Data Link In Broadcast Networks: The Media Access Sublayer

- **Broadcast networks with multi-access (or random access) shared channels include the majority of LANS, all wireless and satellite networks.**
- **Medium Access Control (MAC):**

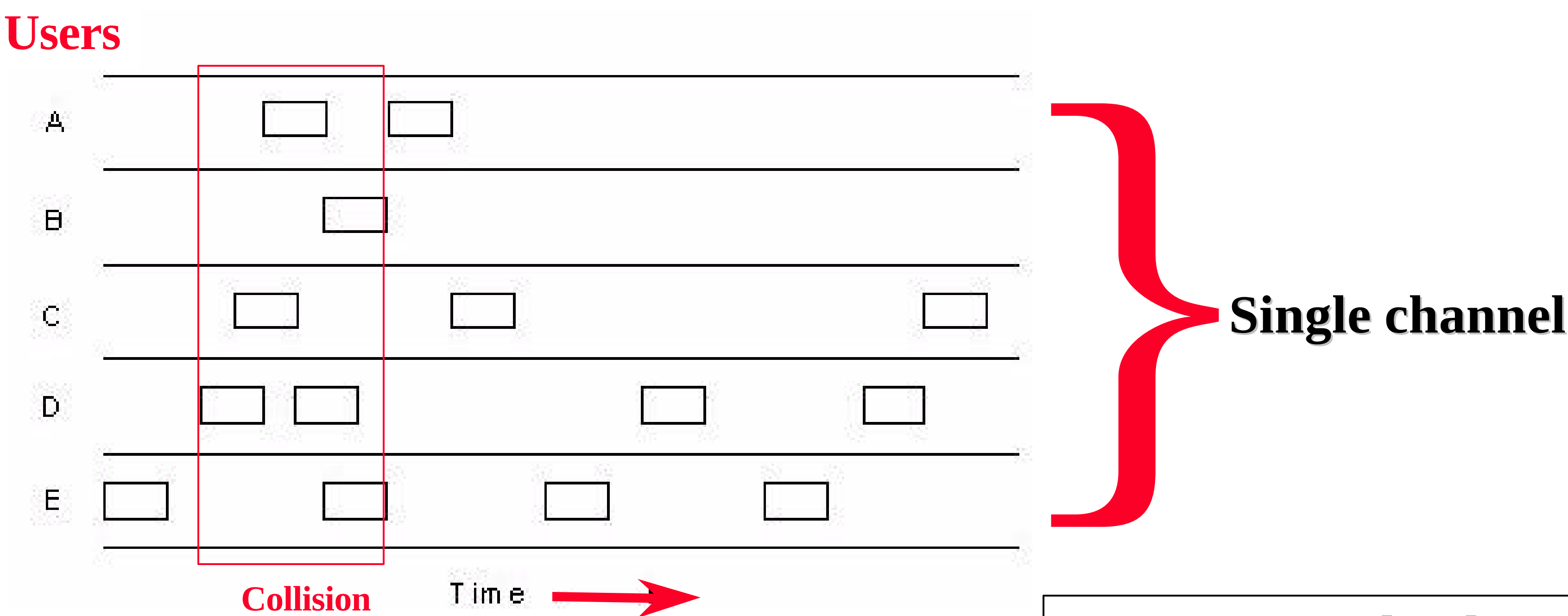
  Protocols to allocate a single shared broadcast channel among competing senders by determining which sender gets access to the channel next and transmit its data.
- **Static Channel Allocation: Frequency Division Multiplexing (FDM), Time Division Multiplexing (TDM) --- too wasteful of available bandwidth.**
- **Dynamic Channel Allocation: No predetermined sender access order to the channel.**

Dynamic Channel Allocation: Protocol Assumptions

- N independent stations (senders or, computers etc.)
- A station is blocked until its generated frame is transmitted.
- Probability of a frame being generated in a period of length Δt is $\lambda \Delta t$ where λ is the arrival rate of frames.
- Only a single channel is available.
- The transmission of two or more frames on the channel at the same time creates a collision and destroyed data.
- Time can be either: Continuous or slotted.
- Carrier sense: A station can sense if a channel is busy before transmission.
- No Carrier sense: Timeout used to sense loss of data.

Multiple Access Protocols: Pure ALOHA

- **Stations transmit whenever data is available at arbitrary times (forming a contention system).**
- **Colliding frames are destroyed**
- **Frame destruction sensed by listening to channel:**
  - **Immediate collision feedback in LANs**
  - **270 msec feedback delay in satellite transmission.**
- **When a frame is destroyed the sender waits a random period of time before retransmitting the frame**



Frame Throughput of Pure ALOHA

- Infinite sender population assumed.
- New frames rate (or frames success rate):

  Poisson distribution with mean rate S frames/frame time.
- Combined frame rate with retransmissions :

  G frames/frame time.
- $S = GP_0$ where P_0 = probability a frame is successful
- t = time required to transmit a frame
- A frame is successful if no other frames are transmitted in the vulnerable period from t_0 to $t_0 + 2t$
- Probability k frames are generated during a frame time:

$$P_r[k] = \frac{G^k e^{-G}}{K!}$$

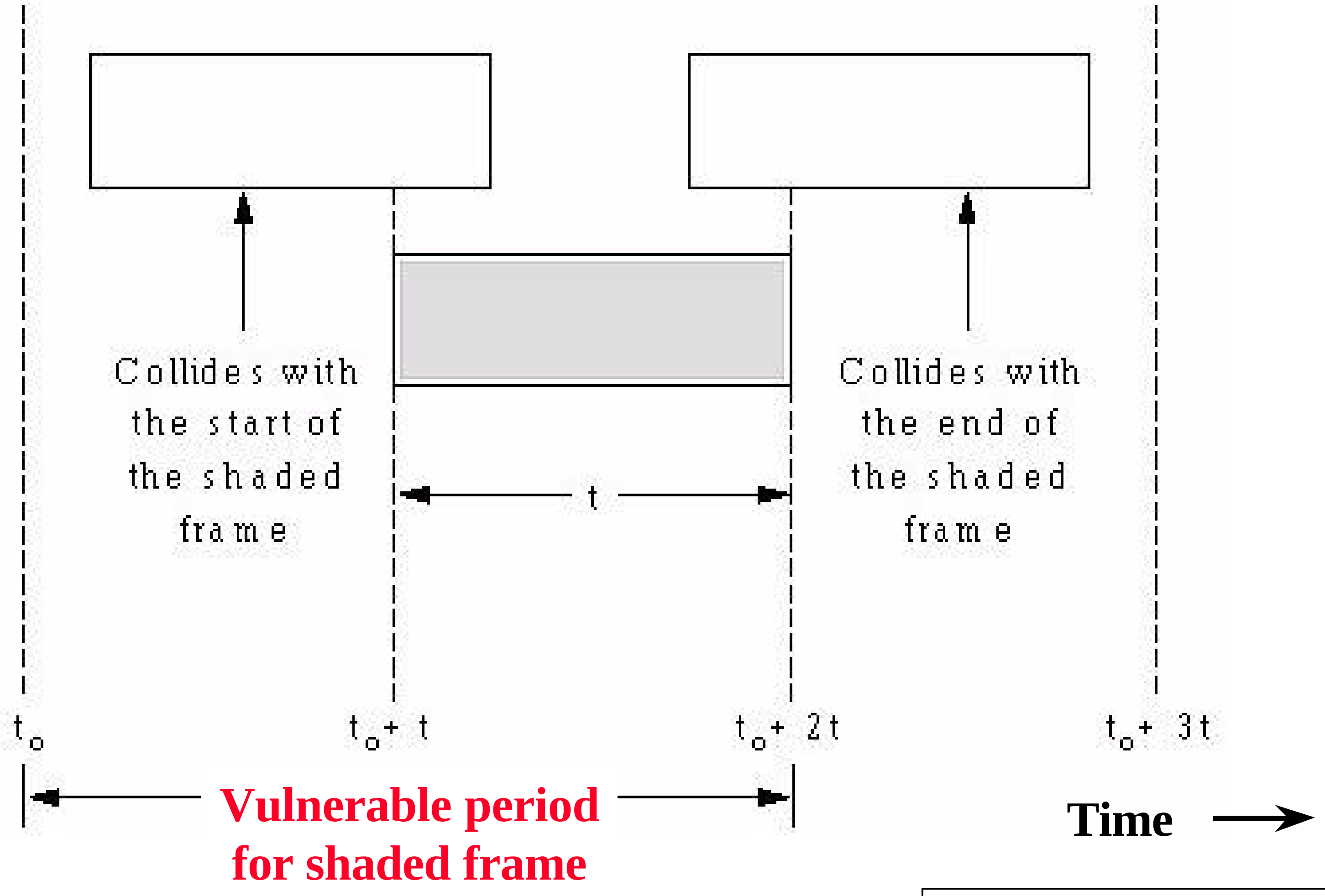
- Probability of zero frames in two frame periods is $P_0 = e^{-2G}$

$\Rightarrow$ $S = G P_0 = G e^{-2G}$ Max (S) = 1/2e at G = .5

Vulnerable Period in Pure ALOHA

For successful frame transmission:

No other frame should be on the channel for vulnerable period equal to twice the time to transmit one frame = $2t$



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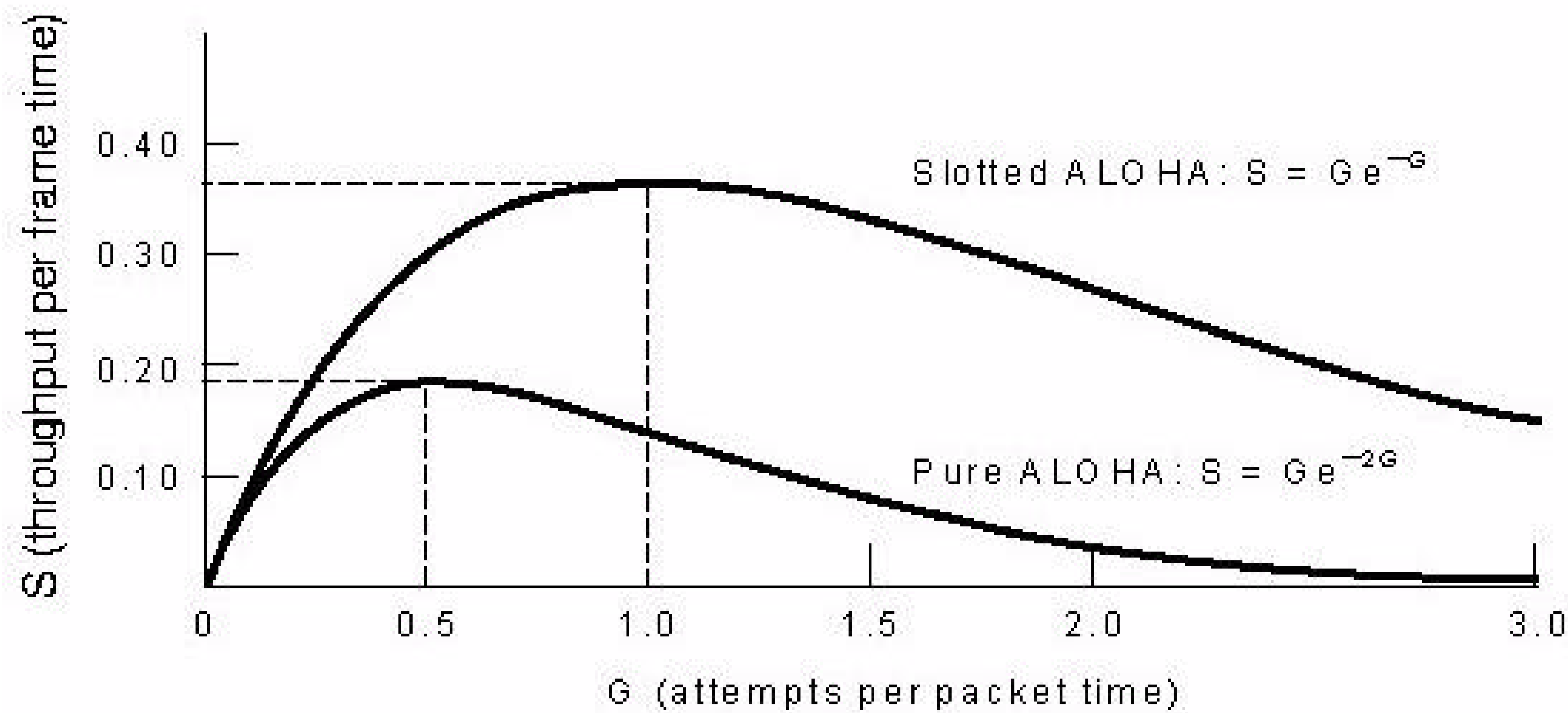
Slotted ALOHA

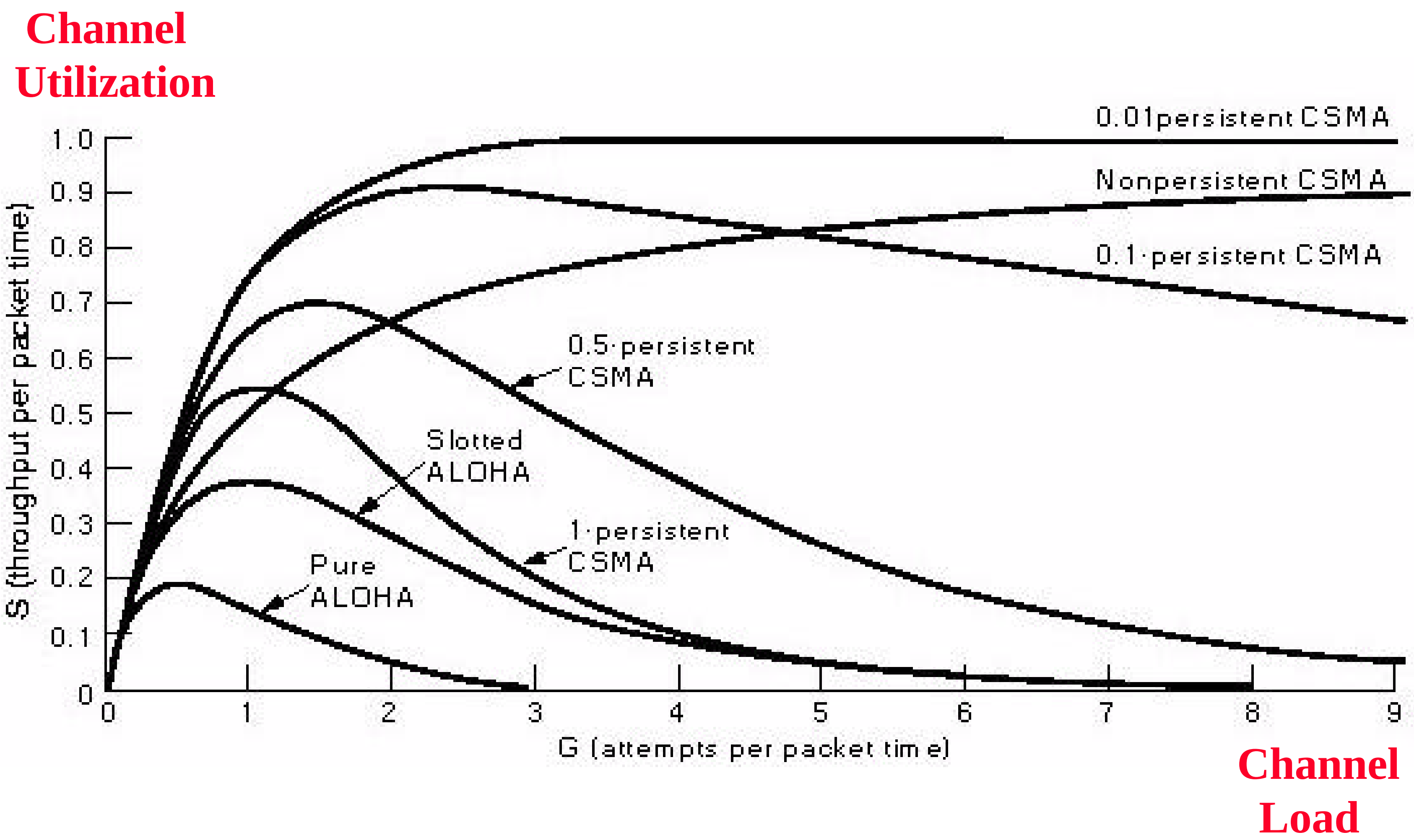
- Time is divided into discrete frame time slots.
- A station is required to wait for the beginning of the next slot to transmit
- Vulnerable period is halved as opposed to pure ALOHA.

$\Rightarrow$ $S = G P_0 = G e^{-G}$ Max (s) = 1/e at G = 1

- Expected number of retransmissions: $E = e^{G}$



Channel Utilization Vs. Load for Random Access Protocols

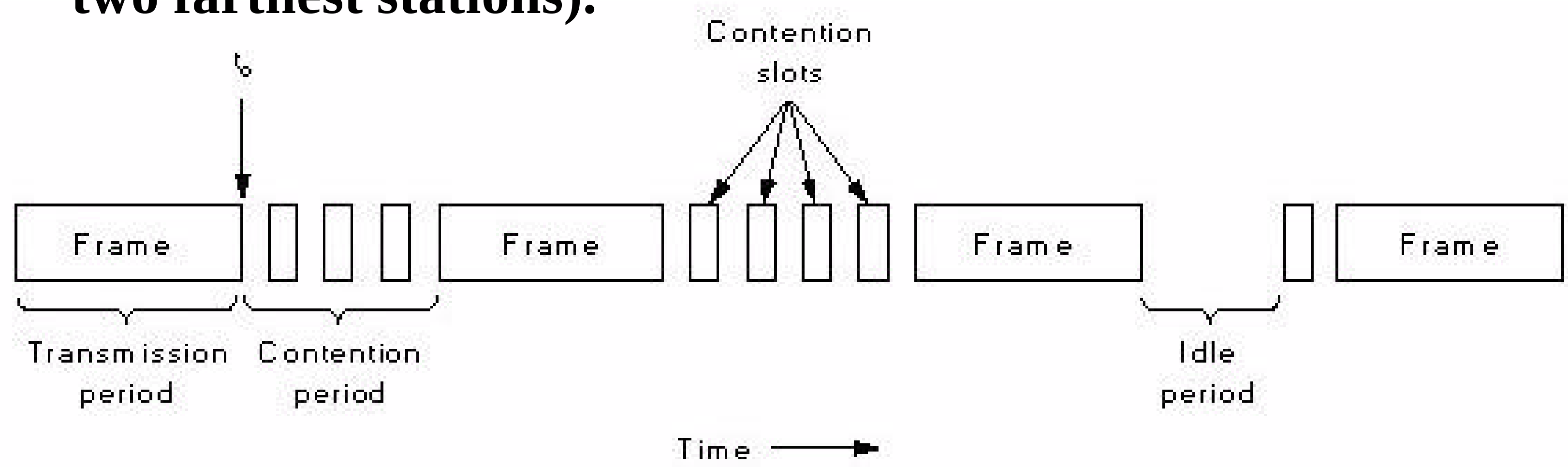


Carrier Sense Multiple Access (CSMA) Protocols

- **Medium Access Control (MAC) Protocols for shared channels where a station listens to the channel and has the ability sense the carrier and thus can detect if the channel is idle before transmitting, and possibly detect the occurrence of a collision after attempting to transmit a frame.**
- **1-Persistent CSMA:**
  - **A ready station first listens to the channel for other transmissions.**
  - **Once it detects an idle channel it transmits a frame immediately.**
  - **In case of a collision, the stations involved in the collision wait a random period of time before retransmission.**
- **Nonpersistent CSMA:**
  - **If a ready station senses an idle channel it starts transmission immediately.**
  - **If a busy channel is sensed a station waits a random period of time before sensing the channel again.**
- **p-Persistent CSMA (applies to slotted channels):**
  - **If A ready station senses an idle channel, it transmits with probability p or defers transmission to the next time slot with probability $q = 1 - p$**
  - **If the next slot is idle it transmits or defers again with probabilities p, q**
  - **The process continues until the frame has been transmitted or another station has seized the channel.**

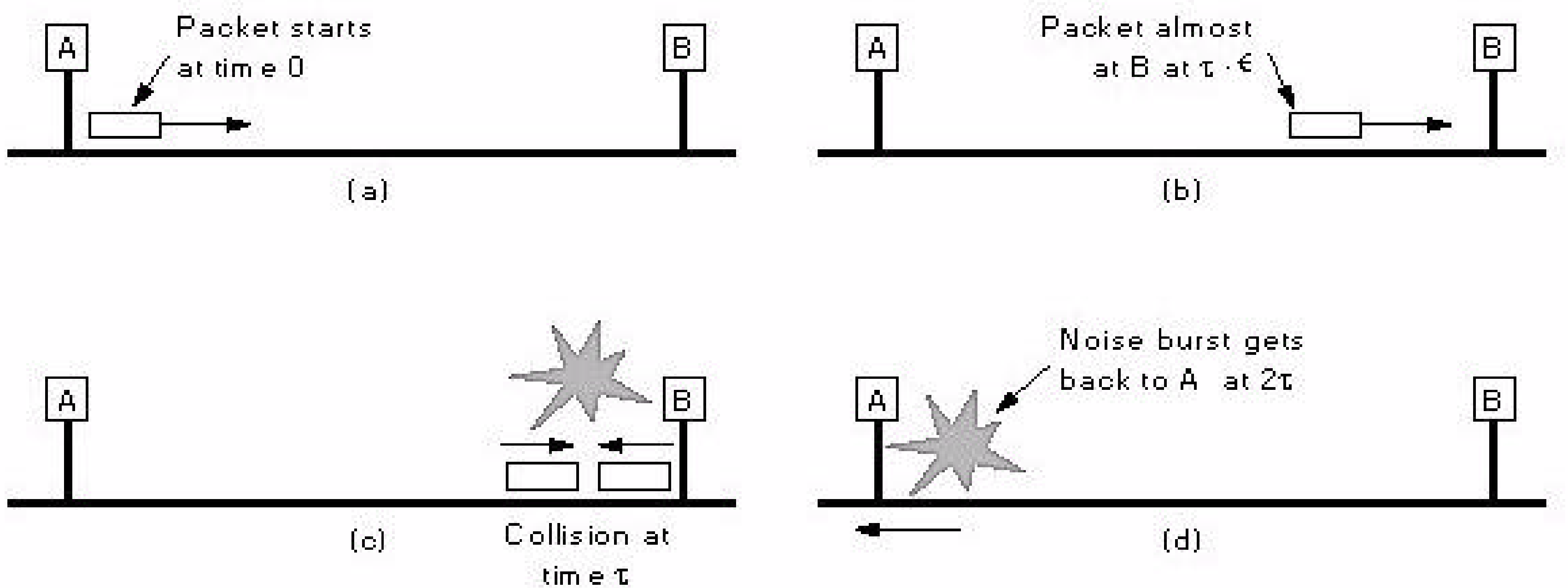
CSMA with Collision Detection (CSMA/CD)

- **If two stations begin transmitting simultaneously and detect a collision, both stations abort their transmission immediately.**
- **Once a collision is detected each ready stations waits a random period of time before attempting to retransmit.**
- **Worst-case contention interval (the duration of a collision lasts) is equal to 2τ (τ is the propagation time between the two farthest stations).**

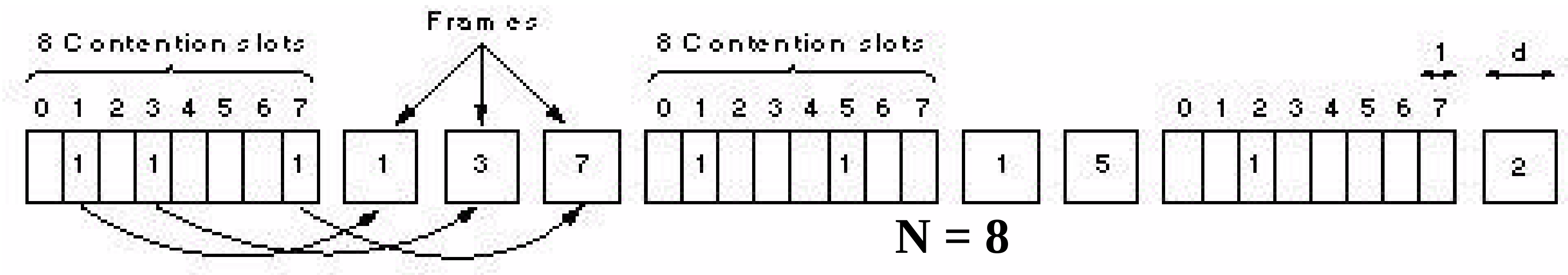


Possible states of CSMA/CD channels

Collision Detection Delay in CSMA/CD



Collision-Free Protocols: Basic Bit-Map Protocol



N = 8

- **N stations with addresses 0 to N-1**
- **N one-bit contention slots.**
- **If a station *i* has a frame to send, it sends a one during contention slot *i*.**
- **Once all stations indicated frame availability, ready frames are transmitted in address order.**
- **Representative of reservation protocols (where each station broadcasts its desire to transmit before actual transmission).**
- **Efficiency per frame:**
  - **With low load = d/(N + *d*) With high load = d/(1 + *d*)**

    ***d* = number of bits in one frame**

Collision-Free Protocols: Binary Countdown Protocol

- Binary station address is used to form **log N** one-bit contention slots.
- Address bits from all stations are Boolean ORed.
- If a station has a frame to send, it transmits its binary address starting with the high-order bit.
- The station with the highest-numbered address gets to transmit.
- Efficiency per frame

$$= d/(d + \log N)$$