Unit 2

Medium Access Control

CSMA/CD , Hidden and exposed terminals, Near and Far terminals,

SDMA,

FDMA,

TDMA- Fixed TDM, Classical Aloha, Slotted Aloha, CSMA, DAMA, PRMA, Reservation TDMA,MACA , Polling

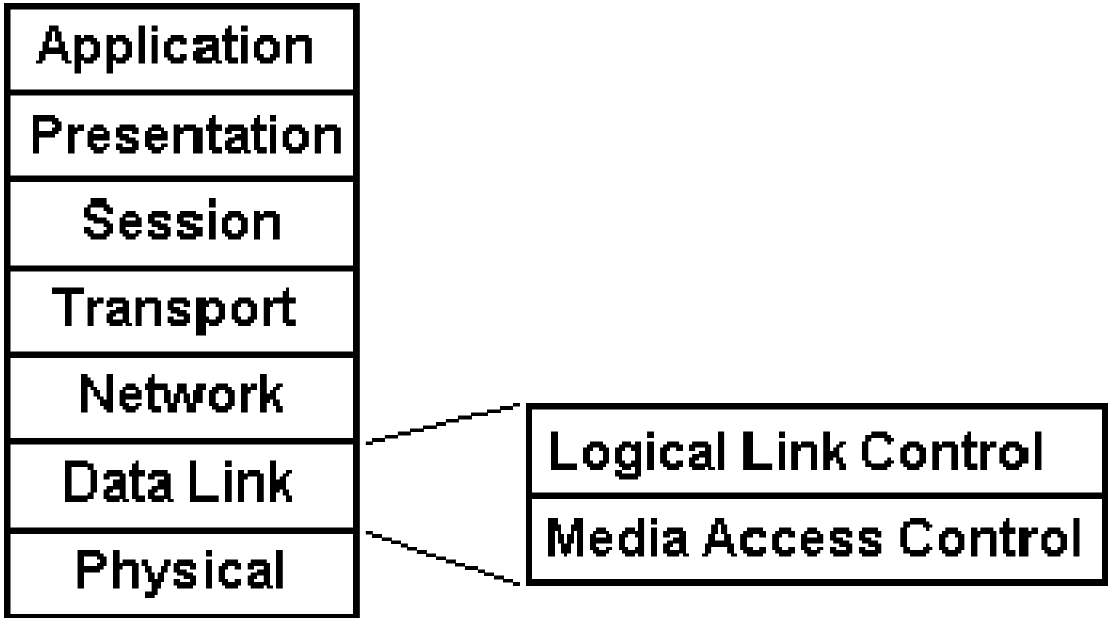
CDMA.

Introduction

- Data link layer is divided into two parts

1. Logical Link Control (LLC)
2. Medium Access Control (MAC)

- MAC – Similar to traffic controller on highways.



CSMA/CD

- A sender senses the medium to see if it is free.
- If medium is busy , then sender waits until it is free.
- If medium is free, then sender starts sending data.
- If there is a collision then then it stops sending data and sends jamming signal.

Motivation for Specialized MAC

Problems in wireless networks

1. signal strength decreases with distance
2. sender applies CS and CD, but collisions happen at receiver
3. sender may not "hear" collision, i.e., CD does not work
4. **Hidden terminal**: CS might not work

Hidden and Exposed Terminals

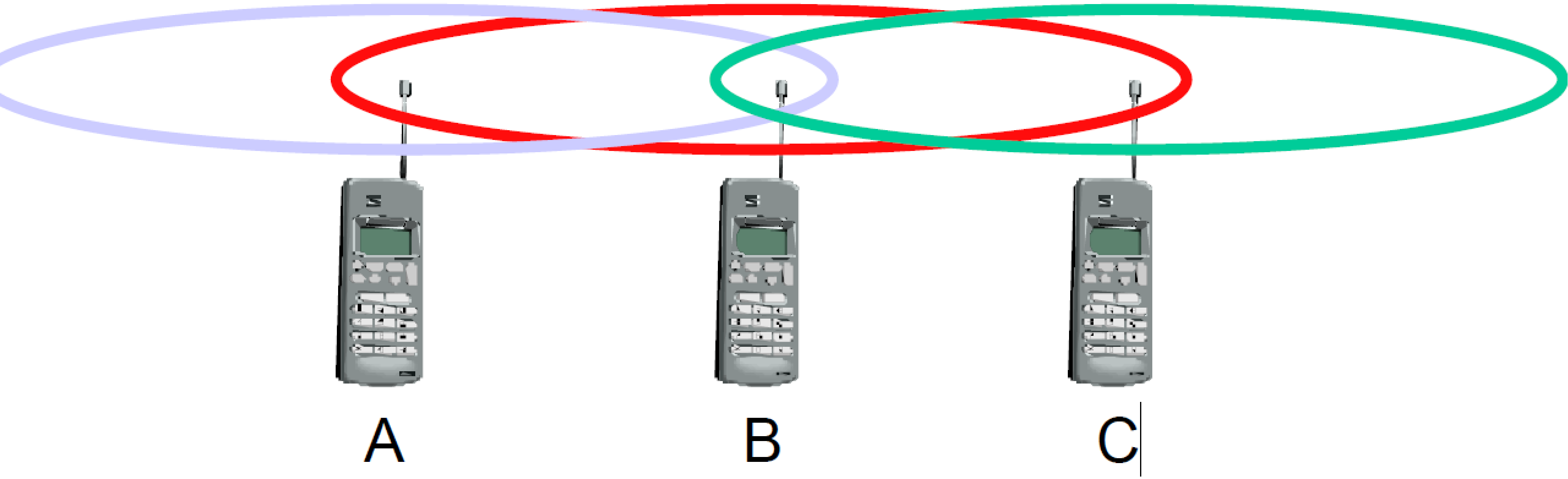
Hidden terminals

- A sends to B, C cannot hear A
- C wants to send to B, C senses a “free” medium (CS fails)
- Collision at B, A cannot receive the collision (CD fails)
- C is “hidden” from A

Exposed terminals

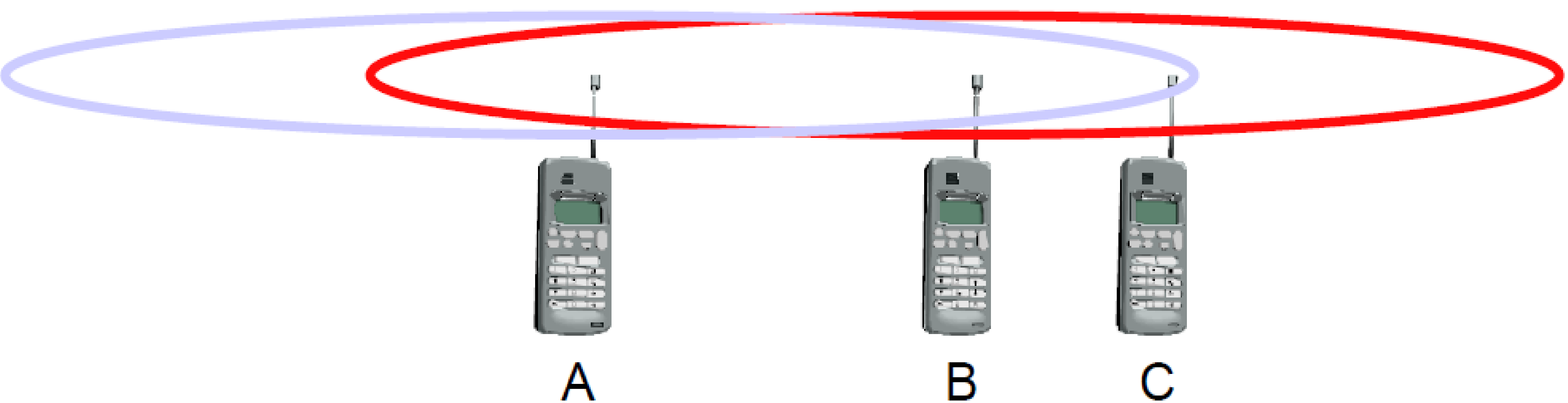
- B sends to A, C wants to send to another terminal (not A or B)
- C has to wait, CS signals a medium in use
- but A is outside radio range of C, waiting is **not necessary**
- C is “exposed” to B

Hidden and Exposed Terminals



Near and Far Terminals

- ✓ Terminals A and B send, C receives
- ✓ signal strength decreases proportional to the square of the distance
- ✓ B's signal drowns out A's signal
- ✓ C cannot receive A



Space Division Multiple Access (SDMA)

- ✓ **Use** – Allocating separate space for users in wireless networks.
- ✓ Mobile phone may receive signals from different stations with different quality.
- ✓ MAC algorithm decides which station is best (considering FDM,TDM and CDM).
- ✓ SDMA always used in combination with one another.
- ✓ Basis for SDMA algorithm

1. Cells
2. Sectorized Antenna
3. SDM

Frequency Division Multiple Access (FDMA)

- Algorithms to allocate frequencies to users using FDM.
- FDM is used for simultaneous access to medium between base station to mobile station.
- This duplex is called as Frequency Division Duplex (FDD).

Uplink – Base station to mobile

Downlink – Mobile to base station

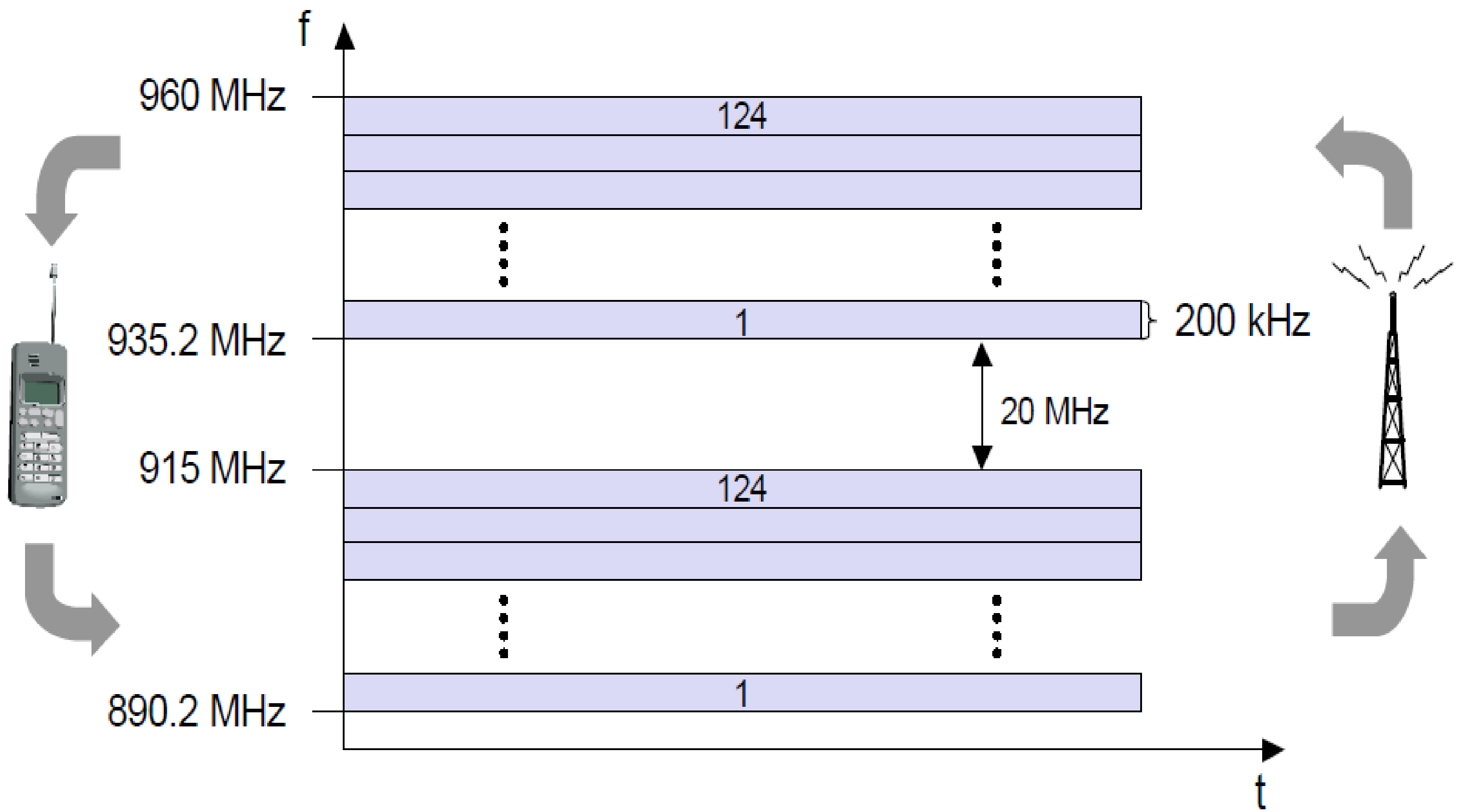
✓ For GSM,

Uplink – 890.2 MHz to 915 MHz

Downlink - 935.2 MHz to 960 MHz

❖ Each channel has bandwidth 200 KHz.

FDMA



Time Division Multiple Access (TDMA)

- Uses TDM.
- Receivers can stay at same frequency whole time.
- Difficult – listening to different frequencies at same time
- Simple – listening many channels separated in time at same frequency.
- Synchronization between sender and receiver is must.
- DCA (Dynamic Channel Allocation)

  requires unique identification for each user (MAC address).

TDMA

- Fixed and Dynamic schemes for Wireless Transmission using TDMA

1. Fixed TDM
2. Classical ALOHA
3. Slotted ALOHA
4. Carrier Sense Multiple Access (CSMA)
5. Demand Assigned Multiple Access (DAMA)
6. Packet Reservation Multiple Access (PRMA)
7. Reservation TDMA
8. Multiple Access with Collision Avoidance (MACA)
9. Polling

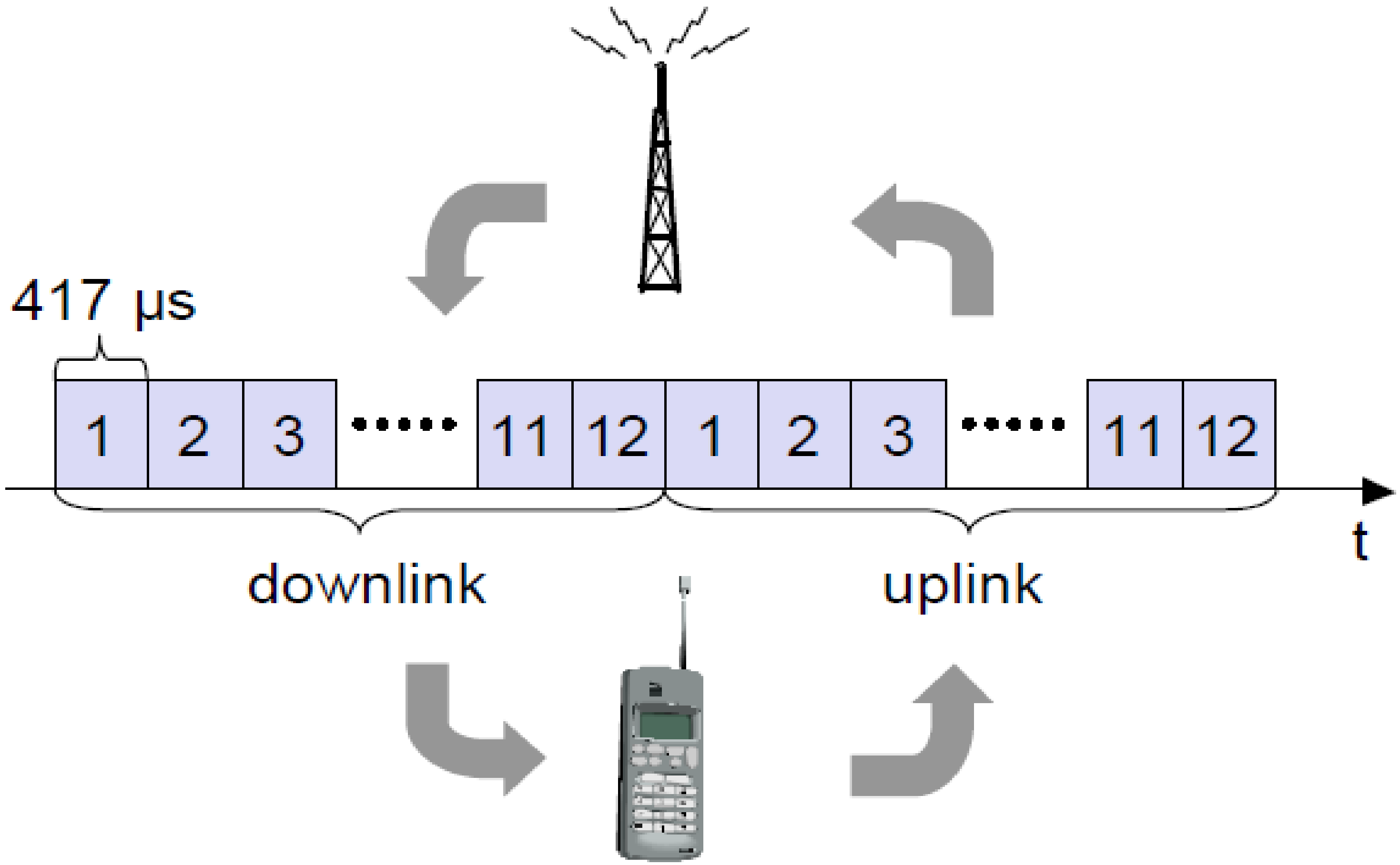
Fixed TDM

- It is an algorithm for allocating time slots for channels in fixed pattern.
- If synchronization is achieved then each station knows it's turn and no interference will happen.
- Fixed TDM used for connections with fixed bandwidth.
- Assigning different time slots for uplink and downlink is called as Time Division Duplex (TDD).

Limitations

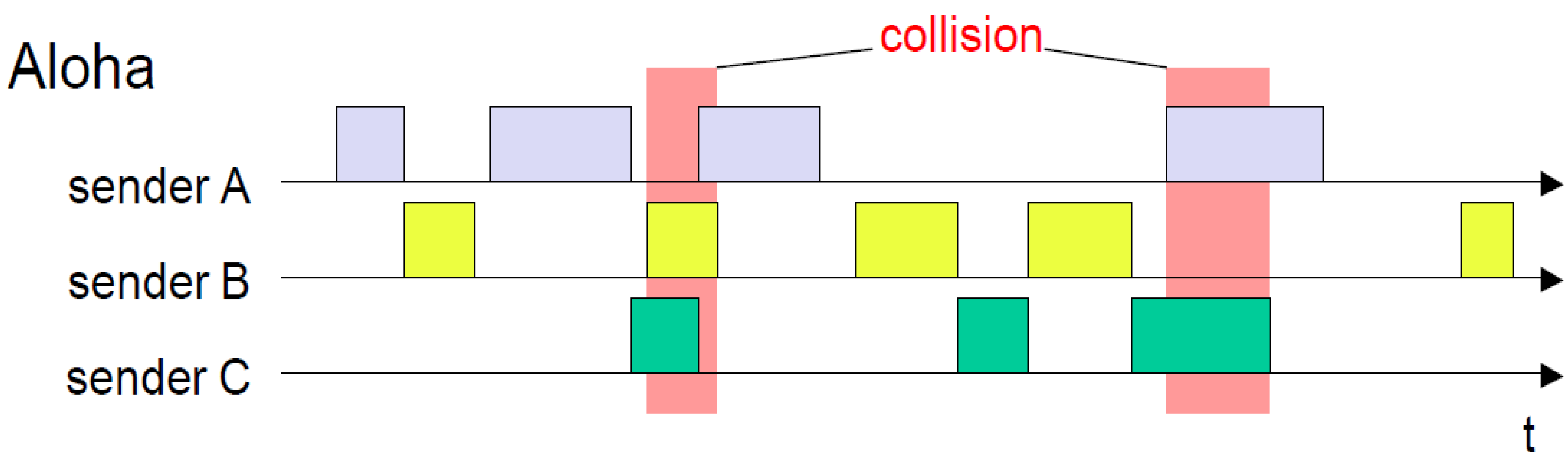
1. Static
2. Inflexible

Fixed TDM



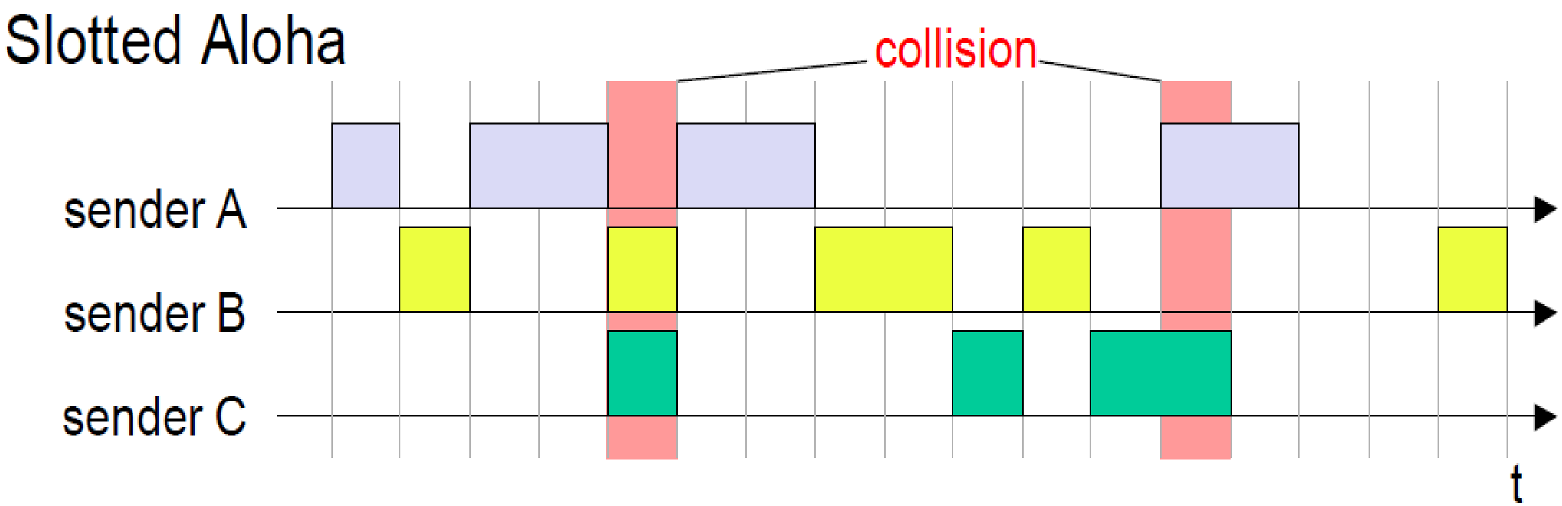
Classical ALOHA

- Abramson's Logic for Hiring Access (ALOHA)
- In Pure ALOHA, TDM is applied without controlling access.
- Stations can transmit whenever they have data to send.
- Multiple station sending data at same time causes collision.



Slotted ALOHA

- Time slots are provided
- All senders have to be synchronized.
- **Transmission can start at beginning of time slots**.
- If station has data to send then it can not send it immediately, it has to wait for beginning of next time slot.



CSMA

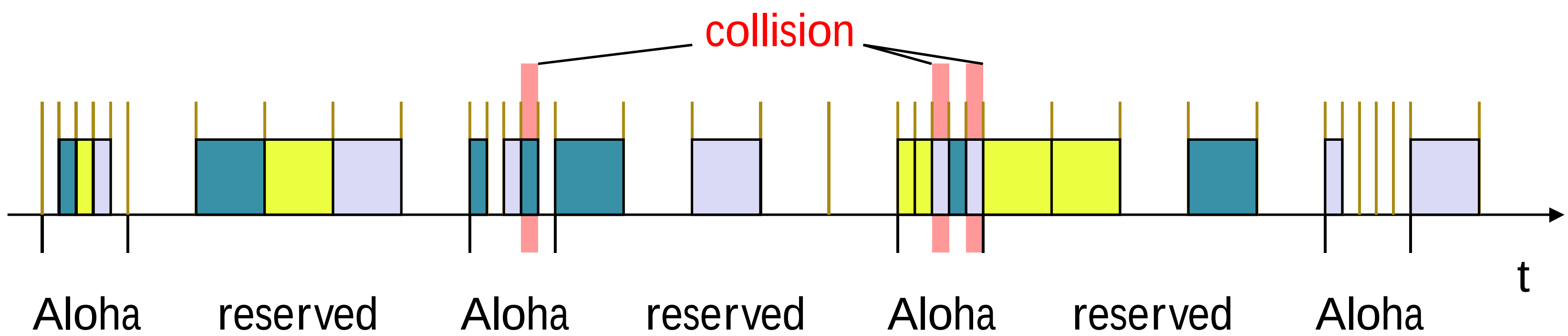
- Sensing the medium and accessing the medium only if carrier is idle decreases the probability of collision.
- But problem of hidden terminals still exists.
- Variations –

1. Non-persistent CSMA- randomized back off algorithm
2. P-persistent CSMA– Senses medium with probability p
3. 1-persistent CSMA- Senses medium with probability 1.

Demand Assigned Multiple Access (DAMA)

- **DAMA** = ALOHA + Reservation + Fixed TDM patterns
- Time is divided as Reservation Period followed by Transmission Period.
- Collision may occur during reservation period.
- Transmission period may be accessed without collision.
- This scheme also known as "**Reservation ALOHA**".

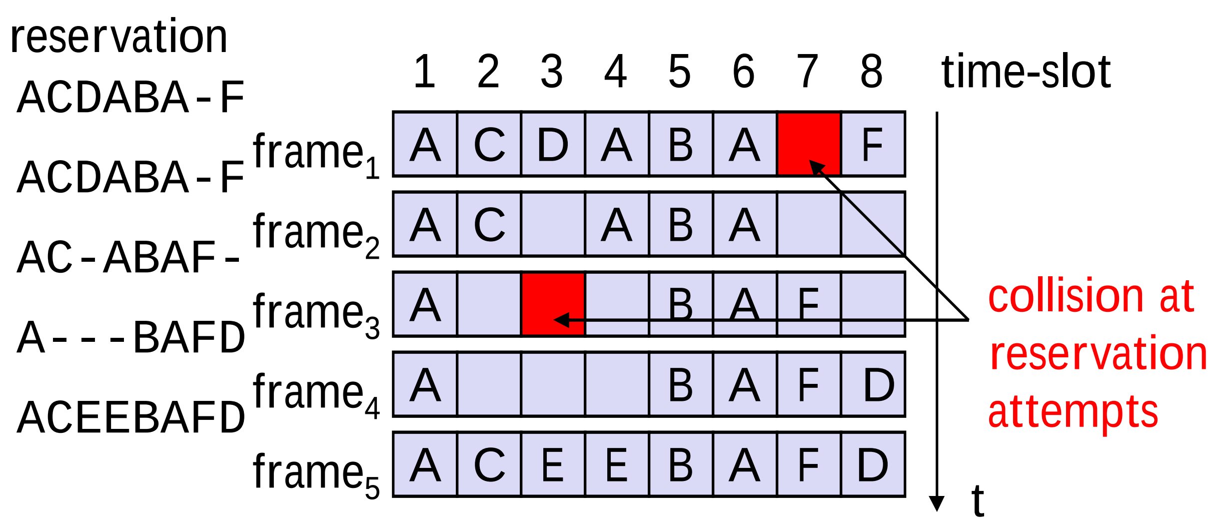
Demand Assigned Multiple Access (DAMA)



- During contention phase all stations can try to reserve future slots.
- If successful, then time slot will be reserved for that station.
- To maintain fixed TDM pattern stations needs to be synchronized.
- **DAMA is an explicit reservation scheme**.

Packet Reservation Multiple Access (PRMA)

- It is an **implicit reservation** scheme with fixed TDM.
- Certain number of time slots are used to form a frame.
- It's not a data frame, it is status of reservation.
- Base station broadcasts the status of reservation to all mobile station.
- Successful transmission of data is indicated by station's name.



PRMA

- Let there are 6 stations: A, B, C, D, E, F
- 8 time slots are available at a time (8 slots/frame).
- Initial allotment of time slots is as given below

A	C	D	A	B	A		F

- So base station broadcasts this status as frame

  A C D A B A – F

- It means, slots 1-6 & 8 are occupied and slot 7 is free.

PRMA

- Now all stations try to occupy the free time slot (7).
- So as a result of their competition, all requests to occupy this slot, will collide.
- Due to collision, reservation failed and time slot 7 will not be allotted to any station.
- So, slot 7 is still free.
- Base station broadcasts this status

A	C	D	A	B	A		F

PRMA

- Now let us assume, station D has completed his transmission in slot 3 and station F in slot 8.
- They have no more data to transmit, so slot 3 & 8 are free now.
- Slot 7 is already free, no one occupied it.
- So base station broadcast this status as,

A	C		A	B	A		

PRMA

- Now all stations try to occupy the free slot 3, due to collision as a result this slot remains free.
- Station C has completed transmission in slot 2 and A in slot 4.
- Station F has now data to send again so it has occupied slot 6.
- So base station broadcasts this status as,

A				B	A	F	

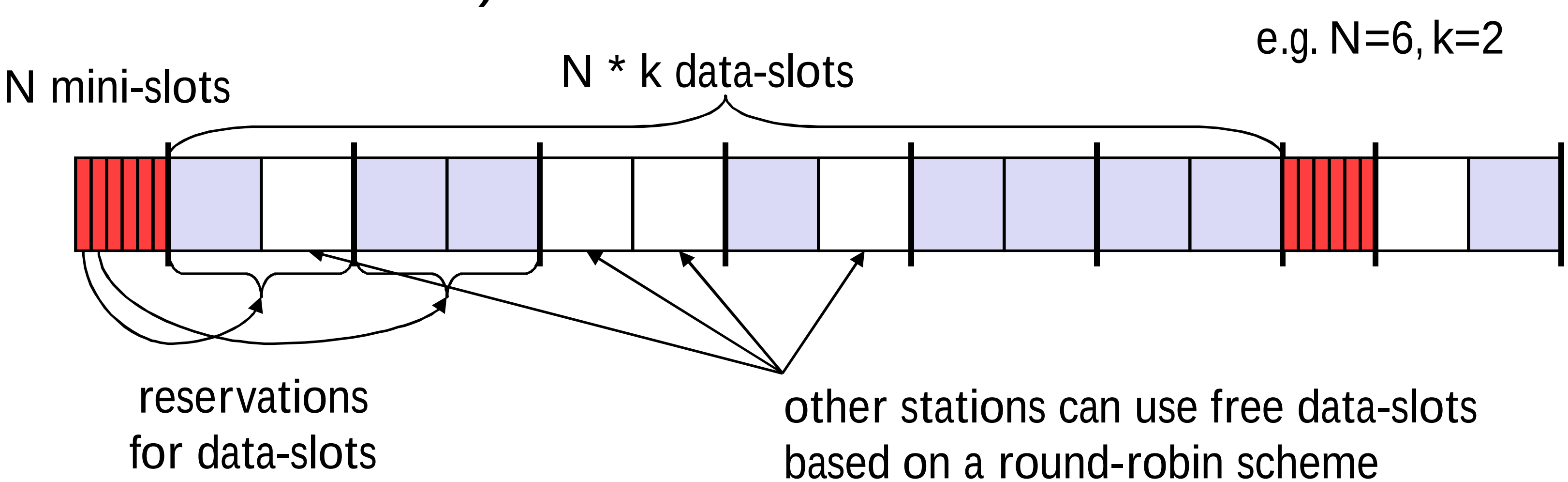
PRMA

- The same process continues till all station complete their transmission.
- In PRMA, **collision does not stop the transmission or there will be no data loss due to collision**.

Reservation TDMA

Reservation Time Division Multiple Access

- every frame consists of N mini-slots and x data-slots
- every station has its own mini-slot and can reserve up to k data-slots using this mini-slot (i.e. $x = N * k$).
- other stations can send data in unused data-slots according to a round-robin sending scheme (best-effort traffic)

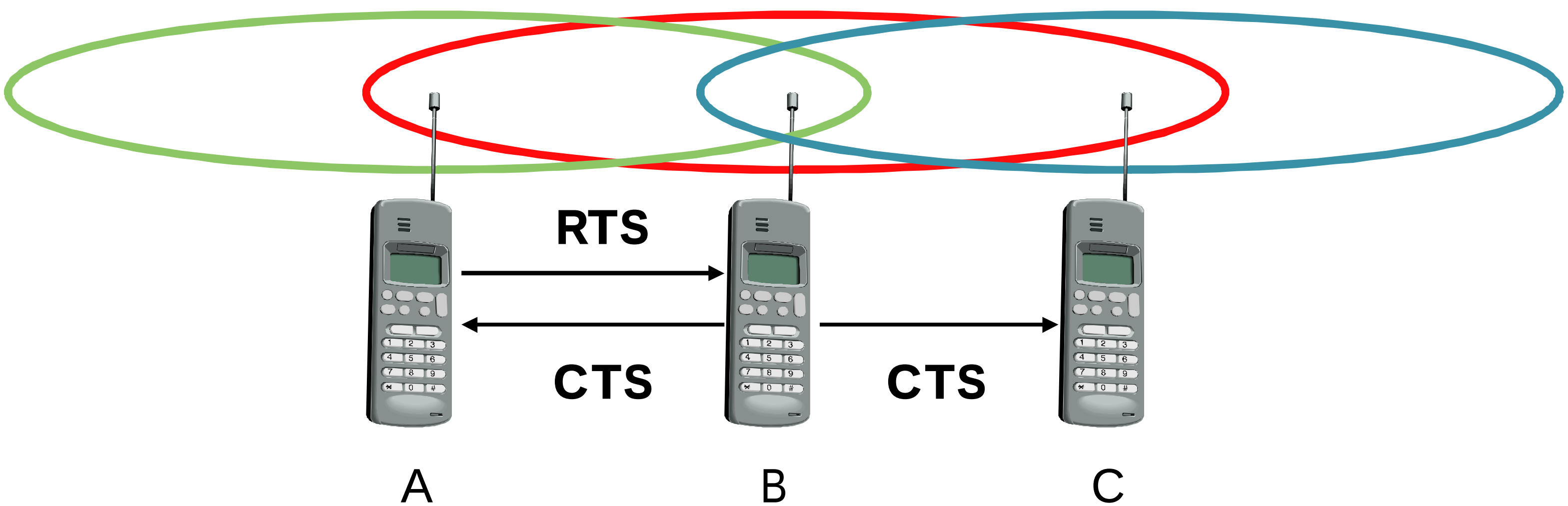


Multiple Access Collision Avoidance (MACA)

- MACA (Multiple Access with Collision Avoidance) uses short signaling packets for collision avoidance
  - RTS (request to send): a sender request the right to send from a receiver with a short RTS packet before it sends a data packet
  - CTS (clear to send): the receiver grants the right to send as soon as it is ready to receive
- Signaling packets contain
  - Sender address
  - Receiver address
  - Packet size (Length of future transmission)

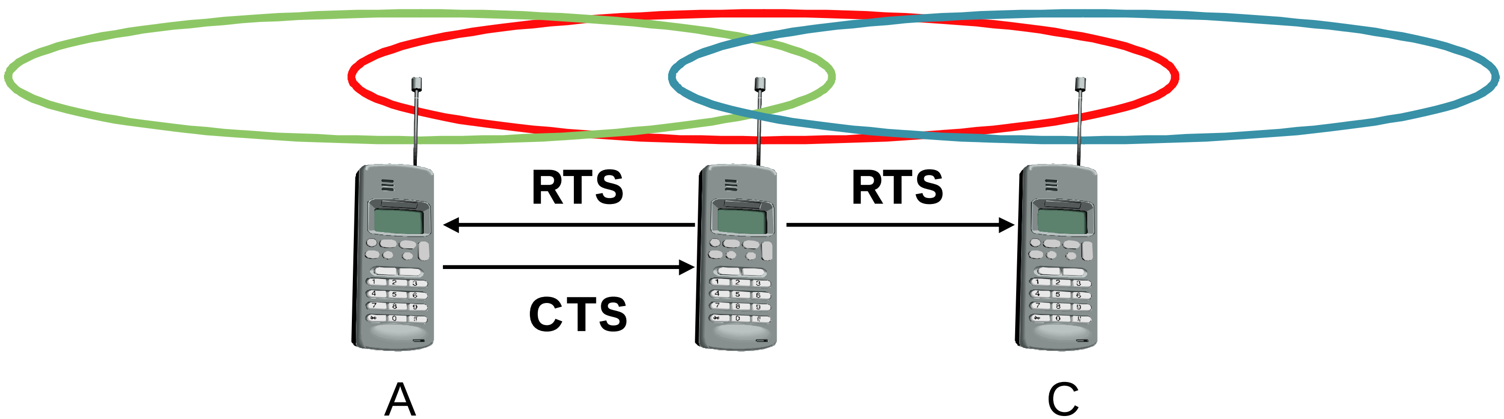
MACA

- MACA avoids the problem of hidden terminals
  - A and C want to send to B
  - A sends RTS first
  - C waits after receiving CTS from B

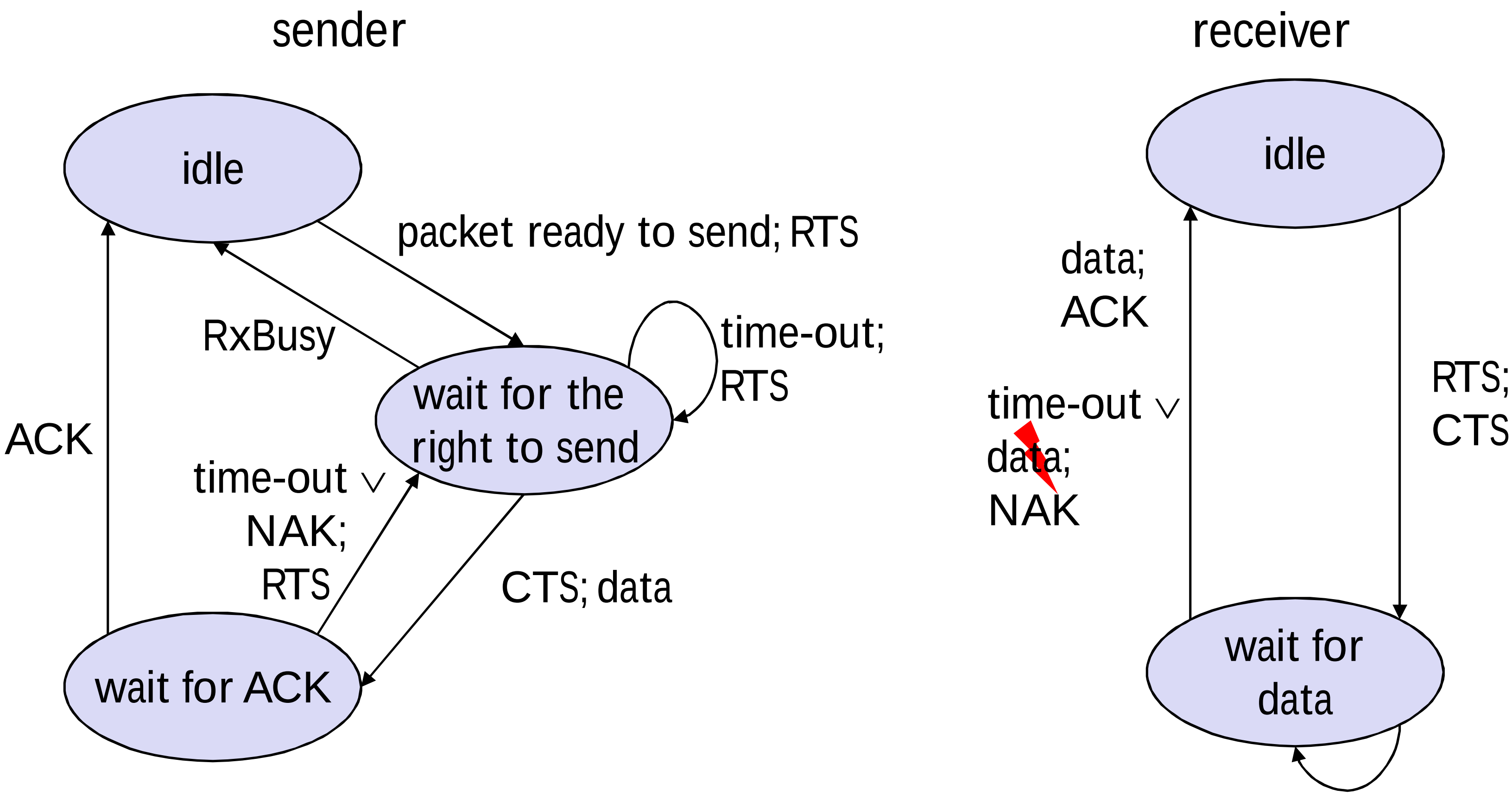


MACA

- MACA avoids the problem of exposed terminals
  - B wants to send to A, C to another terminal
  - now C does not have to wait for it cannot receive CTS from A



MACA



ACK: positive acknowledgement

NAK: negative acknowledgement

RxBusy: receiver busy

Polling

- Where one station has to be heard by all others, poling schemes can be applied.

- Polling is centralized theme with one master and several slave stations.

- Master can poll the slaves according to many schemes (round robin or randomized) according to the reservation.

- The master could also establish a list of stations wishing to transmit during contention phase.

Code Division Multiple Access (CDMA)

Basic function of CDMA –

- A & B want to send data $A_D = 1$ **(+1)** and $B_D = 0$ **(-1)**
- CDMA assigns the unique orthogonal key sequences.

$A_k = 010011$ $B_k = 110101$

- Both sender spread their signal using their key as chipping sequence.

$A_s = A_d * A_k$ $B_s = B_d * B_k$

- Both signals are transmitted at the same time using frequency. Assuming that the signals have same strength at the receiver 'C'.

$C = A_s + B_s$

- C calculates values by computing,

$C * A_K$ and $C * B_K$