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Data Transmission and Home Networks

Gralla: part 2

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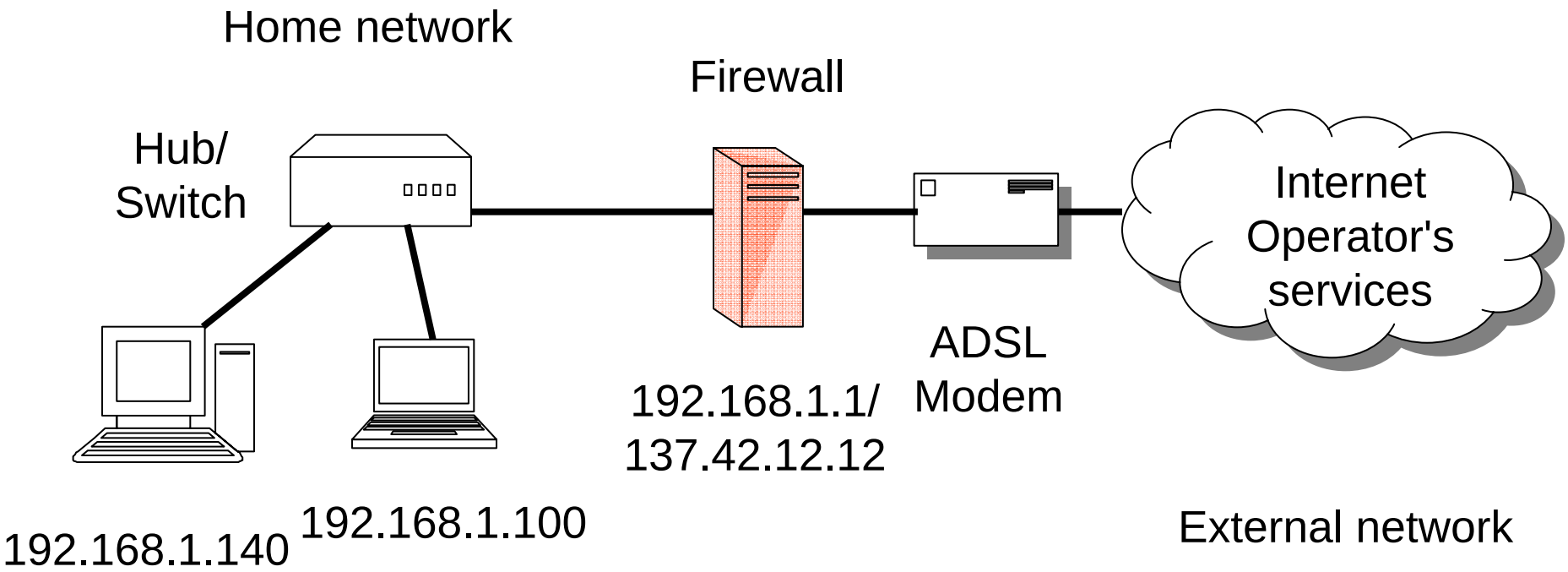
A Home Network



Roughly from: Gralla pp. 80-81

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How the Home Network Works

- The computers are connected by a hub or switch to form one Ethernet segment
  - The Ethernet is a *shared medium*
  - Ethernet frames can be sent to other computers by attaching the recipient's Ethernet address into to the beginning
- Each computer has its own IP address
  - Other computers can be found by their IP address by broadcasting an ARP query to the Ethernet network
- The gateway has two IP addresses
  - One for the inside segment
  - One for the outside interface

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Local Area Network

- A LAN (lähiverkko) means usually a physical network and the lower layer (1-2) protocols related to it
- Current common standards are Ethernet and WLAN
  - Both standards use 6 byte Medium Access Control (MAC) addresses inside the *network segment*
  - Both require an adapter to the computer and a device driver to translate the signals to data
- Ethernet uses various media, most common is a twisted pair cable
  - IEEE 802.3 defines the protocol behavior. Cabling and capacity differs in versions.
- Wireless LAN uses radio frequencies
  - The most common standard is IEEE 802.11b/g, aka. WLAN or WiFi

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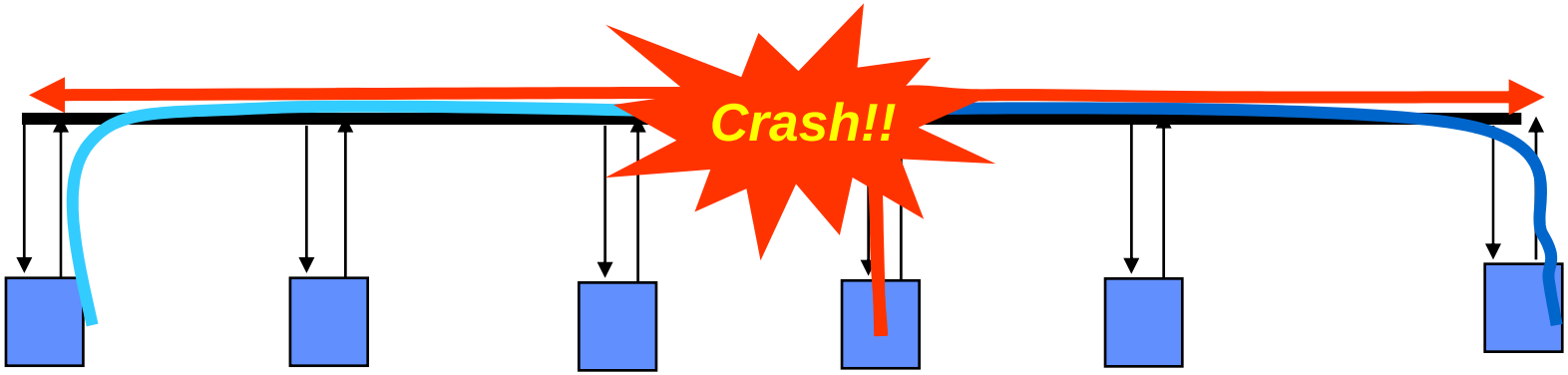
A Shared Media

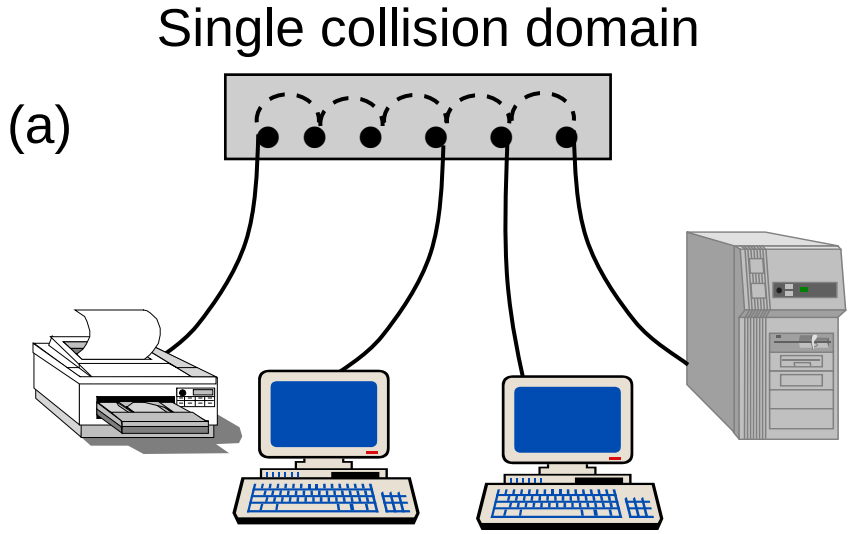
- The traditional Ethernet media is a shared bus,
  - Only one station can send at the same time or signals confuse each other
  - Likewisw with WLAN
- Solution: everybody waits until nobody is sending
  - CSMA, Carrier Sense Multiple Access
- Other solutions: have a master controller or give everybody a fair share
  - Many sensor or field bus networks have a master controller
  - Token Ring nodes are organized in a ring and a data pattern called token is passed around in order, whoever has the token has a right to send

Collisions in the Shared Media



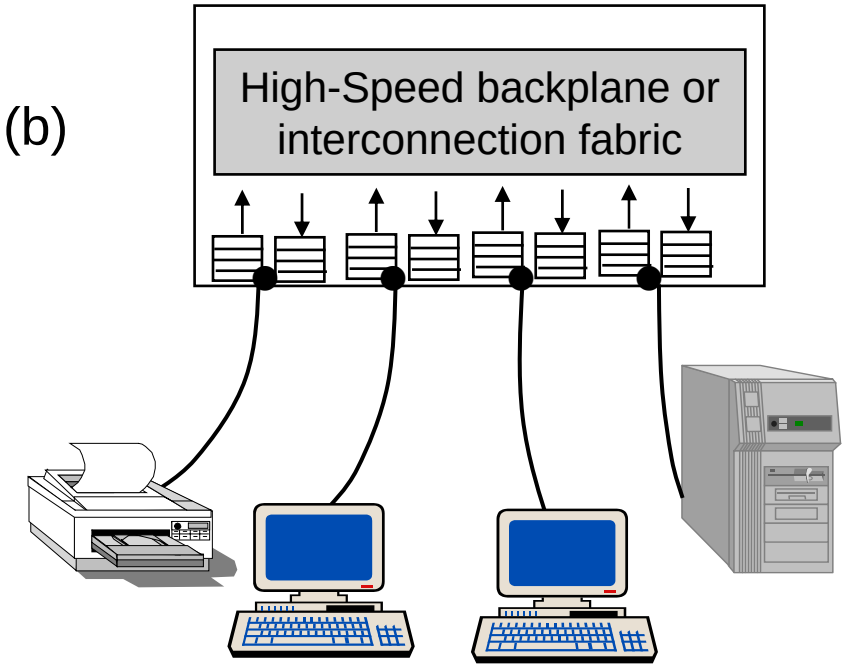
- Collisions happen, so a strategy is needed to manage them
  - Collision Detection and resend: CSMA/CD (Ethernet)
    - When two stations on an Ethernet send simultaneously they recognize the collision, each party stops sending and starts again after a random time
  - Collision Avoidance e.g. reservation of the media: CSMA/CA (WLAN)
    - WLAN nodes ask the access point for a permission to send

Current Ethernet Hubs & Switches



Hub (keskitin):
Star-topology CSMA/CD

Both:
Twisted Pair is cheap
Easy to work with



Switch (kytkin):
Bridging increases scalability
Separate collision domains
Full duplex operation
Star topology

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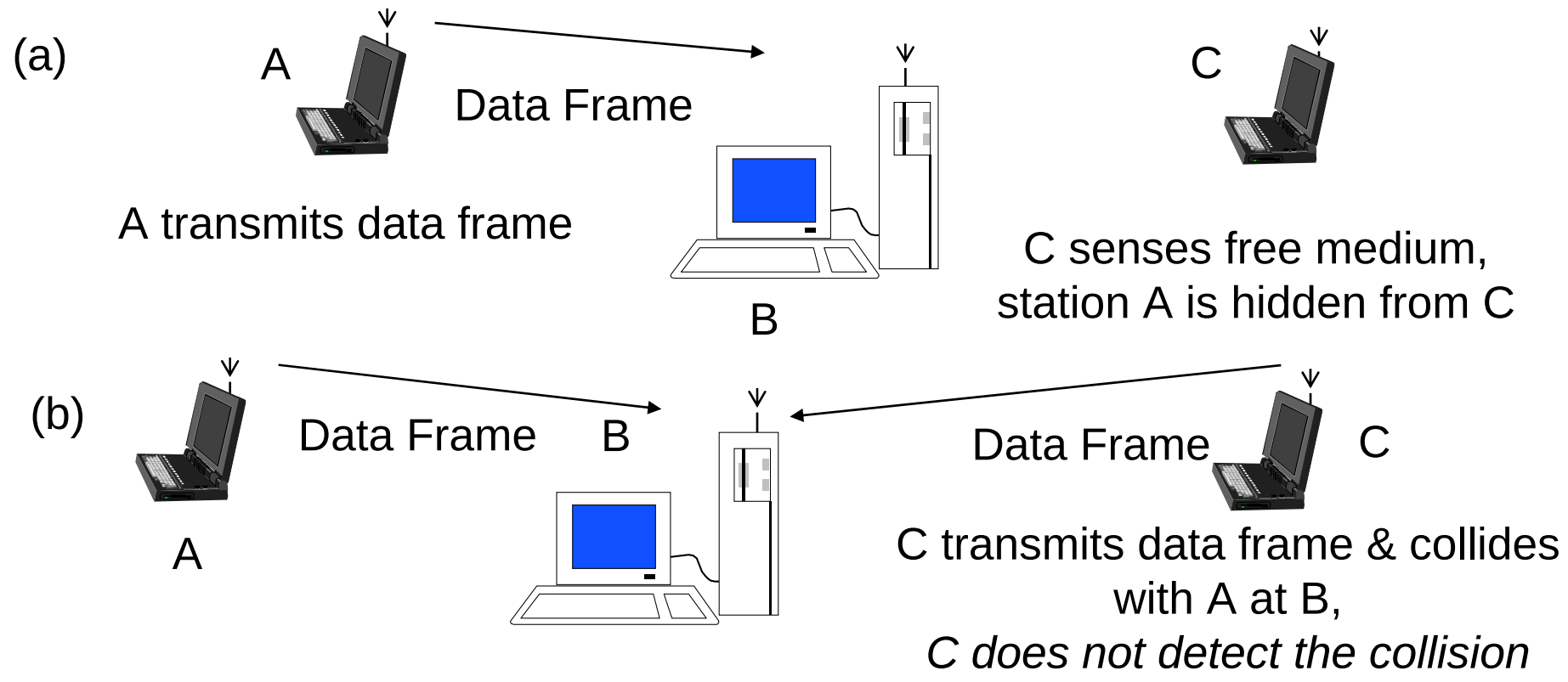
WLAN Hidden Node Problem



- New MAC algorithm: CSMA with *Collision Avoidance*
- A and C send Request To Send messages
- B decides who can send with a Clear To Send message

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IP on LAN

- A computer on the network should know its:
  - Own IP address
  - Gateway (router, firewall) IP address
  - Netmask
- Own IP address is obvious
- Gateway is needed to connect the host to the Internet and is recognized by its IP address
- Netmask is a *binary mask* that enables the operating system to recognize which addresses are on the LAN and which can be accessed through the gateway:

```
IP: 192.168.1.100
GW: 192.168.1.1
NM: 255.255.255.0
```

- This means that all 192.168.1.* addresses are on the LAN

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IP Addresses

- IP address identifies a network interface. A host can have several interfaces.
- Current length is 32 bits (IPv4).
  - Future length is 128 bits (IPv6).
- General syntax:
  - 4 components (bytes) separated by dots ("dotted quad")
  - Represented as decimal numbers (0-255)
  - For example: 193.210.18.18
- Addresses have two components, the network id and the host id.

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Address Resolution Protocol

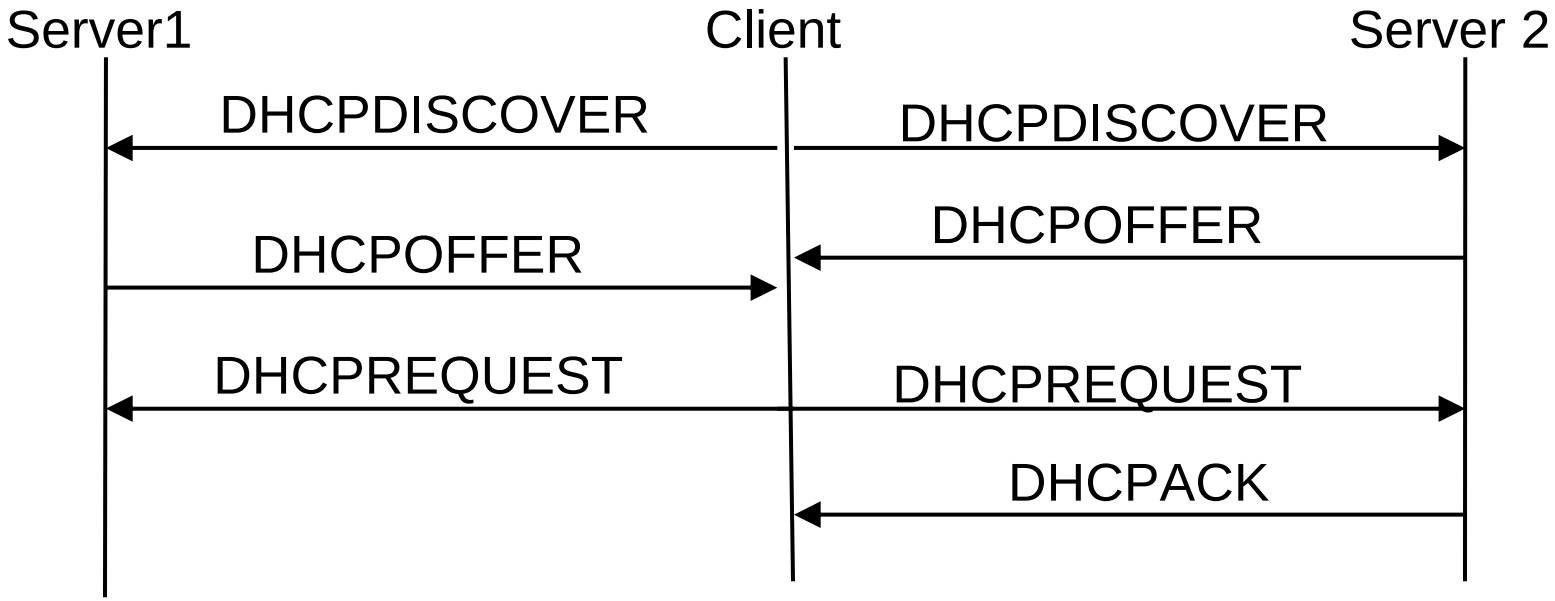
- Problem: IP addresses only make sense to the TCP/IP protocol suite, not to the hardware (Ethernet) interface
- Solution: ARP maps IP addresses to hardware addresses

- A host finds other hosts by broadcasting an ARP query for the IP address
- The host with correct IP address replies with its hardware address
- The address pair is added to receiver's dynamic ARP cache
  - See: `arp -a`

- But how to know my own IP address?

DHCP

- Dynamic Host Configuration Protocol)
- Automatic assignment of IP addresses
  - Dynamic assignment for a limited time
  - Or a permanent address tied to the MAC address
- Used when a host enters a new LAN segment
  - At boot time, or a portable computer connects



DNS

- A translation between host names (mostly for humans) and IP addresses
- Based on distributed servers
- Each organization can maintain the data for their own *zone*
  - Zones are delegated from above organizations in the hierarchy
  - E.g. Ficora in Finland maintains the fi zone and they have delegated tkk.fi to TKK
- Thus:

```
vipunen kiravuo 56 % /usr/sbin/dig www.hut.fi
www.hut.fi.     3600    IN    A   130.233.240.9
ns1.hut.fi.     3600    IN    A   130.233.224.1
```

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The Physical Layer

- What is really happening in the Ethernet network, GSM phones, WLAN etc.

- How to send a digital signal over a physical medium?
  - The digital signal can be coded and the coding sampled at the receiving end
- How to translate an analog signal to digital?
  - Analog signals can be sampled and translated to a digilat representation

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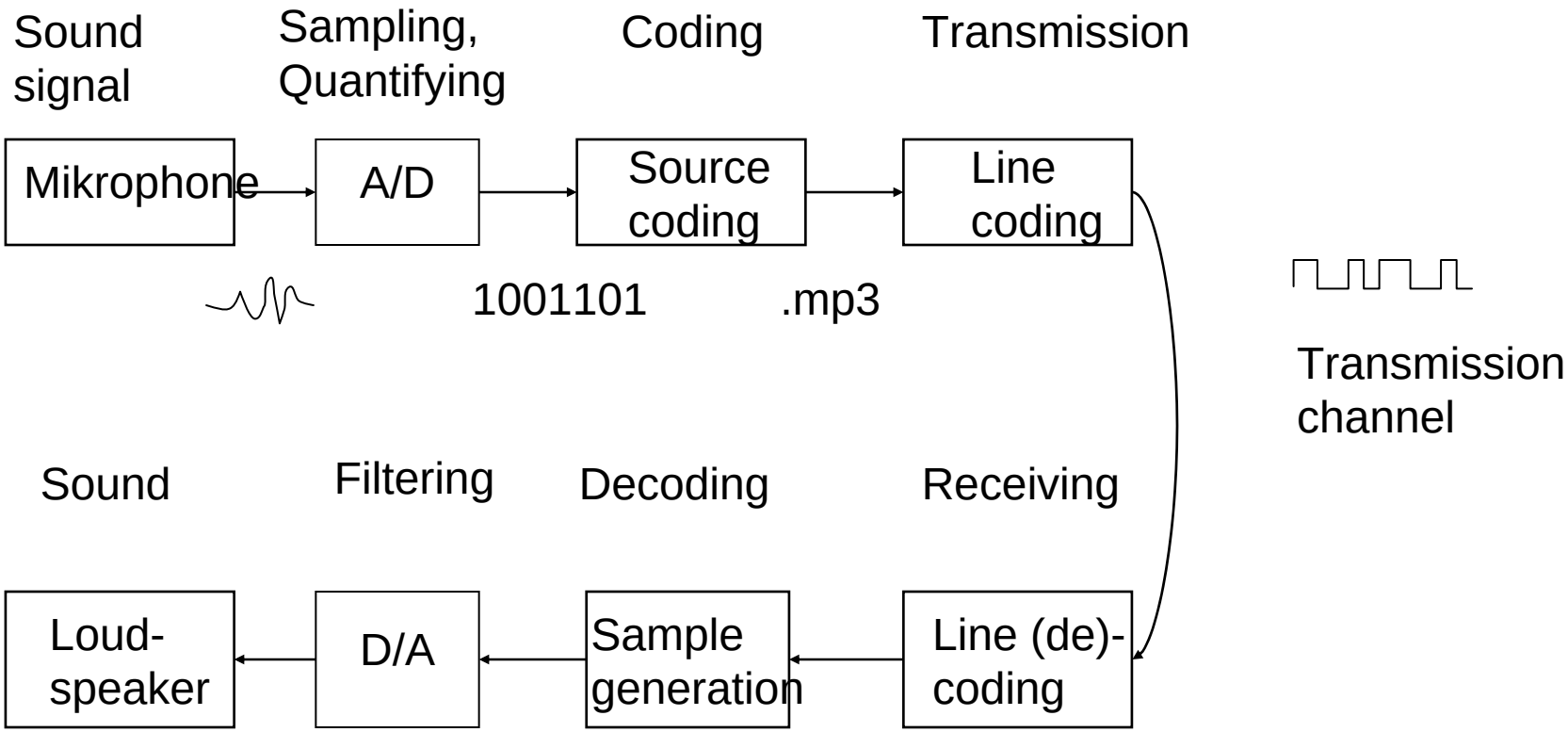
How is Digital Voice Transmitted?



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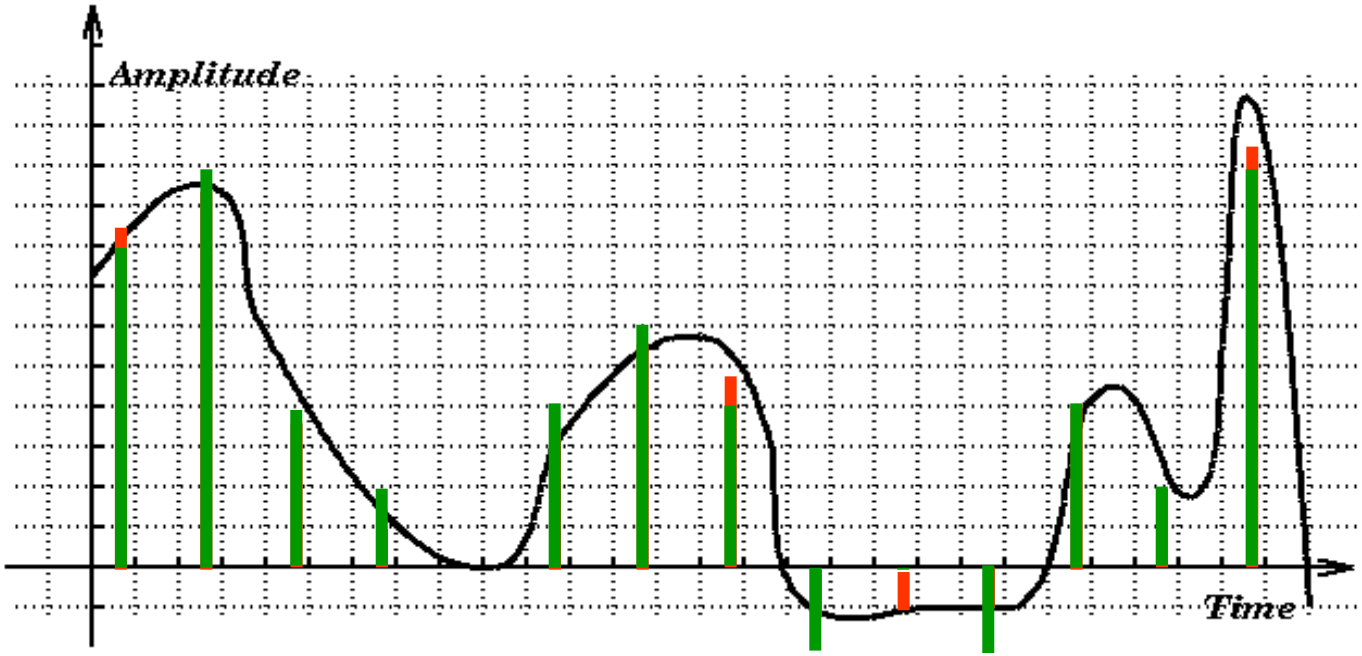
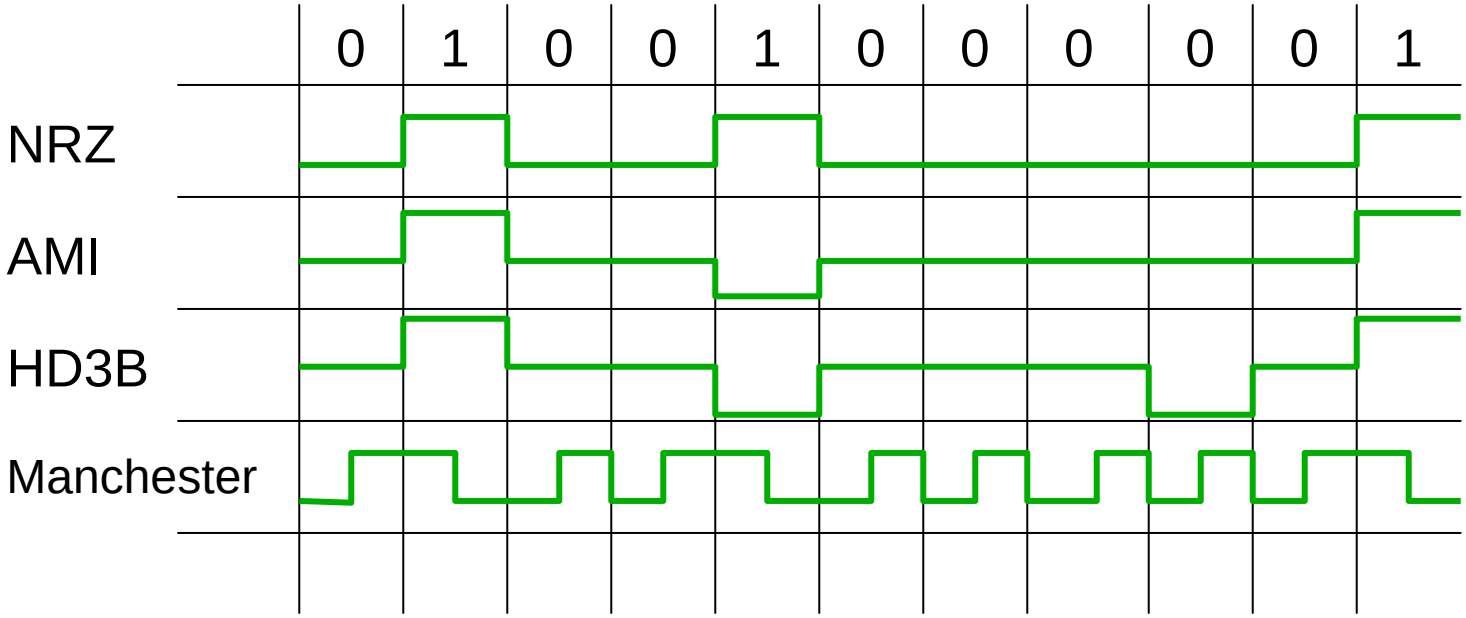
Why Digital Transmission?

- In optimal conditions analog transmission provides superior quality
- However conditions over any meaningful transmission path are usually not optimal
  - It is usually impossible to figure out which part of an analog signal is distortion and which is original
- It is easy to recreate an exact replica of a digital signal
  - Digitalization loses a pre-defined amount of detail

Sampling and Quantizing

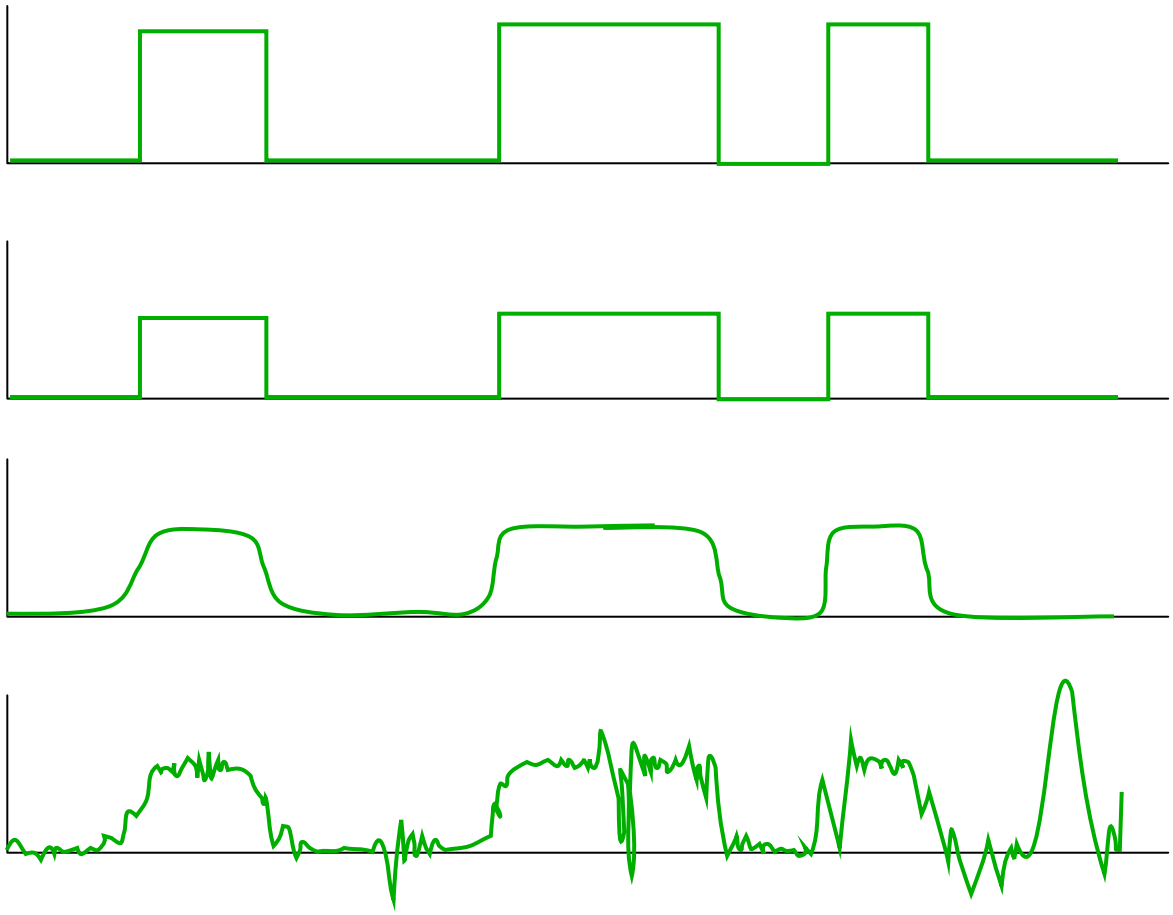


Line Coding for Transmitting Digital Data



- Line coding is used over high quality media (e.g. Ethernet or optical cabling)
  - Very little noise or other signals
- The coding provides a method to identify 0s and 1s

Transmission Errors



- Original signal
- Attenuated
- Limited bandwidth
- Noise

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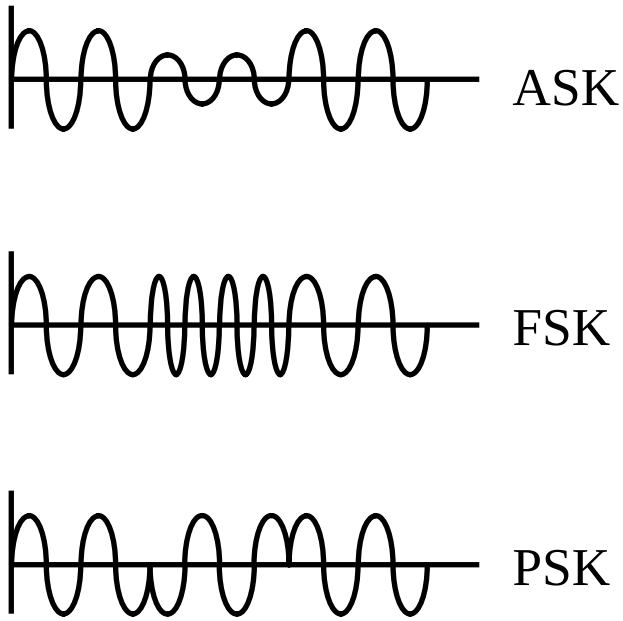
Modulation for Digital Signals

- A carrier wave can be used to transport the signal
- amplitude modulation (AM), amplitude shift keying (ASK)
- frequency modulation (FM), frequency-shift keying (FSK)
- phase modulation (PM), phase-shift keying (PSK),



- Modulation is used when the media has noise or interference, the receiver can create a reference signal and detect the differences that contain the data

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An example of a whole system: ADSL

- ADSL (Asymmetric Digital Subscriber Line) uses a single twisted pair, and allows simultaneous transmission of downstream simplex, duplex, base band analogue, ADSL line overhead and framing, error control, operations and maintenance.
- Uses Discrete Multitone (DMT) modulation, where the frequency spectrum is divided in narrow sub bands, each of which can be configured separately
- ADSL transmission is possible simultaneously with POTS, analogue modems, ISDN.
- ADSL has a low speed full-duplex bearer channel and a high speed bearer channel on the downstream direction.
- ADSL version ITU-T G.992.1 supports 6.144Mbps downstream and 640kbps upstream.
- ADSL version ITU-T G.992.2 supports up to 1.563Mbps downstream and 512kbps upstream.
- ADSL provides transport of STM and/or ATM.

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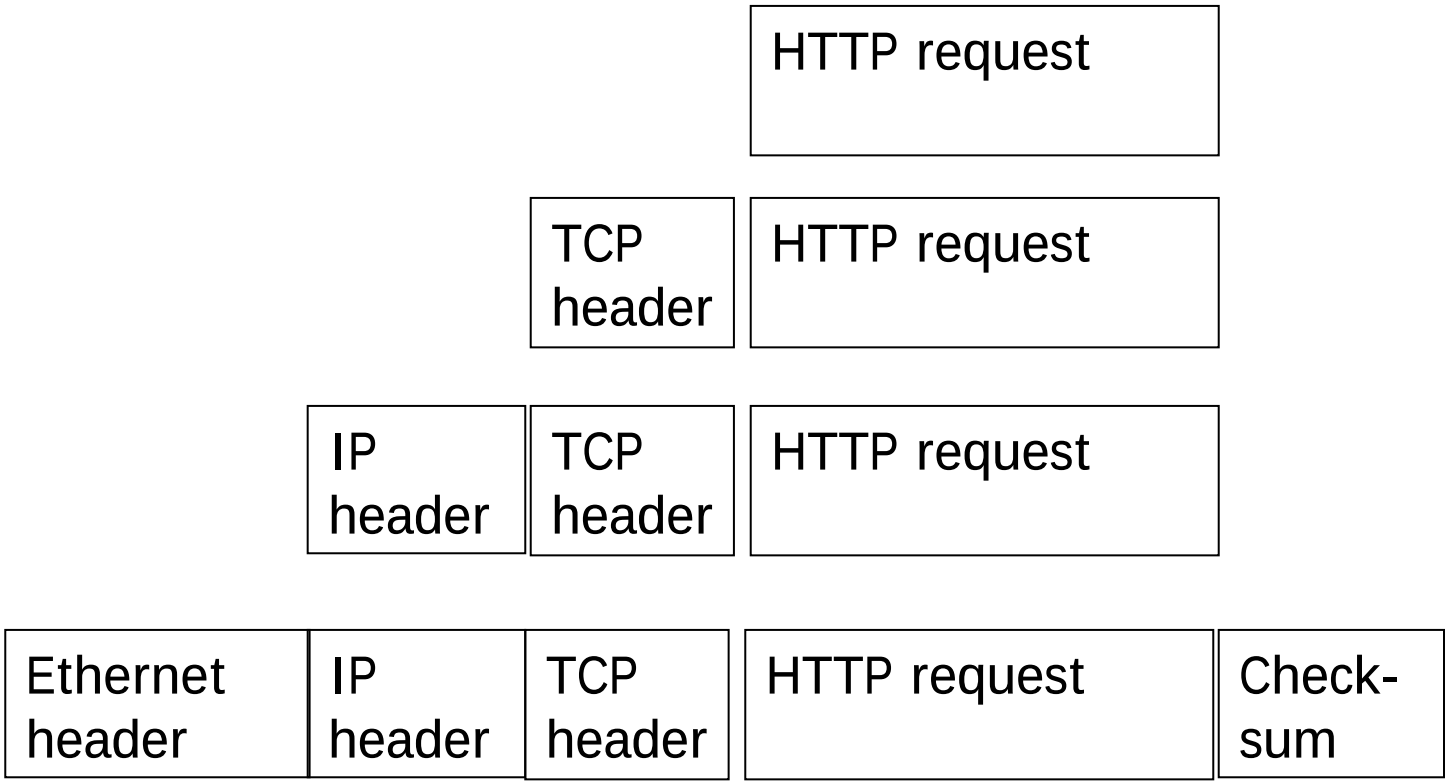
Traffic Encapsulation



- Encapsulation allows the use of several techniques at the same time
  - Different layers implement different methods

Summary

- LANs are needed to move data over shared local networks
- The Internet Protocol transmits data from LANs to other LANs regardless of the differences in underlaying protocols
  - Otherwise WLAN could no provide access to Ethernet services
- Modulation or line coding is used at the physical layer to transmit bits