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Algorithms for Radio Networks

Medium Access – Carrier Sensing

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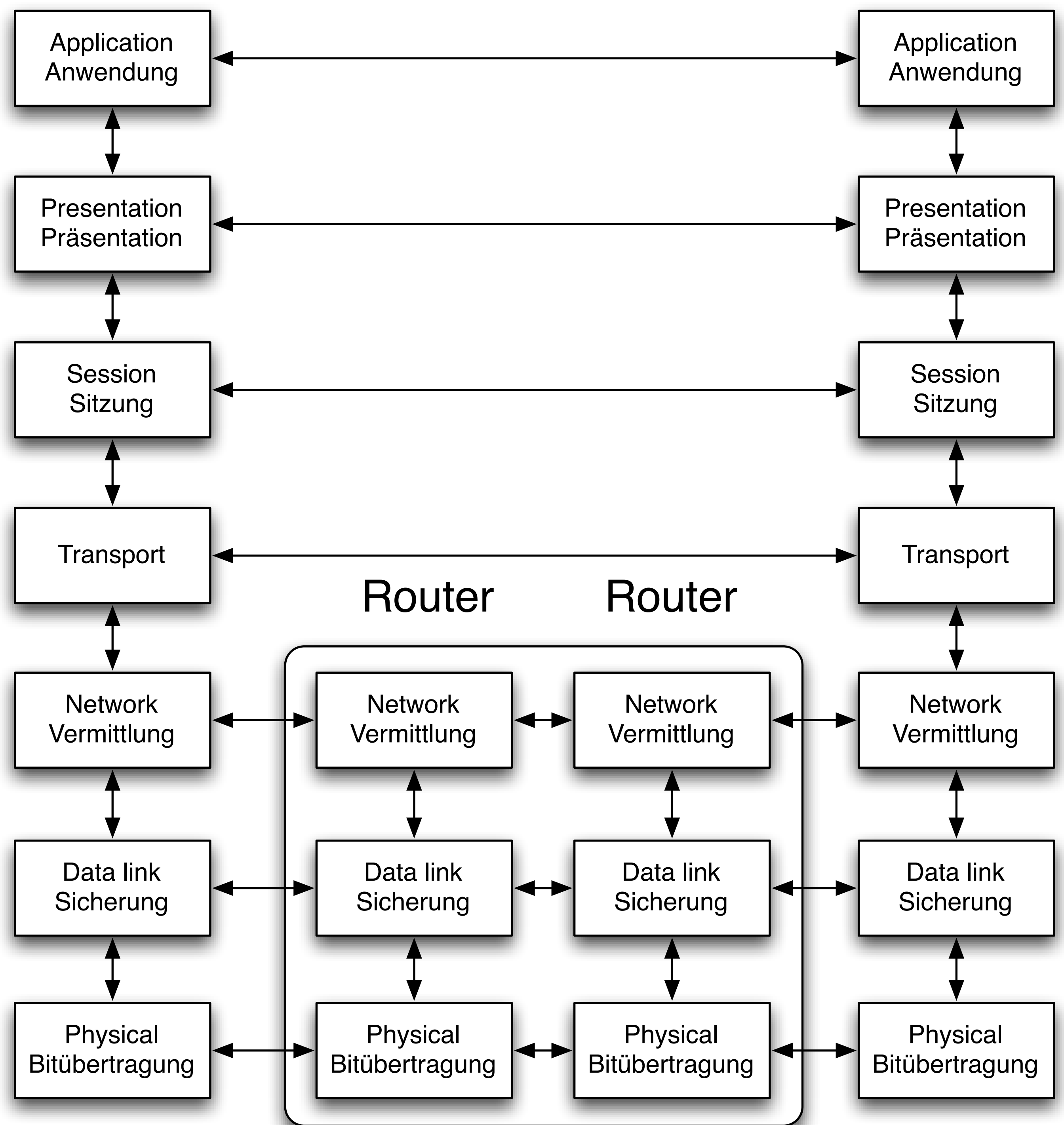
ISO/OSI Reference model

- **7. Application**
  - Data transmission, e-mail, terminal, remote login
- **6. Presentation**
  - System-dependent presentation of the data (EBCDIC / ASCII)
- **5. Session**
  - start, end, restart
- **4. Transport**
  - Segmentation, congestion
- **3. Network**
  - Routing
- **2. Data Link**
  - Checksums, flow control
- **1. Physical**
  - Mechanics, electrics

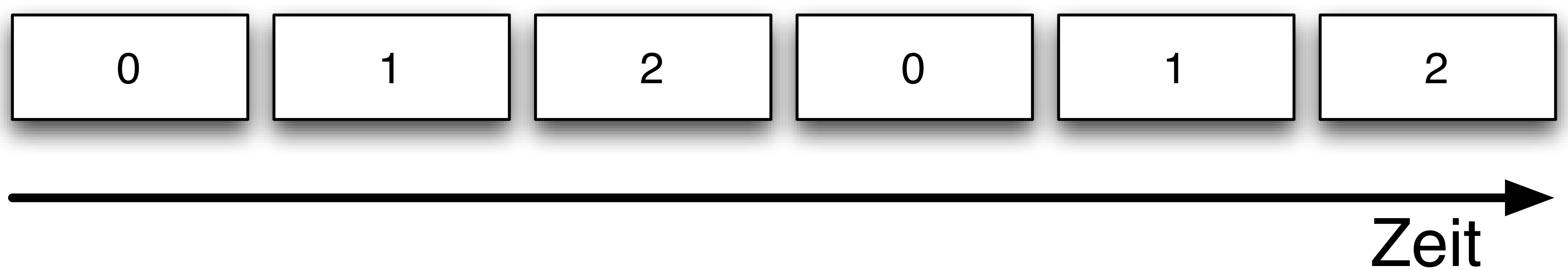


Types of Conflict Resolution

- **Conflict-free**
  - TDMA, Bitmap
  - FDMA, CDMA, Token Bus
- **Contention-based**
  - Pure contention
  - Resctricted contention
- **Other solutions**
  - z.B. MAC for directed antennae

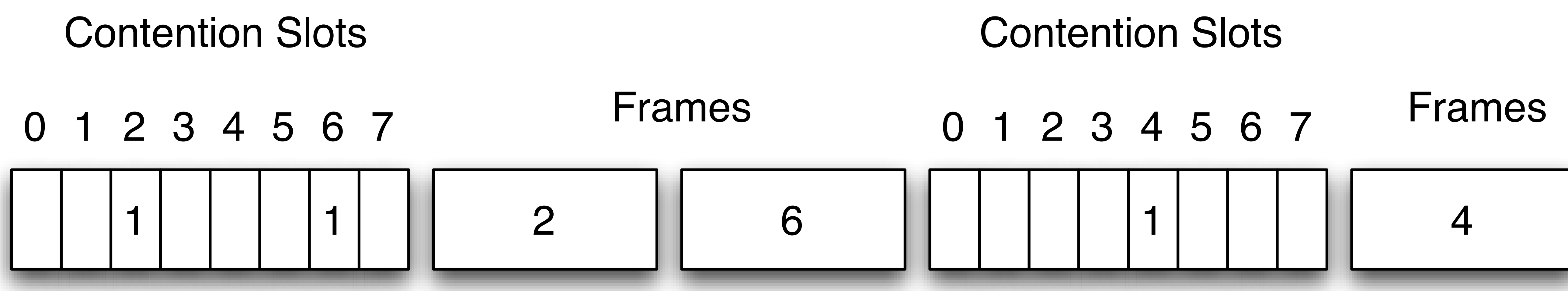
Contention Free Protocols

- **Simple Example: Static Time Division Multiple Access (TDMA)**
  - Each station is assigned a fixed time slot in a repeating time schedule
  - *Traffic-Bursts* cause waste of bandwidth



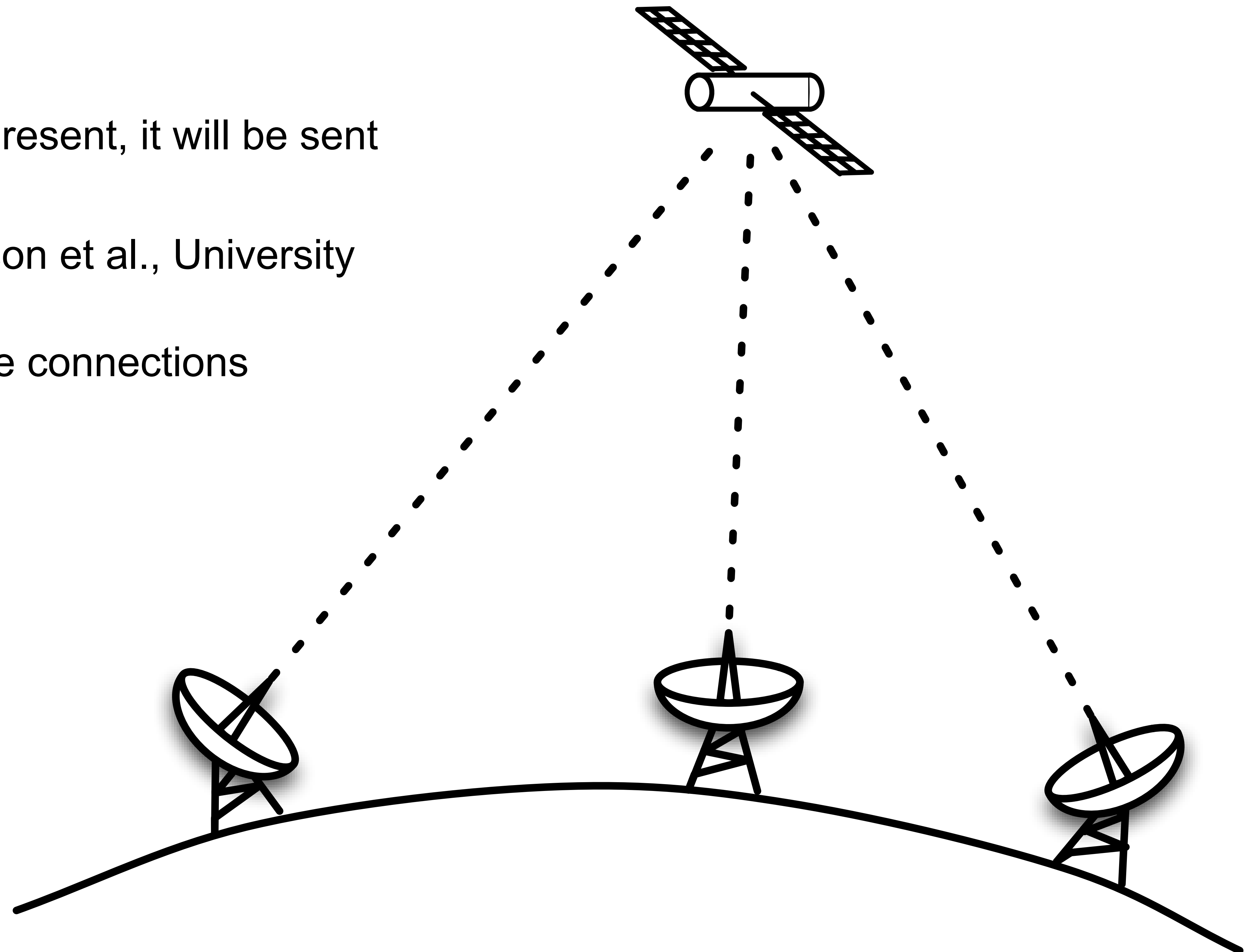
Bitmap Protokoll

- **Problems of TDMA**
  - If a station has nothing to send, then the channel is not used
- **Reservation system: bitmap protoco**
  - Static short reservation slots for the announcement
  - Must be received by each station
- **Problem**
  - Set of participants must be fixed and known a-priori
  - because of the allocation of contention slots

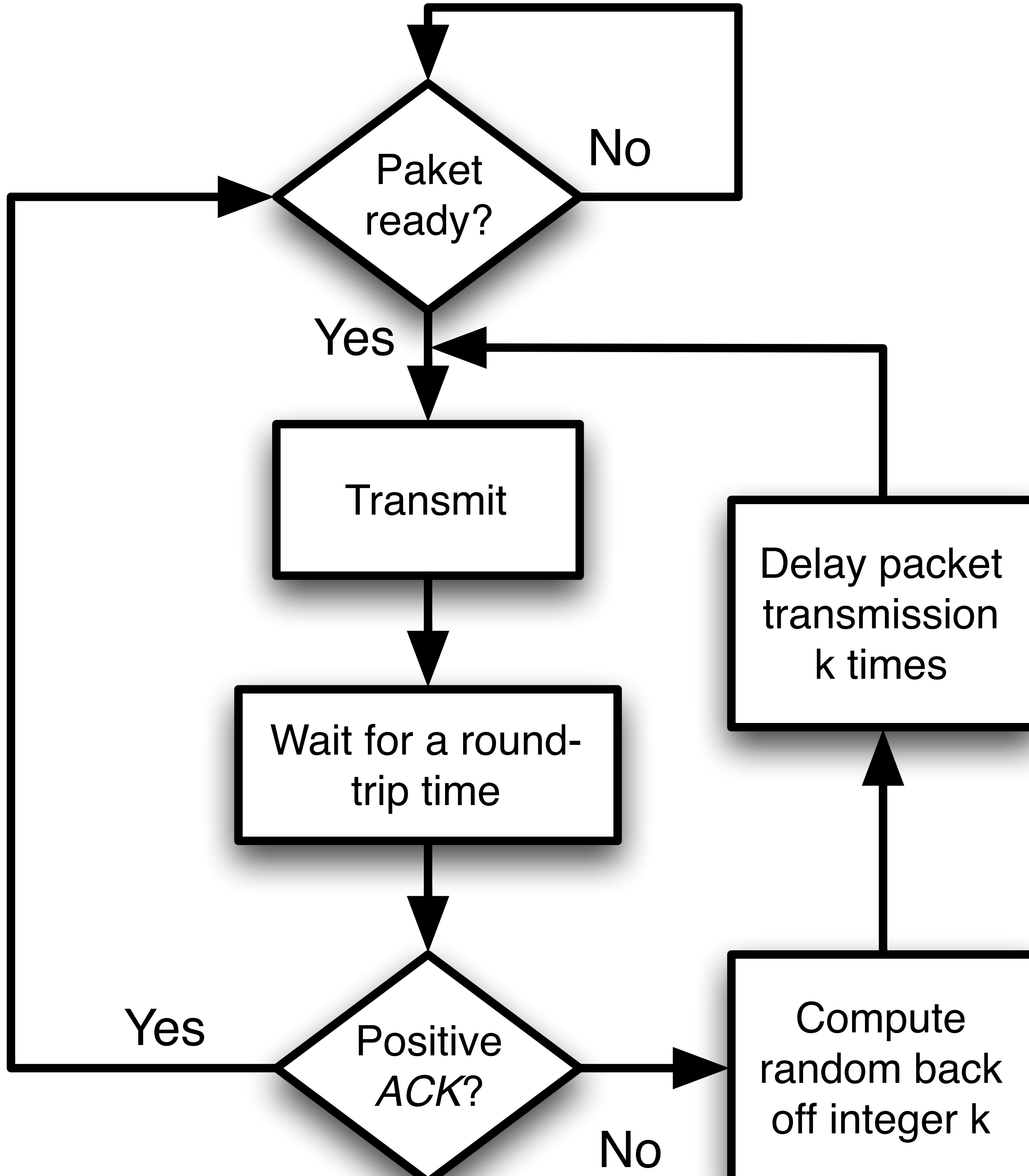


ALOHA

- **Algorithm**
  - Once a paket is present, it will be sent
- **Origin**
  - 1985 by Abrahmson et al., University of Hawaii
  - For use in satellite connections



Aloha



Paket ready?
No
Yes
Transmit
Wait for a round-trip time
Delay packet transmission k times
Positive *ACK*?
Yes
No
Compute random back off integer k

ALOHA – Analysis

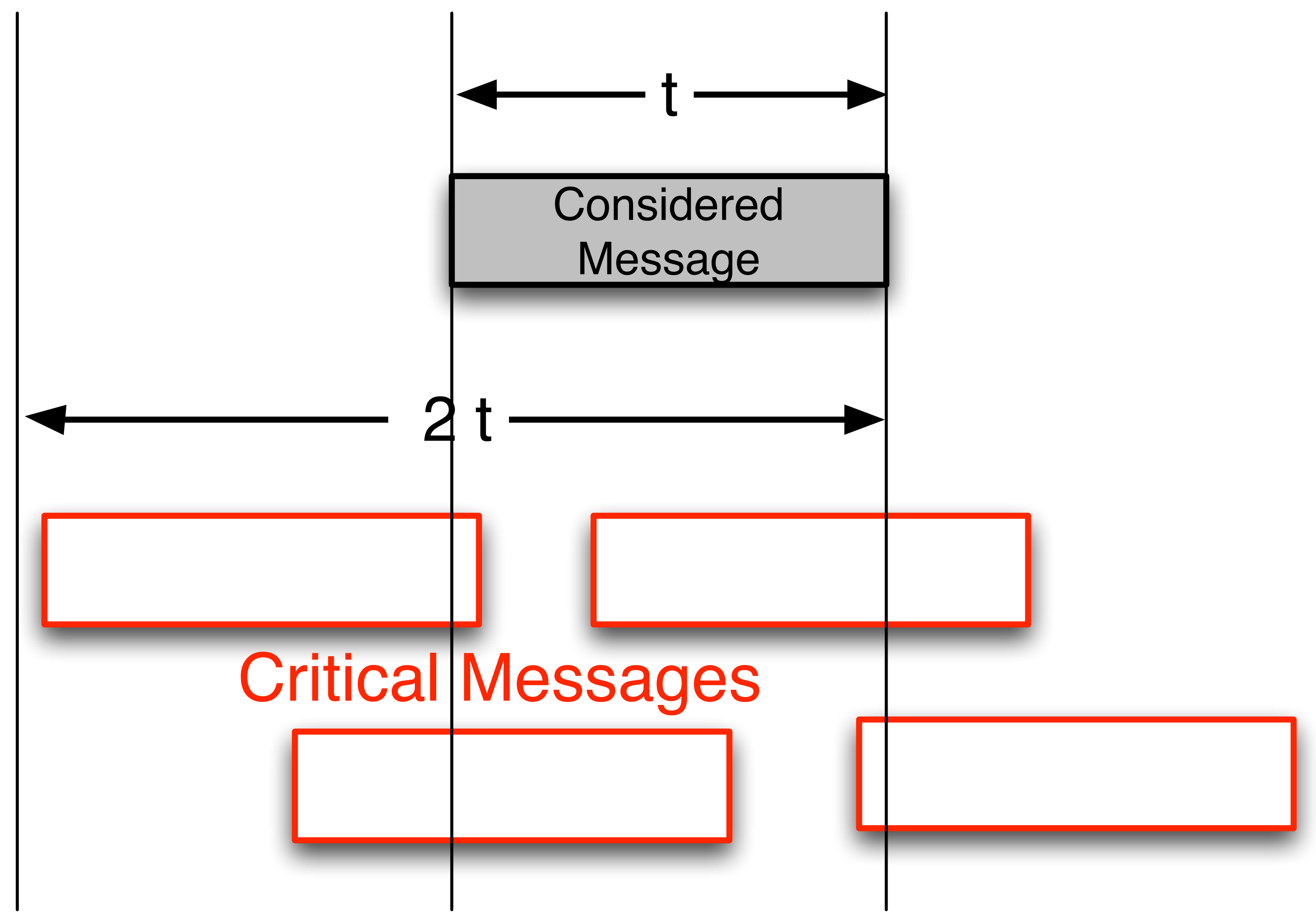
- **Advantage**
  - simple
  - no coordination necessary
- **Disadvantage**
  - collisions
    - sender does not check the channel
  - sender does not know whether the transmission will be successful
    - ACKs are necessary
    - ACKs can also collide

ALOHA – Efficiency

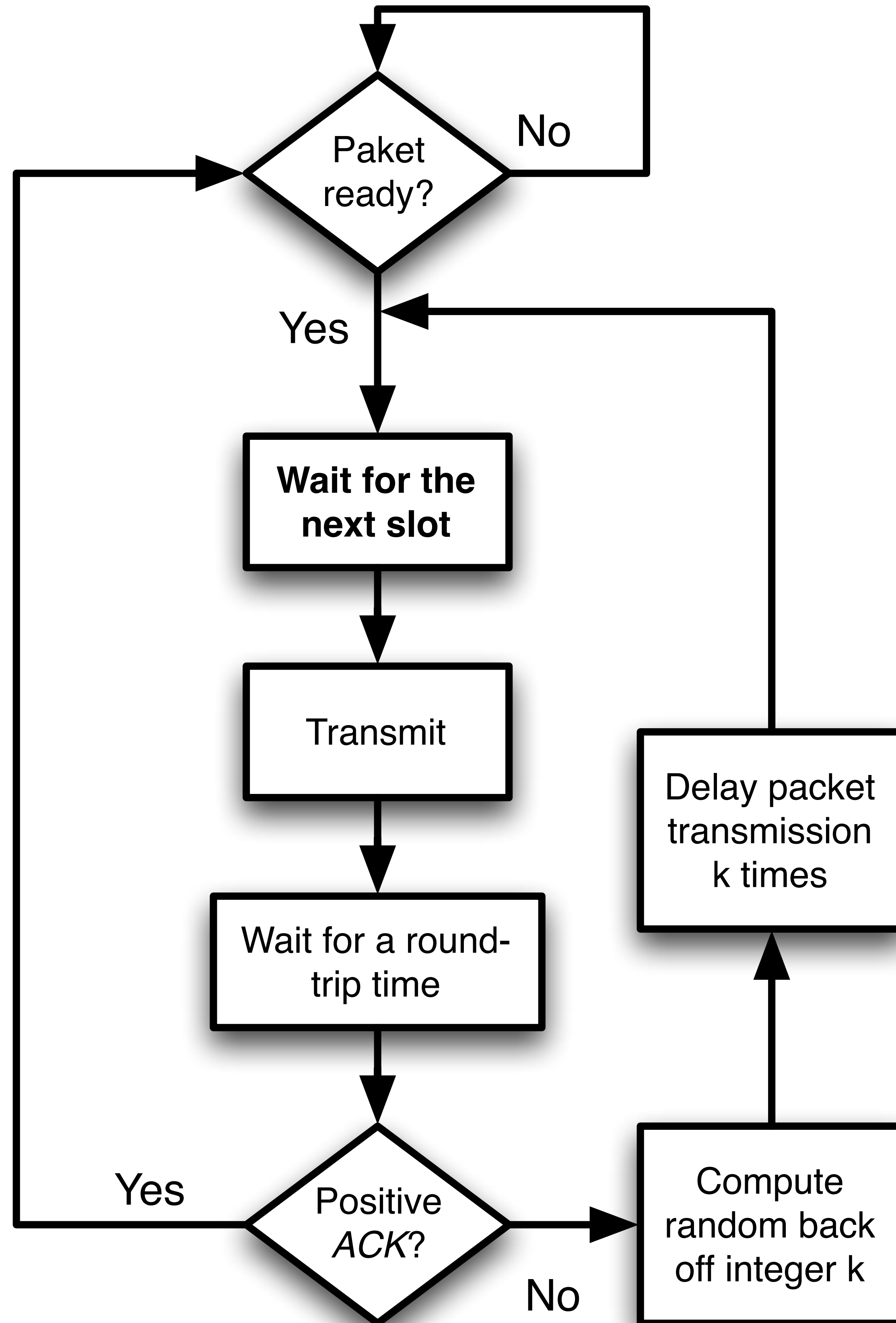
- **Consder Poisson-process for generation of packets**
  - describe “infinitely” many stations with similar behavior
  - time between two transmission is exponentially distributed
  - let G be the expectation of the transmission per packet length
  - all packets have equal length
  - Then we have $P[k \text{ transmissions}] = \frac{G^k}{k!} e^{-G}$
- **For a successful transmission, no collision with another packet may happen**
  - How probable is a successful transmission?

ALOHA – Efficiency

- **A packet X is disturbed if**
  - a packet starts just before X
  - a packet starts shortly after X starts
- **A packet is successfully transmitted,**
  - if during an interval of two packets no other packets are transmitted



Slotted Aloha

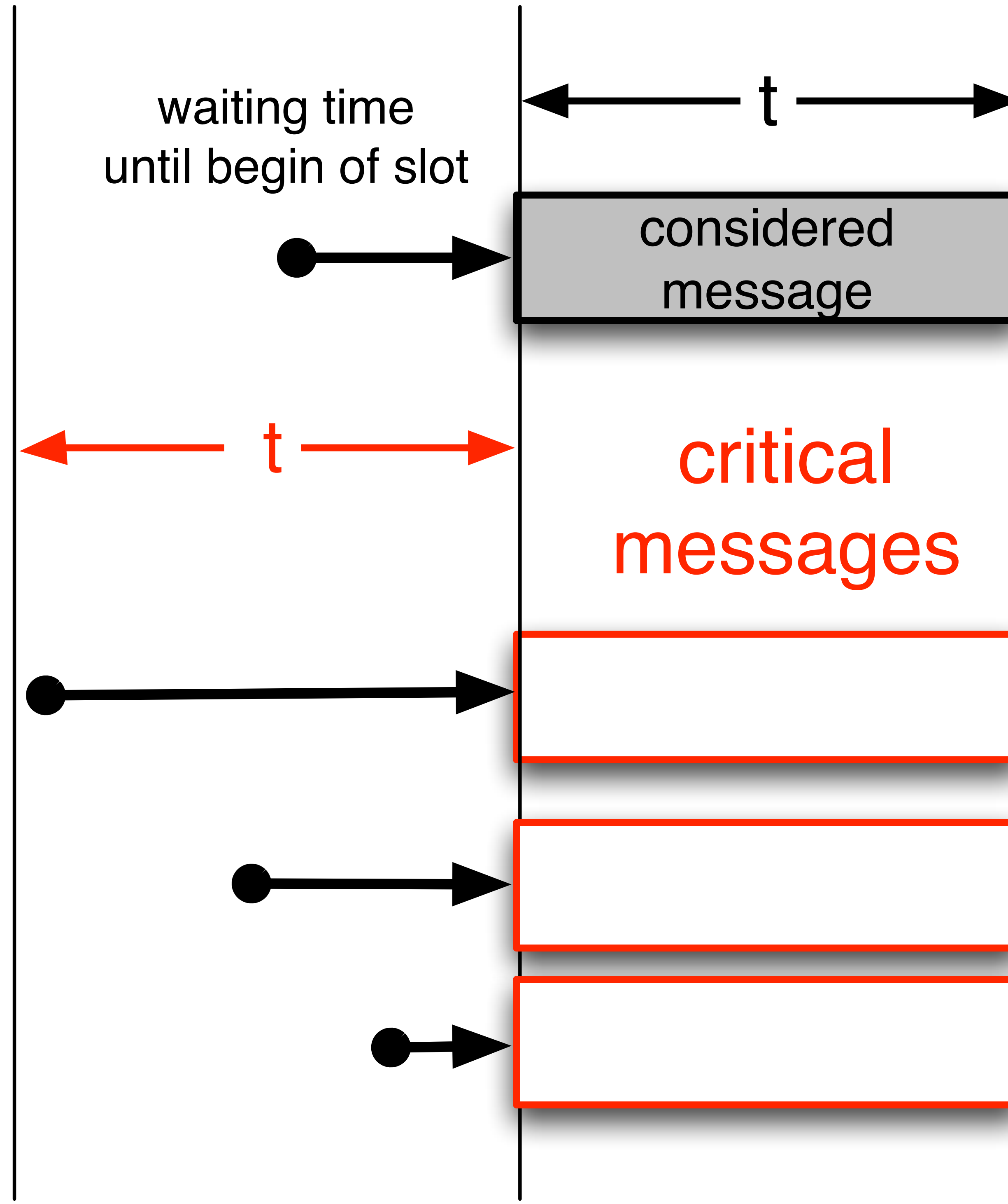


Slotted ALOHA

- **ALOHA‘s problem**
  - long vulnerability of a packet
- **Reduction through use slots**
  - synchronization is assumed
- **Result**
  - vulnerability is halved
  - throughput is doubled
    - $S(G) = Ge^{-G}$
    - optimal for G=1, S=1/e

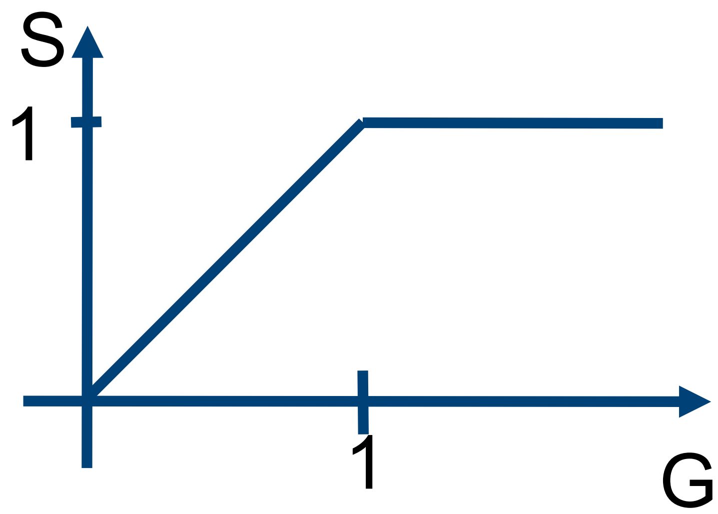
Slotted ALOHA – Effizienz

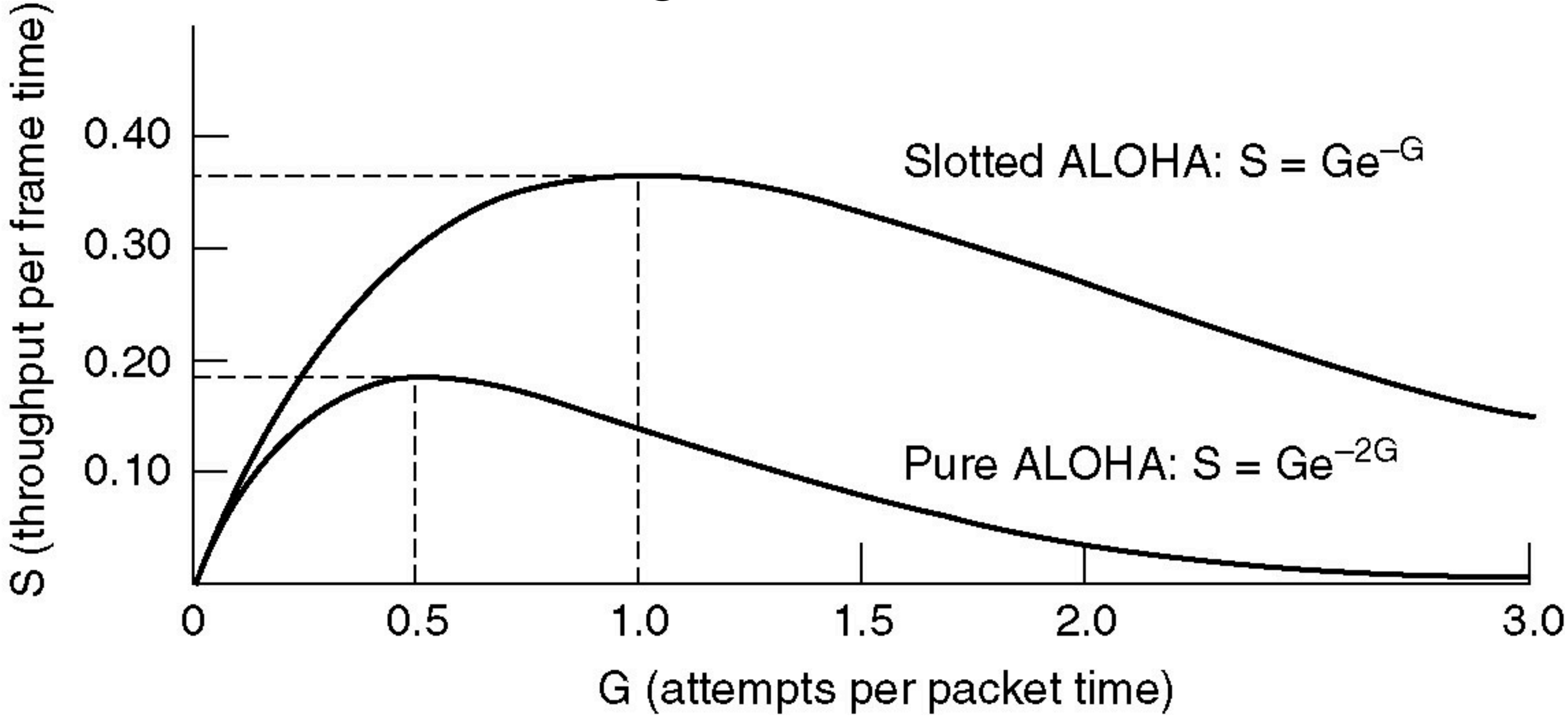
- **A packet X is disturbed if**
  - a package starts just before X
- **The packet is successfully transmitted,**
  - when transmitting over a period of **one** packets no (other) packets appears



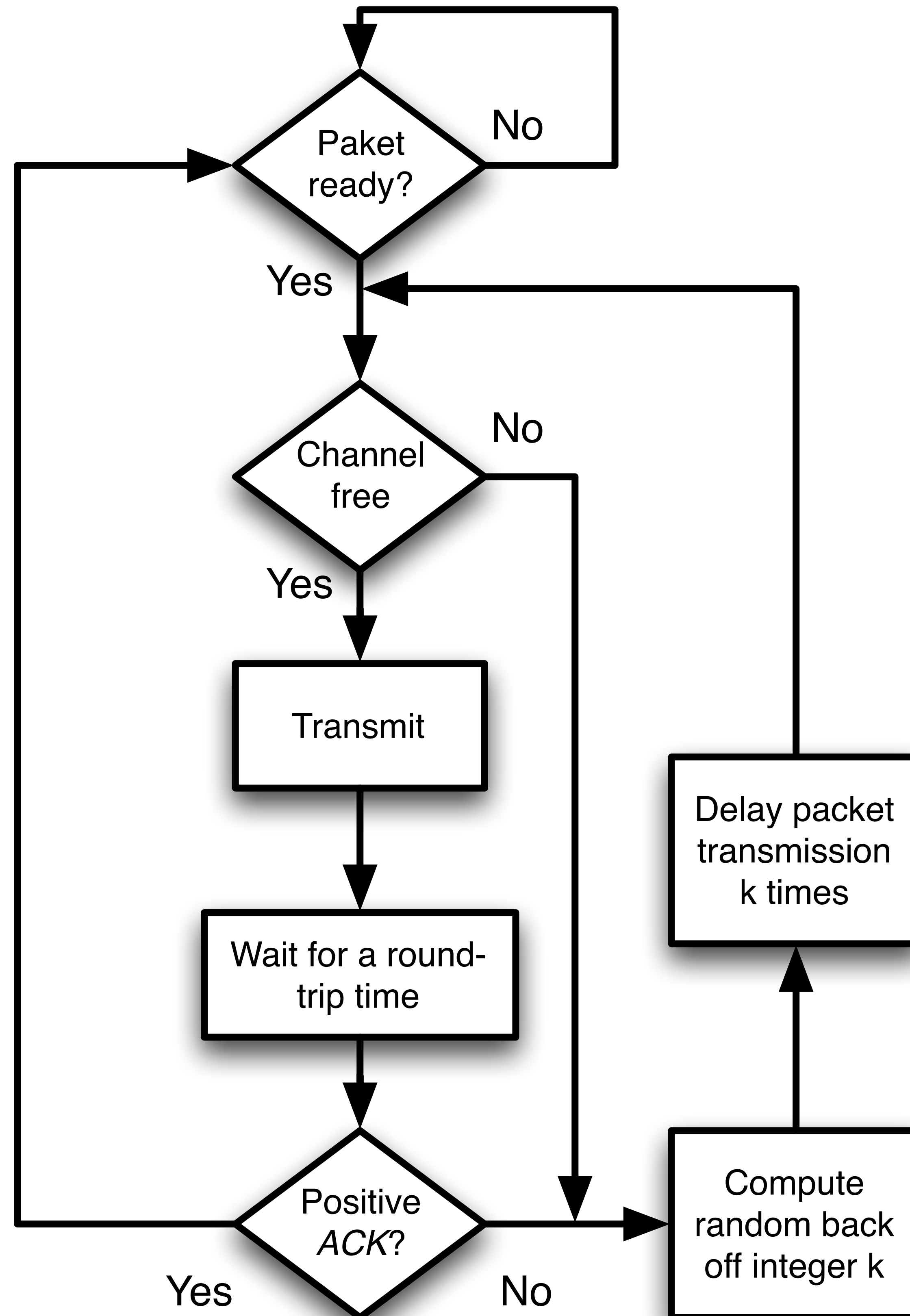
Throughput with respect to the Load

Optimal



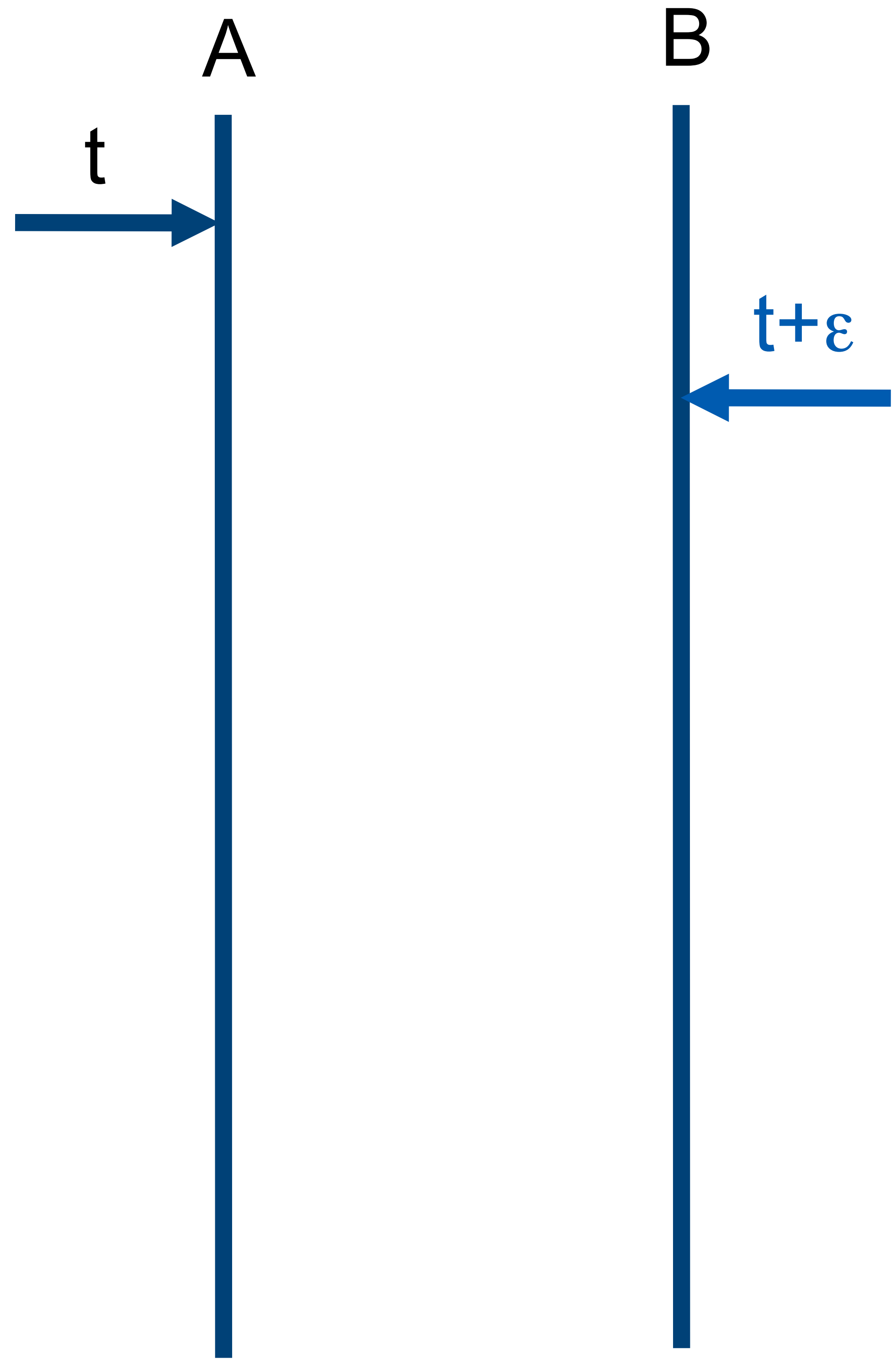


Carrier Sense Medium Access CSMA



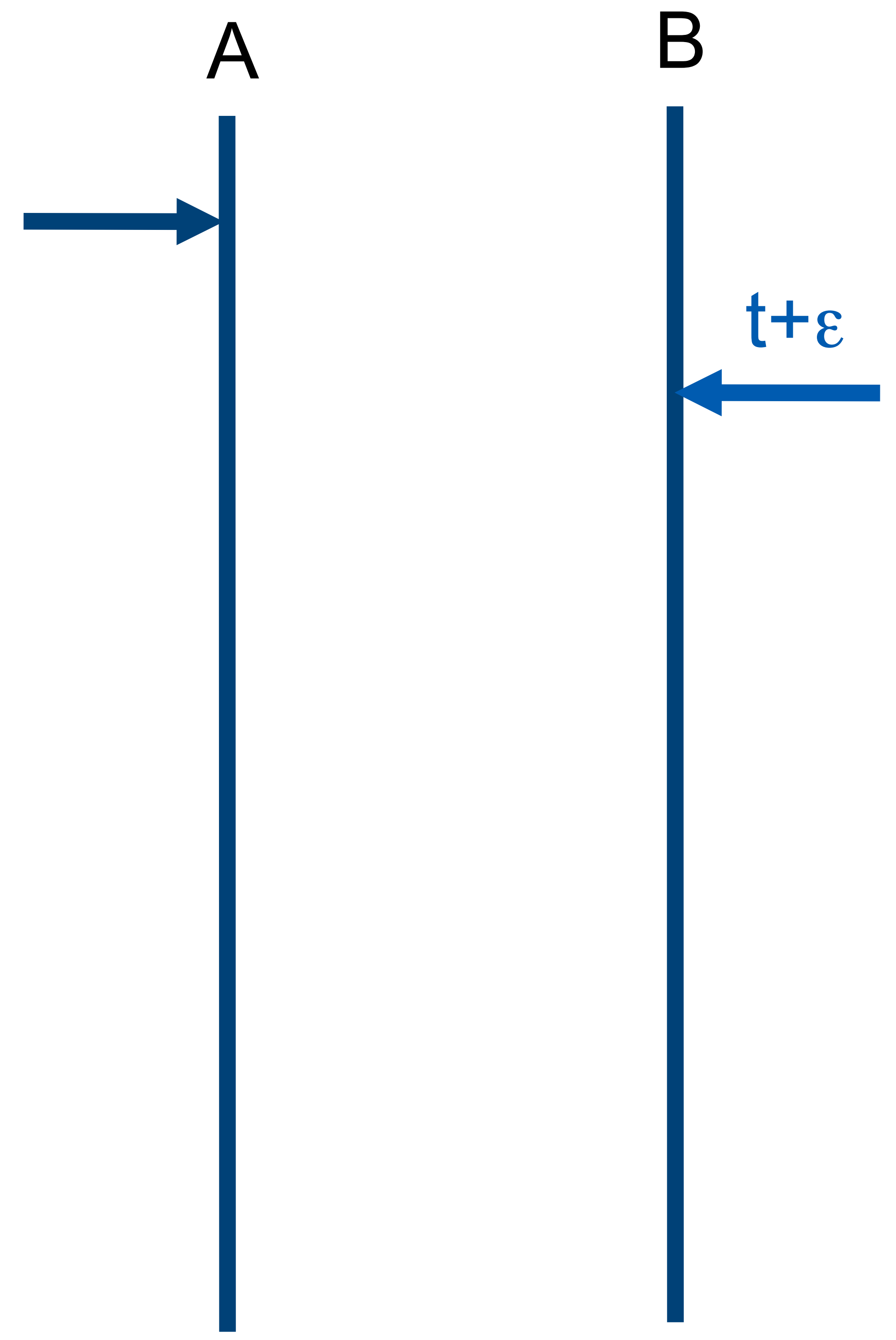
CSMA und Transmission Time

- **CSMA-Problem:**
  - Transmission delay d
- **Two stations**
  - start sending at times t and t + ε with ε <d
  - see a free channel
- **2nd Station**
  - causes a collision

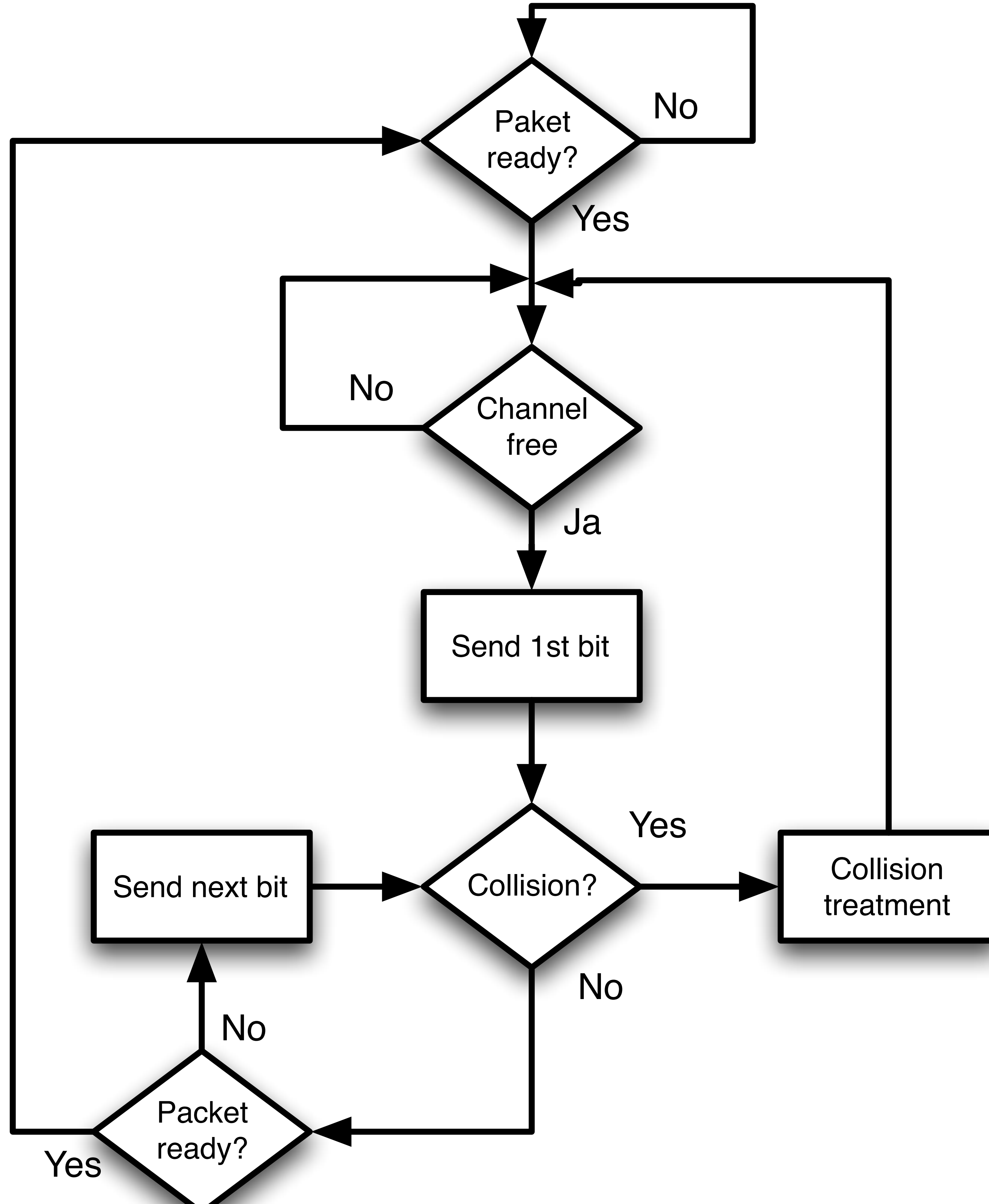


Kollisionserkennung in Ethernet – CSMA/CD

- **CSMA/CD – Carrier Sense Multiple Access/Collision Detection**
  - Ethernet
- **If collision detection during reception is possible**
  - Both senders interrupt sending
  - Waste of time is reduced
- **Collision Detection**
  - simultaneously listening and sending must be possible
  - Is that what happens on the channel that's identical to the message?



Ethernet CSMA/CD



Computation of the Backoff

- **Algorithm: Binary Exponential Backoff**
  - k:=2
  - While a collision has occurred
    - choose t randomly uniformly from {0,...,k-1}
    - wait t time units
    - send message (terminate in case of collision)
    - k:= 2 k
- **Algorithm**
  - waiting time adapts to the number of stations
  - uniform utilization of the channel
  - fair in the long term

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