



ALBERT-LUDWIGS-
UNIVERSITÄT FREIBURG

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

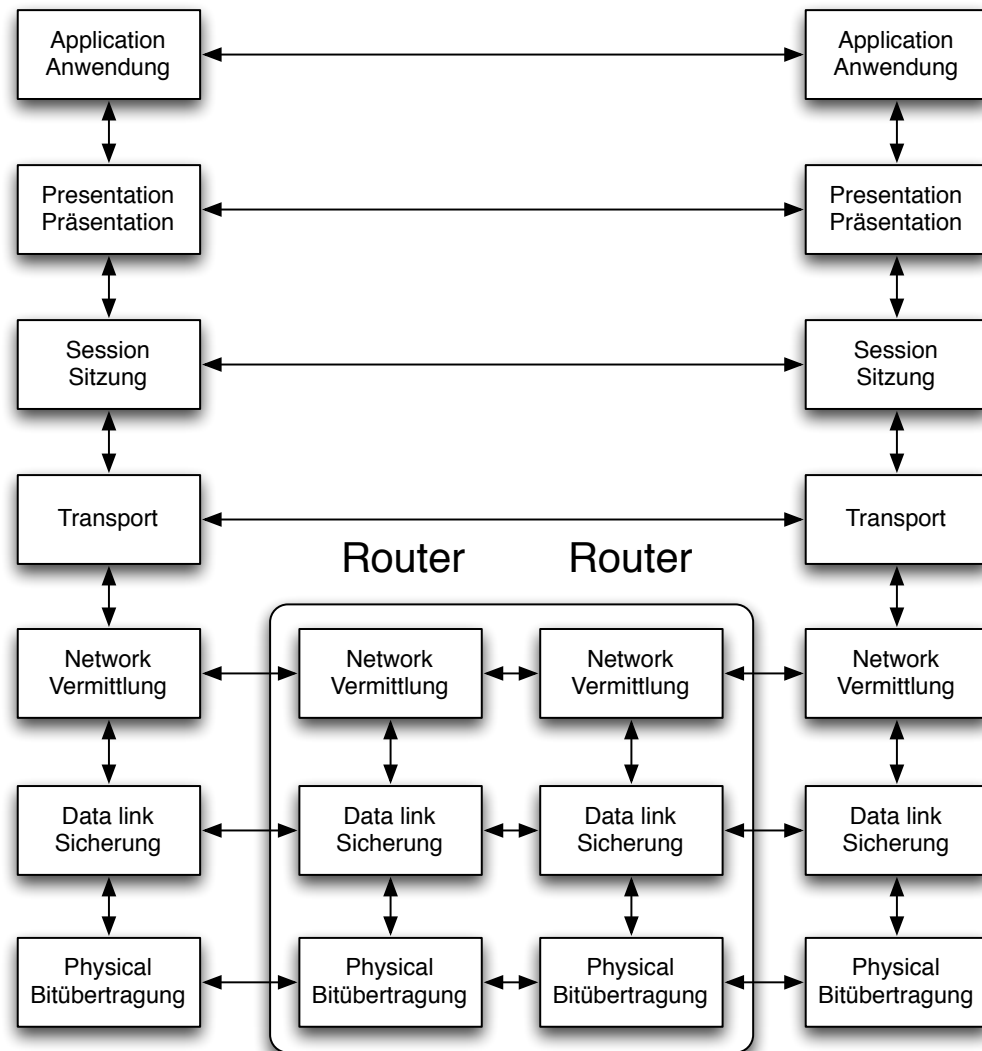
- Routing

► 2. Data Link

- Checksums, flow control

► 1. Physical

- Mechanics, electrics

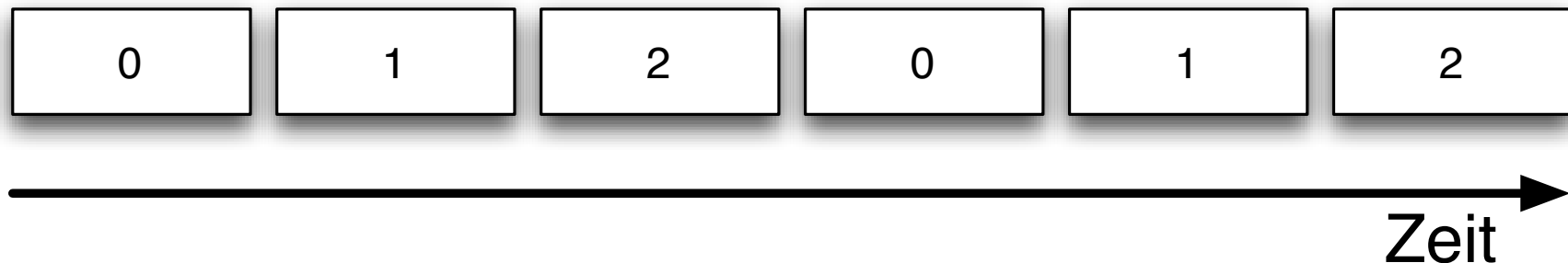


Types of Conflict Resolution

- ▶ **Conflict-free**
 - TDMA, Bitmap
 - FDMA, CDMA, Token Bus
- ▶ **Contention-based**
 - Pure contention
 - Restricted 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

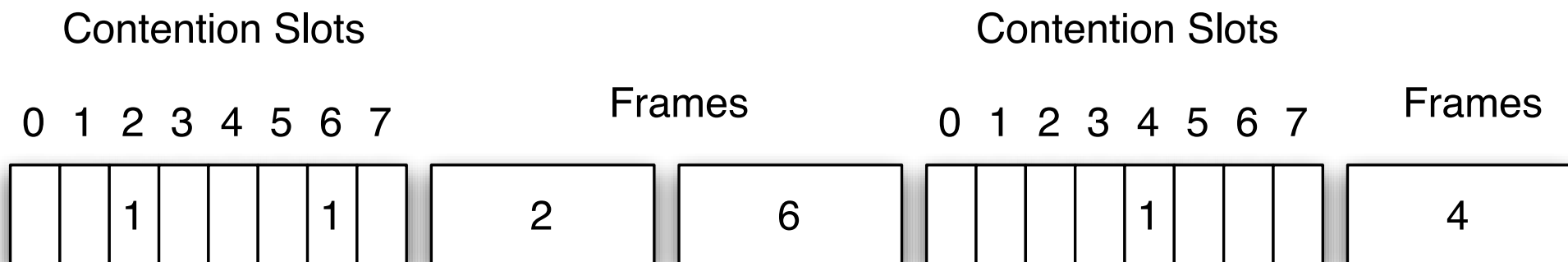
- If a station has nothing to send, then the channel is not used

► 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



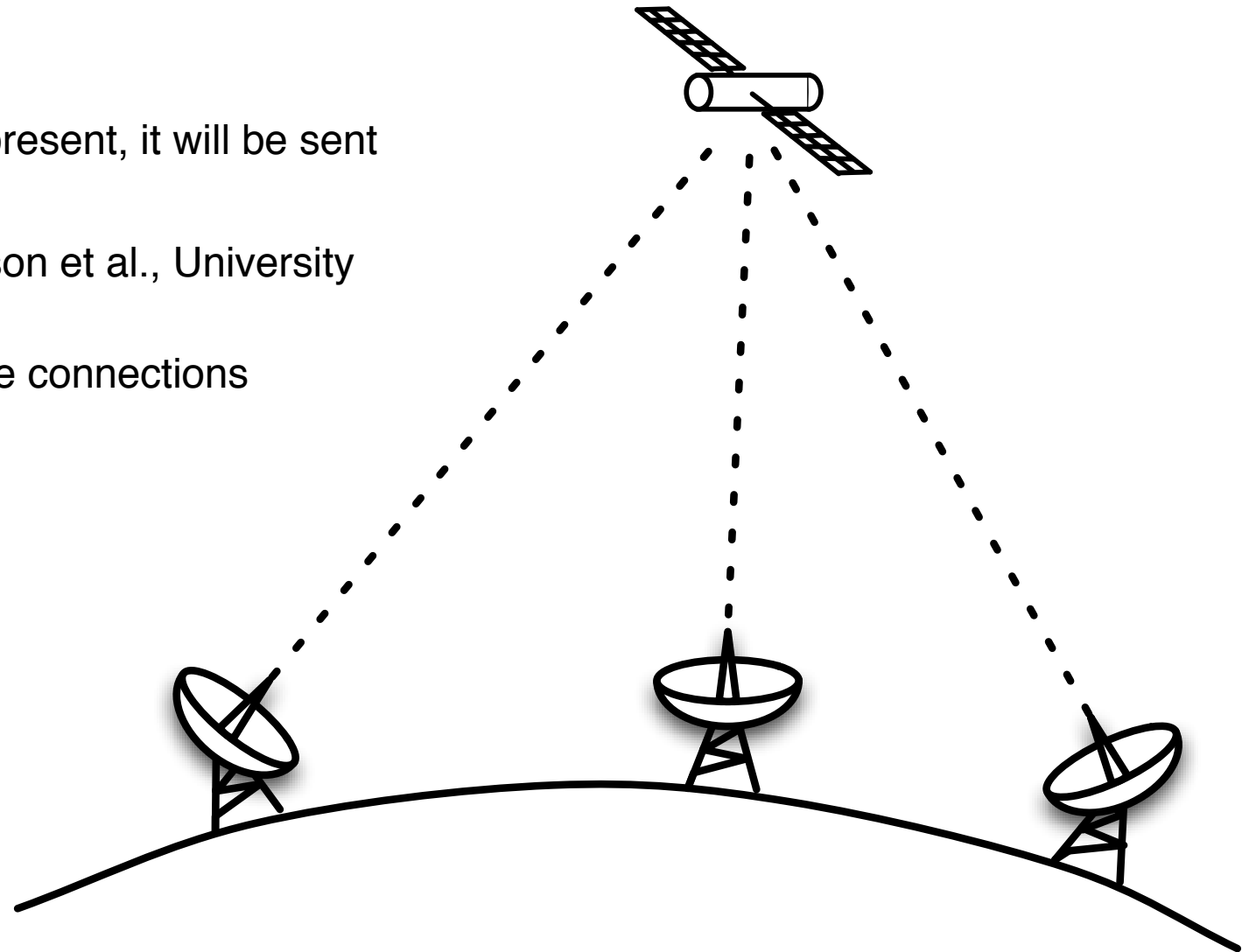
ALOHA

► Algorithm

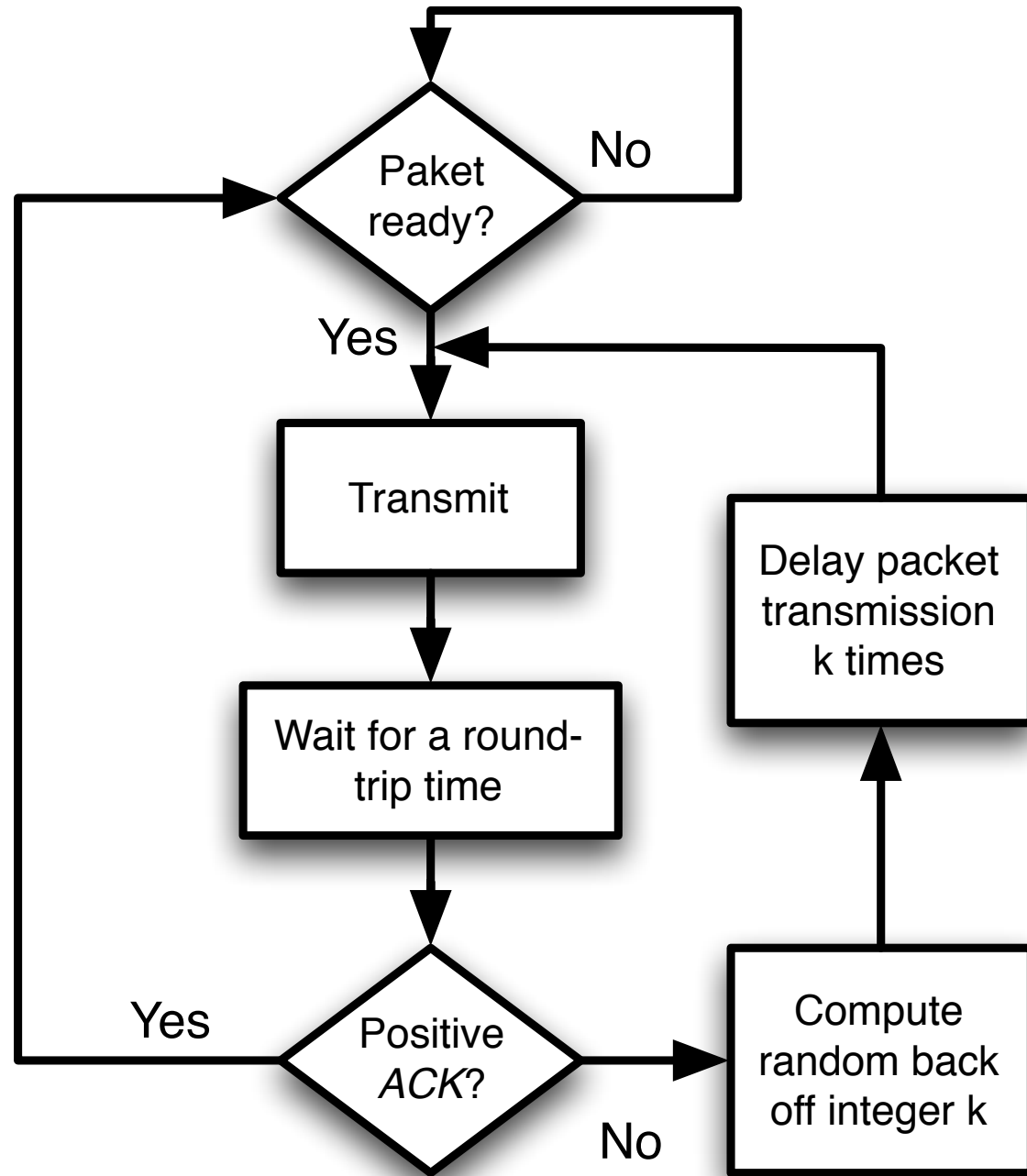
- Once a packet is present, it will be sent

► Origin

- 1985 by Abrahamson et al., University of Hawaii
- For use in satellite connections



Aloha



ALOHA – Analysis

▶ **Advantage**

- simple
- no coordination necessary

▶ **Disadvantage**

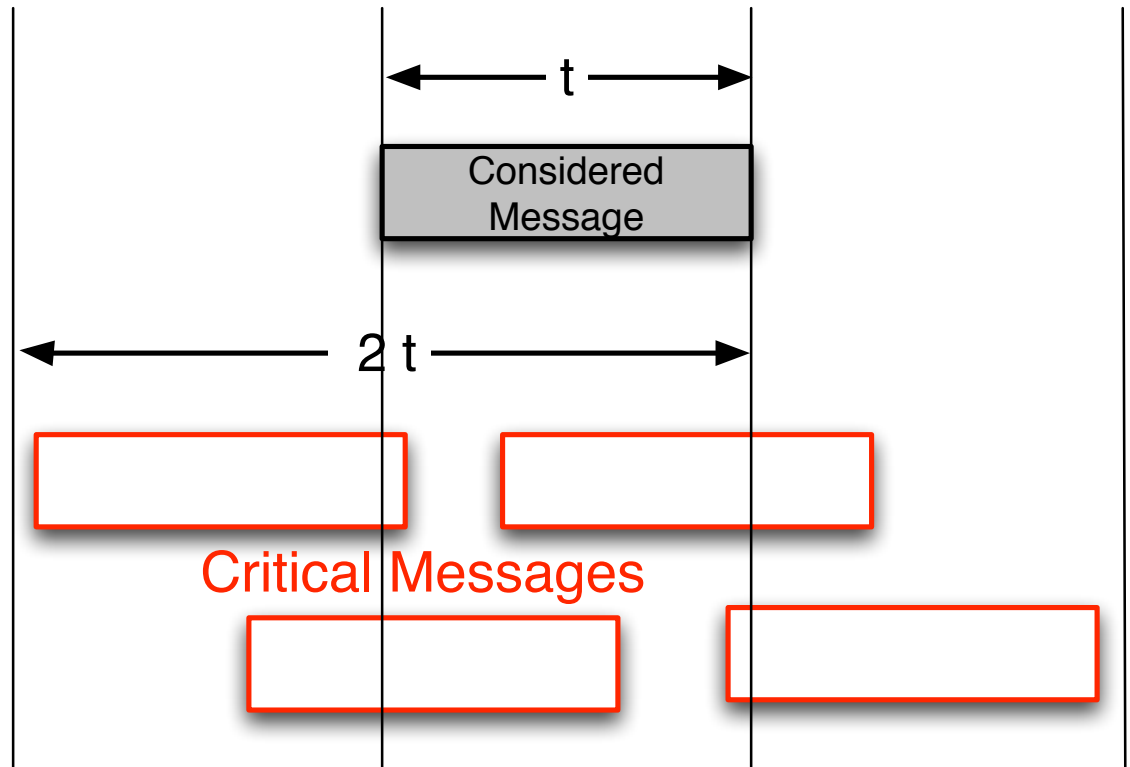
- collisions
 - sender does not check the channel
- sender does not know whether the transmission will be successful
 - ACKs are necessary
 - ACKs can also collide

ALOHA – Efficiency

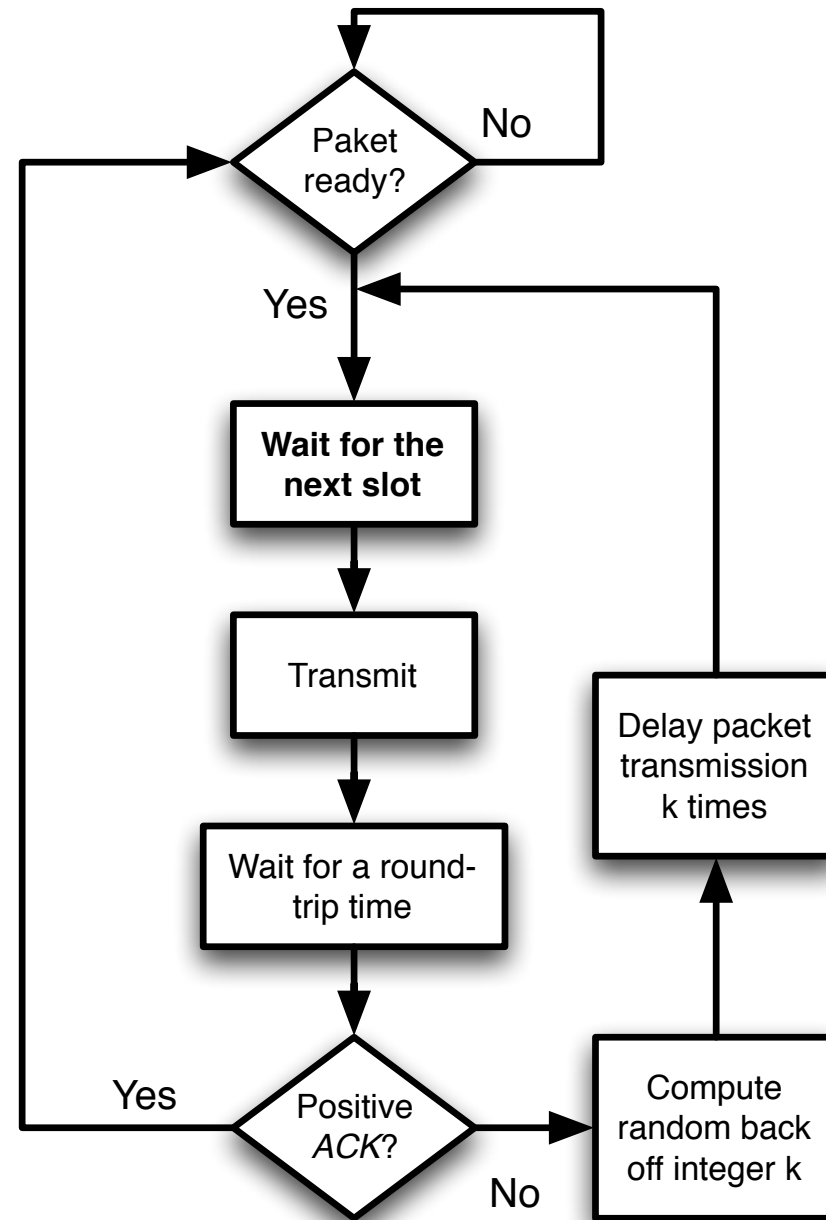
- ▶ **Consider Poisson-process for generation of packets**
 - describe “infinitely” many stations with similar behavior
 - time between two transmission is exponentially distributed
 - let G be the expectation of the transmission per packet length
 - all packets have equal length
 - Then we have $P[k \text{ transmissions}] = \frac{G^k}{k!} e^{-G}$
- ▶ **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

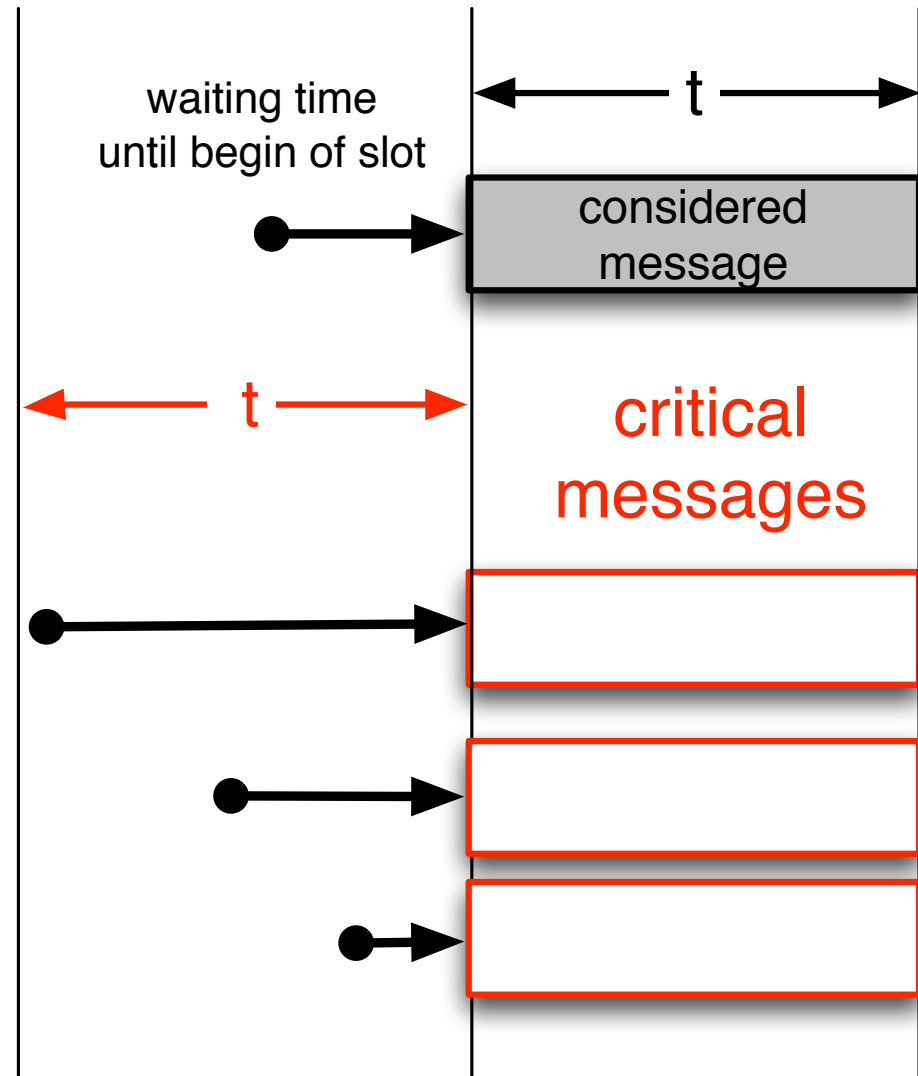


Slotted ALOHA

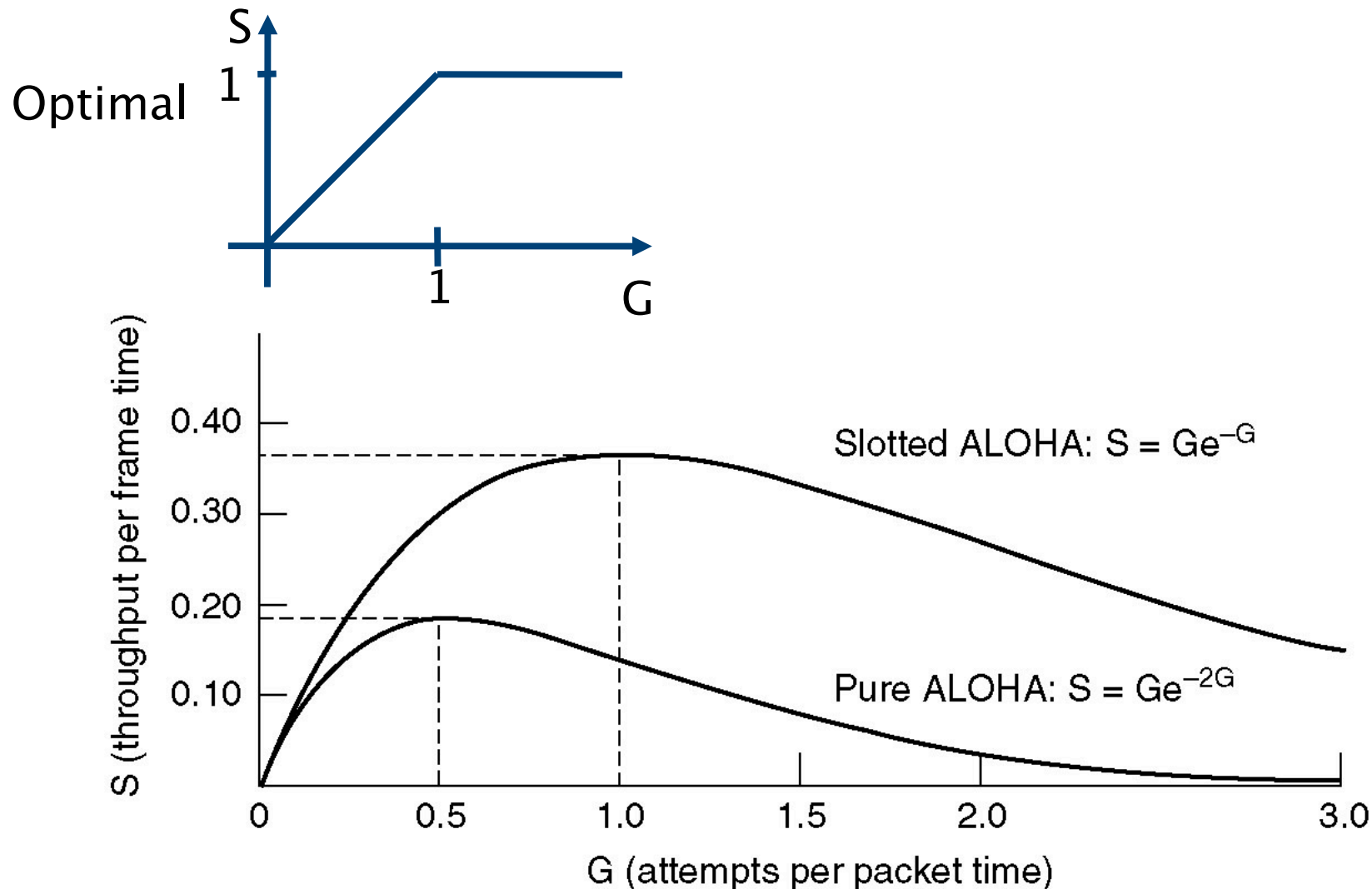
- ▶ **ALOHA's problem**
 - long vulnerability of a packet
- ▶ **Reduction through use slots**
 - synchronization is assumed
- ▶ **Result**
 - vulnerability is halved
 - throughput is doubled
 - $S(G) = Ge^{-G}$
 - optimal for $G=1$, $S=1/e$

Slotted ALOHA – Effizienz

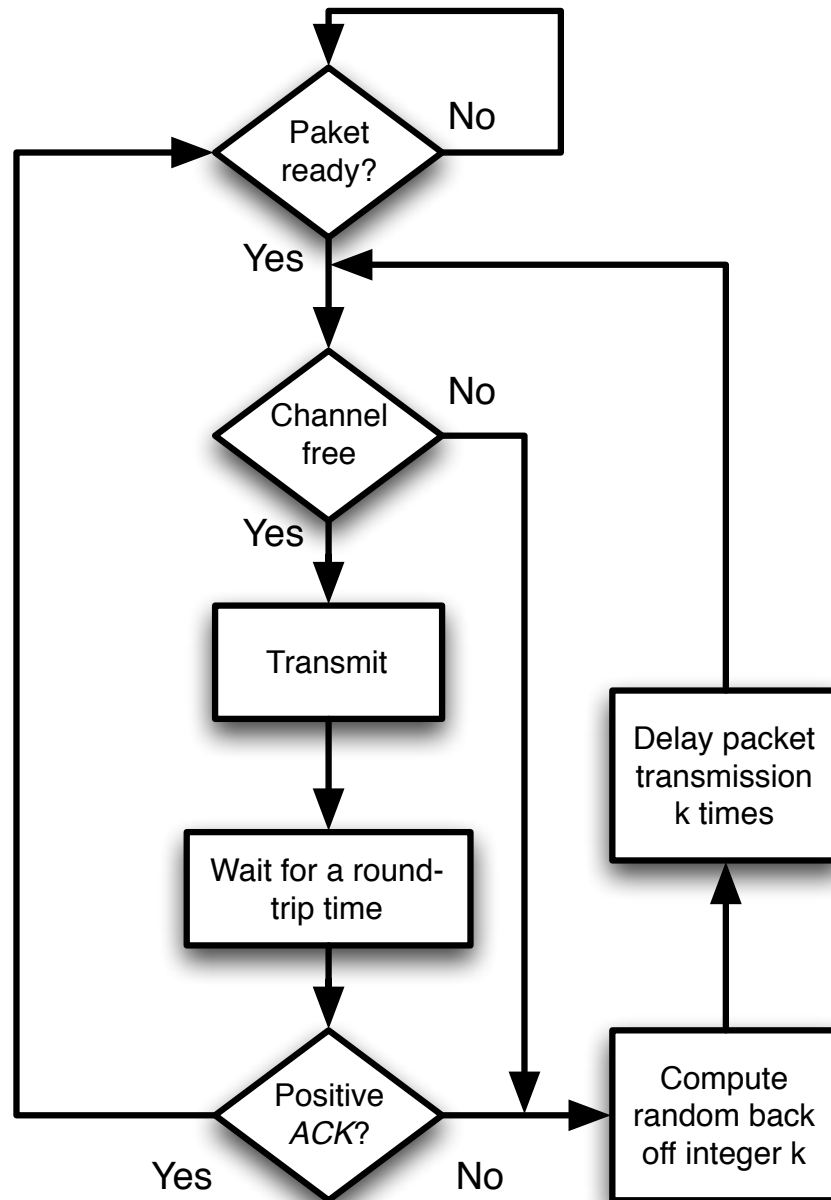
- ▶ **A packet X is disturbed if**
 - a package starts just before X
- ▶ **The packet is successfully transmitted,**
 - when transmitting over a period of **one** packets no (other) packets appears



Throughput with respect to the Load



Carrier Sense Medium Access CSMA



CSMA und Transmission Time

► CSMA-Problem:

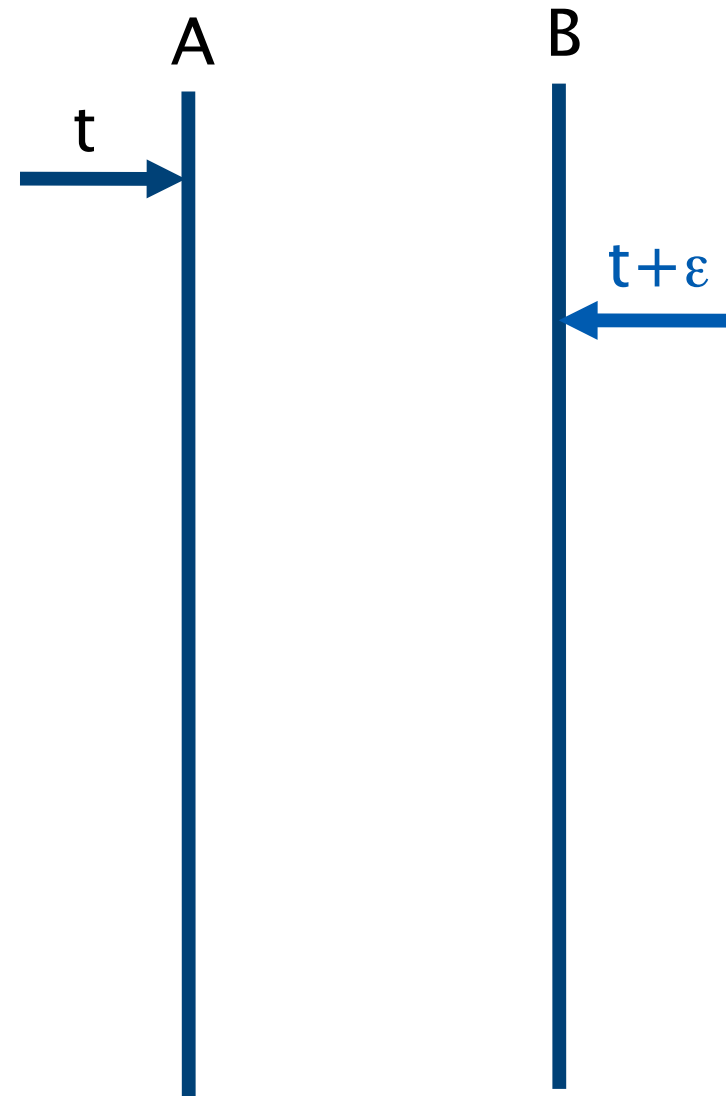
- Transmission delay d

► Two stations

- start sending at times t and $t + \varepsilon$ with $\varepsilon < d$
- see a free channel

► 2nd Station

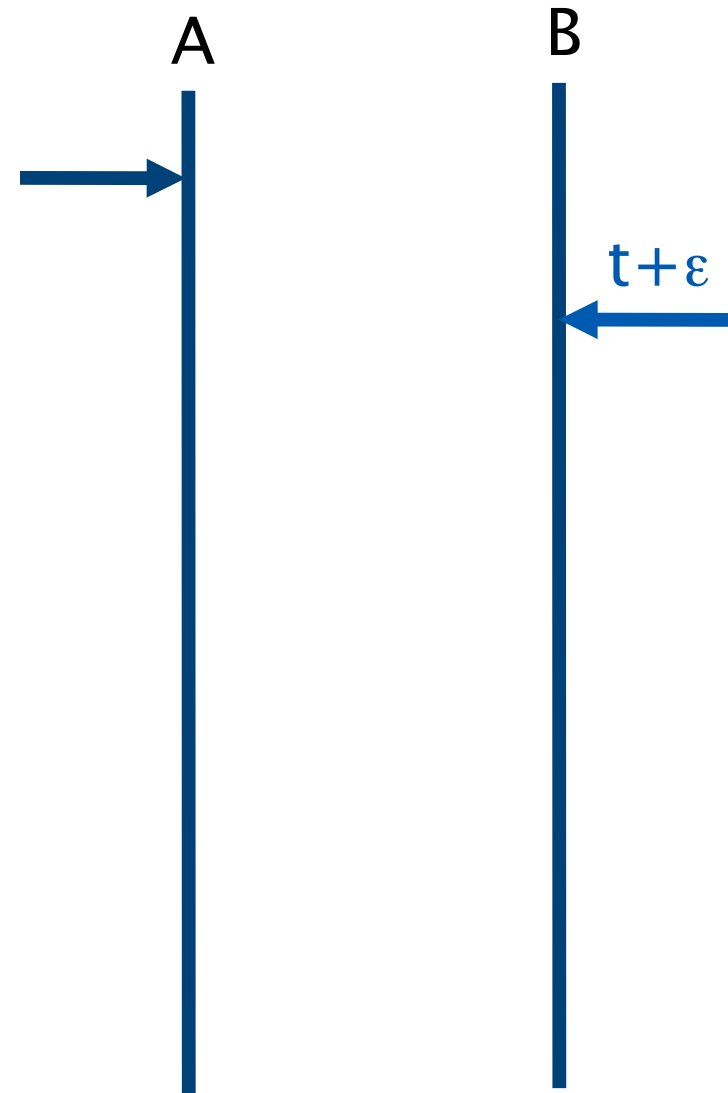
- causes a collision



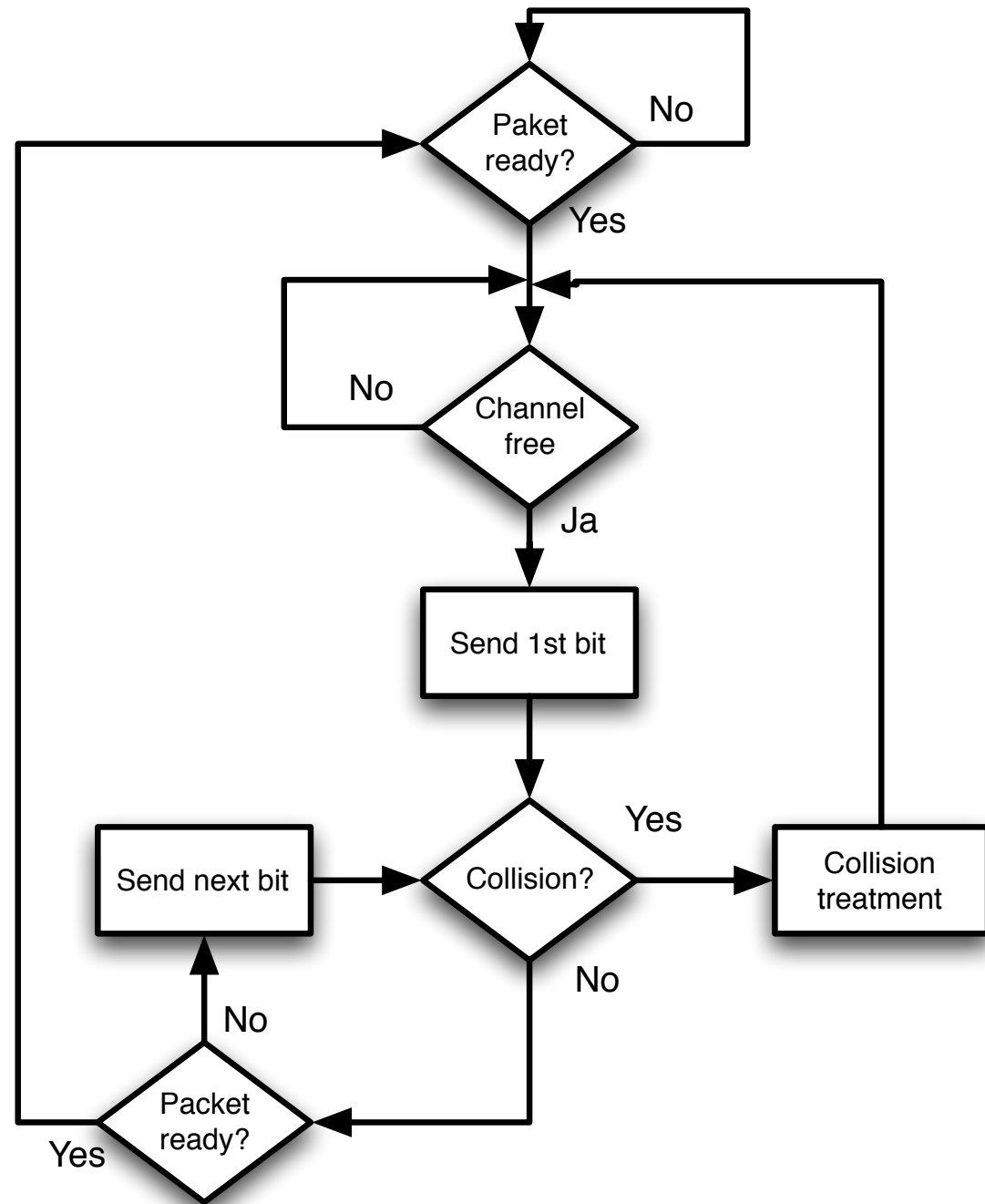
Collision Detection in Ethernet

– 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 $\{0, \dots, k-1\}$
 - wait t time units
 - send message (terminate in case of collision)
 - $k := 2k$

‣ Algorithm

- waiting time adapts to the number of stations
- uniform utilization of the channel
- fair in the long term



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