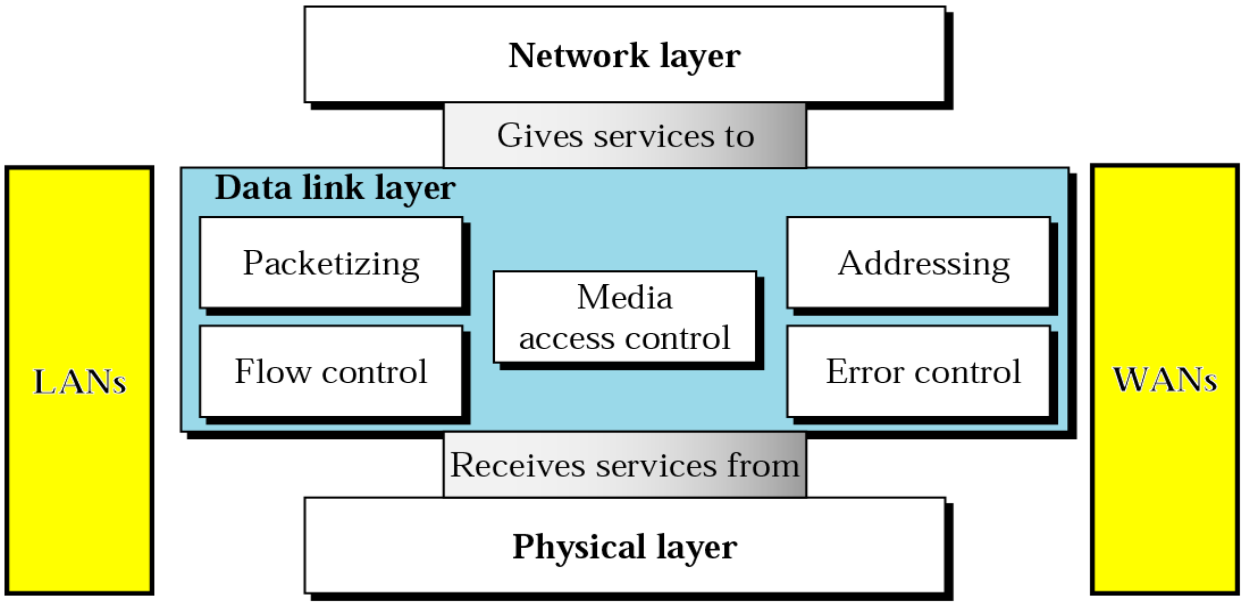
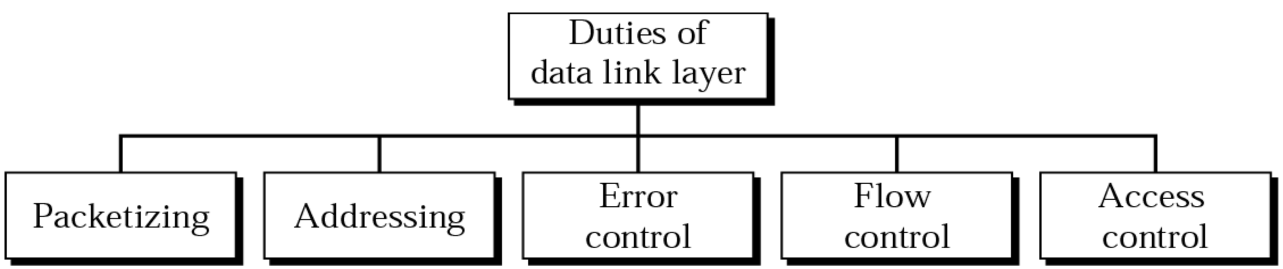
Multiple Access (1)

Required reading:
Forouzan 12.1.1
Garcia 6.1, 6.2.1, 6.2.2

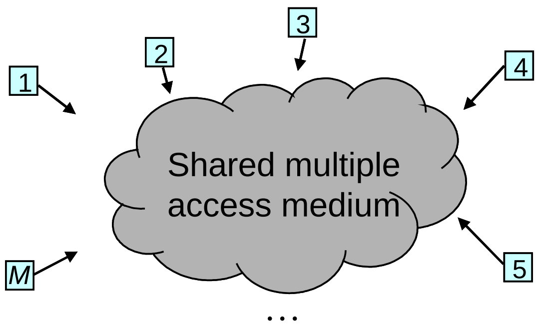
CSE 3213, Fall 2015
Instructor: N. Vlajic


Network layer
Gives services to
Data link layer
Packetizing
Flow control
Media
access control
Addressing
Error control
Receives services from
Physical layer
LANs
WANs


Duties of
data link layer
Packetizing
Addressing
Error
control
Flow
control
Access
control

Multiple Access Communications

Broadcast Networks – aka **multiple access networks** – multiple sending & receiving **stations share the same transmission medium**



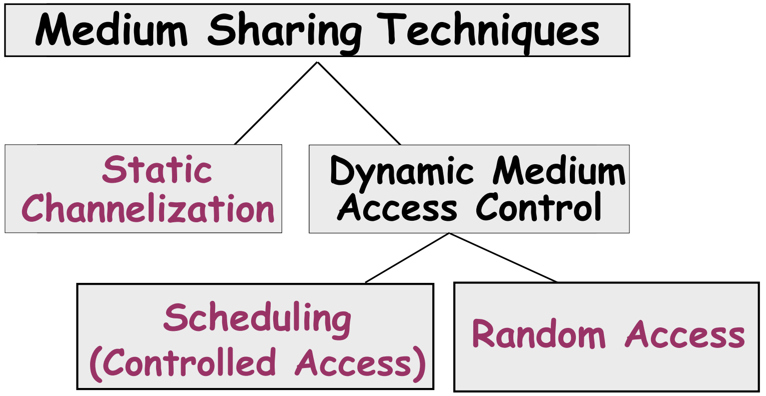
- **advantages:**
  1) low cost infrastructure
  2) all stations attached to the medium hear transmission from any other station ⇒ routing not necessary

- **disadvantages:**
  - access of multiple sending and receiving nodes to the shared medium must be coordinated
    1) stations should not be transmitting simultaneously or interrupting each other
    2) stations should not be able to 'monopolize' the transmission/shared medium

- **examples: LAN, cellular and satellite networks**

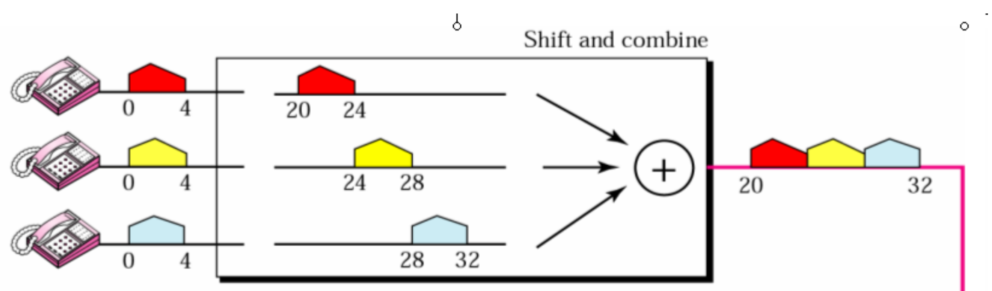
Multiple Access Communications (cont.)

Approaches to Medium Sharing



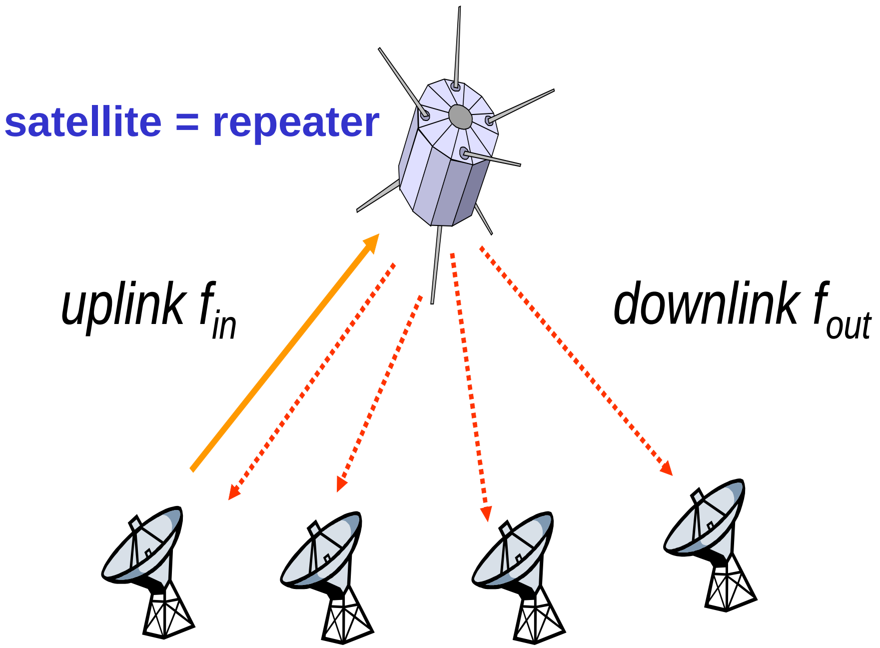
(1) Static Channelization – static & collision free sharing

- **partition medium into separate channels, which are then dedicated to particular users**
- **advantage: no collisions, perfect fairness – each node gets a dedicated transmission rate R/N during each time interval** (suitable for 'streaming data', e.g. voice streams)
- **disadvantage: each user gets only a fraction of the full channel capacity, even when no other station is transmitting**

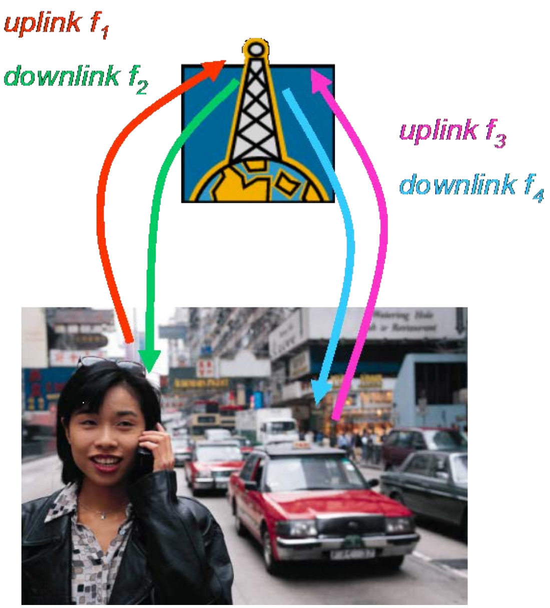


Multiple Access Communications (cont.)

Example [systems employing static channelization]



satellite network



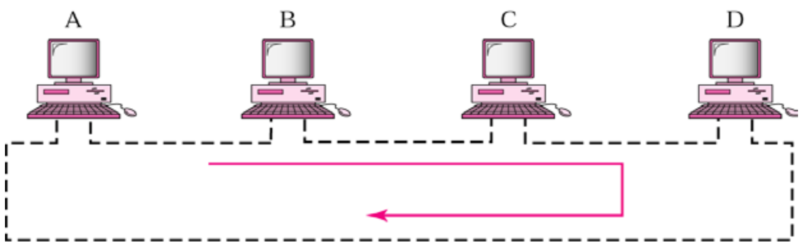
cellular network

- **two frequency bands: one for uplink and one for downlink**
- **each station is allocated a channel in the uplink and in the downlink frequency band**
- **different approaches can be employed to create uplink/downlink channels (FDMA, TDMA, CDMA)**
- **although each station can theoretically transmit to and listen to any channel, stations remain within their pre-allocated channels to avoid interference**

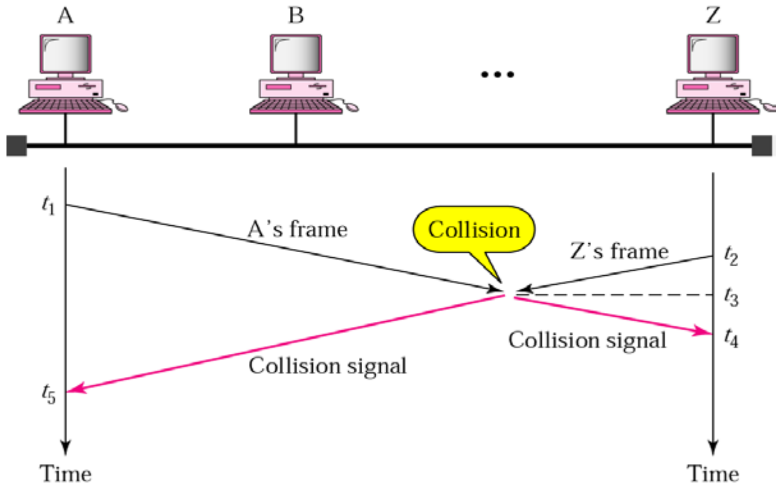
Multiple Access Communications (cont.)

(2) Dynamic Medium Access – MAC Schemes

- the medium is shared on a 'per frame' basis
- advantage: transmitting node transmits at the full rate of the channel
  (suitable for 'bursty data', e.g. short messages)
- disadvantage: simultaneous attempts by two or more stations to access the channel result in 'collision'
- collision can be minimized through scheduling or random access control

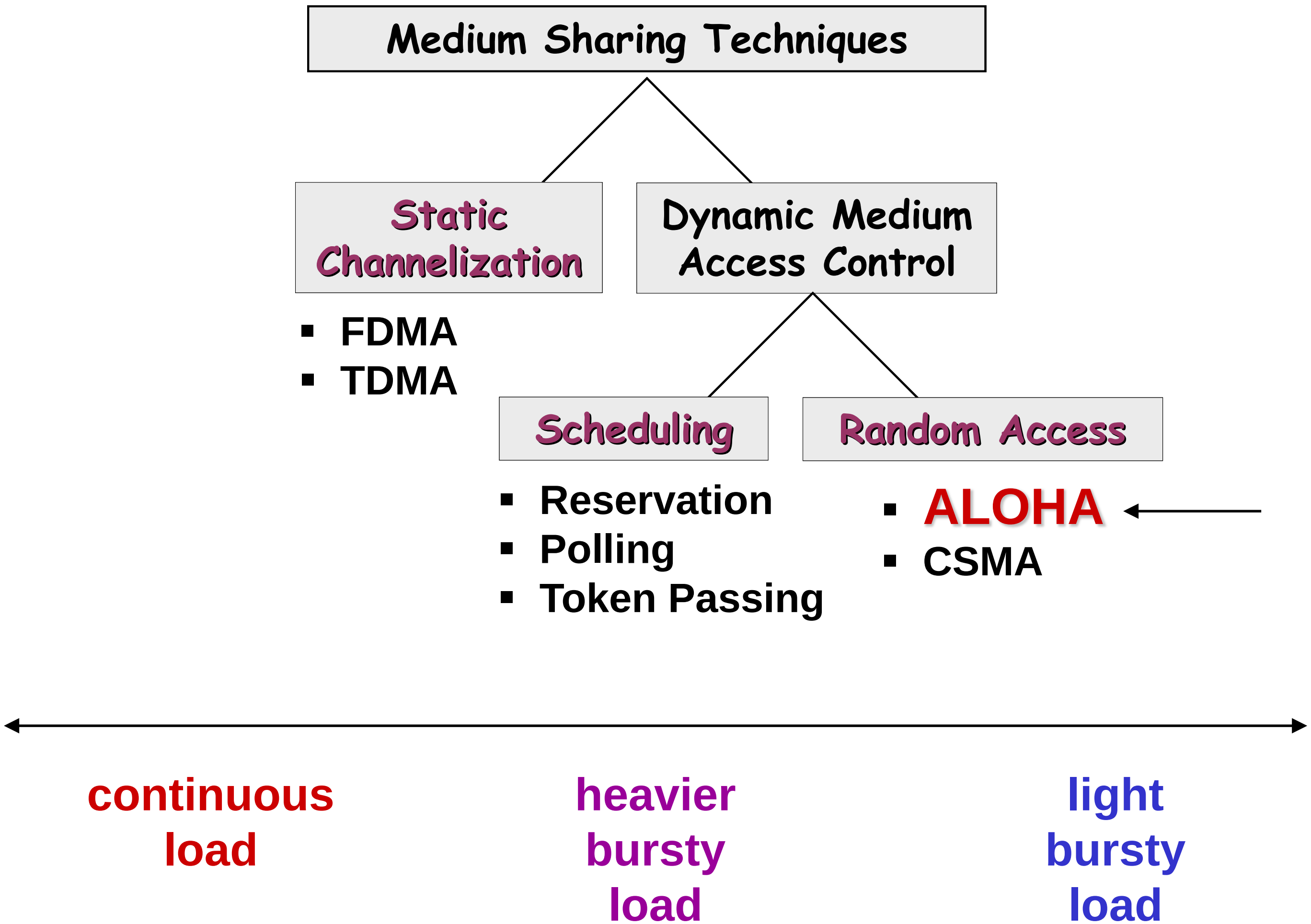


Ring Network



Bus Network

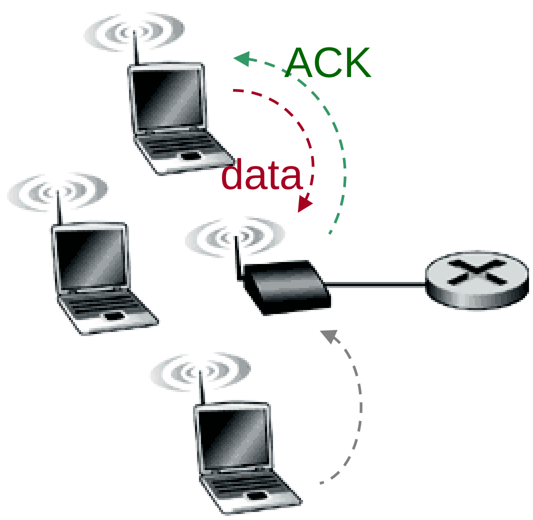
Multiple Access Communications (cont.)

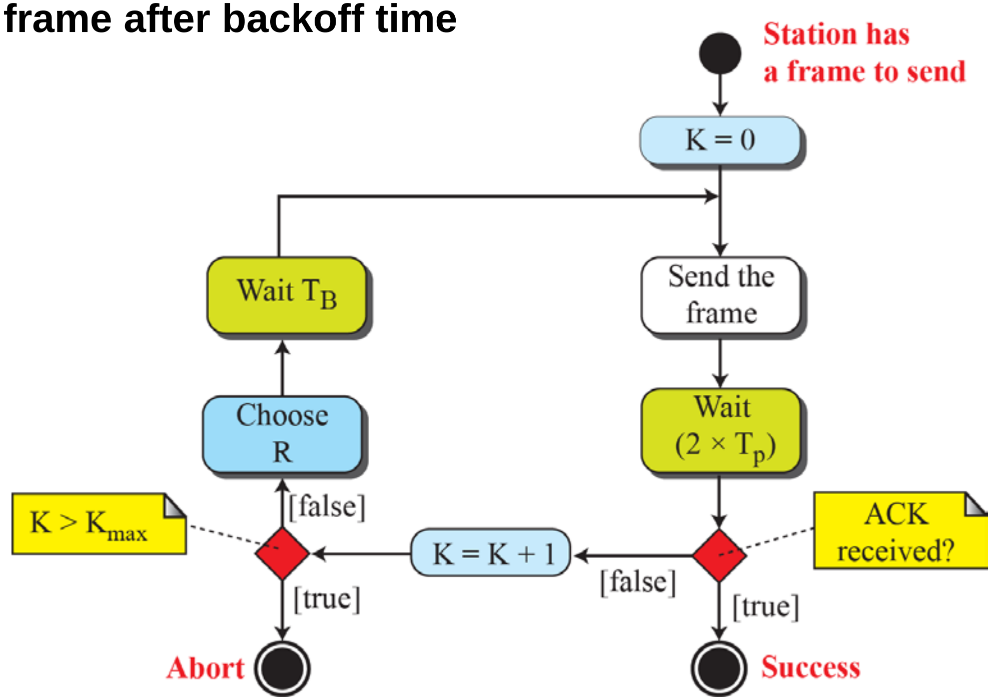


Random Access Techniques: ALOHA

ALOHA – the earliest random-access method (1970s) – still used in wireless cellular systems for its simplicity

- **a station transmits whenever it has data to transmit, producing smallest possible delay – receiver ACKs data**
- **if more than one frames are transmitted at the same time, they interfere with each other (collide) and are lost**
- **if ACK not received within timeout (2*propagation delay), the station picks random backoff time (to reduce likelihood of subseq. collisions)**
  - **station retransmits frame after backoff time**

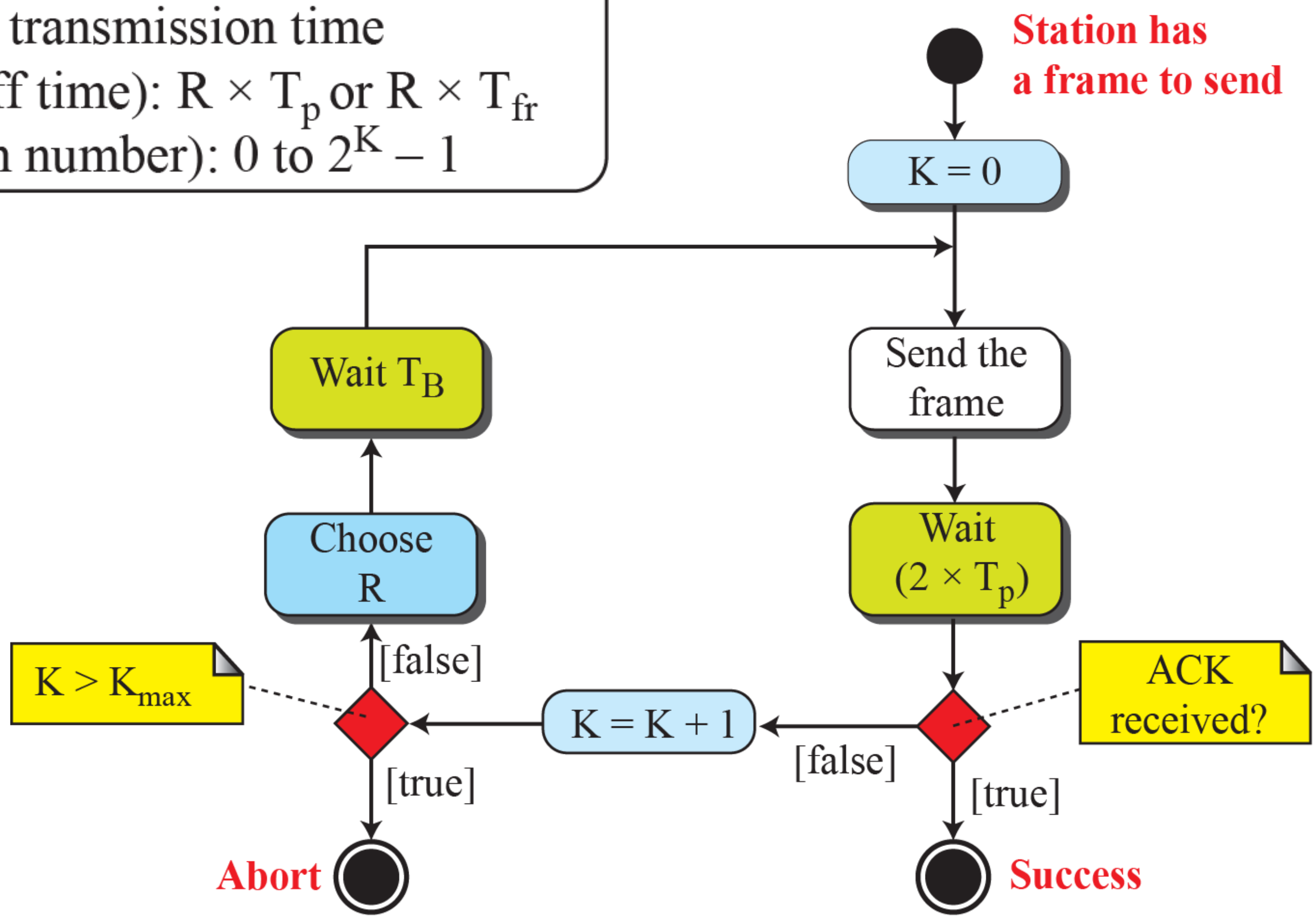




Random Access Techniques: ALOHA (cont.)

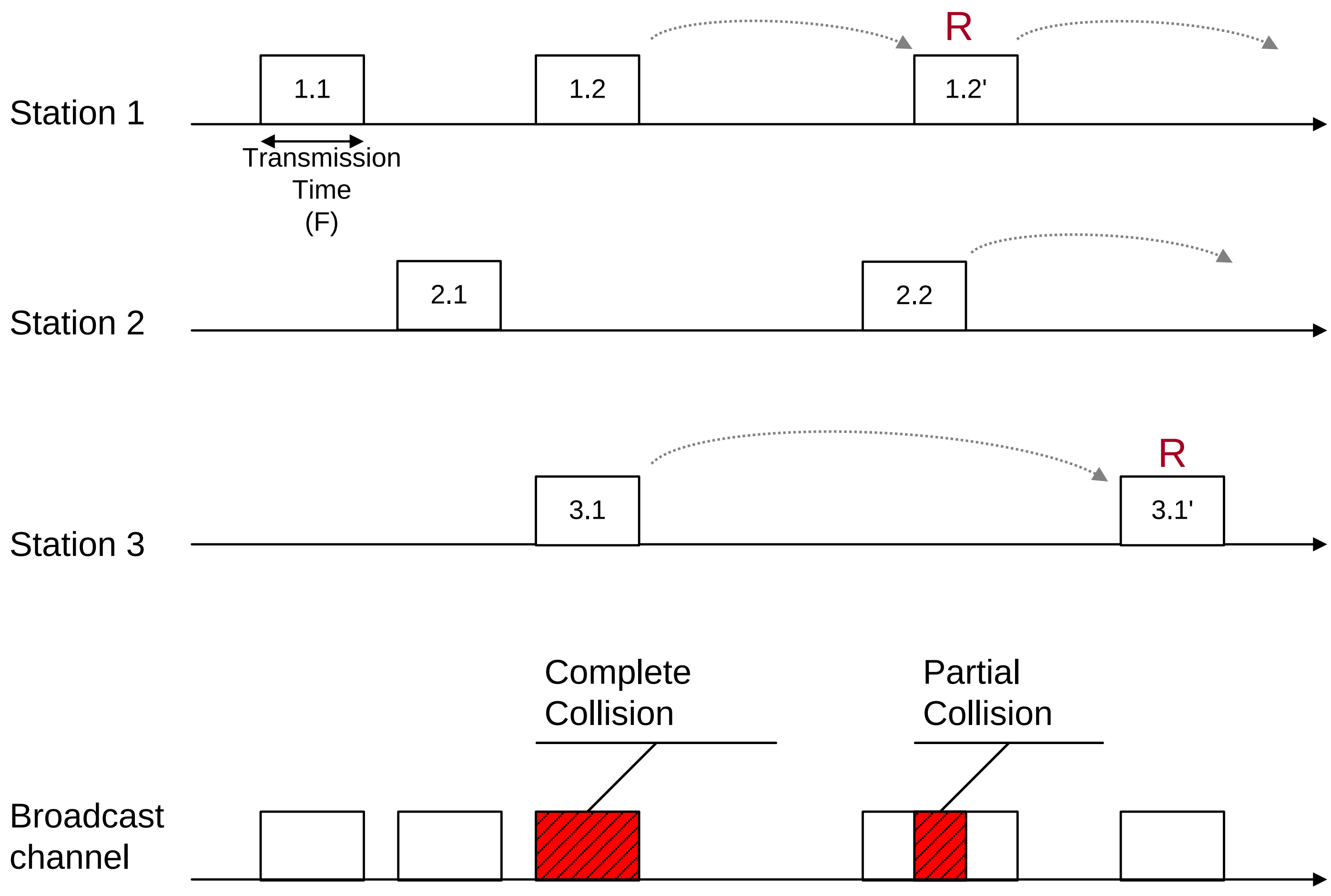
Legend

K : Number of attempts
T_p : Maximum propagation time
T_{fr}: Average transmission time
T_B: (Back-off time): $R \times T_p$ or $R \times T_{fr}$
R : (Random number): 0 to $2^K - 1$



Random Access Techniques: ALOHA (cont.)

Example [Aloha throughput]



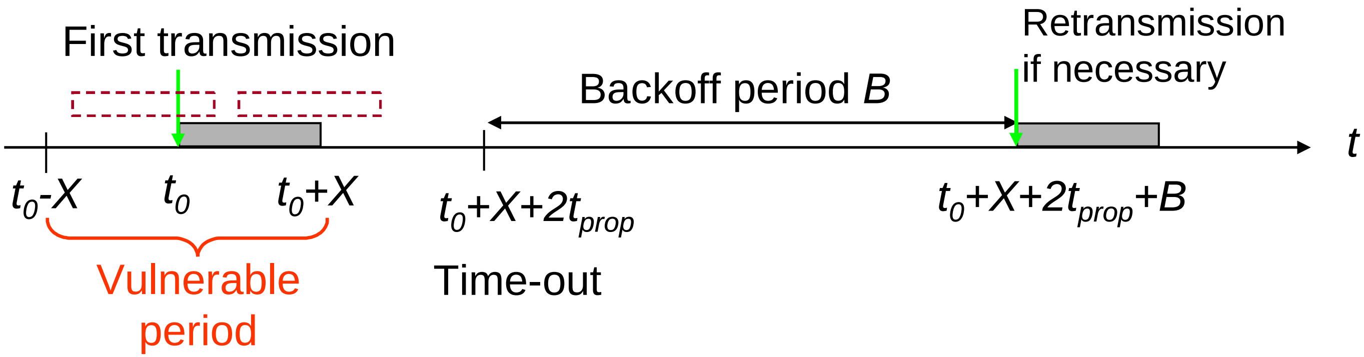
http://www.invocom.et.put.poznan.pl/~invocom/C/P1-4/p1-4_en/p1-4_3_7.htm#pureAapplet

Random Access Techniques: ALOHA (cont.)

Vulnerable Period

- assume frames of constant length (L) & transmission time (X=L/R)
- consider a frame with starting transmission time t_o – the frame will be successfully transmitted if no other frame collides with it
  - any transmission that begins in interval [t_0, t_0+X], or in the prior X seconds leads to collision

vulnerable period = [t_0 – X, t_0+ X]

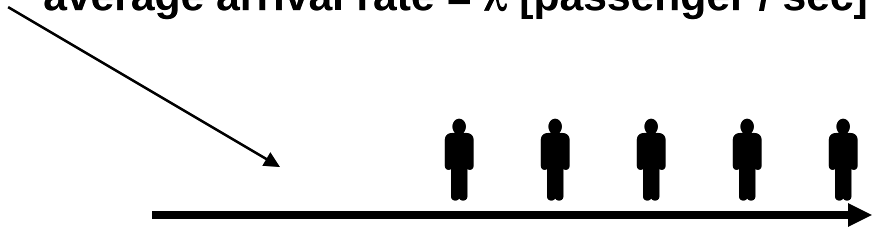


What is the probability of no other transmission, i.e. no collision, in the vulnerable period?!

Arrival: passengers arrive randomly and independently – a Poisson process

Passenger arrivals are equally likely at any instant in time.

average arrival rate = λ [passenger / sec]



average # of arrived passengers in T [sec]:

$$\text{average \# of passengers in T [sec]} = \lambda T$$

probability of having exactly k passengers in line after T [sec]:

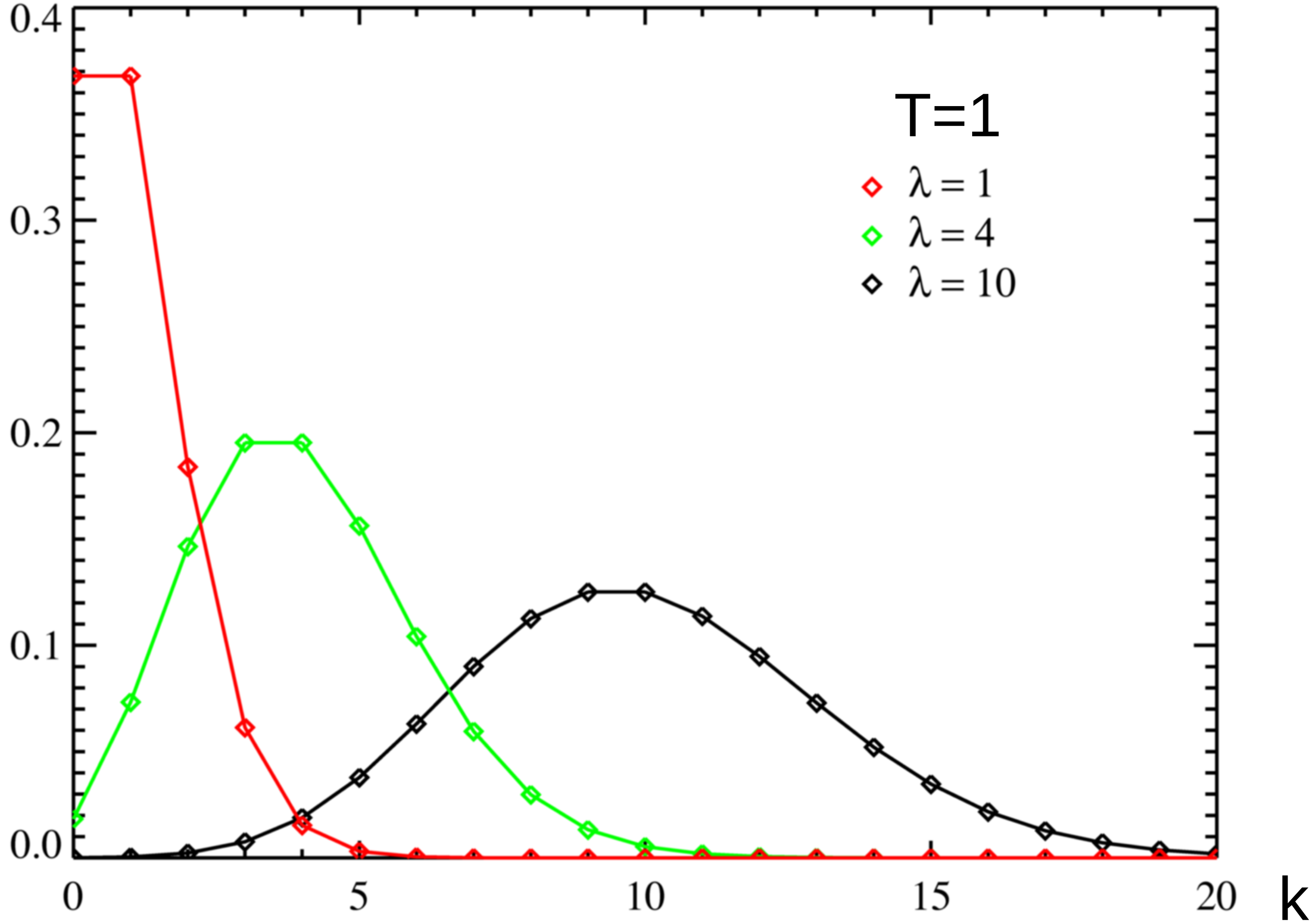
$$P[\text{k arrivals in T seconds}] = \frac{(\lambda T)^k}{k!} e^{-\lambda T}$$

Departure:

What is the probability that exactly 1 passenger arrives to the station, off the buss, in T sec?

λ [passenger / sec]

$$P[\text{k arrivals in T seconds}] = \frac{(\lambda T)^k}{k!} e^{-\lambda T}$$



http://commons.wikimedia.org/wiki/File:Poisson_distribution_PMF.png