ADHOC – MAC : a new, flexible and reliable MAC architecture for ad-hoc networks

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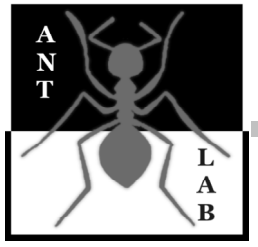
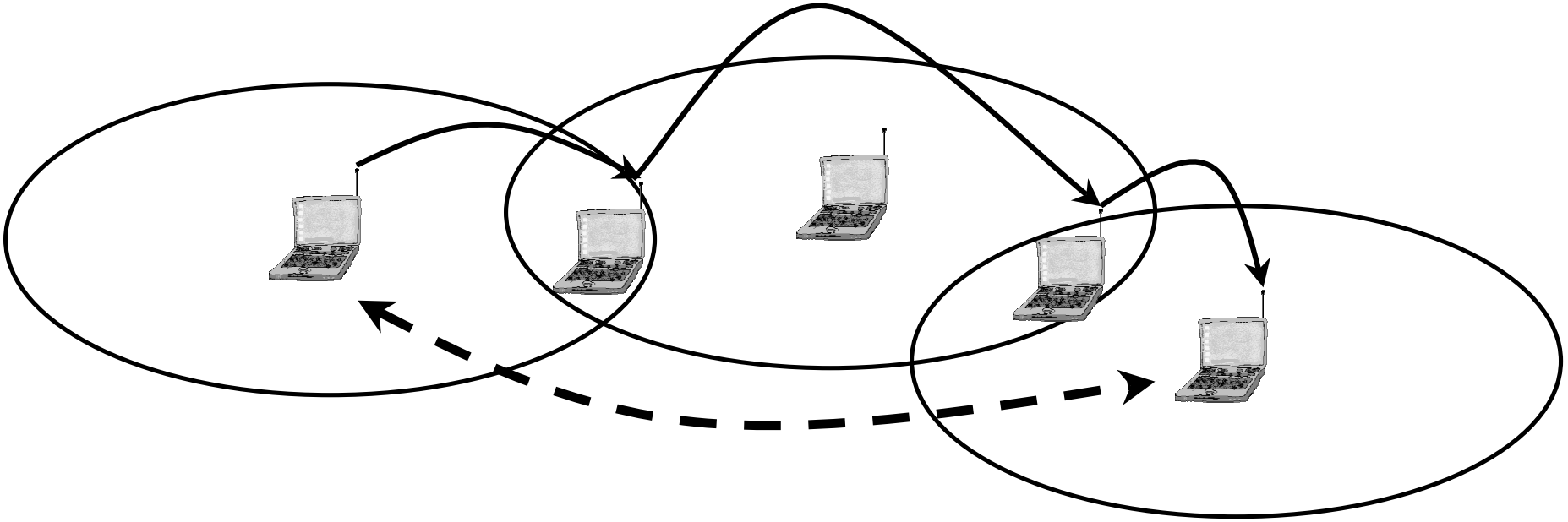
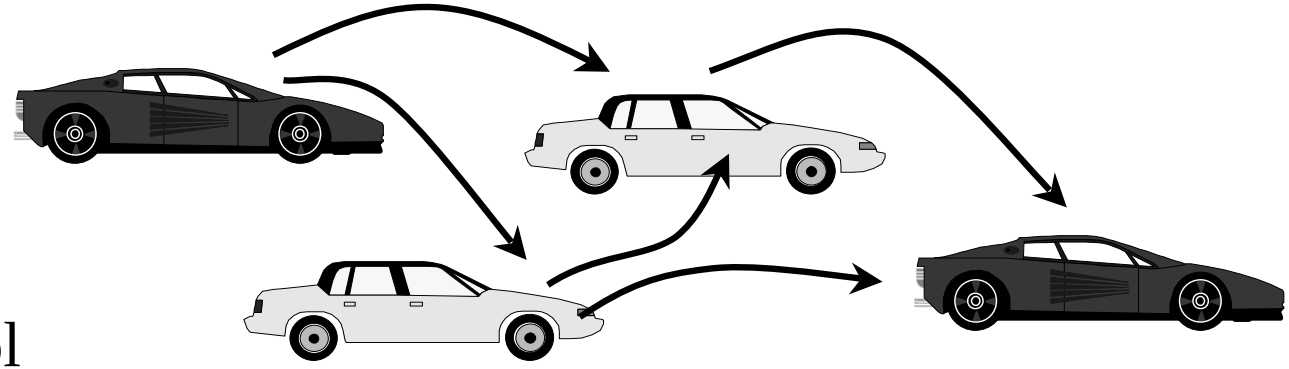


Ad-Hoc Networks



- No fixed infrastructure
- Limited propagation range
- Need for terminal relaying/routing

Inter-vehicles ad-hoc Networks



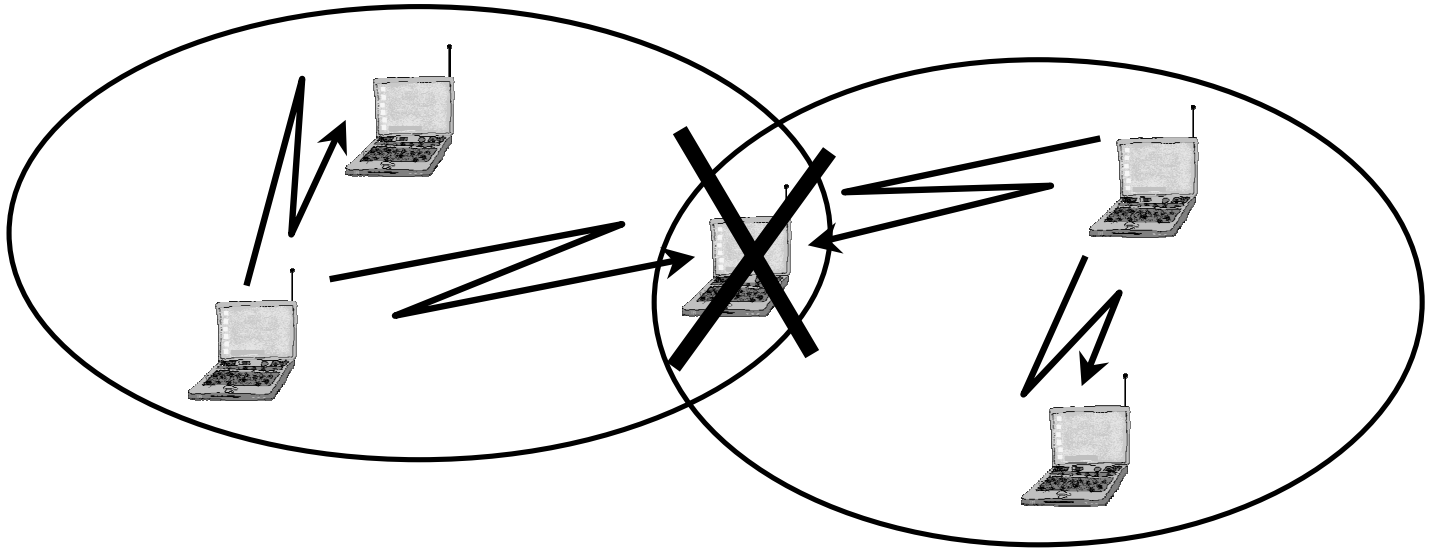
- Traffic control
- Entertainment
- Internet access

Speed poses stringent requirements

No centralized operation

MAC problem: Hidden terminal

not completely solved by IEEE 802.11(CSCA)



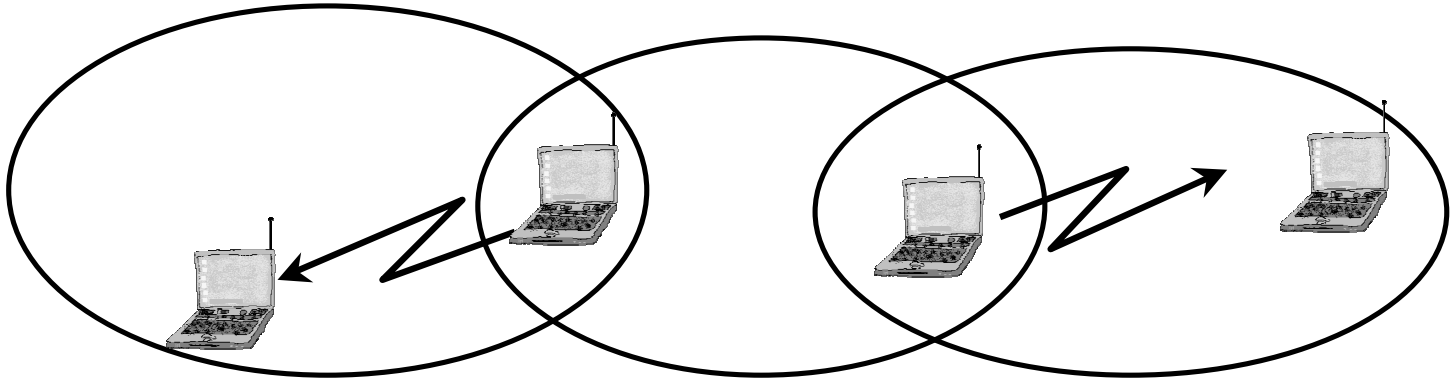
Impact on :

– radio access

– local broadcast

MAC problems: exposed terminal

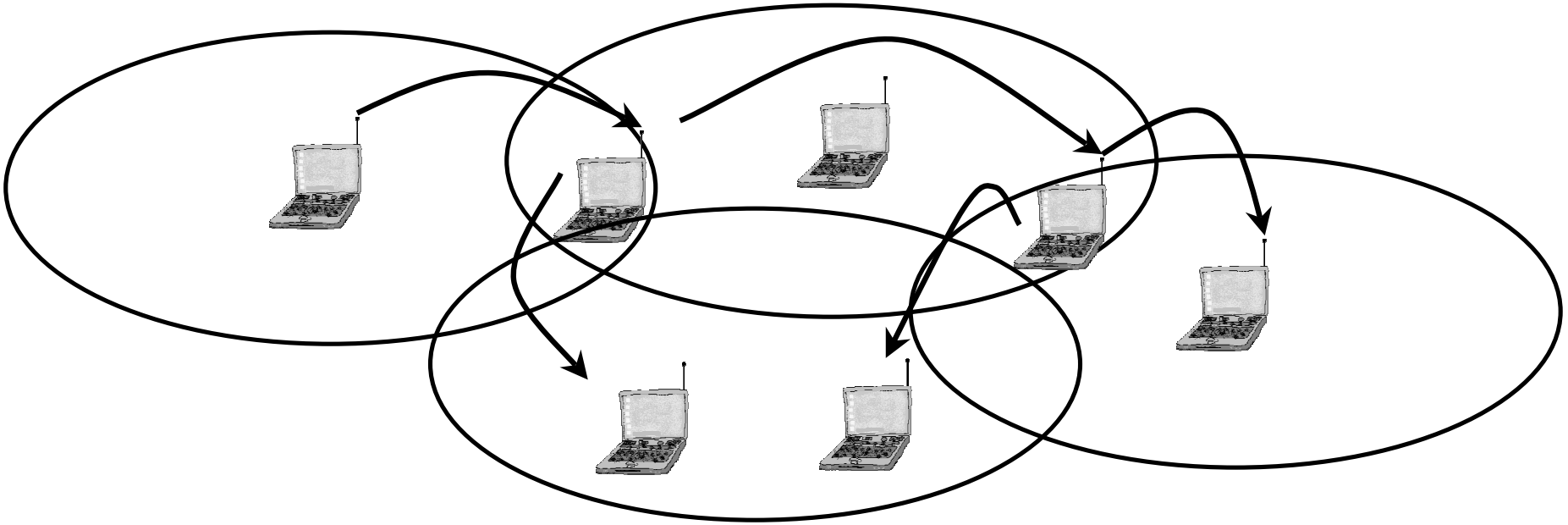
unsolved by IEEE 802.11 (RQS/CLS)



Impact on efficiency since parallel transmissions can be prevented

MAC problems: broadcast service

how to chose bridges



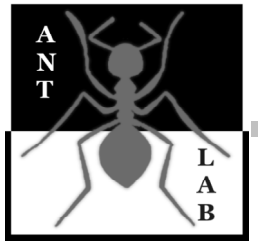
Tree-based protocols not applicable due to dynamic topology

Flooding highly inefficient with high degree of connectivity

(n transmissions instead of 1)

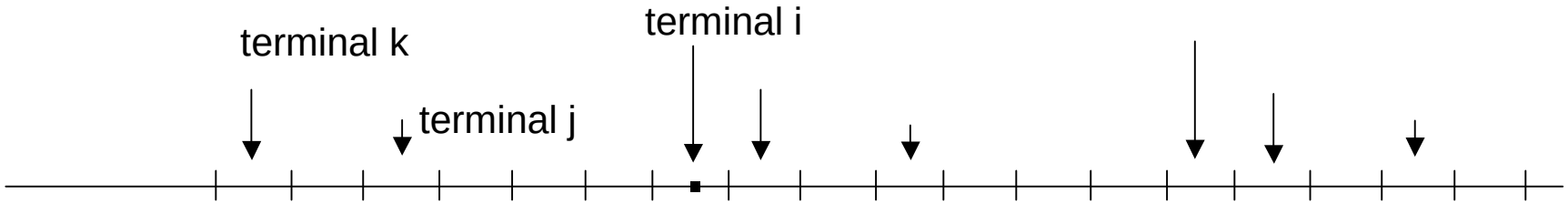
ADHOC MAC

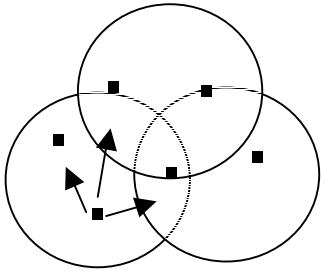
- **Features:**
  - Layer two connectivity information
  - Access to a reliable single-hop broadcast
  - QoS support for different applications
  - Efficient point-to-point communication (parallel transmissions)
  - Efficient multi-hop broadcast



ADHOC MAC

- Time slotted channel (eg, using GPS time synch)
- Basic Channel (BCH)
  - Each active terminal owns a slot (Basic Channel)
  - It periodically transmits channel status information in it
  - Slots are grouped into virtual frames (VF) of length N
  - Transmissions are received by all terminals within one hop range



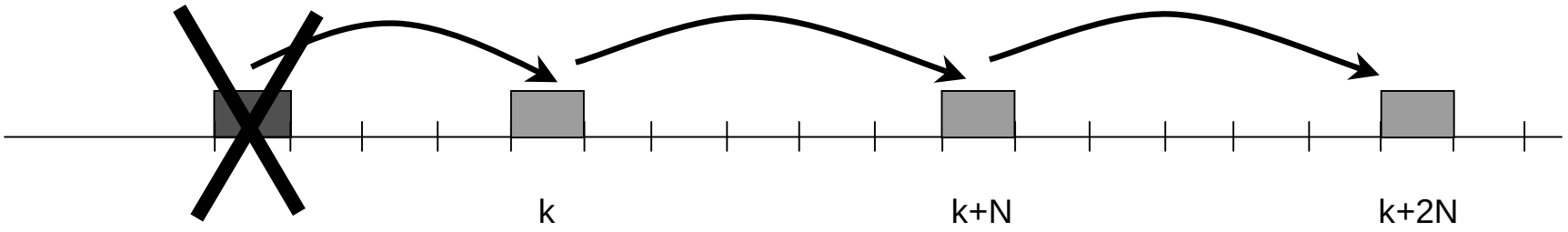


BCH is established using the **Reliable Reservation ALOHA** protocol

Reservation ALOHA

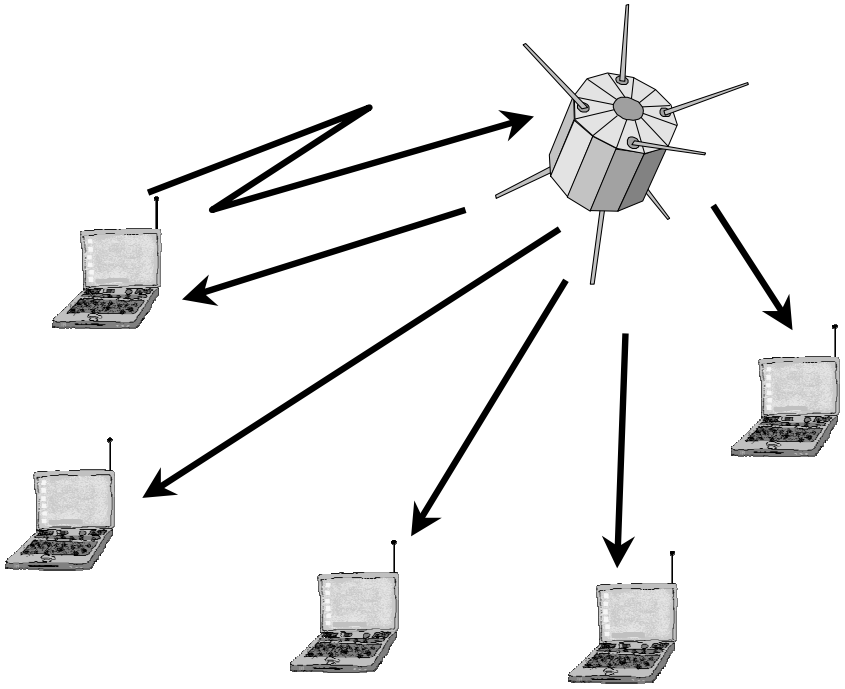
a distributed way to establish TDMA channels

a slot successfully captured is periodically reserved (every N slots) until released



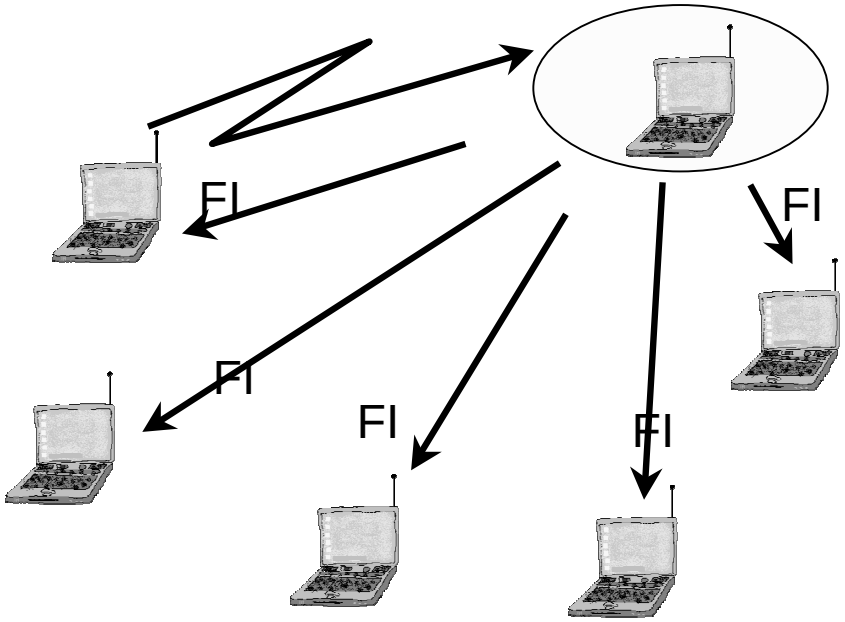
Reservation ALOHA

needs a centralized radio environment with central station feedback, so that all terminals "see" the same slot status: busy, free, collided



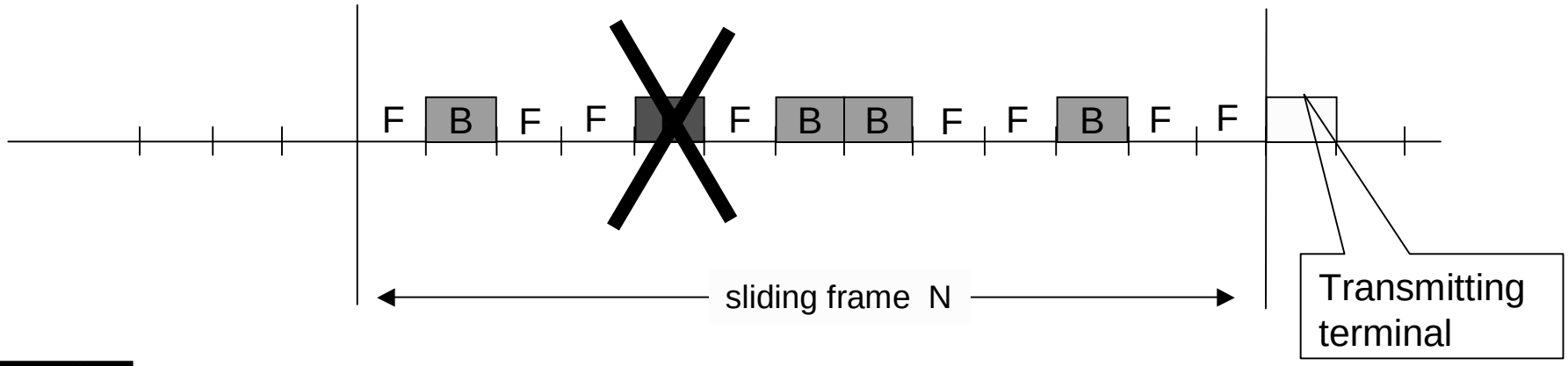
Reliable Reservation ALOHA

- operates in a distributed radio environment
- each terminal propagates slot status information (Frame Information) using BCH

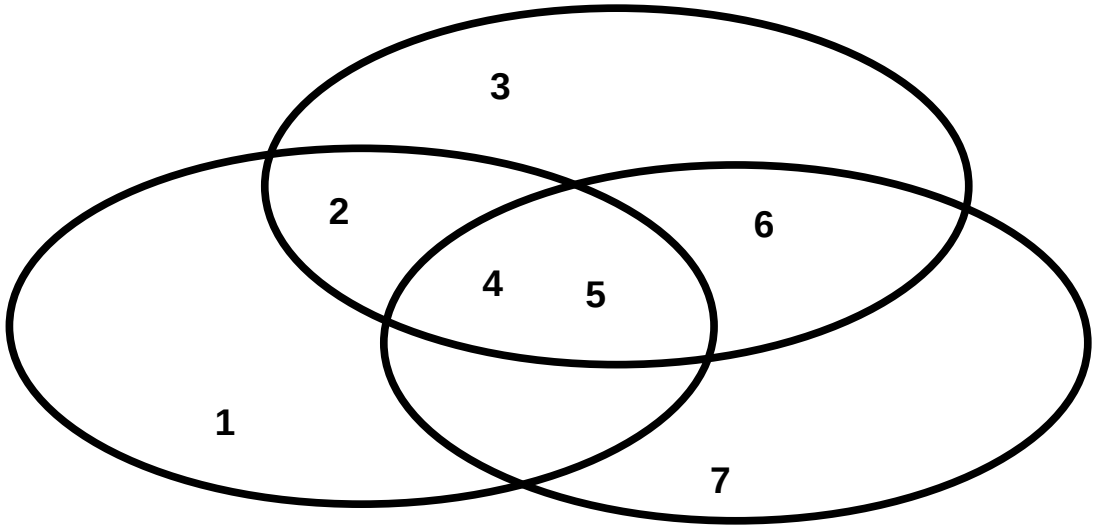


Reliable Reservation ALOHA

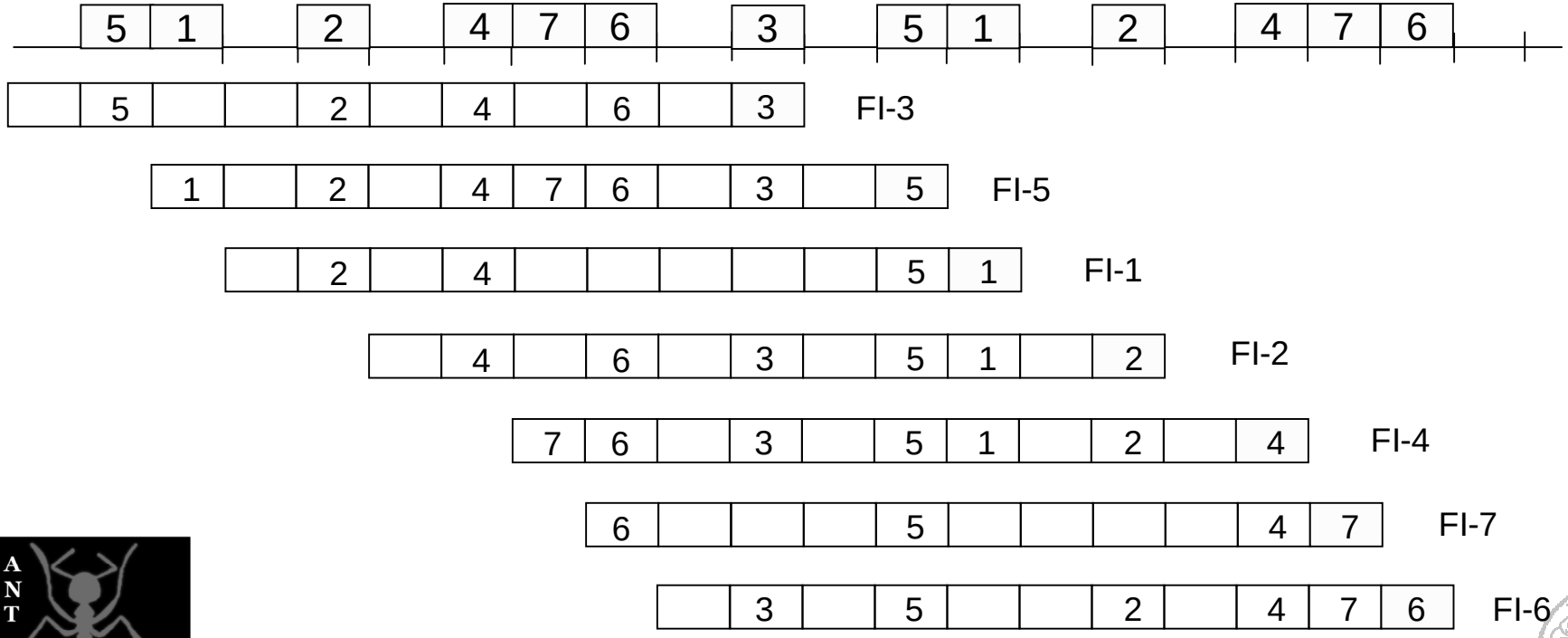
- all active terminals transmit the **Frame Information** every N slots (within the virtual frame)
- FI specifies the status of the previous N slots (in the Sliding Virtual Frame) as observed by the terminal
  - BUSY correct transmission
  - FREE no transmission or collision



RR-ALOHA : Frame Information



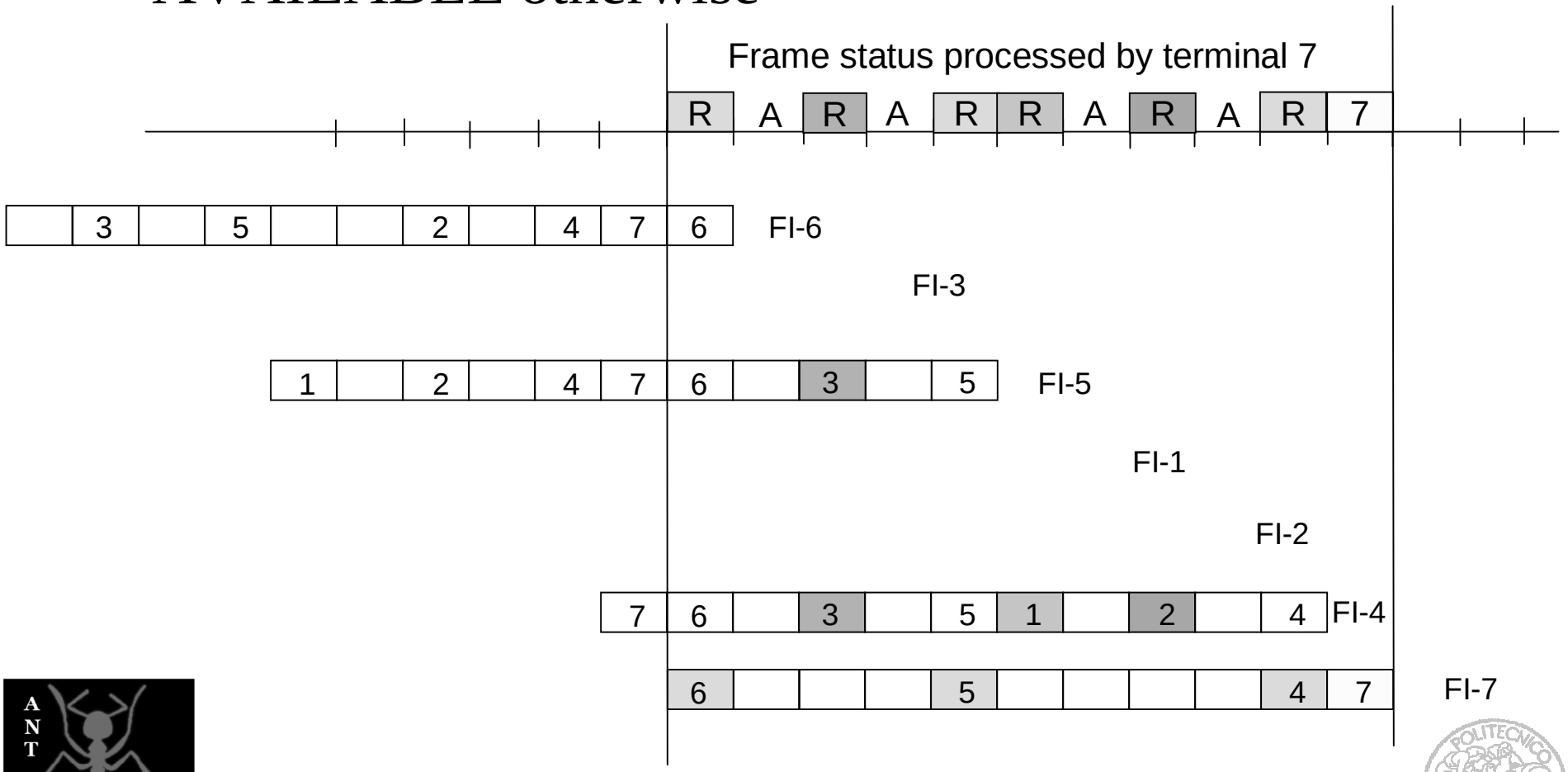
Transmissions



RR-ALOHA : slot status

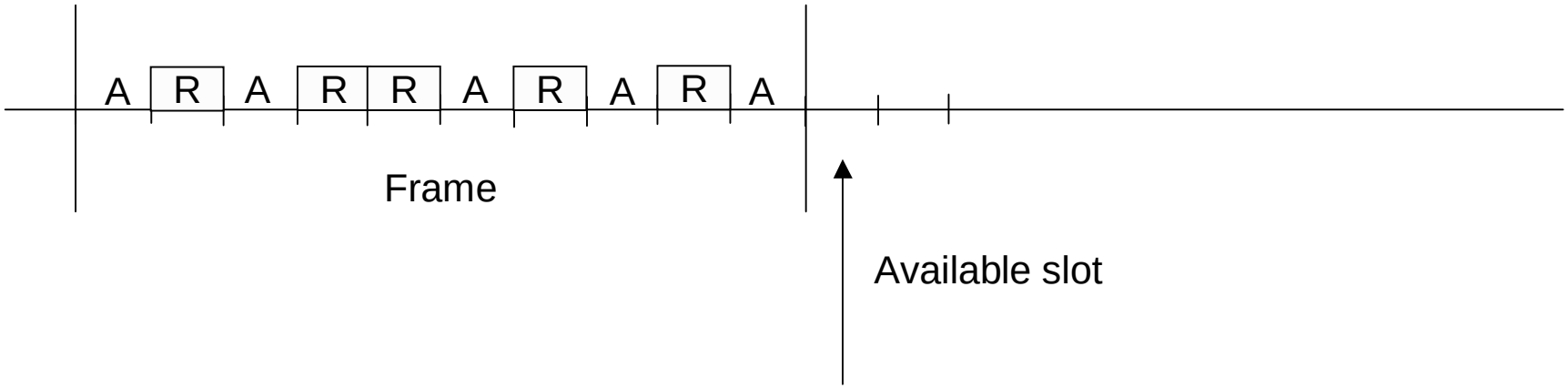
RESERVED if at least one FI says “BUSY”

AVAILABLE otherwise



RR-ALOHA : access

- AVAILABLE slots can be used:
  - by a new active terminal (as in R-ALOHA)
  - by an already active terminal to increase its transmission bandwidth
- No Hidden-Terminal problem

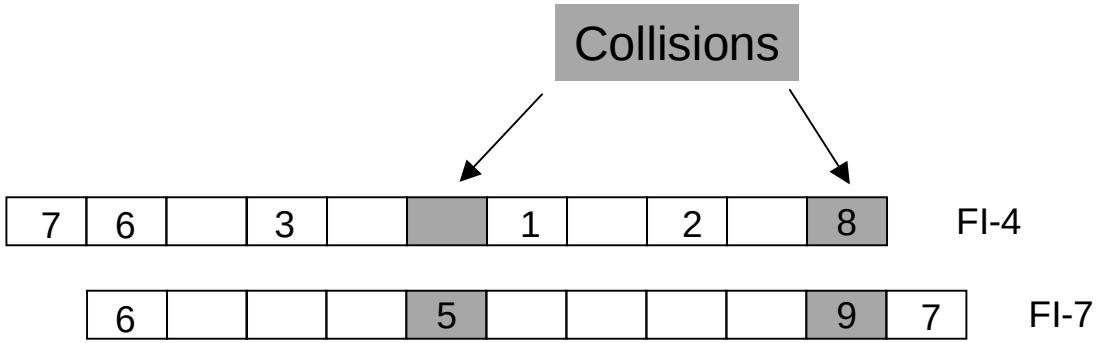


RR-ALOHA : access

The ID of the slot “owner” must be included in the FI

The transmission is successful if

- the slot is coded as BUSY with the same station ID in all the received FI



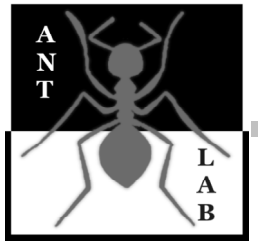
RR-ALOHA : access

One terminal attempting access:

- All terminals in the same cluster recognize the transmission.
- All FIs will mark the slot as BUSY.
- All other terminals will receive FI with the slot marked as BUSY.
- The slot is declared RESERVED.

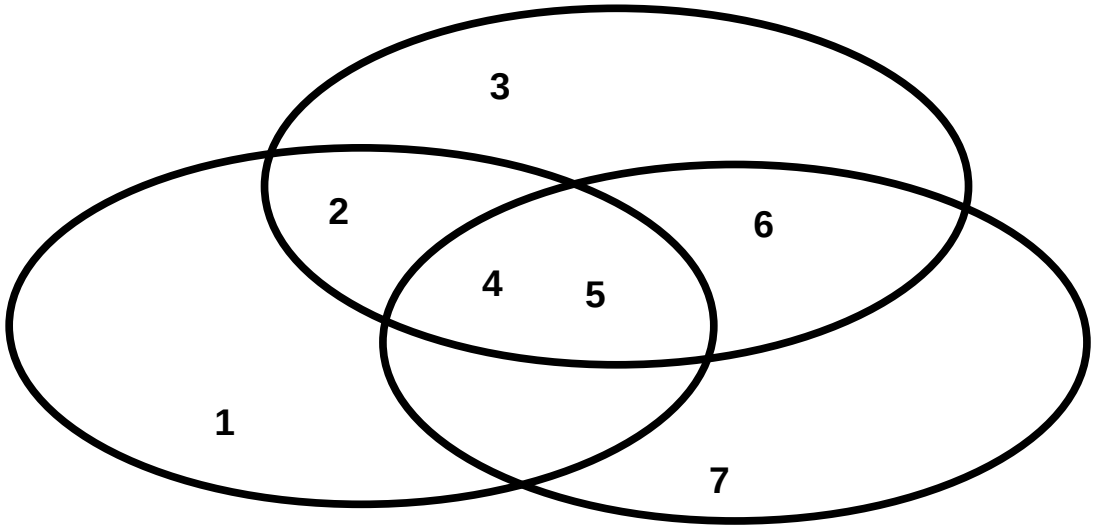
Multiple terminals attempting access:

- Each terminal upon detecting collision leaves the slot as FREE.
- The slot remains AVAILABLE.

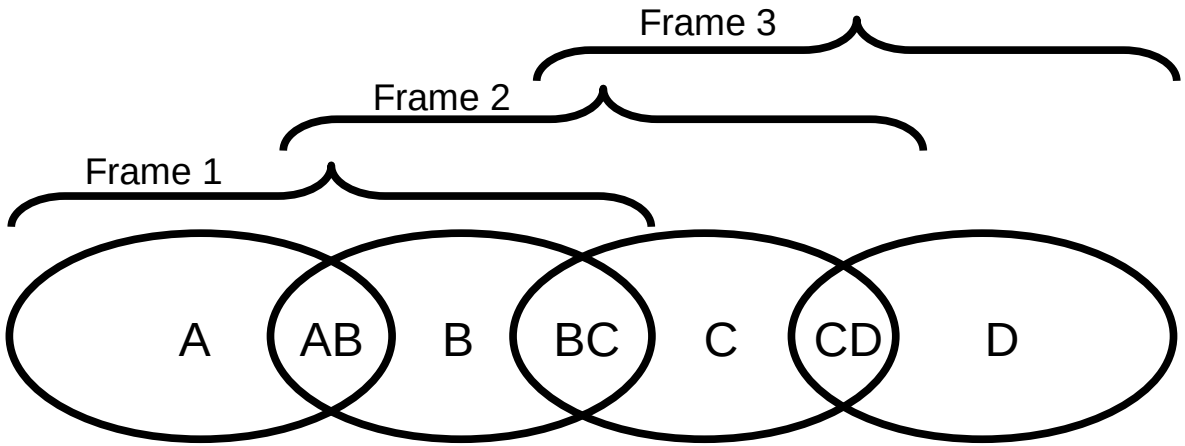


RR ALOHA : common frame

- a unique frame is established among non disjoint radio broadcast domains based on FIs transmitted by nodes in common



RR ALOHA: slot reuse

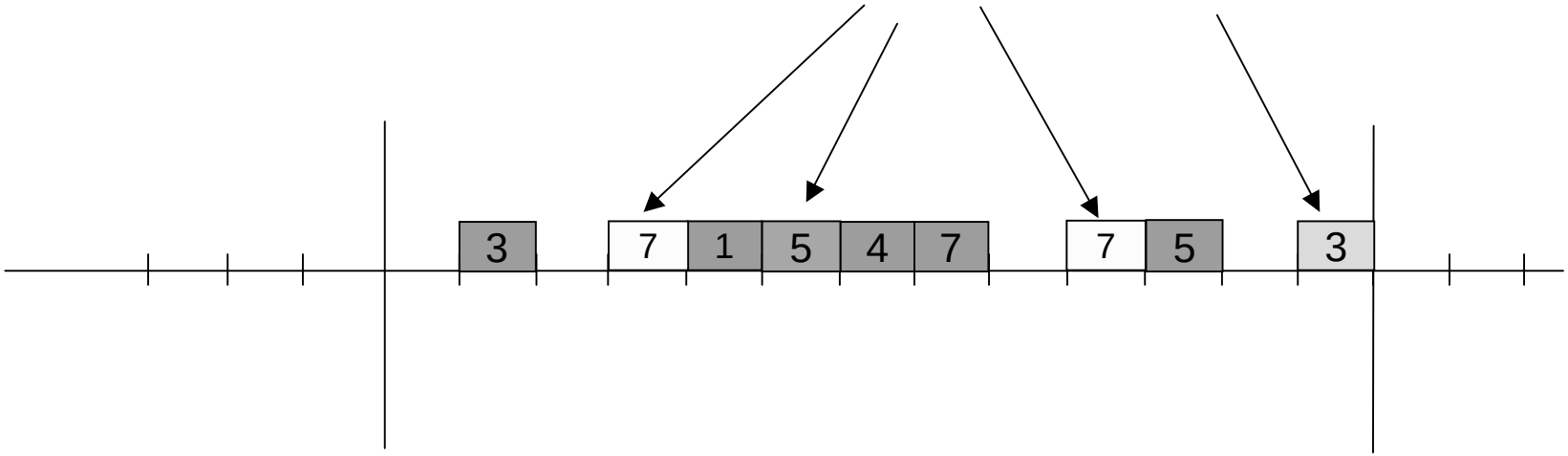


A	B	AB	A	BC	B	BC	AB	A	B	BC	A	AB	Frame 1
C	B	AB	C	BC	B	BC	AB	CD	B	BC	C	AB	Frame 2
C	D	CD	C	BC	D	BC	D	CD	D	BC	C	CD	Frame 3

23 transmissions in 13 slots

ADHOC MAC : Reserving additional bandwidth

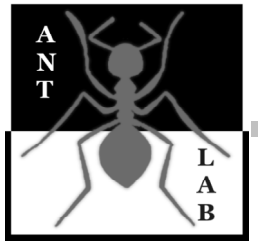
- Each active station sets up and manages a BCH
- Payload can be transmitted in the BCH slots
- Additional available slots can be reserved for increasing transmission bandwidth (**additional channels**)



ADHOC MAC : Reserving additional bandwidth

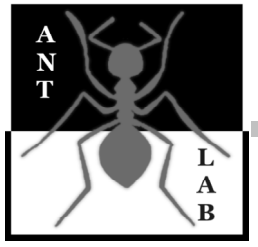
- Using RR- ALOHA procedure on the AVAILABLE Slots

- Using estabilished BCH.
  - New channel requests are signaled
  - Possibility of priority management
  - FI guarantees reservation collision detection

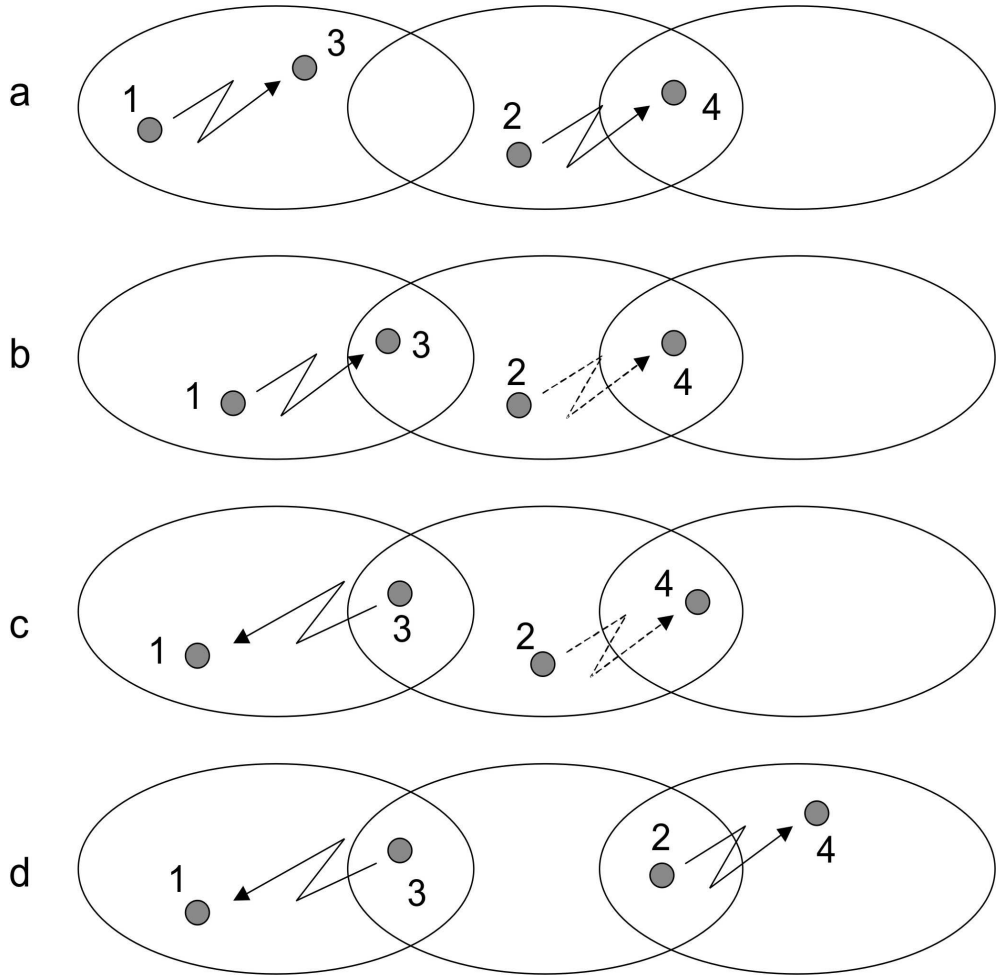


ADHOC MAC : Point-to-point channels

- To exploit slot reuse in the same or adjacent clusters (parallel transmissions)
- PTP flag is needed in the FI for each slot
- PTP flag is set by a terminal if:
  - The packet received is broadcast or
  - The packet is destined to the terminal itself
- A reserved slot can be accessed if:
  - The PTP flag is off in all received FI and
  - The FI received from the intended destination marks the slot FREE
- Due to concurrent access attempts: the transmission is successful if the slot is coded as BUSY in the FI of the destination terminal.



ADHOC MAC : Point-to-point channels



ADHOC MAC : Multi-hop Broadcast service

C_i the set of neighbors of i

$S_i \subseteq C_i$ the subset of neighbors that have not received the broadcast packet in slot k

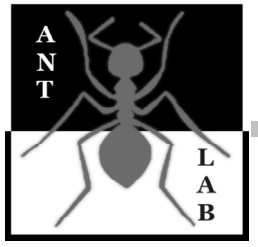
from FIs

Terminal *i* relays the broadcast packet received in slot k if

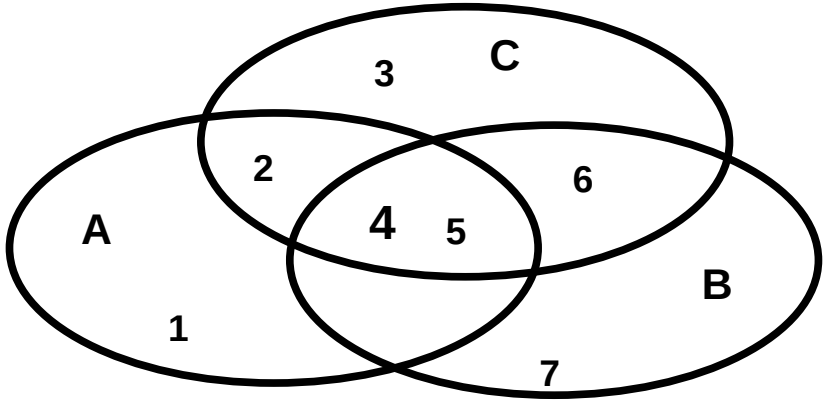
$$|S_i| > 0$$

and the following condition is **not** satisfied for all *j*

$$S_i \subseteq C_j \text{ AND } \left\{ |C_j| > |C_i| \text{ OR } \left\{ |C_j| = |C_i| \text{ AND } ID_j > ID_i \right\} \right\}$$



Multi-hop Broadcast mechanism



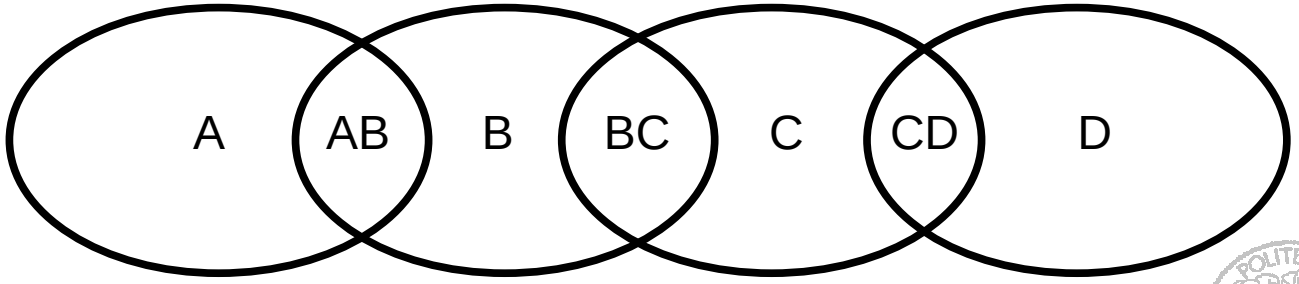
for j in ABC

$S_i \subseteq C_j$ satisfied

$|C_j| > |C_i|$ satisfied if i not in ABC

$|C_j| = |C_i|$ if i in $ABC \Rightarrow$ LowestID

One terminal for each set AB, BC and CD is elected as relay terminal



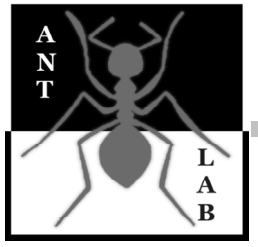
RR ALOHA PERFORMANCE
Implementation overhead

- N slots >= M terminals (in the cluster)
- For inter-vehicles applications M=100 N=200

FI must contain:

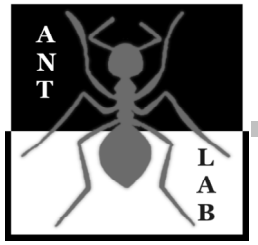
- BUSY status (1 bit)
- Terminal temporary ID (8 bits)
- Priority field (2 bits)
- PTP service flag (1 bit)

- Overhead due to FI 2400 bits /slot
- Overhead due to other information 100 bits/slot
- Packet length 5000 bits
- Payload 2500 bits/slot in BCH
- At 10 Mbit/s frame duration 100 ms:25kb/s in BCH
- 5Mb/s for reservation

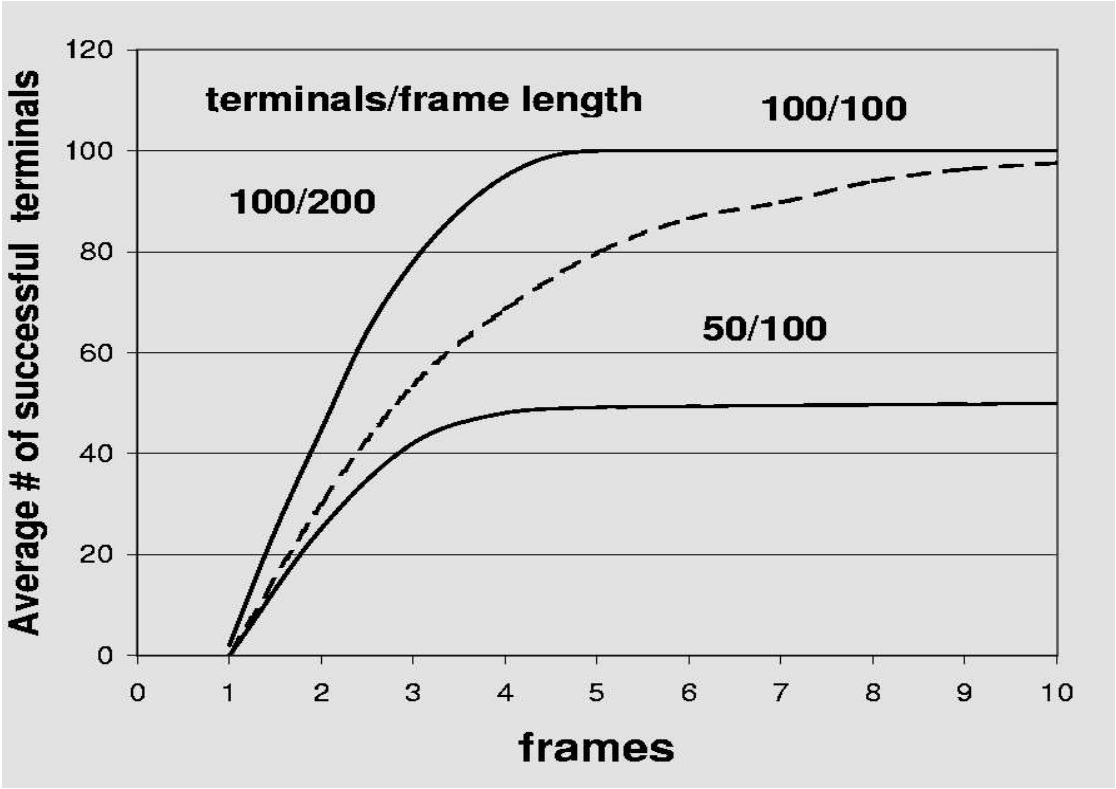


RR ALOHA PERFORMANCE
Implementation overhead

- Overhead reduction:
  - Insert ID and priority information in the FI once every *k* frames
  - Used by the MAC in the access phase only and needed to be repeated for new active terminals
  - Ex: Add information once every 10 frames
    - FI reduces to 400 bits 90% of the time
    - 93% maximum efficiency with 5000 bits packets
- With reduced channel speed, 3.84 Mb/s (UTRA-TDD), packet length must be reduced to keep 100 ms frame



RR ALOHA PERFORMANCE
Time responsiveness



Conclusions

PROs

- Suitable for highly variable ad-hoc net environment
- Fast access to a reliable single-hop broadcast
- Provision of different QoS according to applications needs
- Parallel transmissions for point-to-point communications
- Efficient multi-hop broadcast

CONs

- High overhead (25%)
- Power saving is jeopardized by the need for the BCH