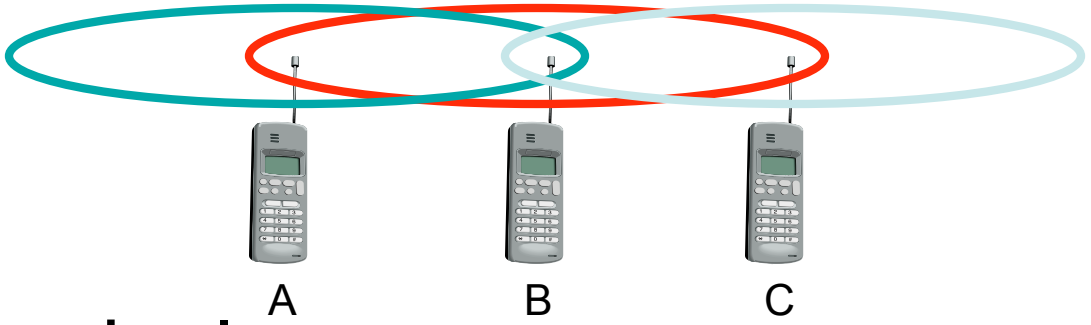
Medium Access Control

Medium Access Control (MAC)

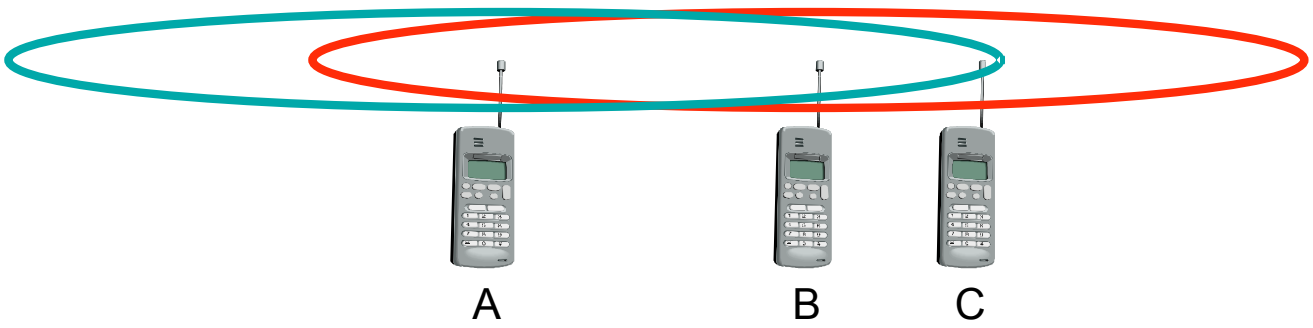
- MAC algorithms regulate access to a medium using any of the multiplexing schemes
- Wired networks: sender can detect collisions
- Wireless networks
  - Signal strength decreases proportional to $1/d^2$
  - Collisions happen at the receiver
  - Sender can't "hear" the collision

Hidden / exposed terminals



- Hidden terminal
  - A sends to B, C senses “free” medium
  - Collision at B, A can’t receive it
  - A is “hidden” for C
- Exposed terminal
  - B sends to A, C wants to send to a 4th terminal
  - C has to wait, senses medium in use
  - C is “exposed” to B

Near and far terminals



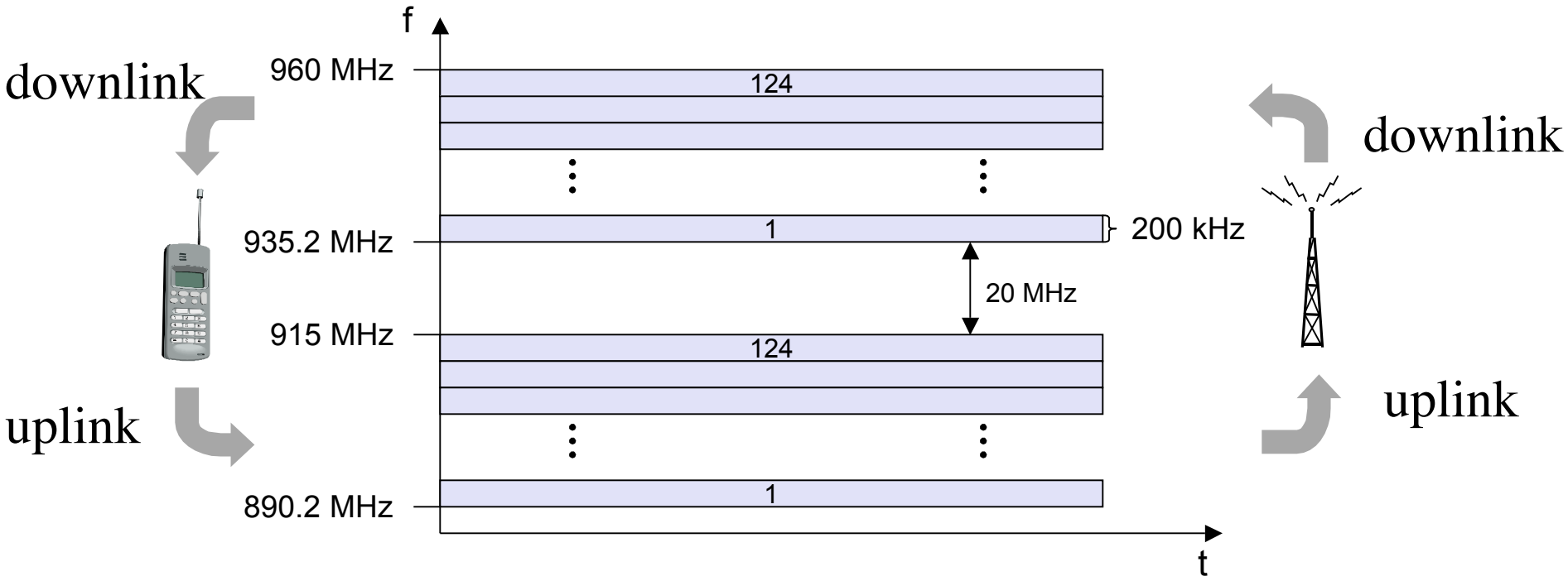
- A and B send to C
- Signal of terminal B drowns out A’s signal
- C can’t receive A

- Problematic in CDMA
- Power control required to receive all senders with the same strength (UMTS)

SDMA and FDMA

- Space Division Multiple Access (SDMA)
  - Segment space into sectors, use directed antennas
  - Cell structure
- Frequency Division Multiple Access (FDMA)
  - Allocate frequencies to channels using FDM
  - Fixed or dynamic allocation
  - Pure FDMA or FDMA + TDMA
  - FDM used for duplex channels
    - Frequency Division Duplex (FDD): uplink and downlink at different frequencies

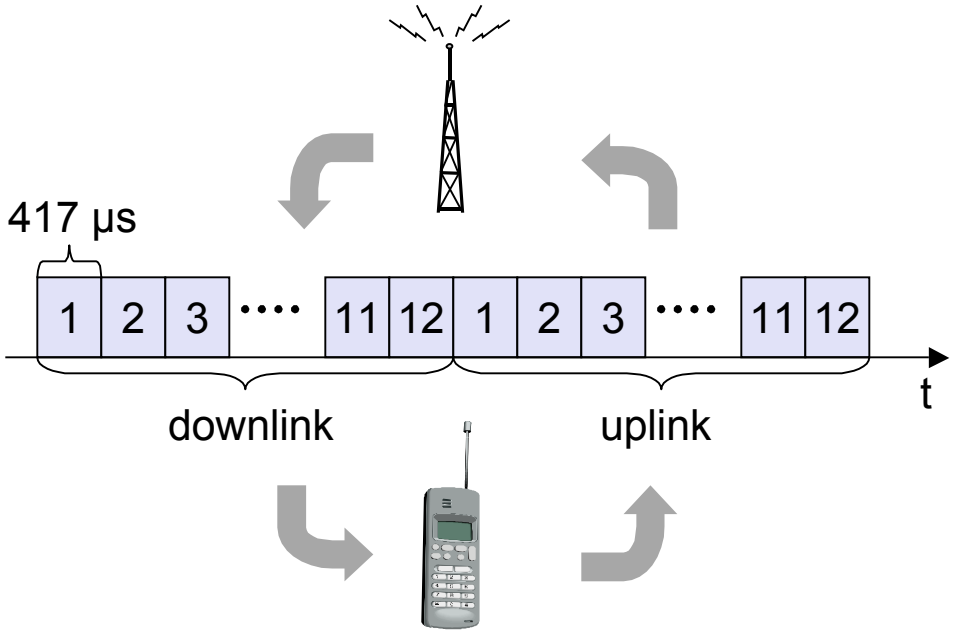
FDD/FDMA example: GSM



Time Division Multiple Access (TDMA)

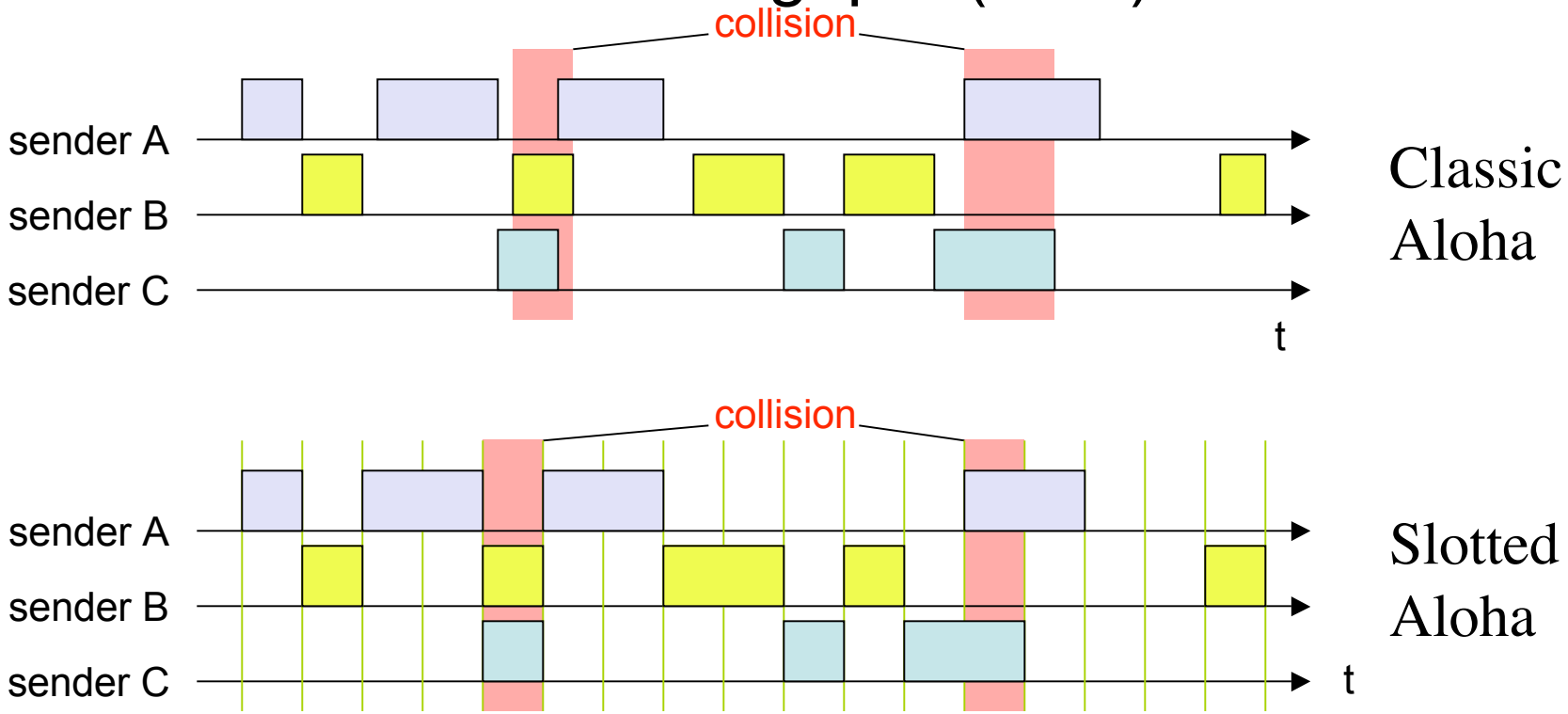
- Used for most wired MAC schemes (ethernet)
- Sender-receiver synchronisation in the time domain:
  - Dynamic allocation requires identification of each transmission (MAC address)
  - Fixed schemes don't need identification, but not as flexible with varying bandwidth requirements
- Fixed TDM
  - Time slots allocated in fixed pattern
  - Simple, just need to sync with base station slot pattern
  - Good for fixed delay and bandwidth applications
  - Time Division Duplex (TDD)
    - Slots on same frequency for uplink and downlink
  - Inefficient for bursty or asymmetric data communication

TDD/TDMA example: DECT



Aloha

- Stations can always access the medium
- Collisions resolved by higher layers
- Works fine for light load, maximum throughput is 18%
- Slotted Aloha doubles throughput (36%)

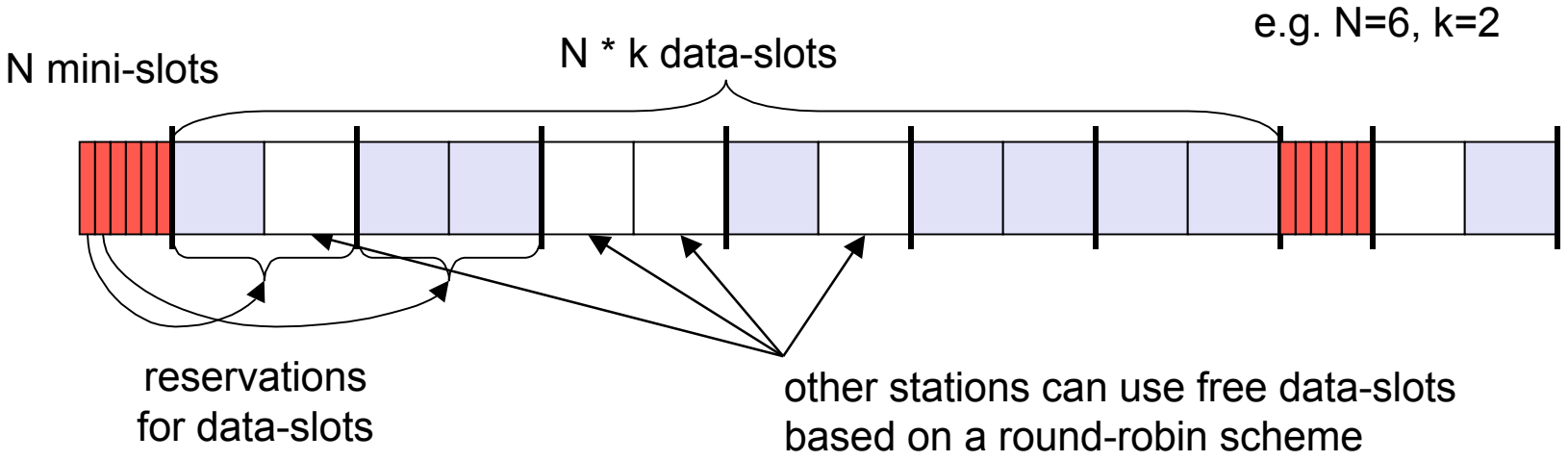


Reservation schemes

- Explicit reservation: Demand Assigned Multiple Access (DAMA)
  - Used in satellite systems
  - Aloha used for reservation phase
  - Collisions destroy only requests for transmission
- Implicit reservation: Packet Reservation Multiple Access (PRMA)
  - Several slots form a frame
  - If a station succeeds with reservation all future slots reserved for it
  - Transmission with guaranteed data rate and delay, Aloha used only for idle slots

Reservation schemes II

- Reservation TDMA
  - Each frame consists of N mini-slots and x data-slots
  - Each station has its own mini-slot used to reserve up to k data-slots in the next frame
  - Other stations can send data on unused data slots on round-robin or Aloha fashion (best effort traffic)

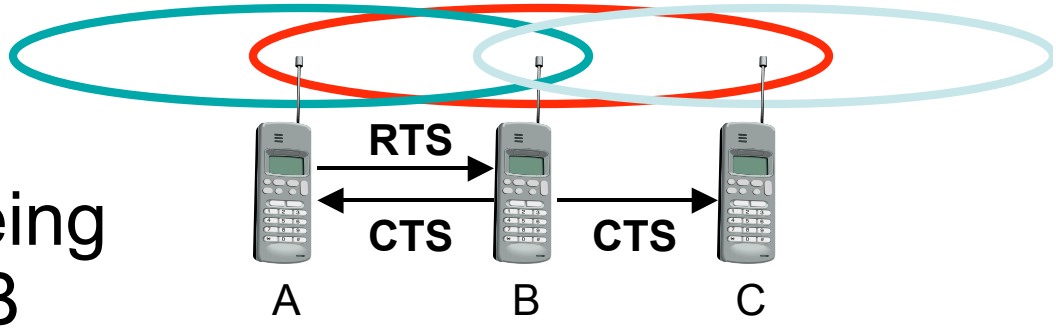


Multiple Access Collision Avoidance (MACA)

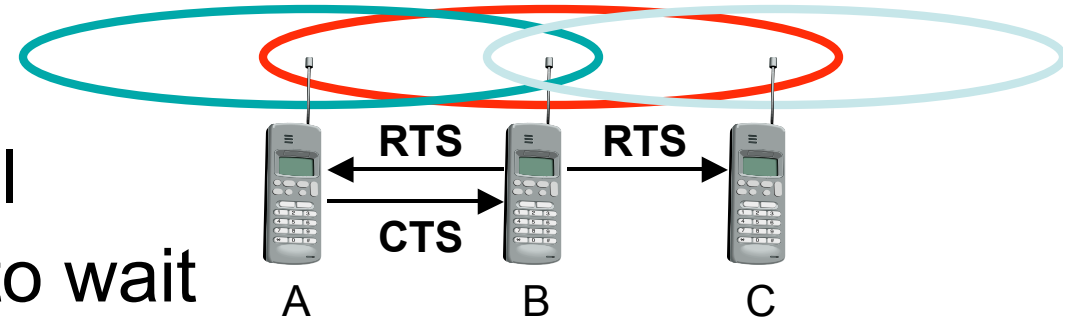
- Uses short signaling packets for collision avoidance
  - RTS (Request To Send): sender sends RTS before sending data with name of sender and receiver
  - CTS (Clear To Send): receiver sends CTS with names of sender and receiver
- Hidden terminal see the CTS and know that the medium is reserved for the sender
- Exposed terminals don’t see a the CTS so can assume that they won’t interfere with sender
- Disadvantage: overhead of RTS and CTS signals

MACA examples

- Solving hidden terminals
  - A and C want to send to B
  - C waits after seeing CTS for A from B



- Solving exposed terminals
  - B wants to send to A, C to a different terminal
  - C doesn't have to wait as it can't receive the CTS from A



Polling and ISMA

- Polling
  - Centralised scheme with a master (base) station and several slave stations
  - Master can poll according to several different schemes (round-robin, random, …)
- Inhibit Sense Multiple Access (ISMA)
  - Base station signals BUSY/IDLE tone
  - Terminals don’t access medium while BUSY
  - After BUSY stops uplink access is free
    - Base station acknowledges successful transmissions

Code Division Multiple Access (CDMA)

- Uses codes to separate users and enable shared access
- Main issues
  - Finding good codes: good autocorrelation and orthogonal to others
  - Separating signal from noise
- Spread Aloha Multiple Access (SAMA)
  - SAMA uses Spread Spectrum with a single code for all users (“CDMA without CD”)
  - Signal separation for synchronised sender-receiver
  - Maximum throughput of 18%, like Aloha
  - Robust against narrowband interference