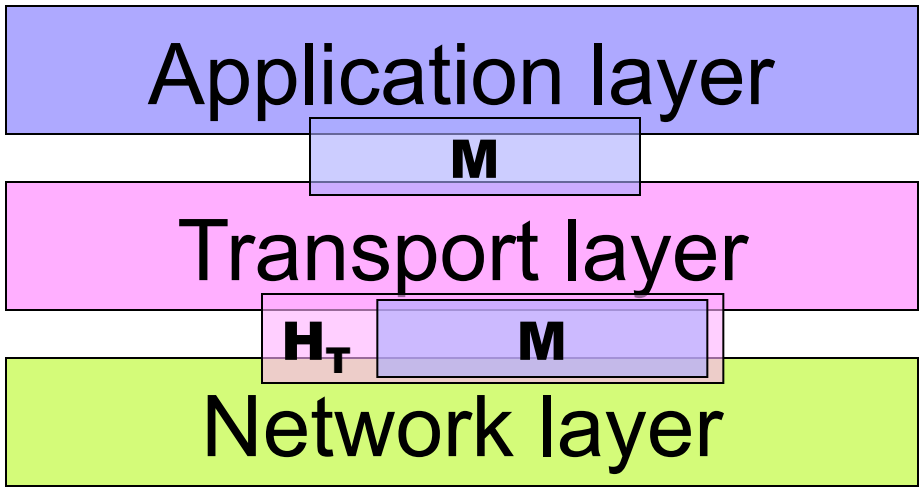
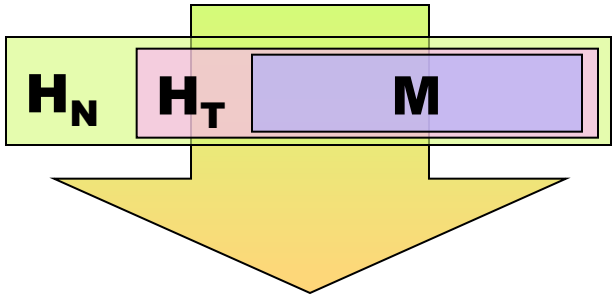
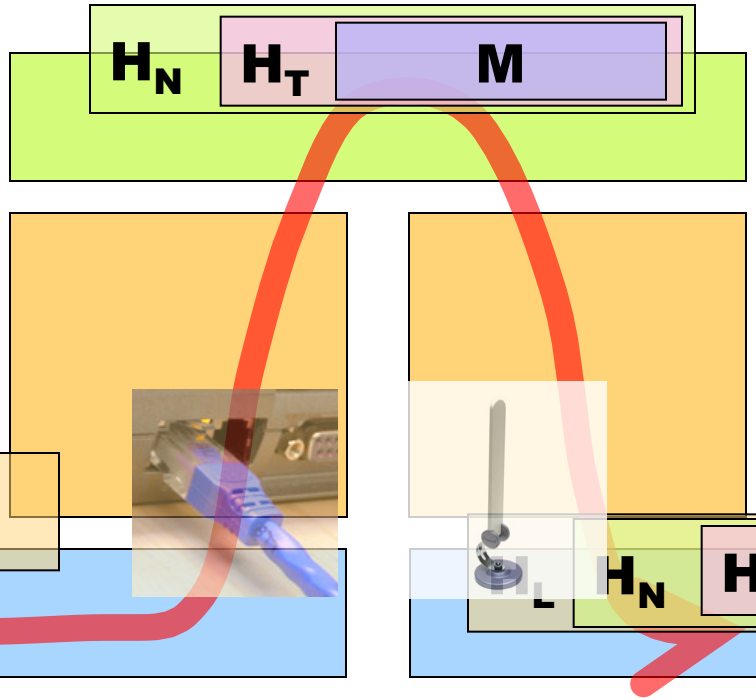
Access networks & Physical layer

Task of the link layer

Delivery of messages to another node attached to the same physical medium or channel







Issues to deal with in the link layer

- Synchronization
  - The recipient must read the information at the right rate
  - Sender and receiver may disagree on the current transmission rate
- Coordination
  - For shared media or channels
    - Who should send now?
    - What happens when two nodes send at the same time?
  - For point to point connections
    - What is the maximum rate that can be used?
    - Negotiating special features
      - Compression, Error correction, ARQ scheme, encryption...

Protocols in the link layer

- Medium Access Control (MAC) protocols
  - Link layer is sometimes called ”The MAC layer”
  - Own addresses (”MAC addresses”)
    - Also called link layer addresses or physical addresses
- Translating IP addresses to MAC addresses
  - ARP (Address Resolution Protocol)
  - Broadcast query ”Who has IP x.x.x.x?”
  - Node with matching IP address answers, ”me, and my MAC address is x:x:x:x:x:x”

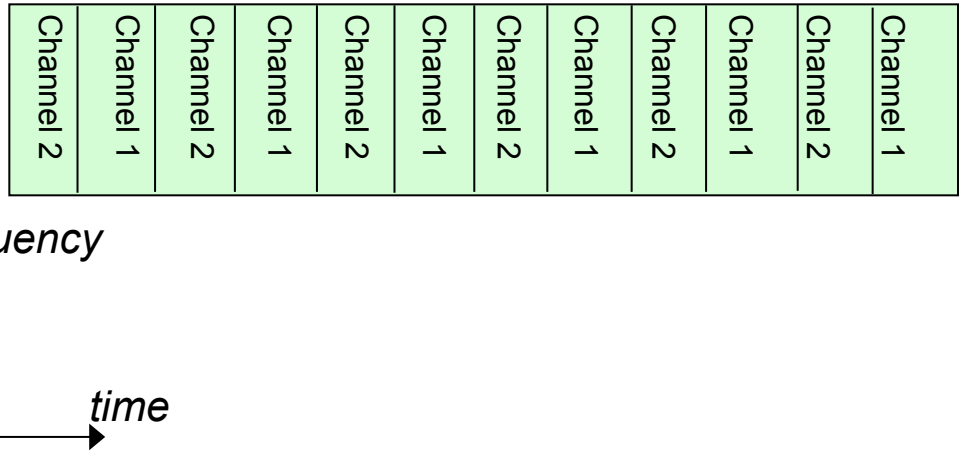
Different types of MAC protocols

- Channel partitioning
- Random access
- Taking turns

Channel Partitioning

- Divide channel in smaller pieces
  - w.r.t. frequency, time, ...
- FDMA: Frequency Division Multiple Access
  - Creating separate frequency bands

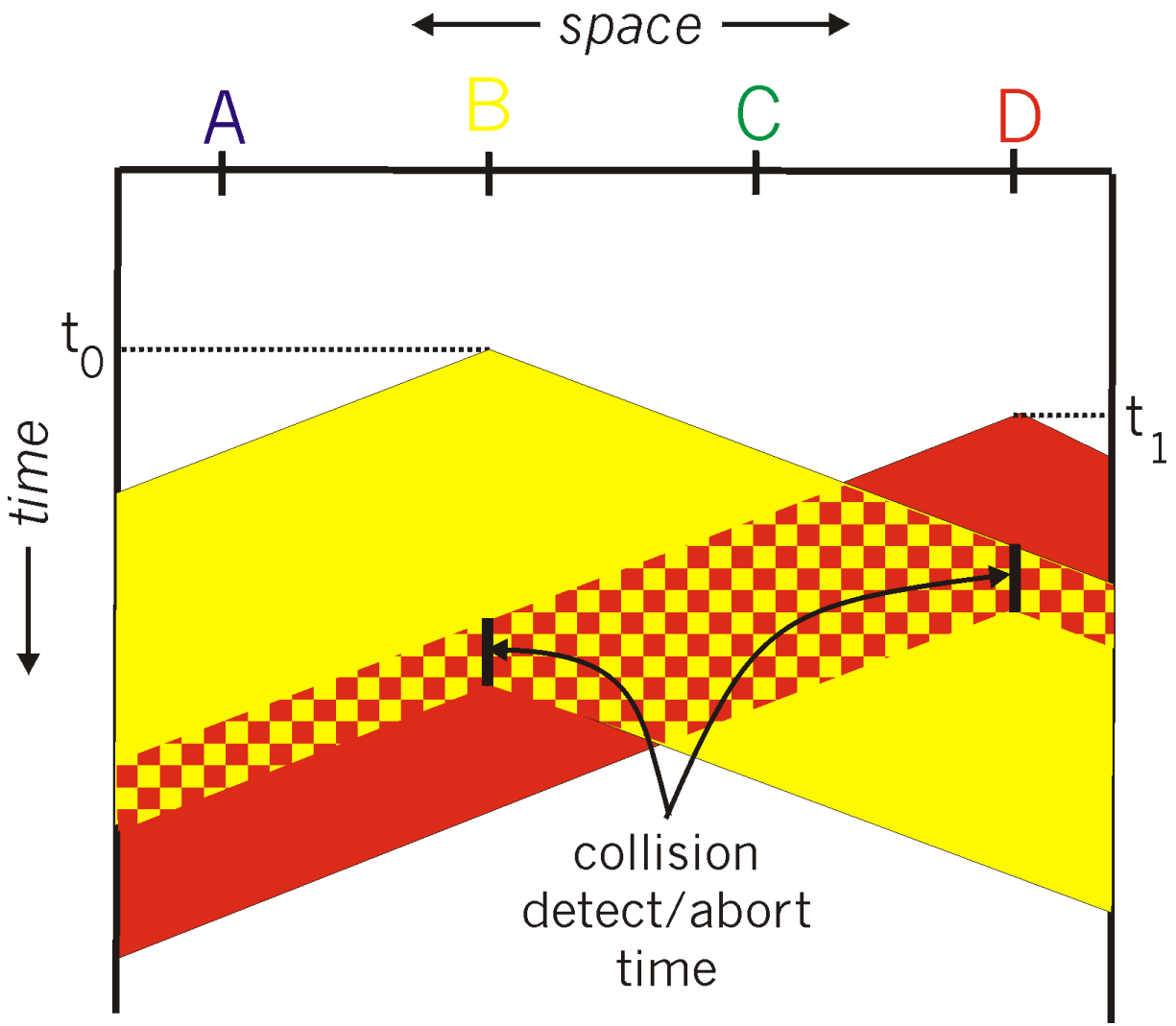
- TDMA: Time Division Multiple Access
  - Creating time slots



Random Access

- When a node has something to send
  - Attempt to send if it seems ok
  - Detect collisions
- No coordination between nodes
  - Collisions are dealt with afterwards
- The MAC protocol defines
  - How to detect if it is ok to send
  - How to detect and handle collisions
  - How to avoid collisions

Collision detection for Random Access MAC protocols



Collision handling in Ethernet

- Listen while transmitting data

- If colliding transmission is detected:
  - Send jam signal
  - Back off for a random amount of time
    - Increases with every collision for the same frame
  - When 96 bit times of silence is detected, make another try

Synchronization and Coordination in Ethernet

- No coordination
  - Distributed collision handling
- Synchronization
  - Before each frame, a *preamble* is sent

Carrier sense and Collision detection in Ethernet

Consider two nodes A and B on the same Ethernet segment, and suppose the propagation delay between them is 225 bit times.

a) Suppose at time t=0, both nodes A and B begin to transmit a frame. At what time do they detect the collision?

b) Assuming both nodes transmit a 48-bit jam signal after detecting a collision, at what time (in bit times) do nodes A and B sense an idle channel? How many seconds is this for a 10 Mbps Ethernet?

Taking turns

- Polling
  - One master and several slaves
  - The master node offer slaves to transmit, one at a time
  - Issues
    - Extra overhead
    - Increased latency
    - Single point of failure
- Token passing
  - Pass virtual token around
  - Node with token may transmit
  - After completed transmission, or if no data to send, pass token along
  - Issues
    - Latency

What about coordination and synchronization in taking turns-style access networks?

Wireless Access networks

- Hard to transmit and receive simultaneously
  - Collision detection may be hard
- Uncontrolled medium
- Coordinated transmissions

Communication in the ISM band

- Unlicensed frequency bands
  - 900 MHz, 1.9 GHz, 2.4 GHz, 5.8 GHz
  - Slight variations in some countries
- Max 100 mW transmission power
- Used by WiFi, Bluetooth, ...
  - Interference by poorly shielded microwave ovens

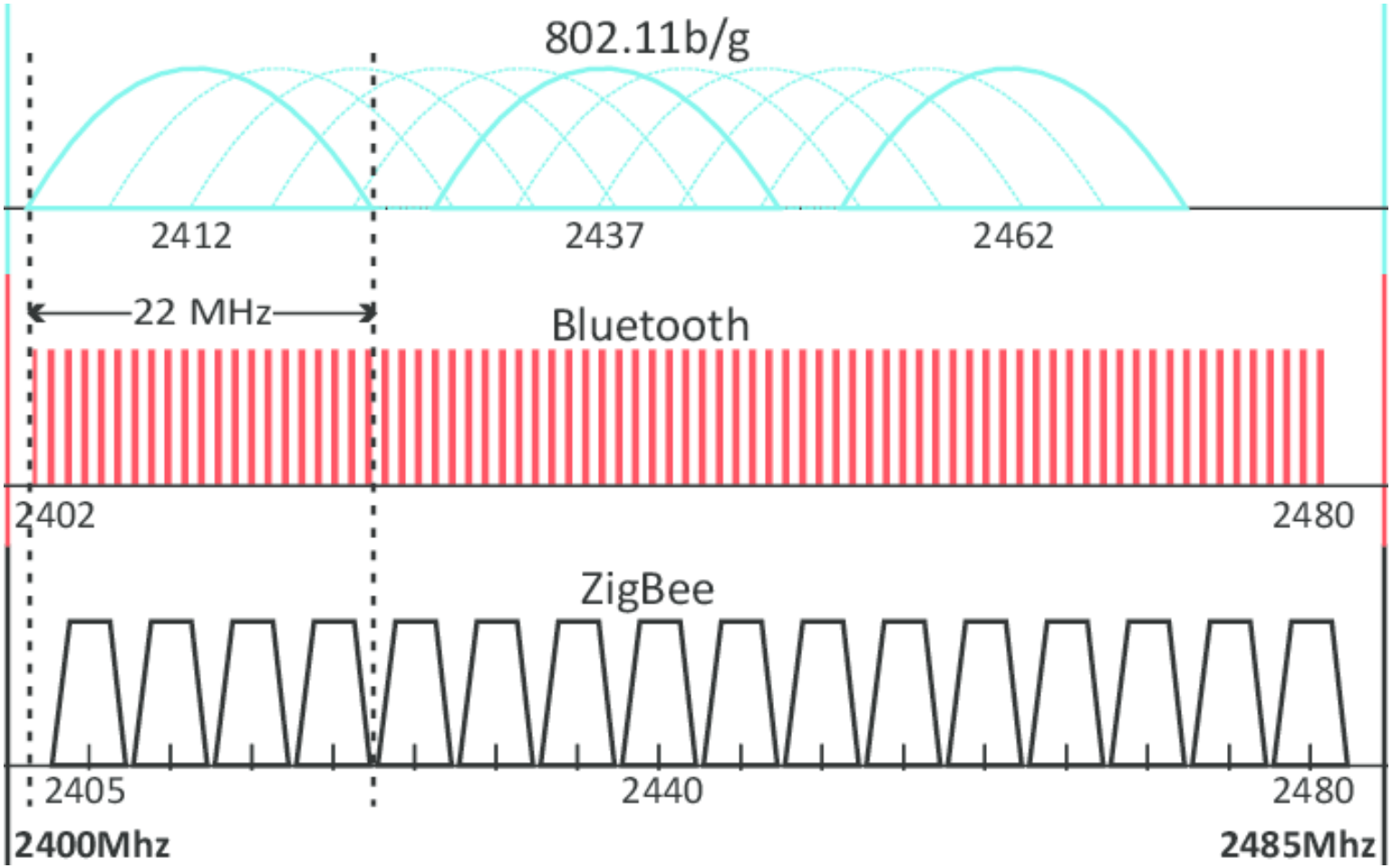
WiFi

- Several standards, from 2Mbit/s to 54 Mbit/s
  - Using multiple channels for higher speeds
- Range: in general 20-100m, depending on the environment
- Can be used in ad hoc or infrastructure mode
  - Ad Hoc: like a wireless Ethernet
  - Infrastructure: a coordinating base station
- Networks identified with SSID:s
  - Used to scramble signal somewhat
- Encryption with WEP (bad), WPA(better), WPA2 (best)

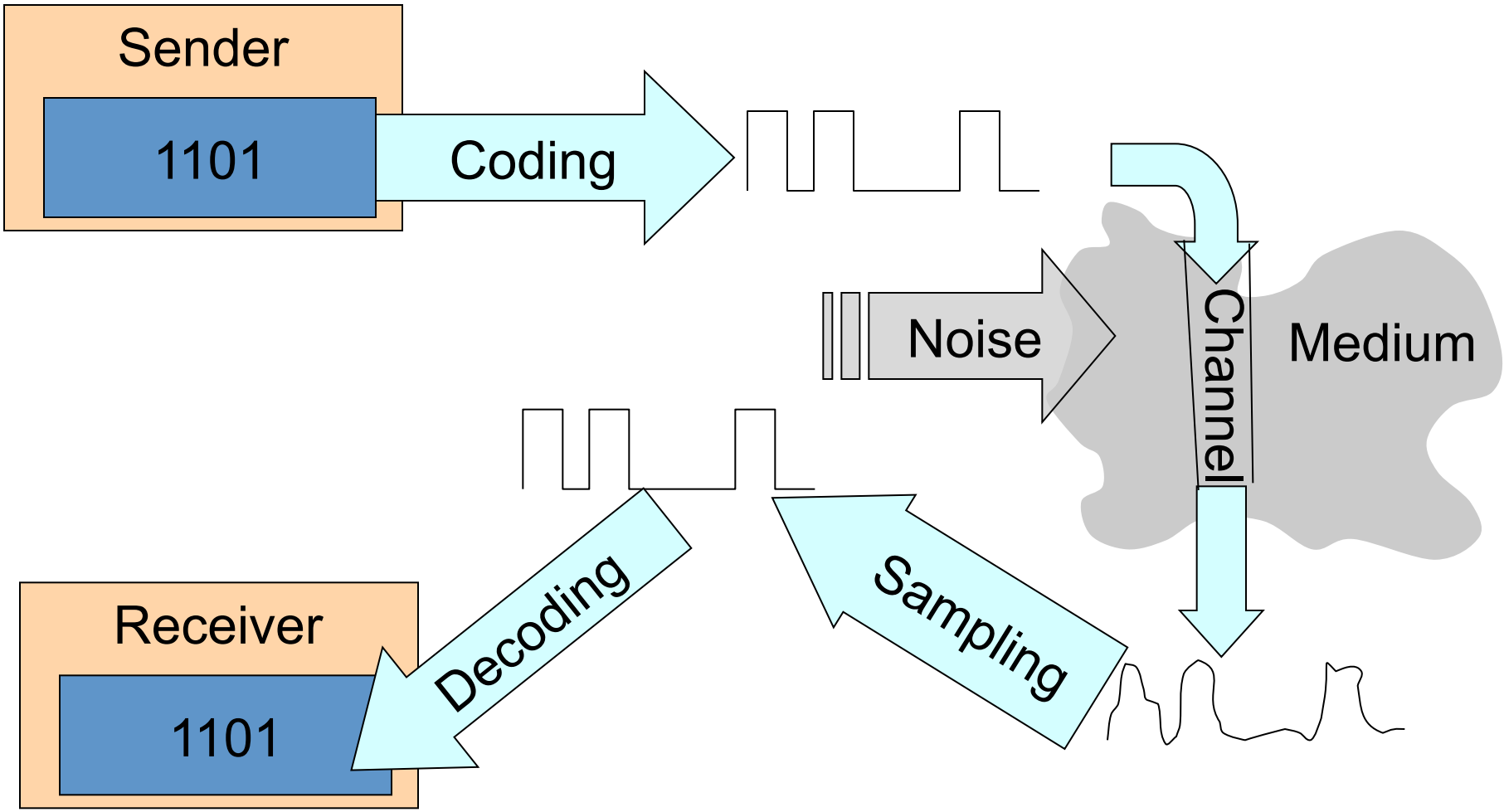
Bluetooth

- Several different versions
  - Different transmission power (and hence ranges)
- Different profiles for different applications
- Frequency hopping 1600 times/s in ISM band
- Peer to peer or piconet networks
- Max 7 simultaneous connections
  - Max 255 units in a piconet
- Encryption available

Channels in ISM band

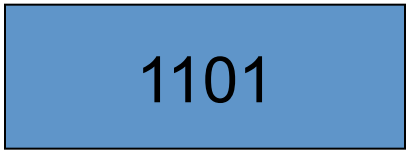


The physical layer

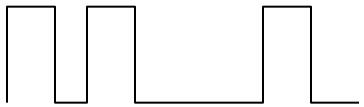


Coding

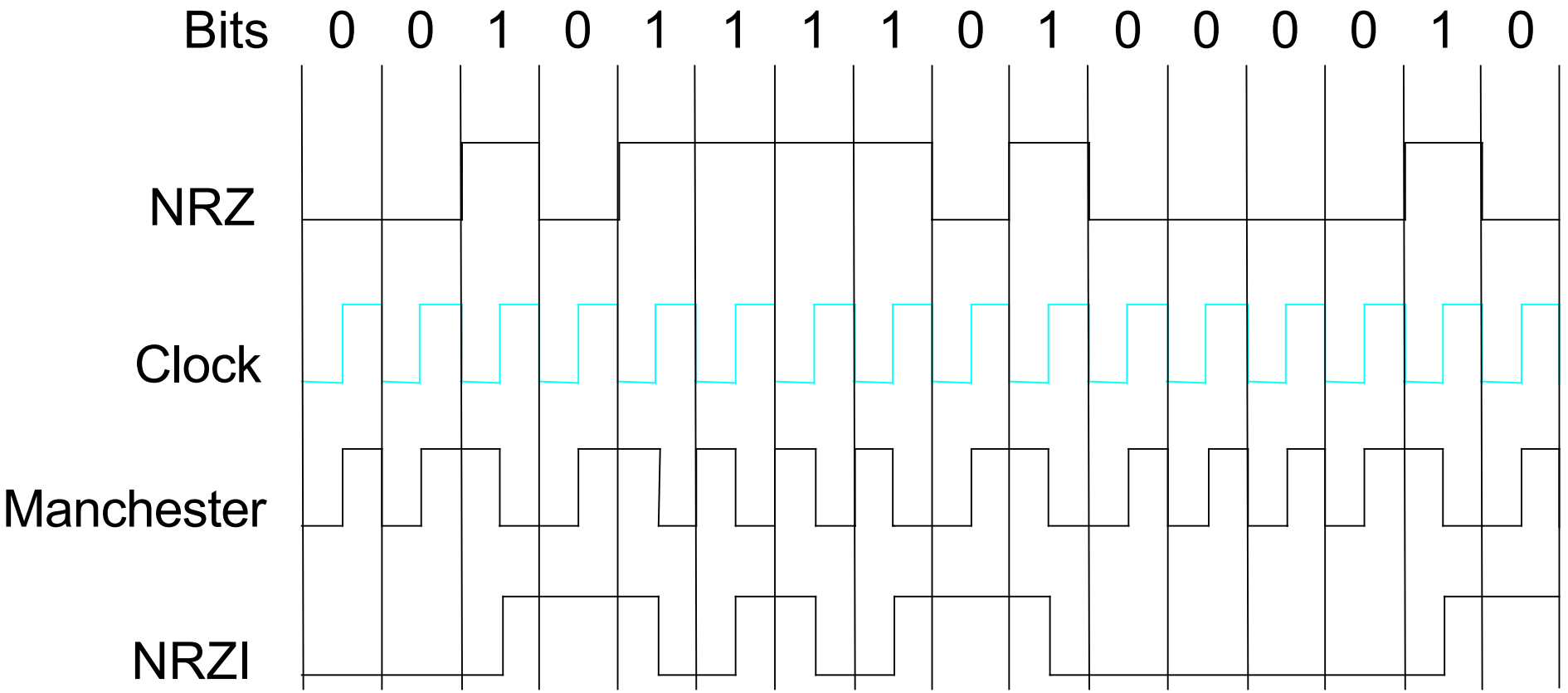
- Input: A sequence of bits



- Output: A sequence of *symbols*



Examples of coding schemes



Coding vs Modulation

- Coding
  - Translating data to symbols
  - Digital representation
- Modulation
  - Analog representation
  - Combine the symbols with a carrier
    - Amplitude modulation
    - Frequency modulation
    - Phase modulation

Properties of a medium

- Bandwidth *B*
  - Frequency range for signals transmitted in medium
- Signal/noise ratio *S/N*, *SNR*
  - Signal level / noise level
  - Measured at the receiver
  - Can be approximated with Maxwell's equations
- Capacity $C=B\ log_2\ (1+S/N)$

Sampling

- Bandwidth *B Hz* is sampled at *2*B* Hz
  - Nyquist criteria
  - Sampling at <2*B result in distortion
  - Sampling at >*2*B* unnecessary
    - Makes it easier for non-linear filters