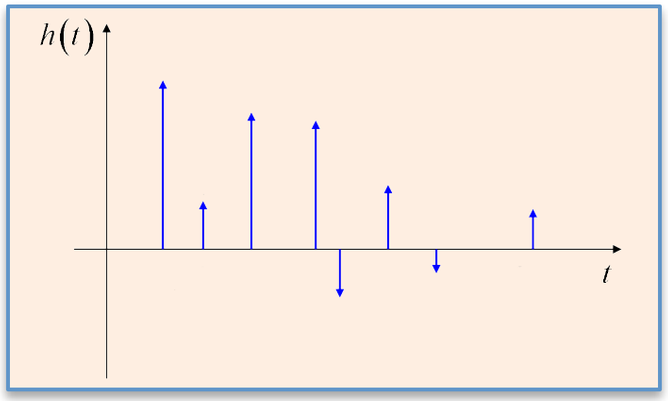
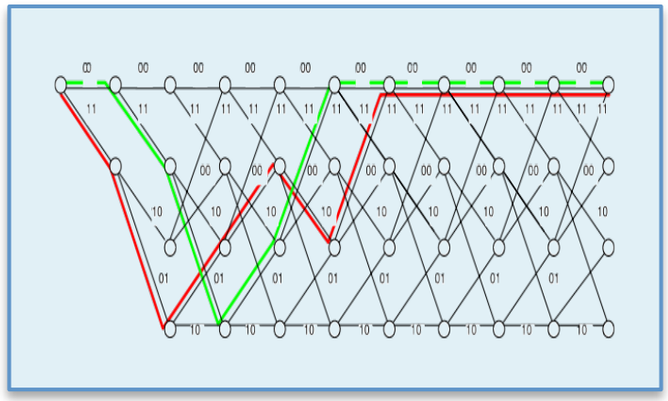
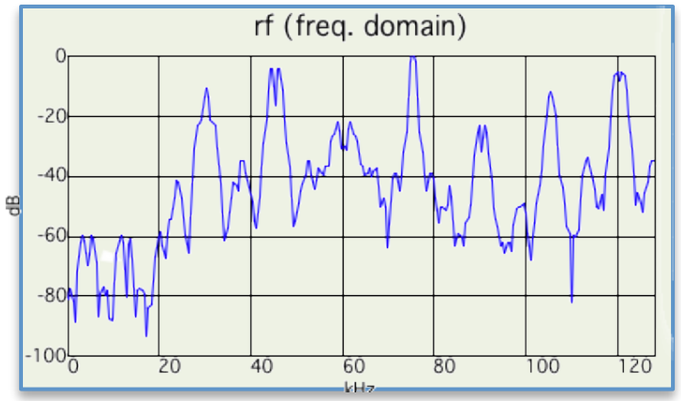
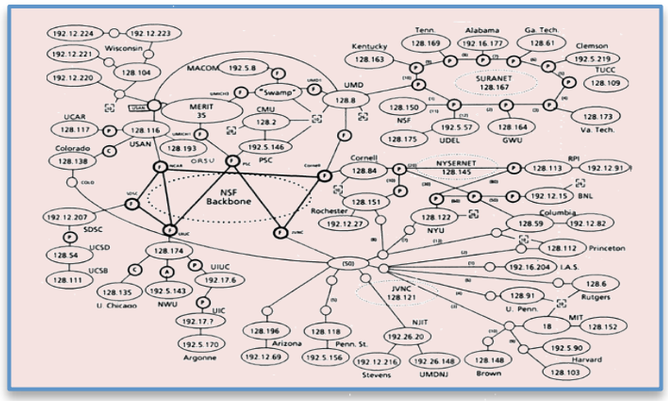








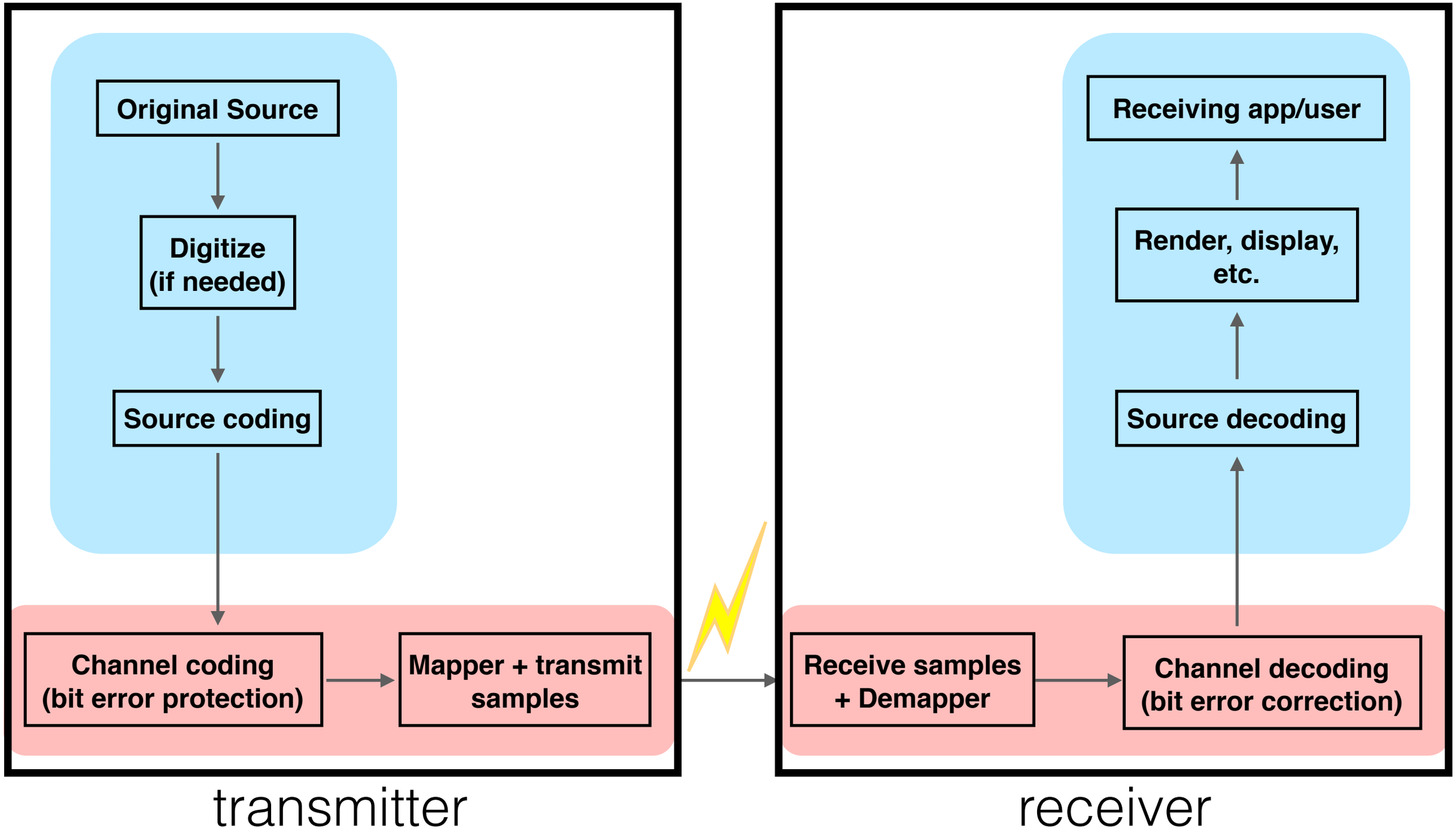
INTRODUCTION TO EECS II

DIGITAL COMMUNICATION SYSTEMS

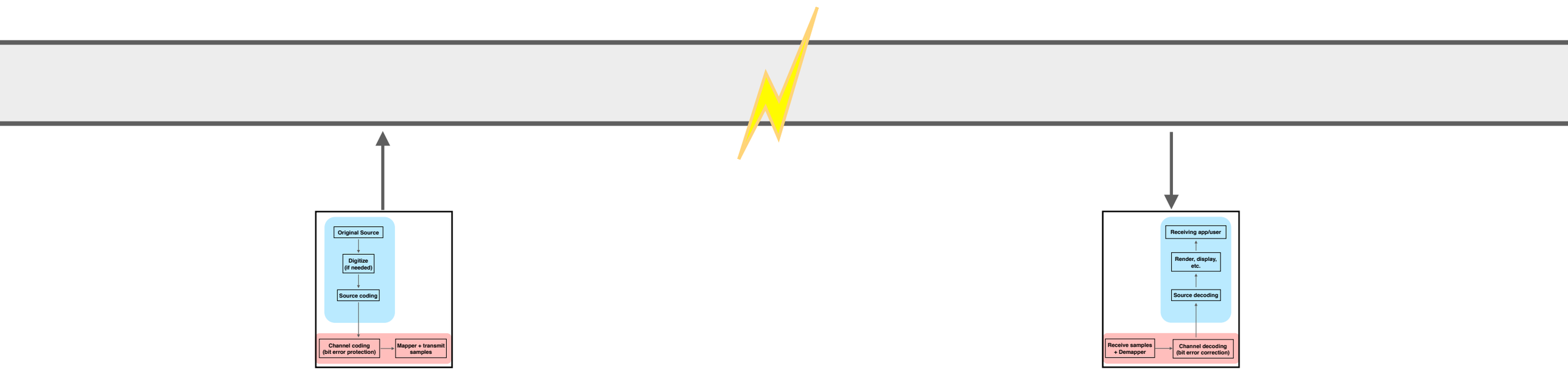
6.02 Fall 2014
Lecture #18

- Abstractions for shared communications
- Performance metrics
- MAC protocols (TDMA, ALOHA, CSMA)

Single Link Communication Model



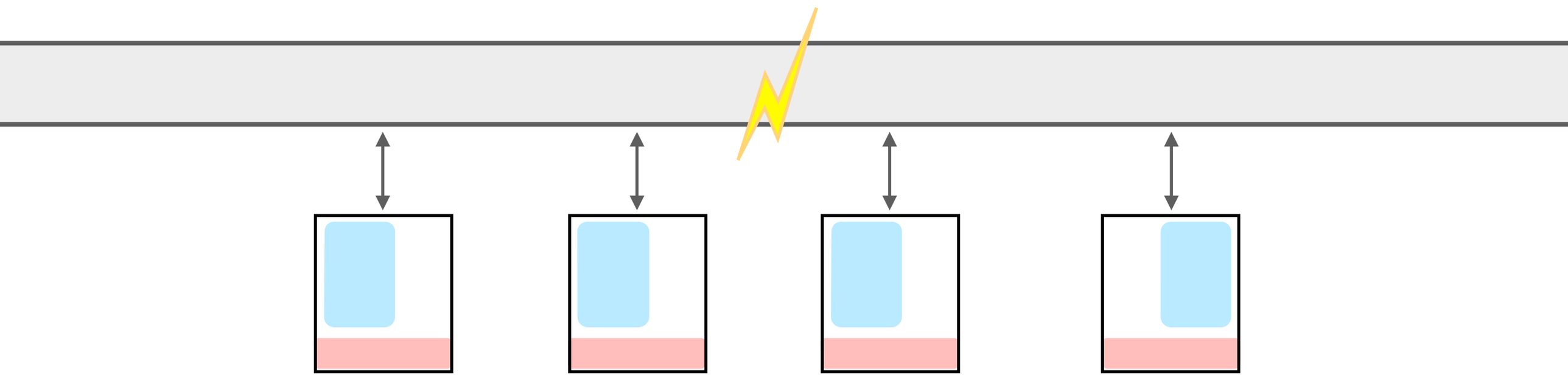
Single Link Communication Model



transmitter

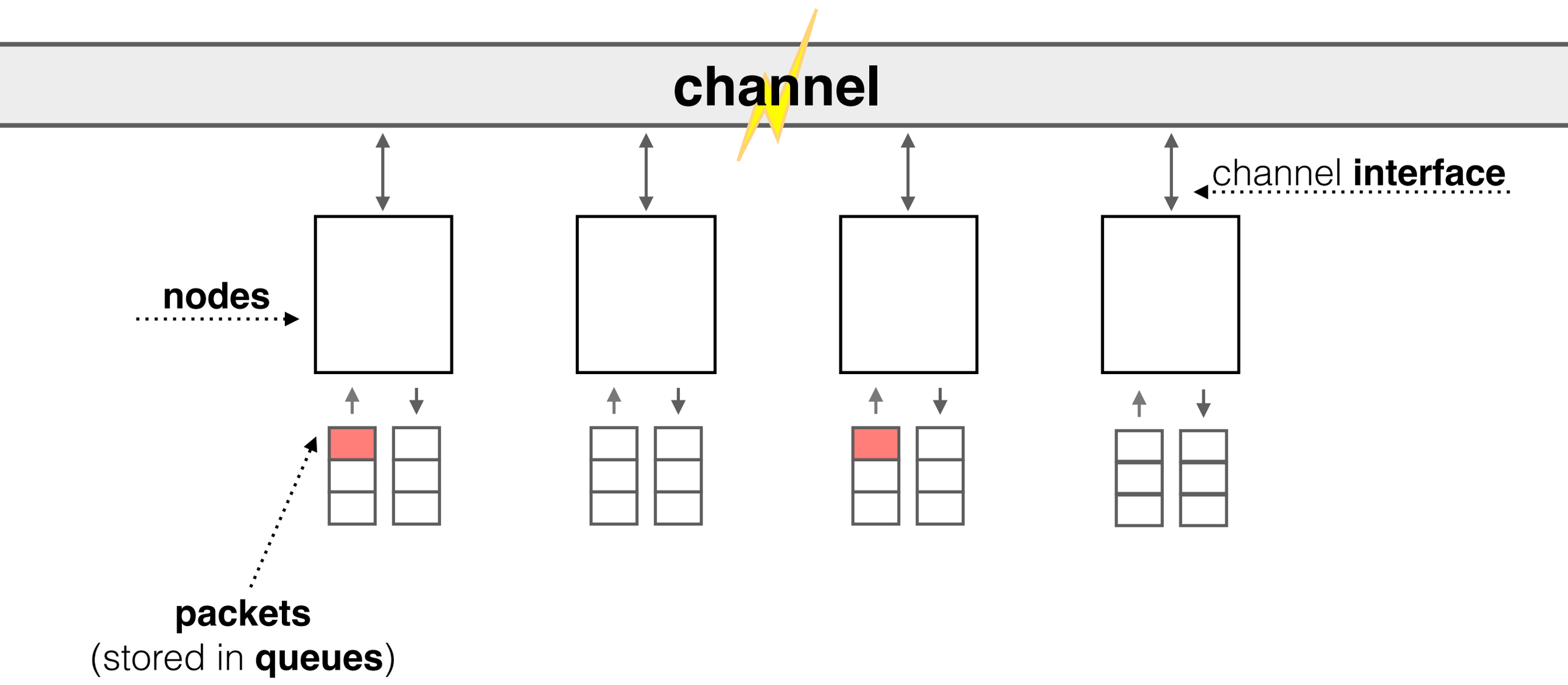
receiver

Shared Communications Channel

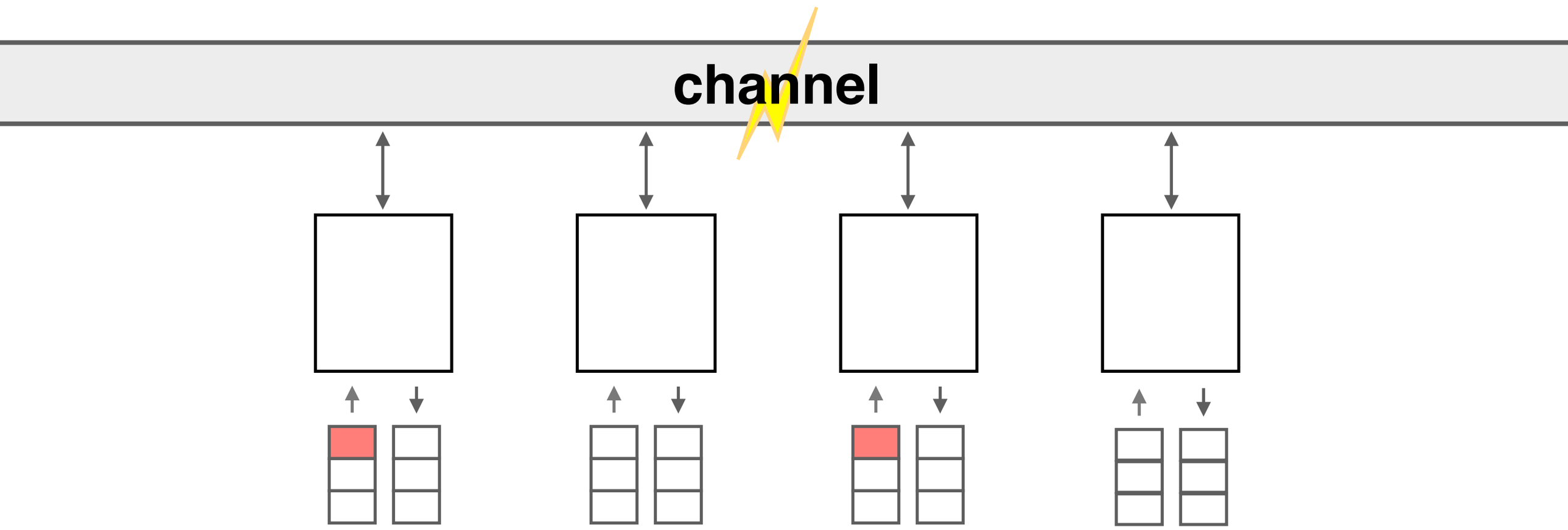


today's goal: analyze protocols that allow many nodes to share a single channel

Shared Communications Channel



goal: design a **media access protocol** — which nodes will use to access the channel — that **avoids collisions** and ensures **good performance**



Good Performance

1. **utilization** - the channel should be used efficiently

$$U = \frac{\text{total throughput over all nodes}}{\text{maximum data rate of the channel}}$$

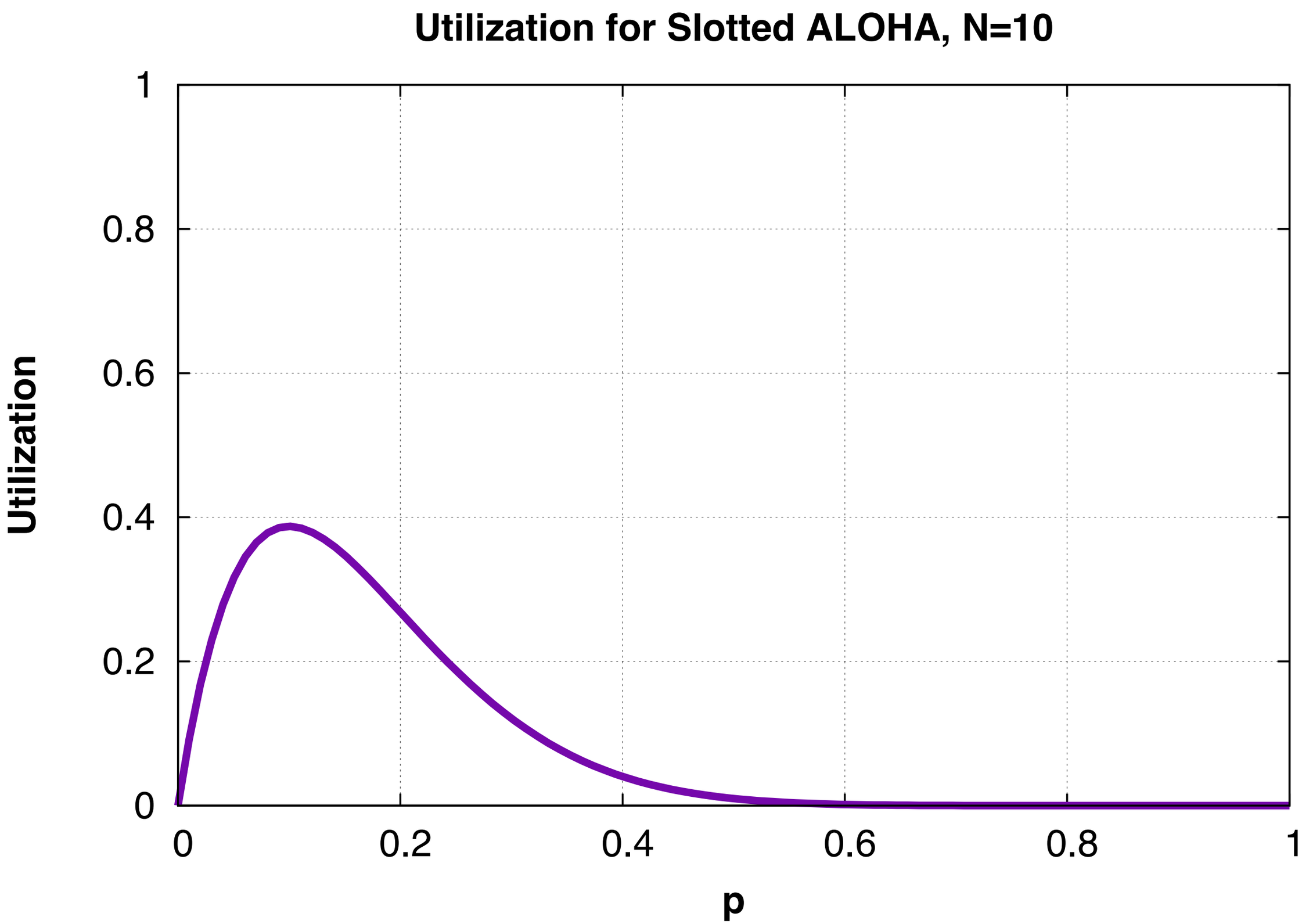
2. **fairness** - the channel should be divided evenly (if possible)

$$F = \frac{\left(\sum_{i=1}^{N} x_i\right)^2}{N \cdot \sum_{i=1}^{N} x_i^2}$$

goal: design a media access protocol that avoids collisions and ensures high utilization and high fairness

goal: design a media access protocol that avoids collisions and ensures high utilization and high fairness even under skewed workload

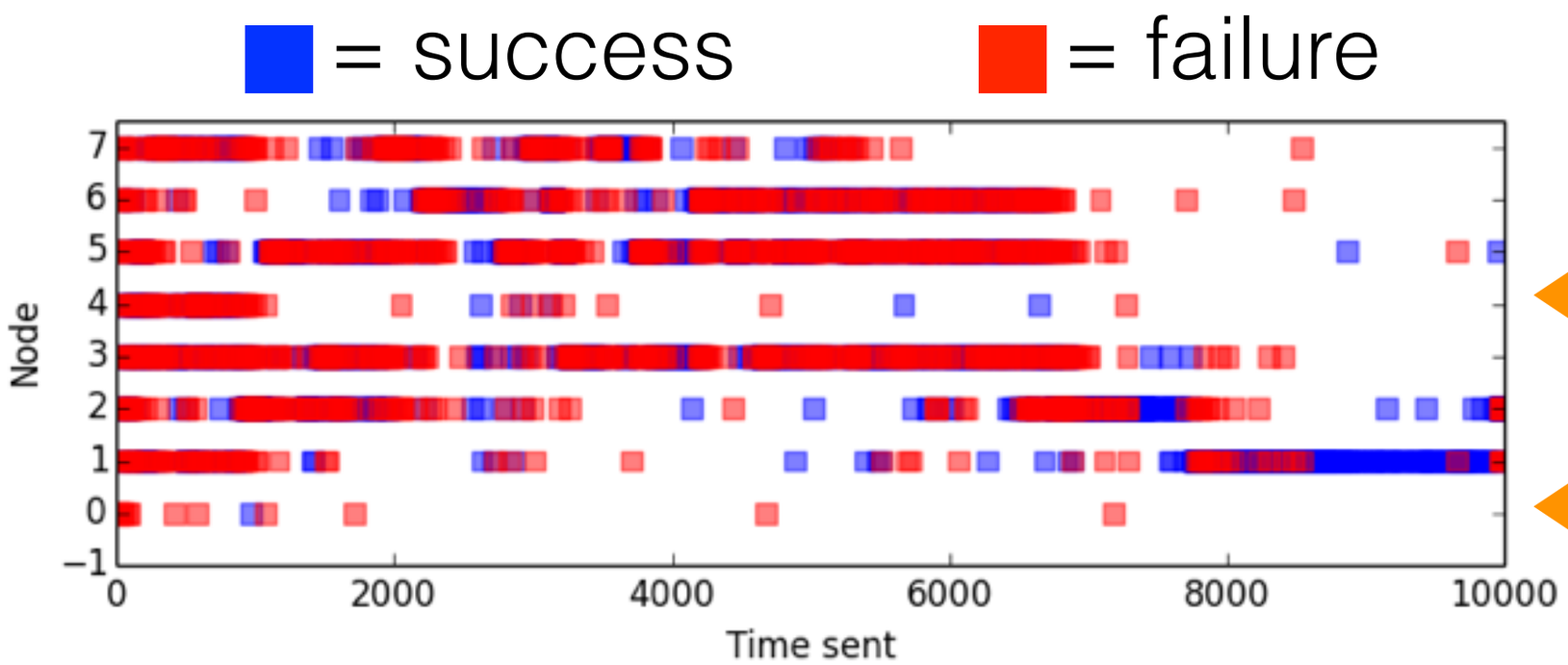
(TDMA is only good when workload is uniform)


Utilization for Slotted ALOHA, N=10
Utilization
p
0
0.2
0.4
0.6
0.8
1
0
0.2
0.4
0.6
0.8
1

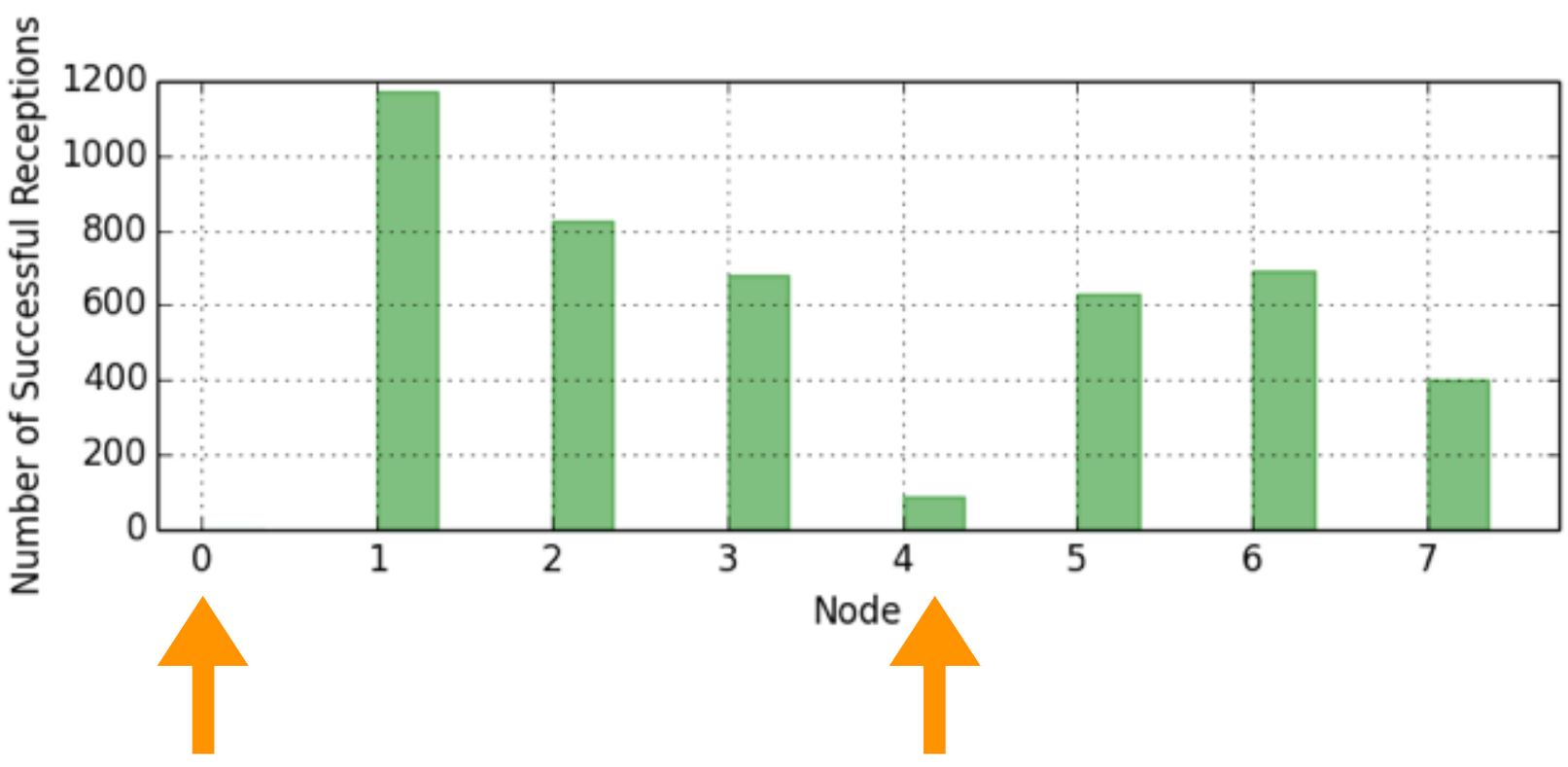
goal: design a media access protocol that avoids collisions and ensures high utilization and high fairness even under skewed workload and that allows nodes to independently decide when to transmit

(TDMA is only good when workload is uniform)

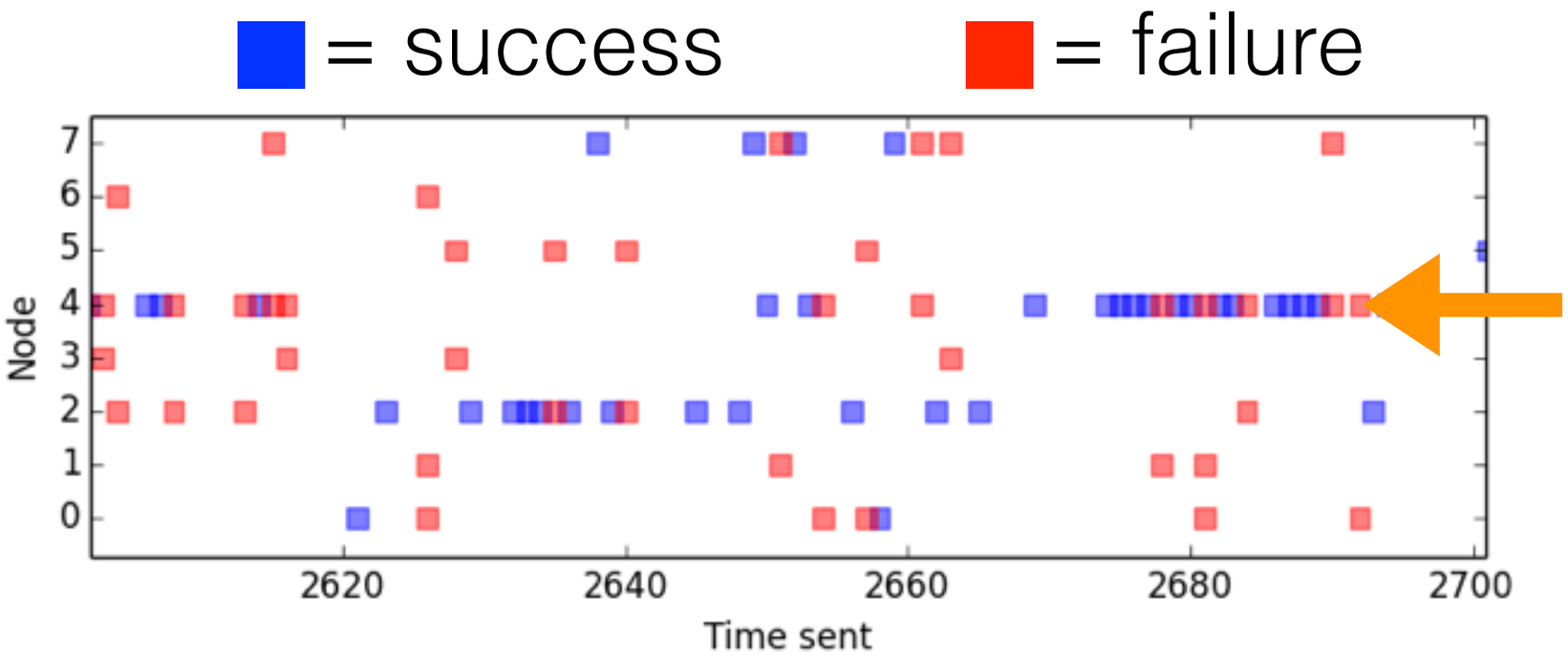
(Slotted ALOHA requires all nodes to know the number of backlogged nodes, which is very hard to do in practice)



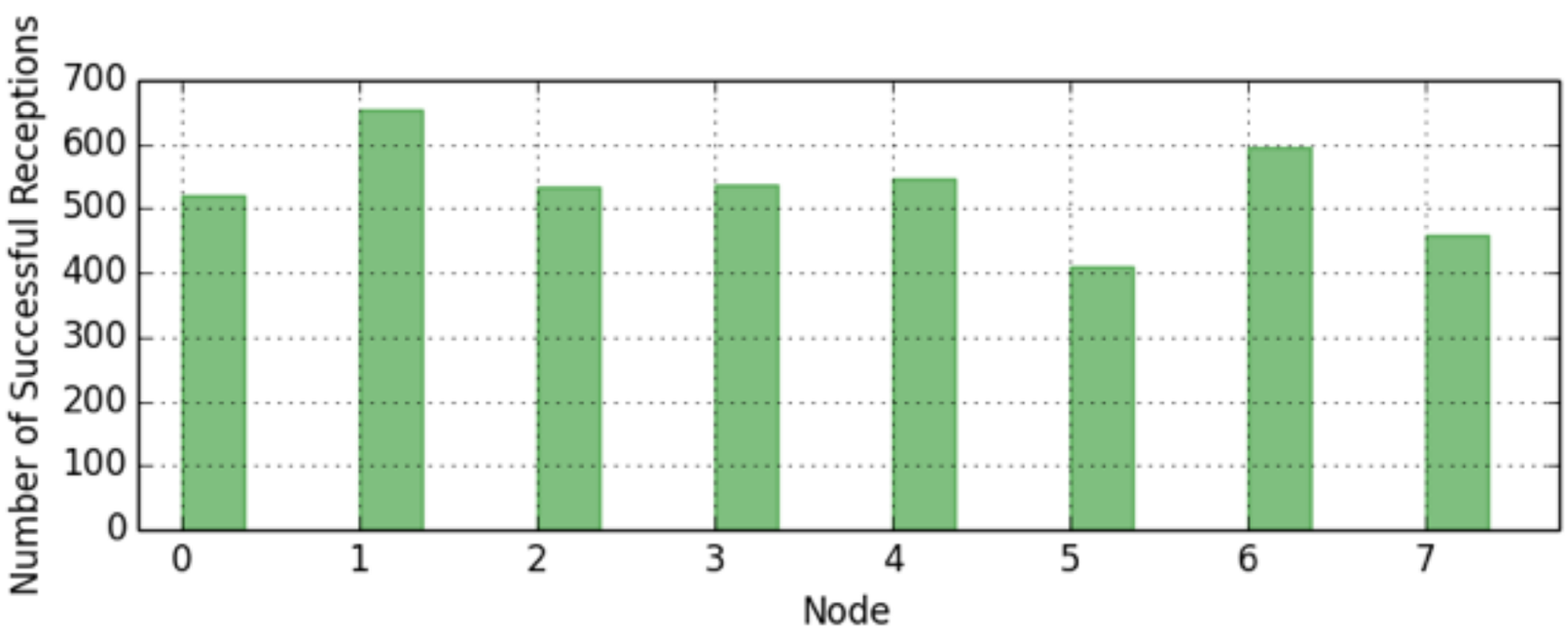
some nodes are **starved** out of the system



utilization = .45
fairness = .71

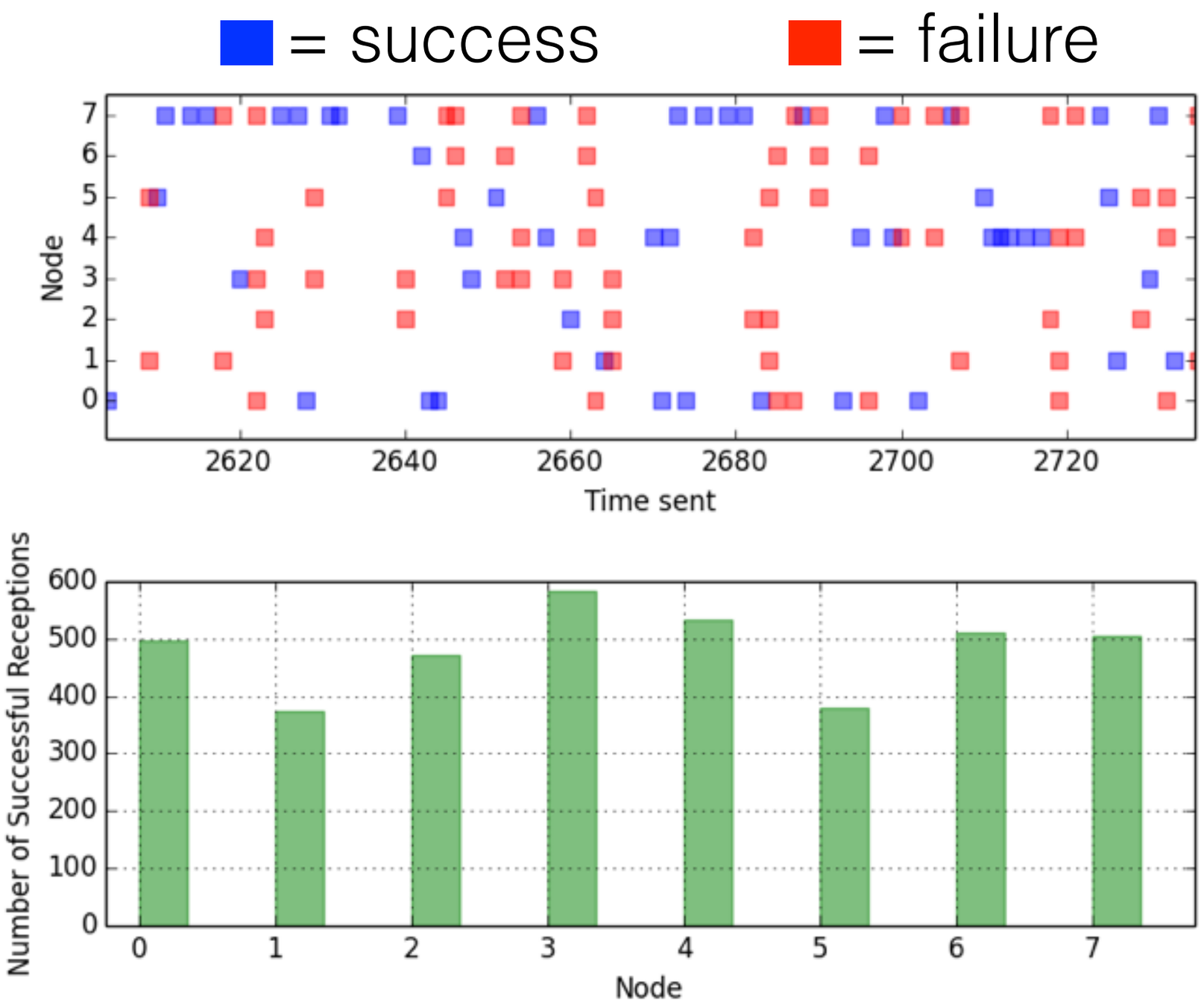


significant short-term unfairness ("capture effect")



p_{min} = .05
utilization = .43
fairness = .98

(with a smaller p_{min}, utilization can increase further)



using p_{min} and p_{max}
utilization = .4
fairness = .97

Good Performance

1. **utilization** - the channel should be used efficiently

2. **fairness** - the channel should be divided evenly (if possible)

3. **bounded wait** - have an upper bound on the wait before a successful transmission

4. **dynamism** - handle variability

5. **scalability** - work for a large number of users

- **Abstractions for shared communications**
  Nodes send packets, can detect when a collision happens, and can potentially hear each other

- **Performance metrics**
  Utilization and fairness first, then bounded wait, dynamism, and scalability

- **MAC protocols**
  TDMA is poor when workload is skewed; Slotted ALOHA handles skew, but doesn't allow nodes to set p individually; Stabilized ALOHA does, but we must be smart about how we increase and decrease p