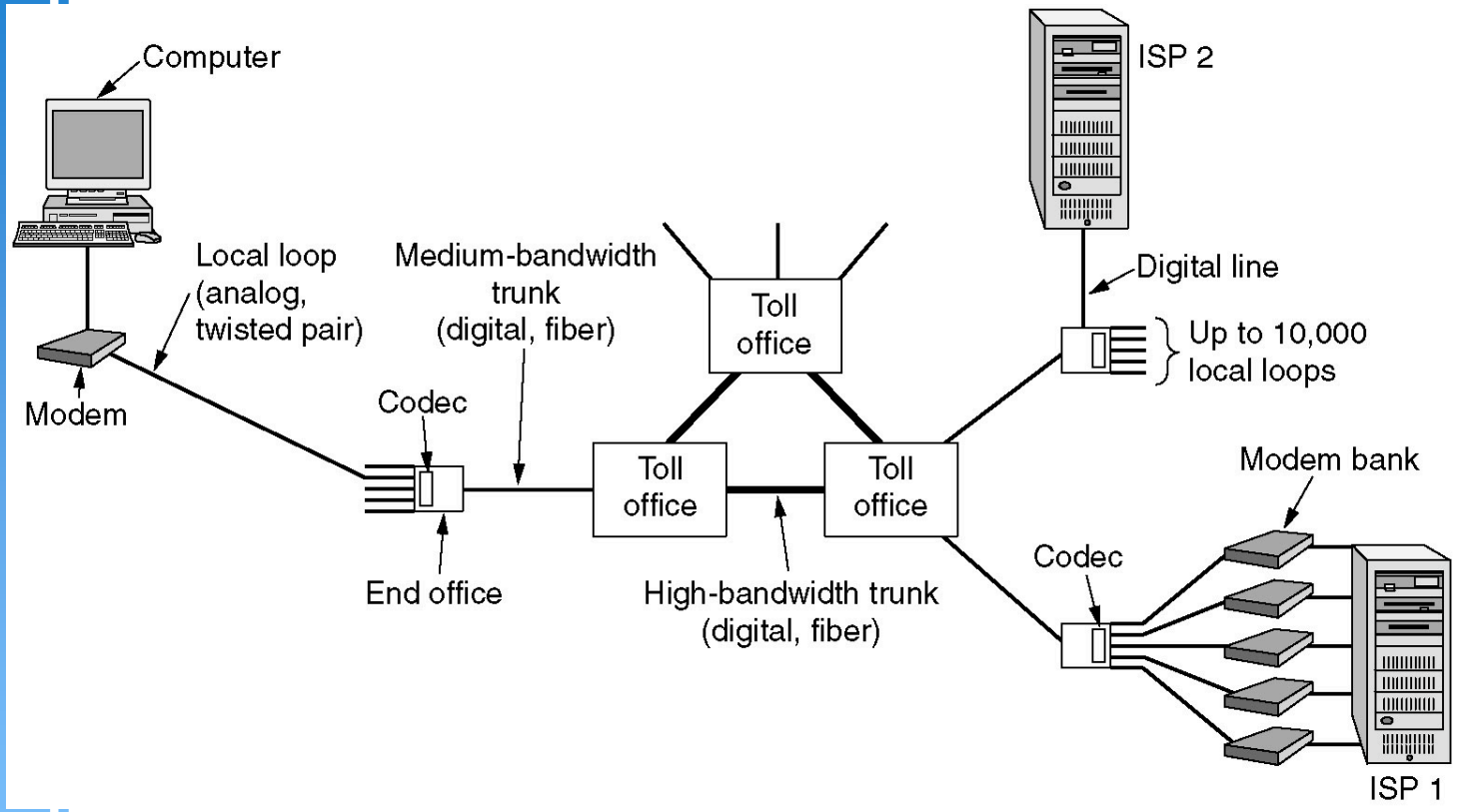
Telephone setup

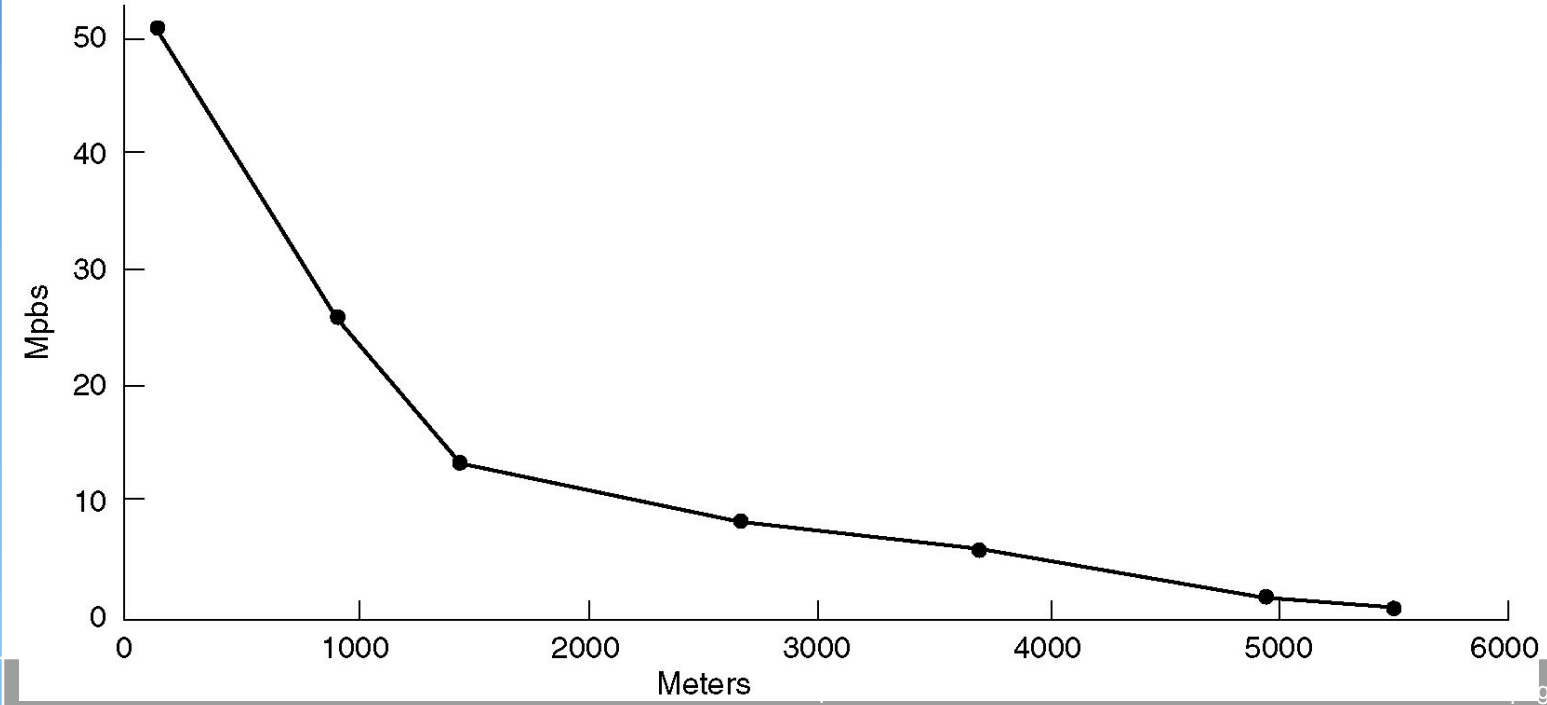


Modems

- Line to your home, the last mile, is analog
- Modems convert network signals in digital form to analog to transmit over the phone and vice versa
- Telephone networks can transmit 2400 baud (symbols)
  - By sending more bits per symbol, we can reach higher speeds (e.g., V.34 bis encoding uses 14 data bits/symbol at 2400 baud to achieve 33600 bps)
  - Shannon's limit: 35000 bps (assuming analog conversions at both end points). Eliminate one conversion and use pure digital at ISP and you can get up to 70 kbps. Nyquist's theorem limits it to 56 kbps
- Essentially, modems make it look like a wire between the two ends

ADSL - Asymmetric Digital Subscriber Line

- Once the customer signs up, switching happens separately at the local toll office without imposing voice type limits (2400 baud etc.)
- Now the limit is the quality of cable from home to the local office
  - Can't replace this cable

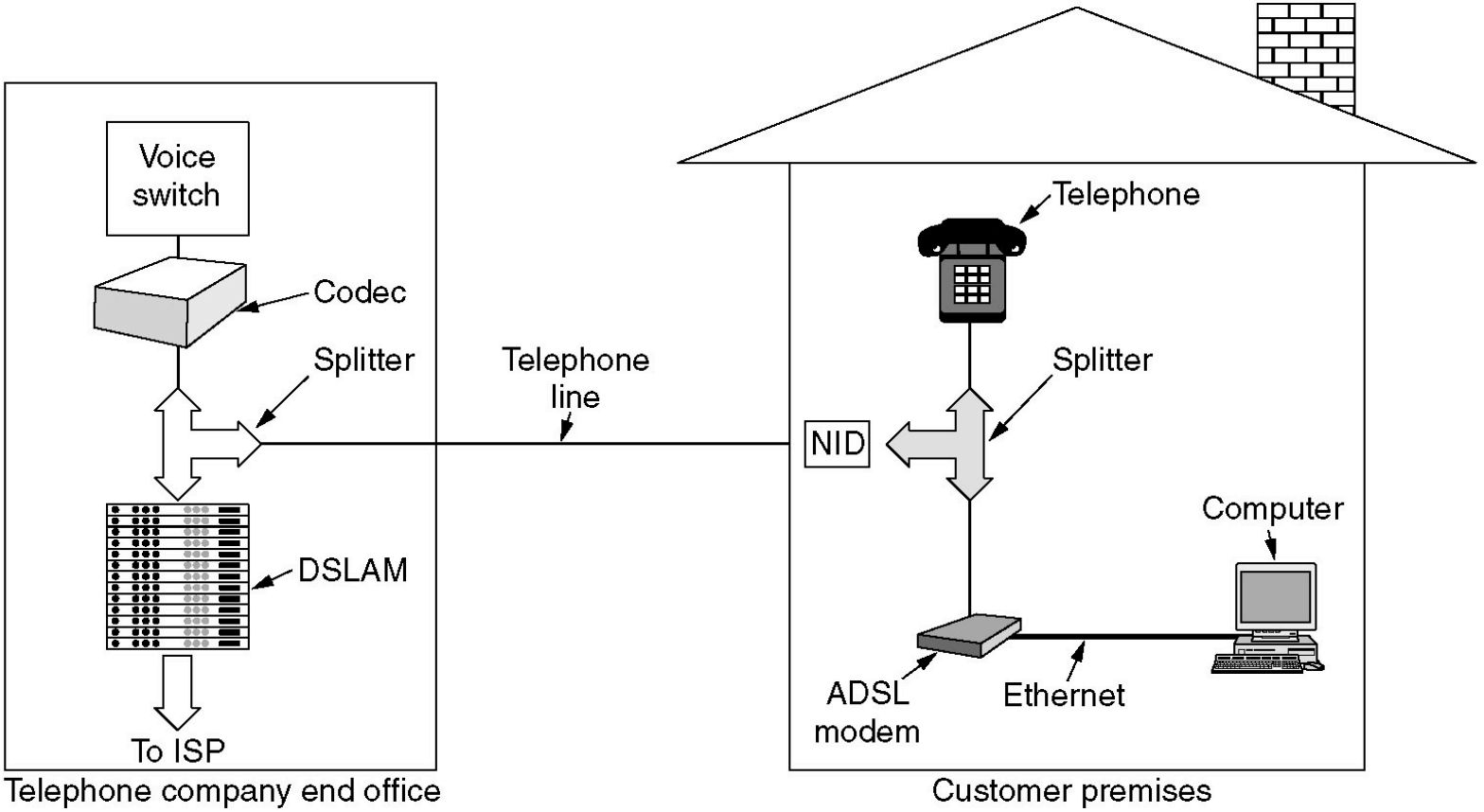


ADSL

- Use a 1.1 MHz band, split it into “channels”, allocate channels for existing telephone service and data service
  - Each channel is 4000 baud
- Splitting data channels 50:50 between uplink and downlink would give symmetric DSL
  - ISPs split it such that downlink has more bandwidth
    - Because users typically download web pages
    - Because ISPs do not want users to upload web pages

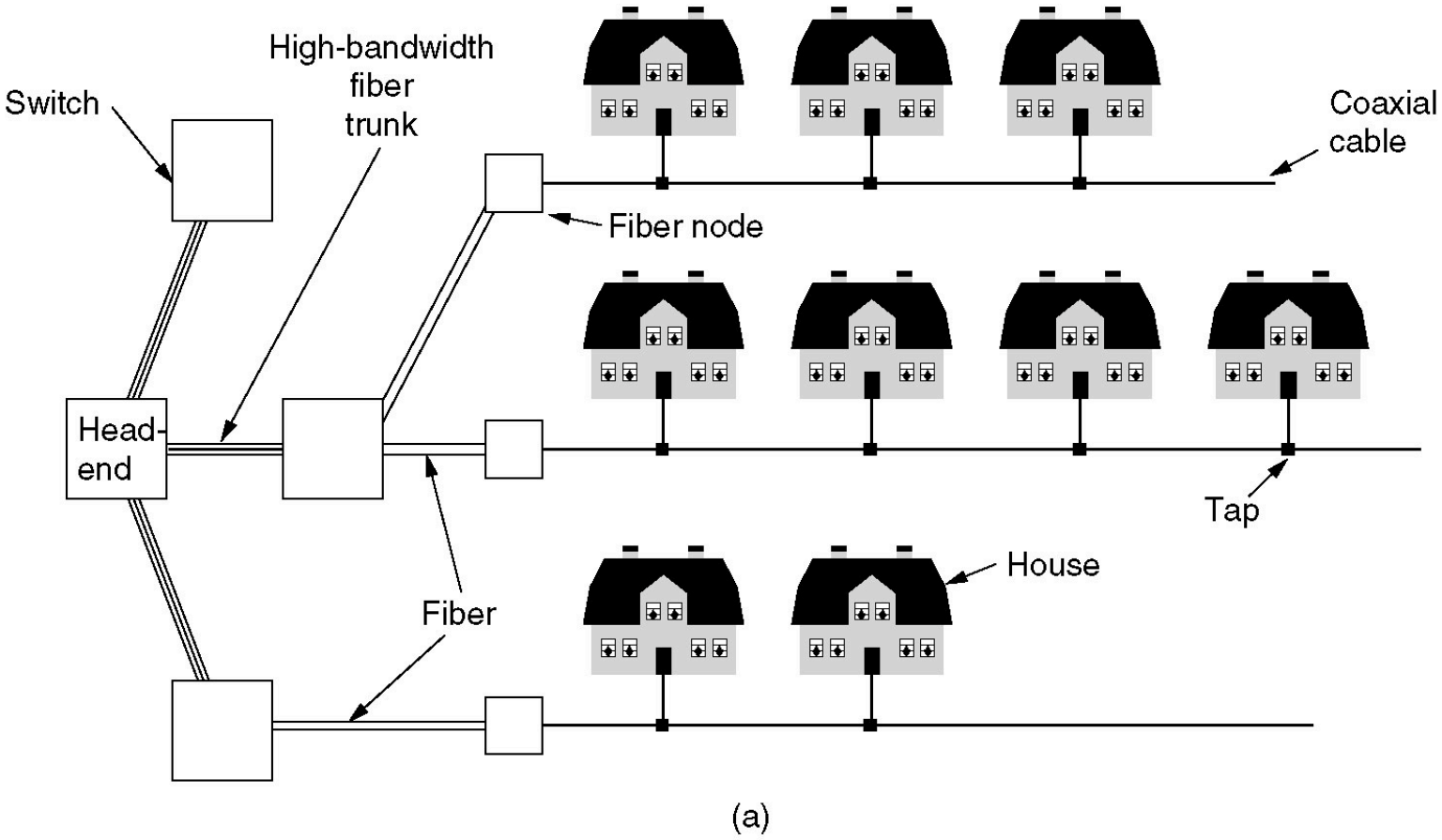
ADSL

- Typical splitters used in home restrict bandwidth to 1.5 Mbps



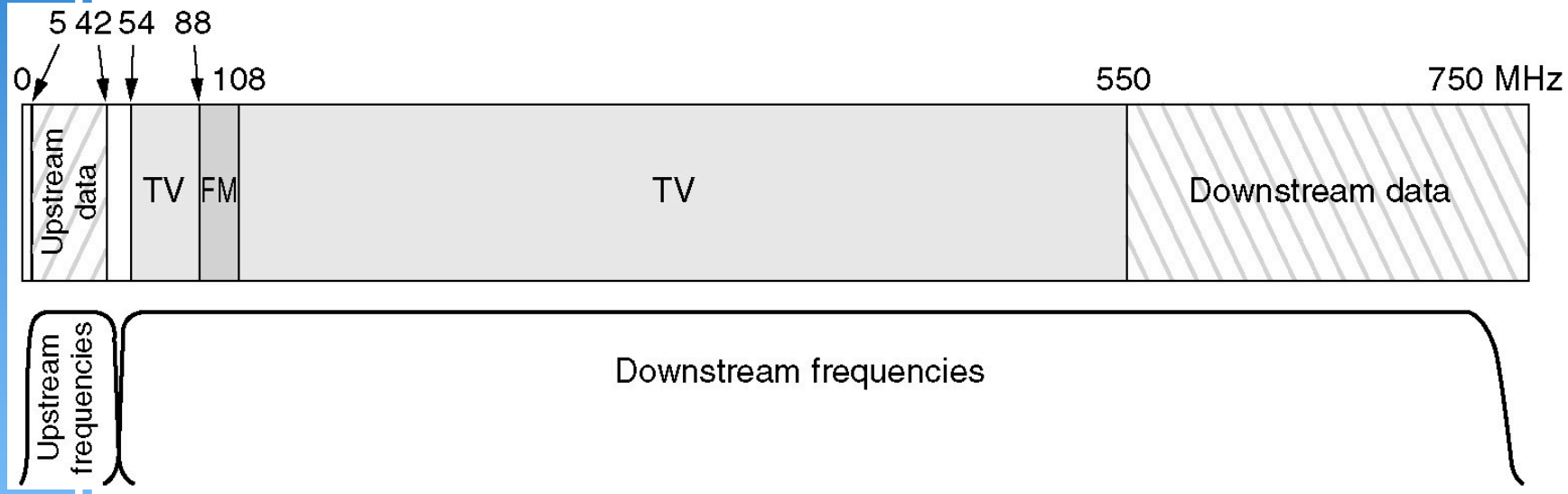
Cable TV

- Local loop is shared, but higher capacity



Asymmetry is inherent to cable

- Cable was designed for pumping lots of channels/data downstream
- Upstream bandwidth is limited



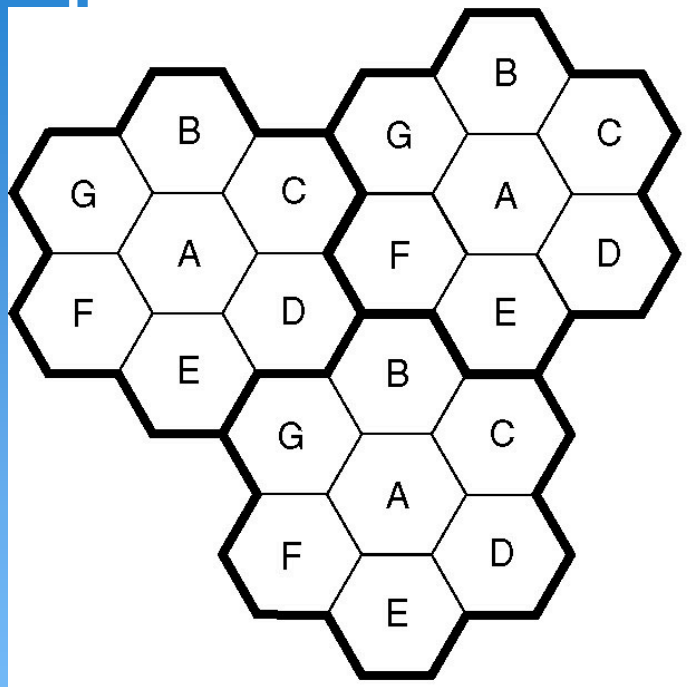
Cable vs ADSL

- Bandwidth
  - ADSL bandwidth (from the end office) is not shared
  - Cable bandwidth that you can see from your home depends on the number of users in your neighborhood
- Security:
  - Cable is a shared medium as compared to ADSL
- Distance:
  - ADSL is limited to a few kms from the end office
- ISPs:
  - ADSL can work with ISPs (for example, you can get DSL from Earthlink, Covad, SBC here)
  - Cable is usually linked to a cable provider

Cellular

- First generation: Analog voice
  - Advanced Mobile Phone systems (AMPS) - 1982
- Geographic region is divided into cells (hence cell phones)
  - Cells are typically 10 to 20 km across (digital cells are smaller)
  - Larger cells means fewer towers, lower capacity as the number of users per tower goes up and cell phones have to use higher power transmitter to talk to the tower
  - Microcells for subways, stadiums etc.
- Hand off from one cell to another is important
- Adjacent cells cannot use same frequency to avoid interference

Choosing non-overlapping channels



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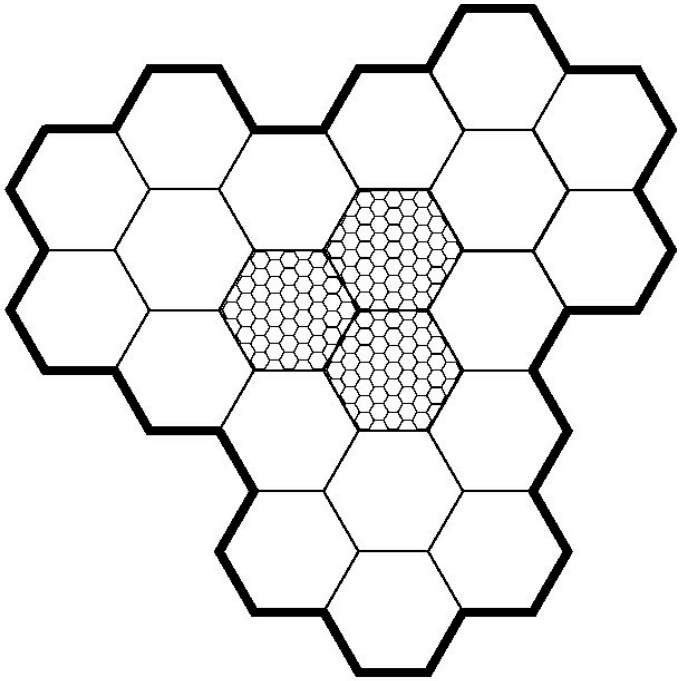

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Second generation: Digital

- D-AMPS (PCS): Popular in the US. Digital allows the operators to squish more users (3 to six times). The voice quality suffers; using these phones as modems can get u less than 9600 kbps. Providers don't advertise the fidelity (only "Can u hear me now" and not "Can u understand me now"!!)
- GSM: Rest of the world, Global System for Mobile Communication (GSM)
- CDMA (Code Division Multiple Access): Pushed by Qualcomm

Third Generation

- Digital voice and data: IMT-2000 (International Mobile Telecommunications)
  - Wideband CDMA (W-CDMA)
  - CDMA2000
- While we wait for 3G, we have 2.5G
  - EDGE (Enhanced Data Rates for GSM Evolution)
    - GSM with more bits per baud
- People are now working with 4G

What we have looked at so far

- Problem of connecting nodes (on a small scale)
  - Point-to-point, broadcast or cell switched
- Encoding to define how signals are sent
- Framing to define frames
- Error detection is important
  - Checksums
- Error recovery
  - ARQ, Sliding windows protocols

- At this point, we know how to connect a small set of nodes to reliably talk to each other