Introduction to CDMA ALOHA

3. Access Control Techniques for CDMA ALOHA

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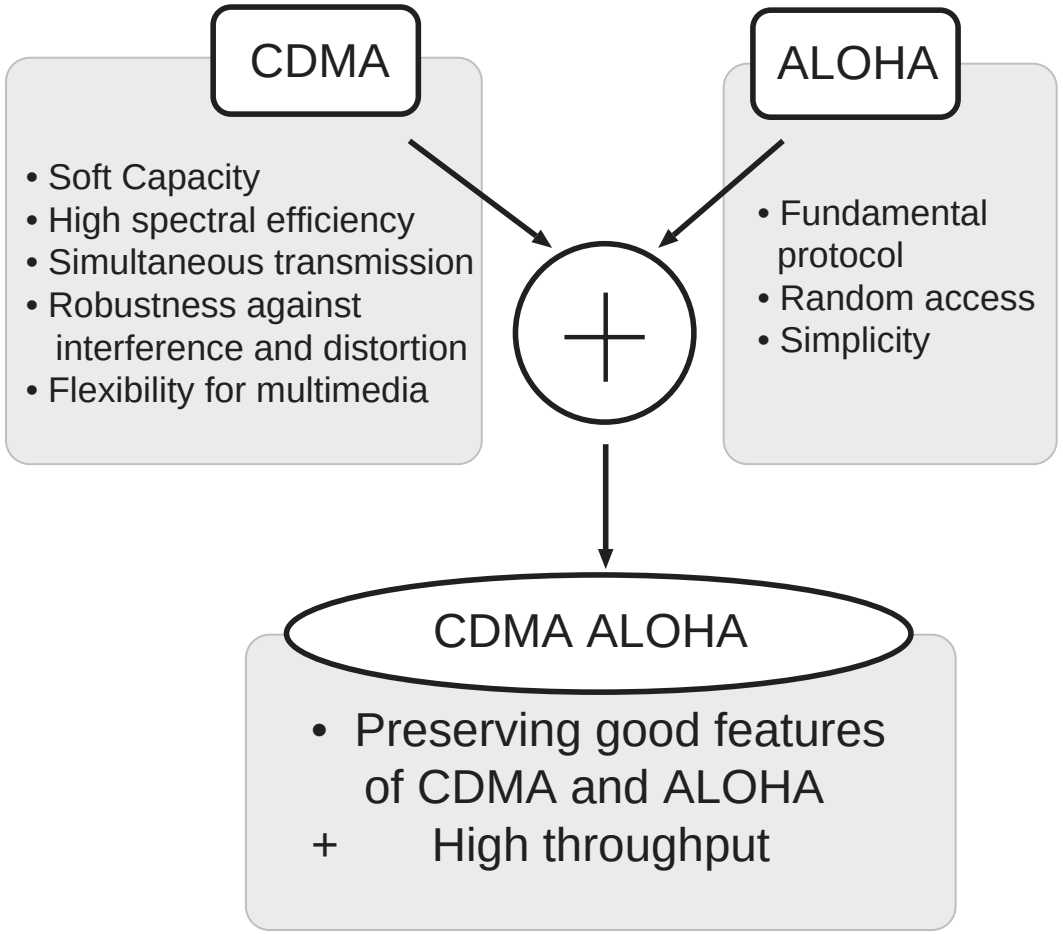
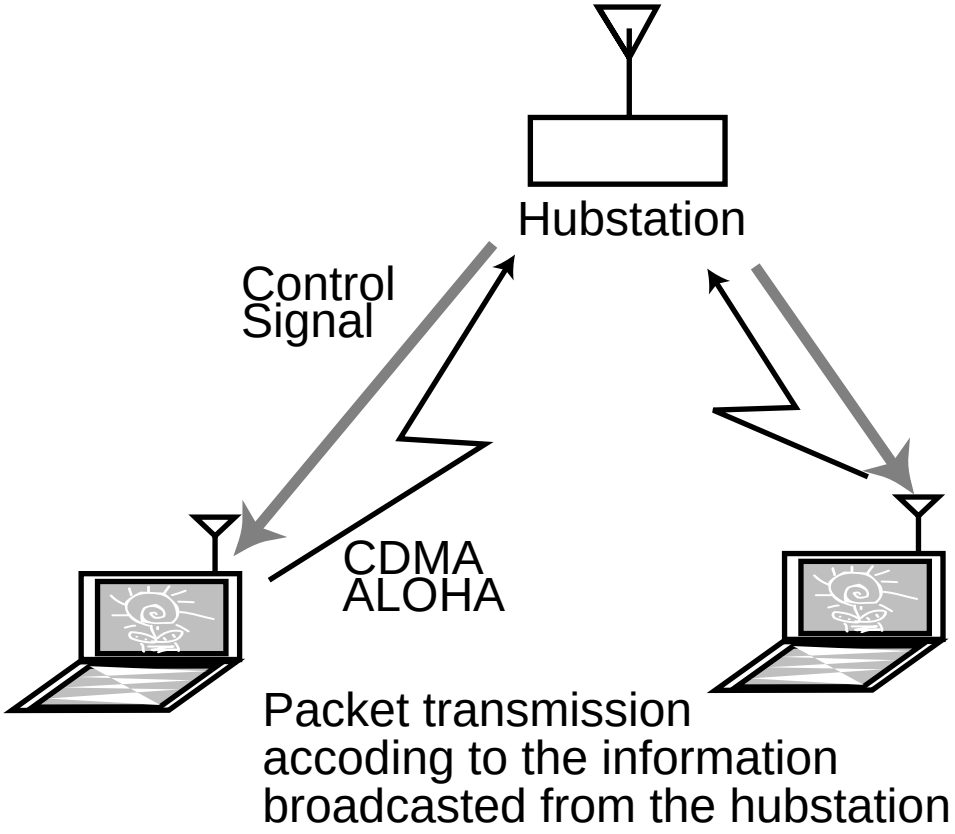
CDMA ALOHA

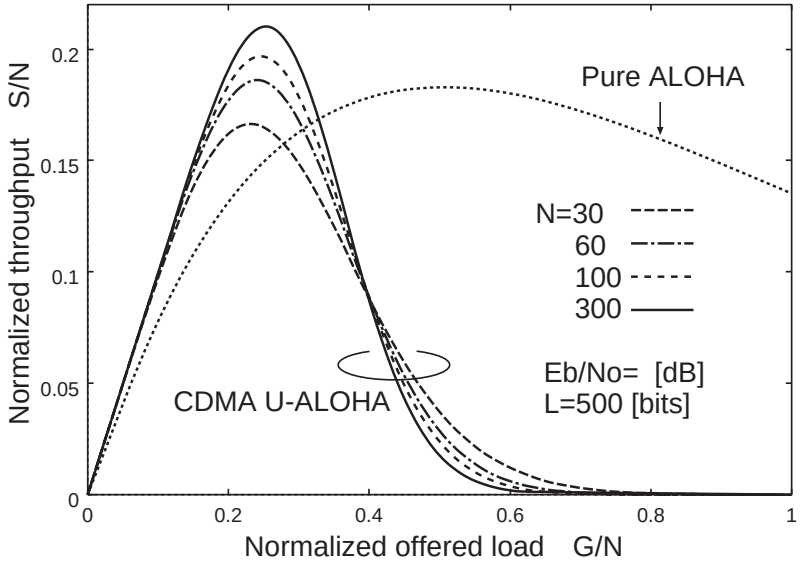


- Random access
- Simultaneous packet transmission
- High throughput performance
- Flexible transmission of multimedia signal

Why Access Control?

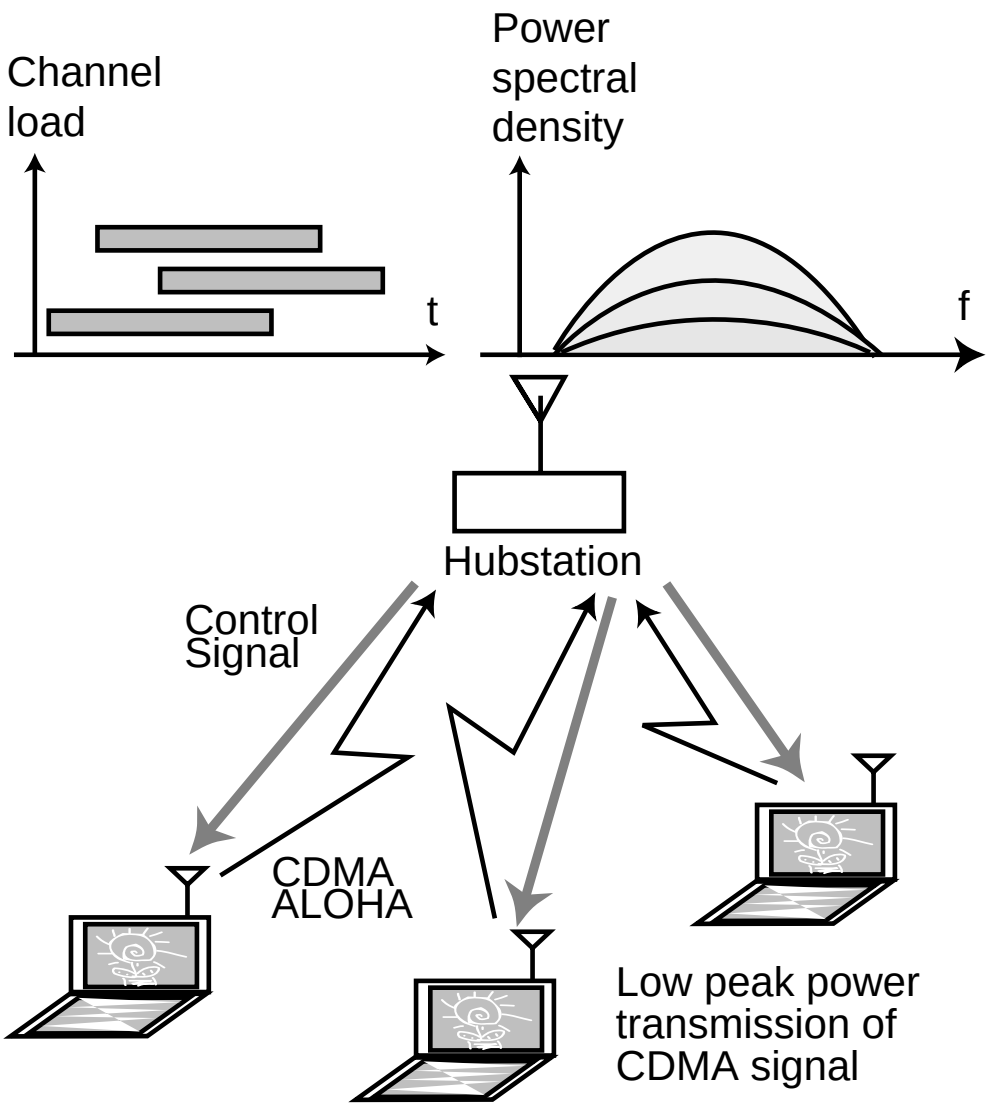


Packet transmission accoding to the information broadcasted from the hubstation



- Improvement of maximum throughput
- No degradation of throughput in high offered traffic load

How ?

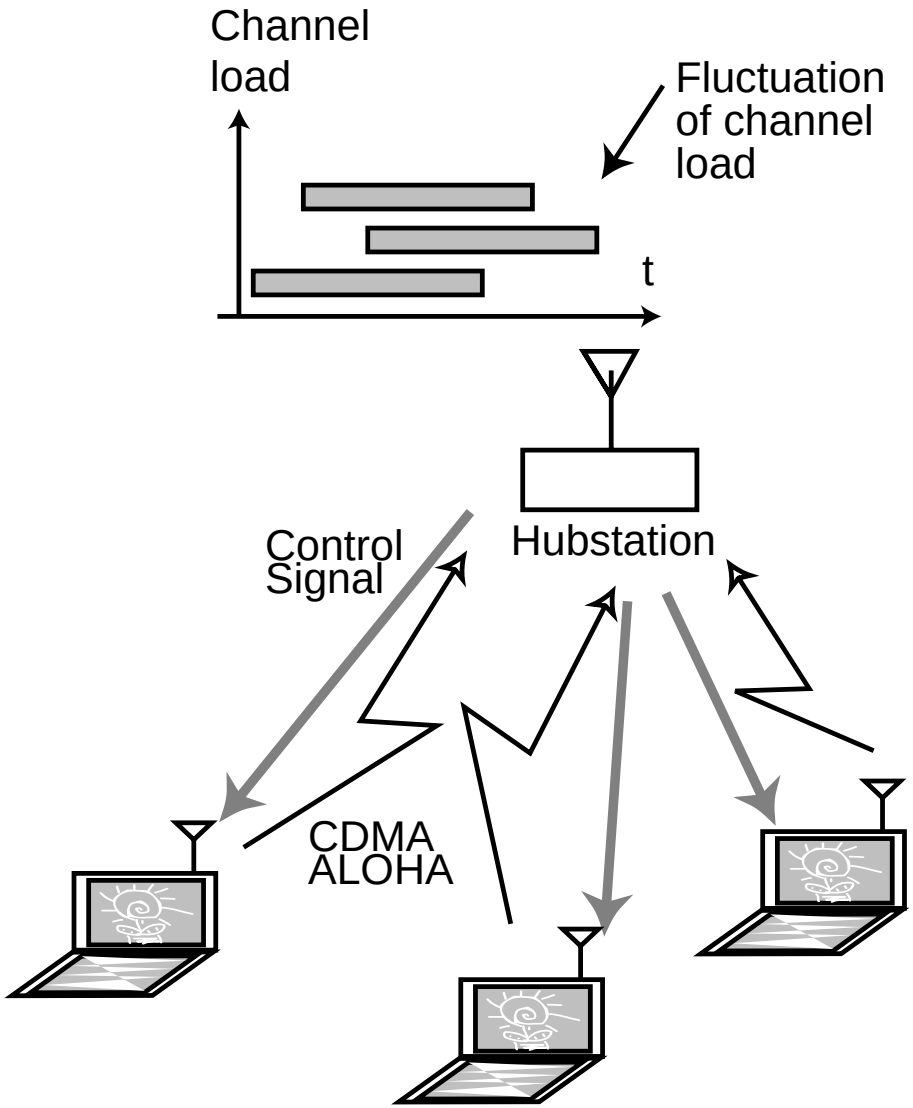


X Difficulty of carrier sensing by each user due to the low peak power transmission.

X Fluctuation of channel load during a packet transmission

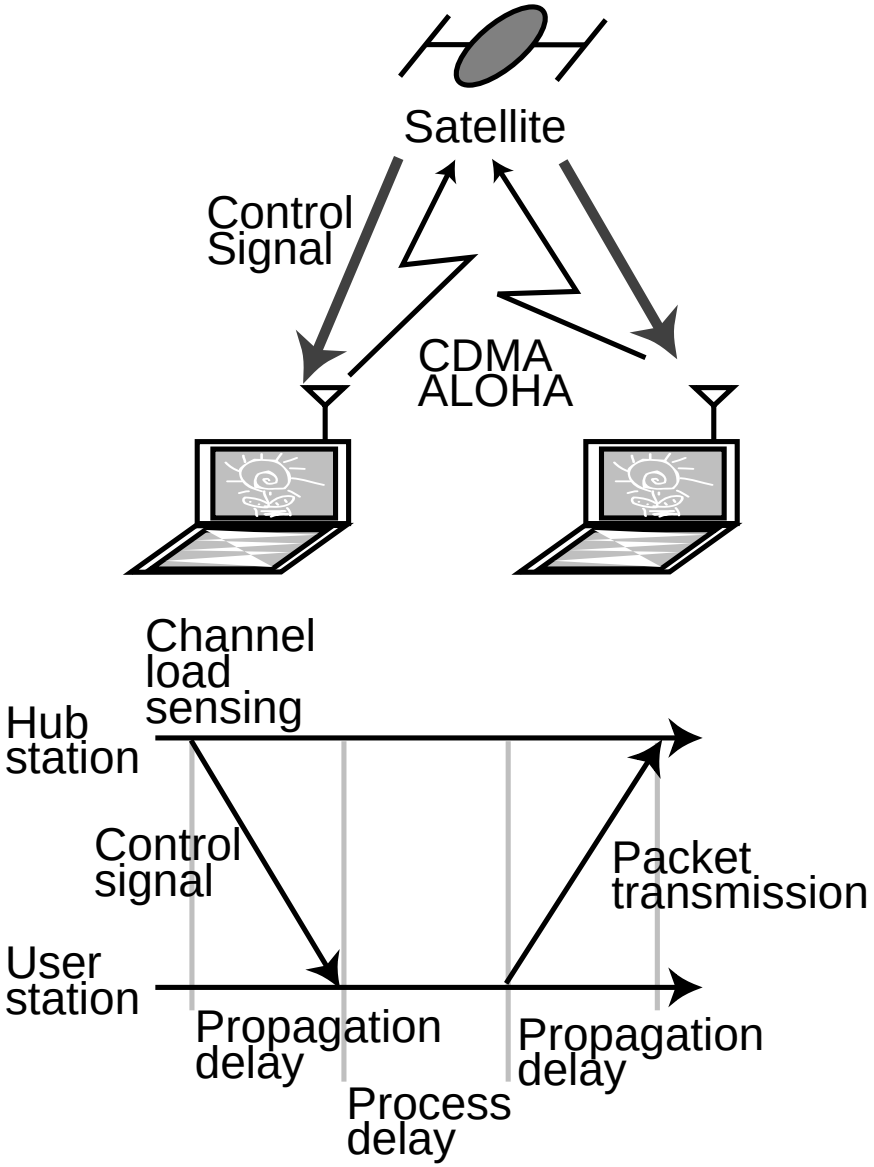
D A little throughput improvement by slotted system

Access Control for CDMA ALOHA



1. Access control protocol should be based on the channel load status observed by hub-station
2. Packet access should be accomplished in accordance with control signal broadcast from hub-station
3. CDMA Unslotted ALOHA (CDMA U-ALOHA) is an appropriate candidate

Access Timing Delay



- Time difference between channel load sensing and associated packet access timing
- Remarkable in satellite communication system
  - GEO : 0.50 [sec]
  - LEO : 0.02 [sec]

Access Control for CDMA ALOHA

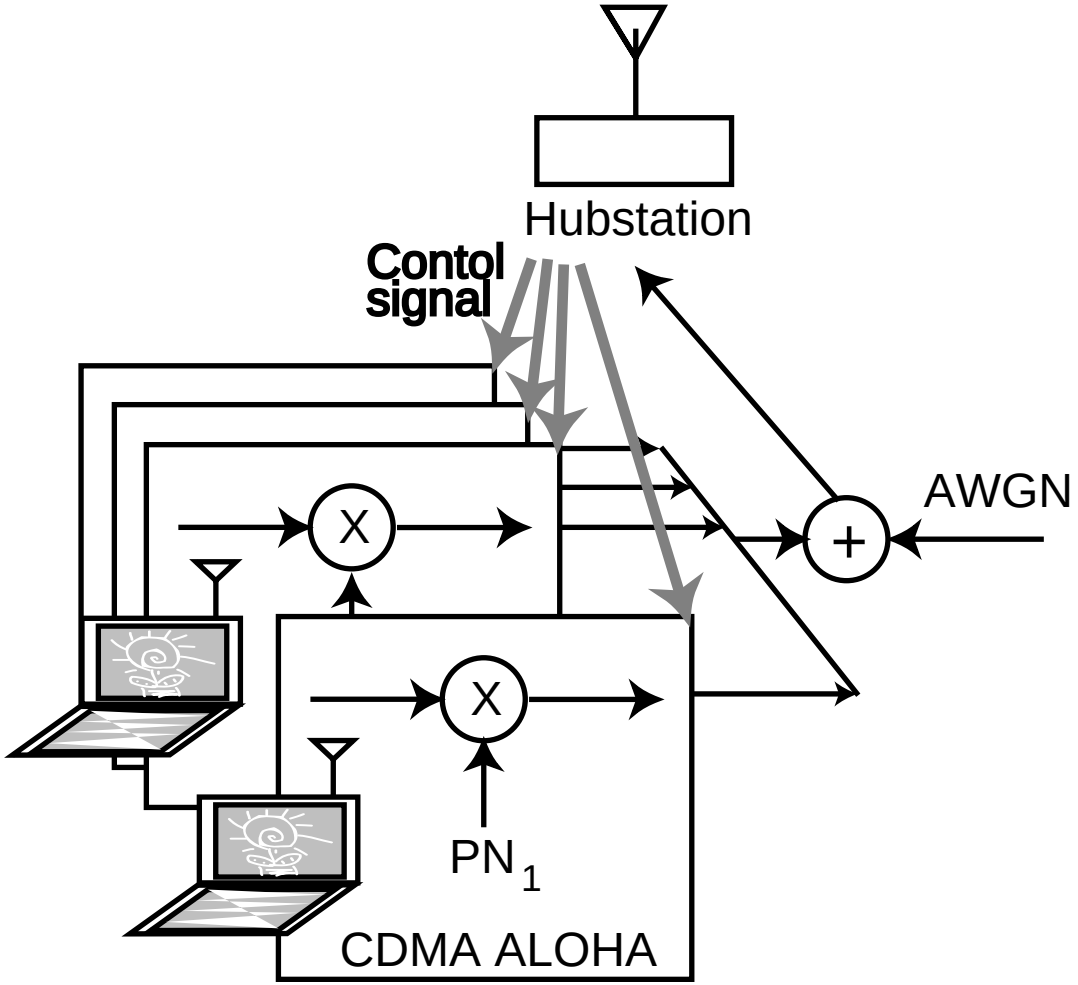
- Transmission access control protocol
  1. Channel load sensing protocol (CLSP)
  2. Modified CLSP

- Retransmission control protocol
  3. Packet retransmission control (PRC)

- Transmission and retransmission control protocol
  4. Optimum access control protocol (OACP)

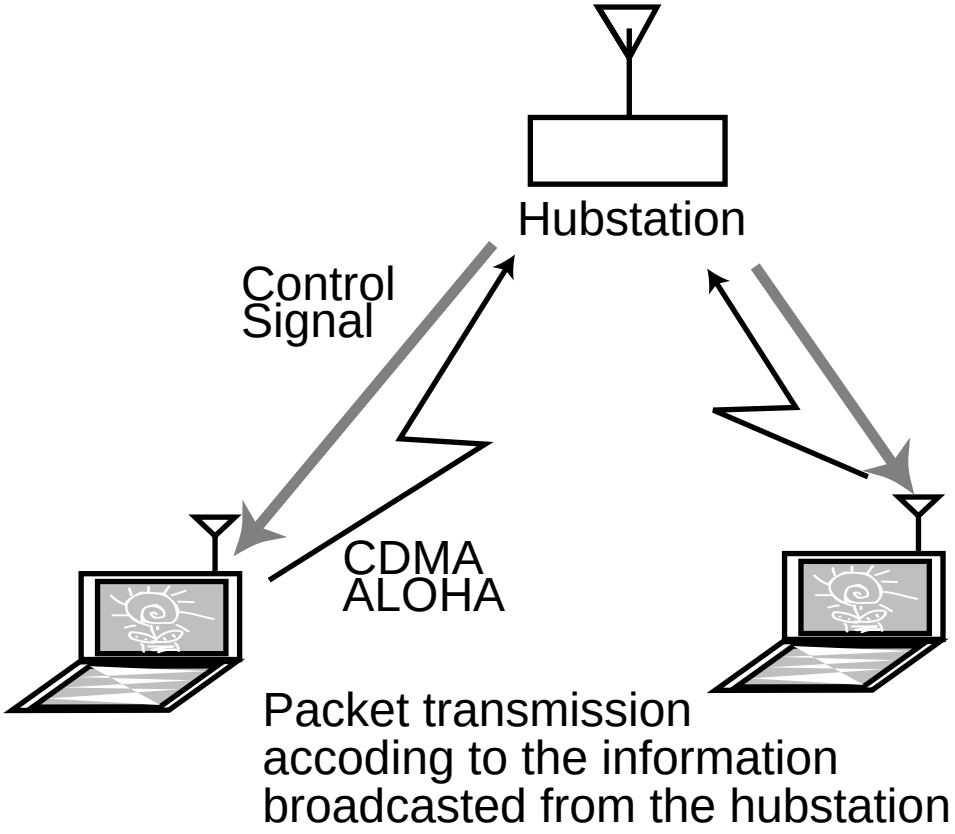
- CDMA Unslotted ALOHA systems with buffers

System Model



- Centralized single-hop network
- DS/SS modulated packet
- Poisson generation of packet
- Equal power reception
- G : Offered load
  L : Fixed packet length [bit]
- BER -- see (2.1)

Transmission Control Protocol

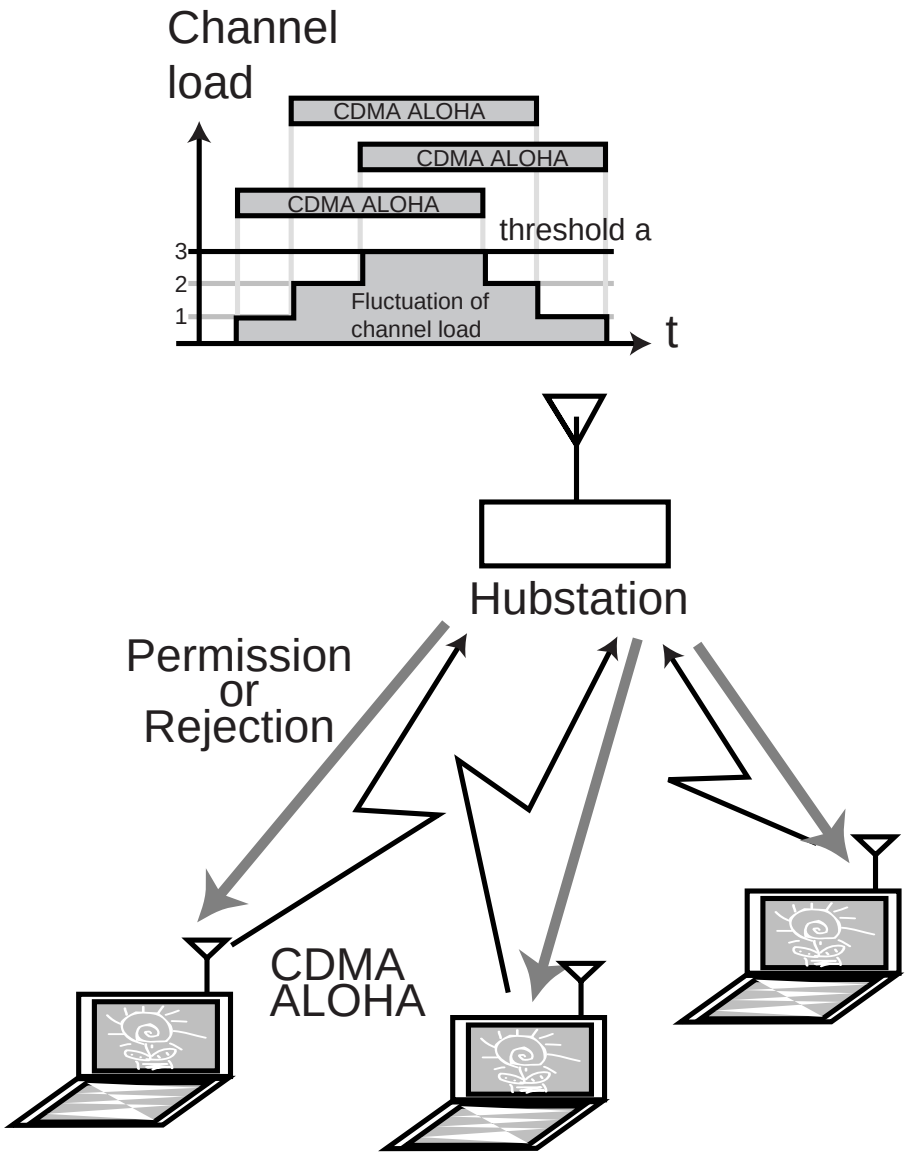


- Packet transmission is controlled by Hub-station

1. Channel load sensing protocol (CLSP)

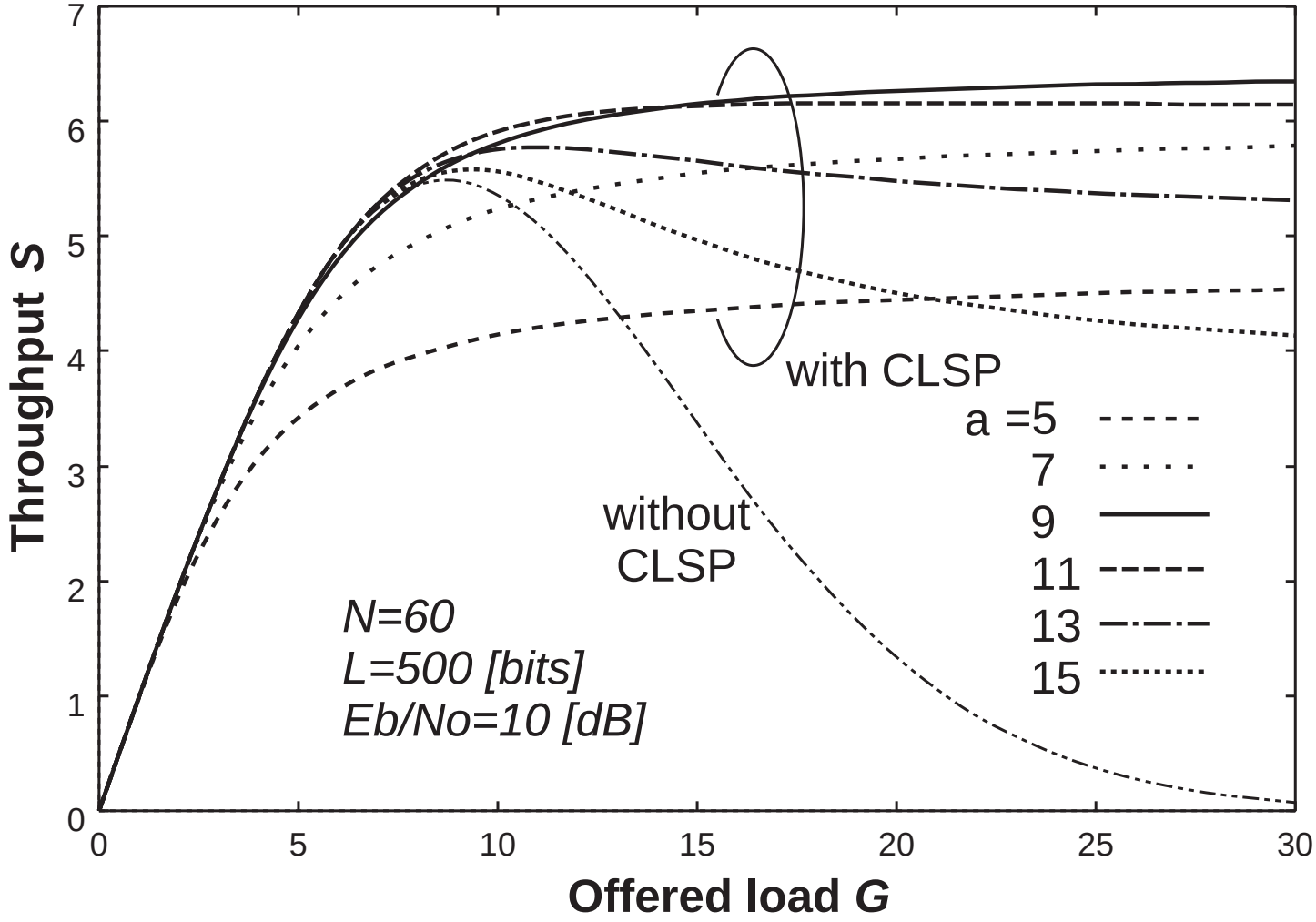
2. Modified CLSP

Channel Load Sensing Protocol (CLSP)



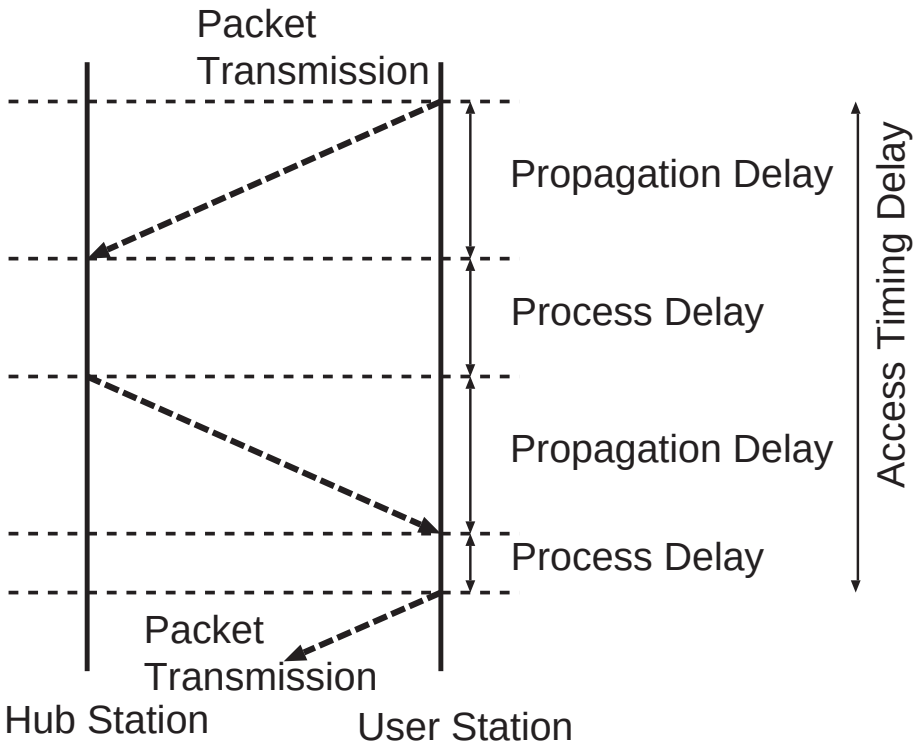
- Hub-station observes the channel load, actual number of on-going packets
- According to the channel load, the information of permission or prohibition is broadcasted.
- Users transmit according to such information.
- Channel load is always kept less than or equal to the threshold, a.

Throughput of CDMA ALOHA with CLSP



- Significant improvement in throughput
- No degradation in high offered load
- Throughput depends on threshold, a

Access Timing Delay

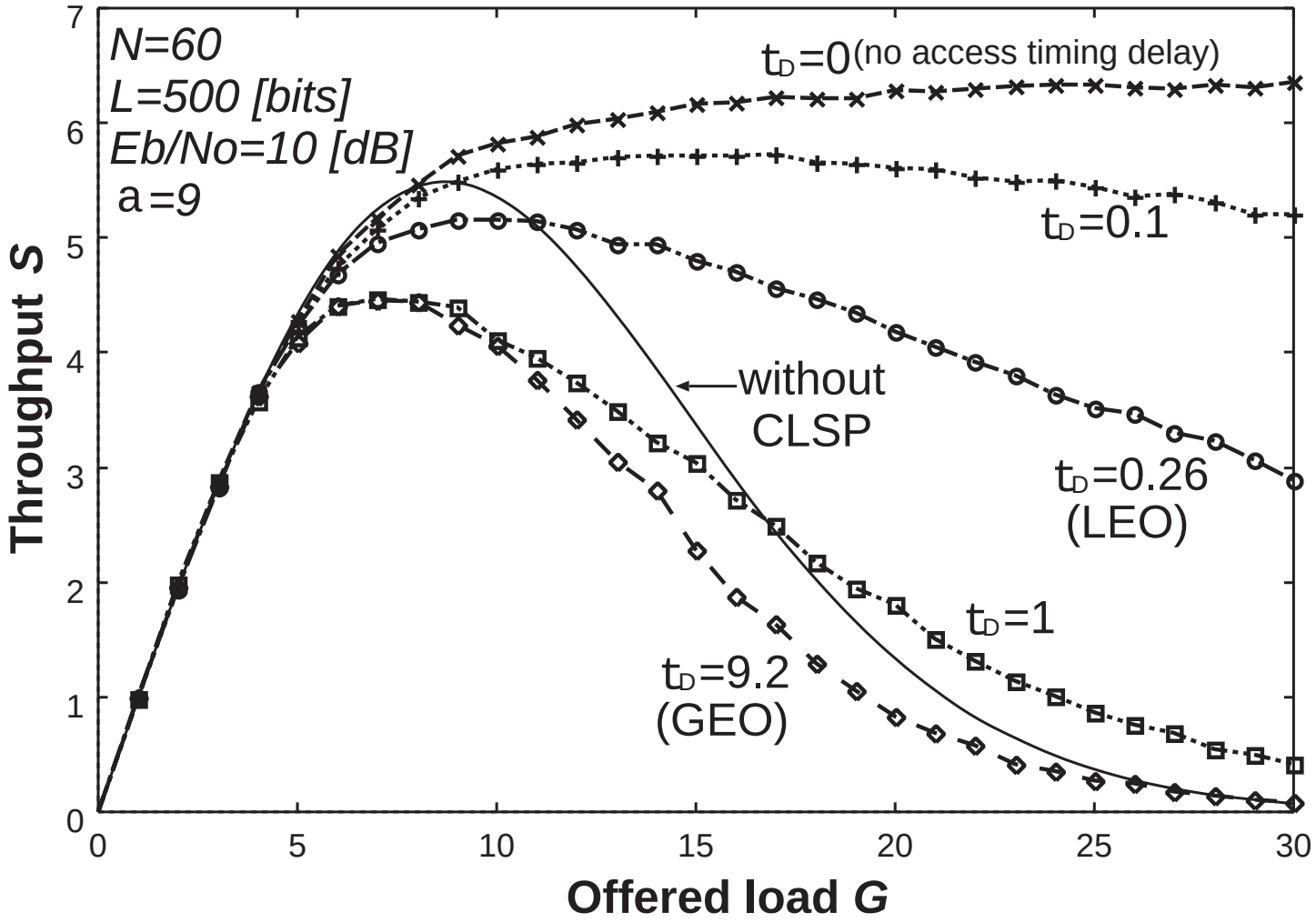


- Time difference between channel load sensing and associated packet access timing

- t_D : Access timing delay normalized by packet duration
  - GEO : $t_D = 9.20$
  - LEO : $t_D = 0.26$

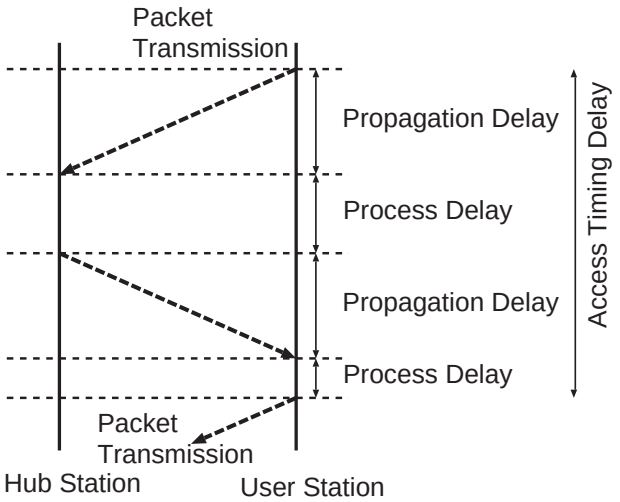
L=500 [bit] R=9,600 [bps]

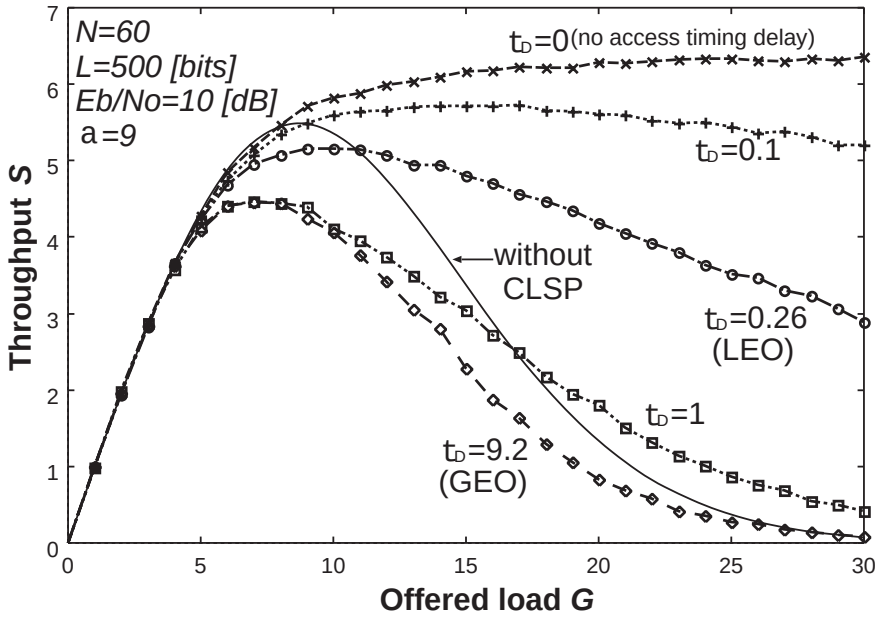
Throughput Degradation of CLSP



- Severe degradation in the presence of access timing delay

Throughput Degradation of CLSP





- In the presence of access timing delay, since the packet access control is done by the past information, the throughput would degrade

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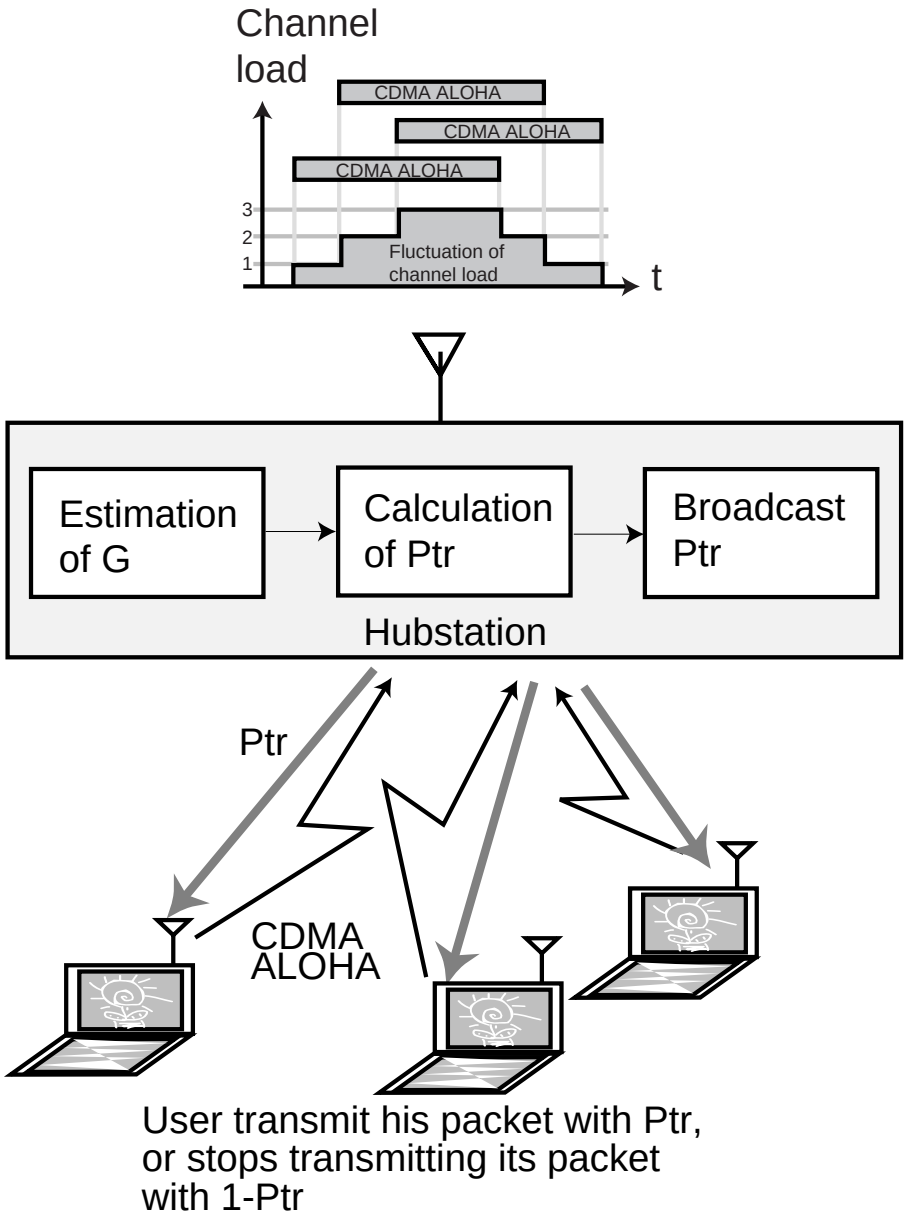
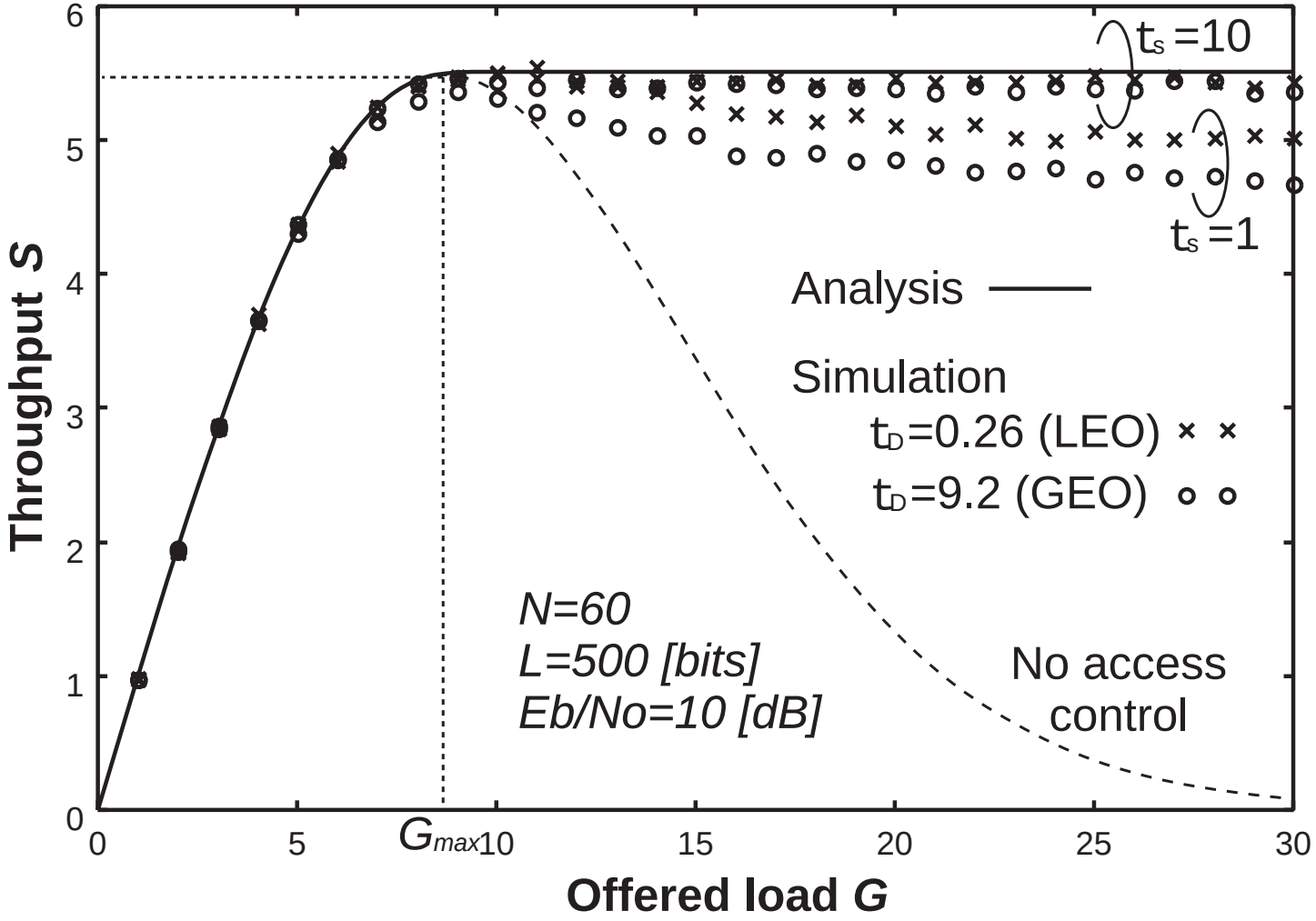
- Access control based not on instantaneous channel load but on average channel load

Modified CLSP



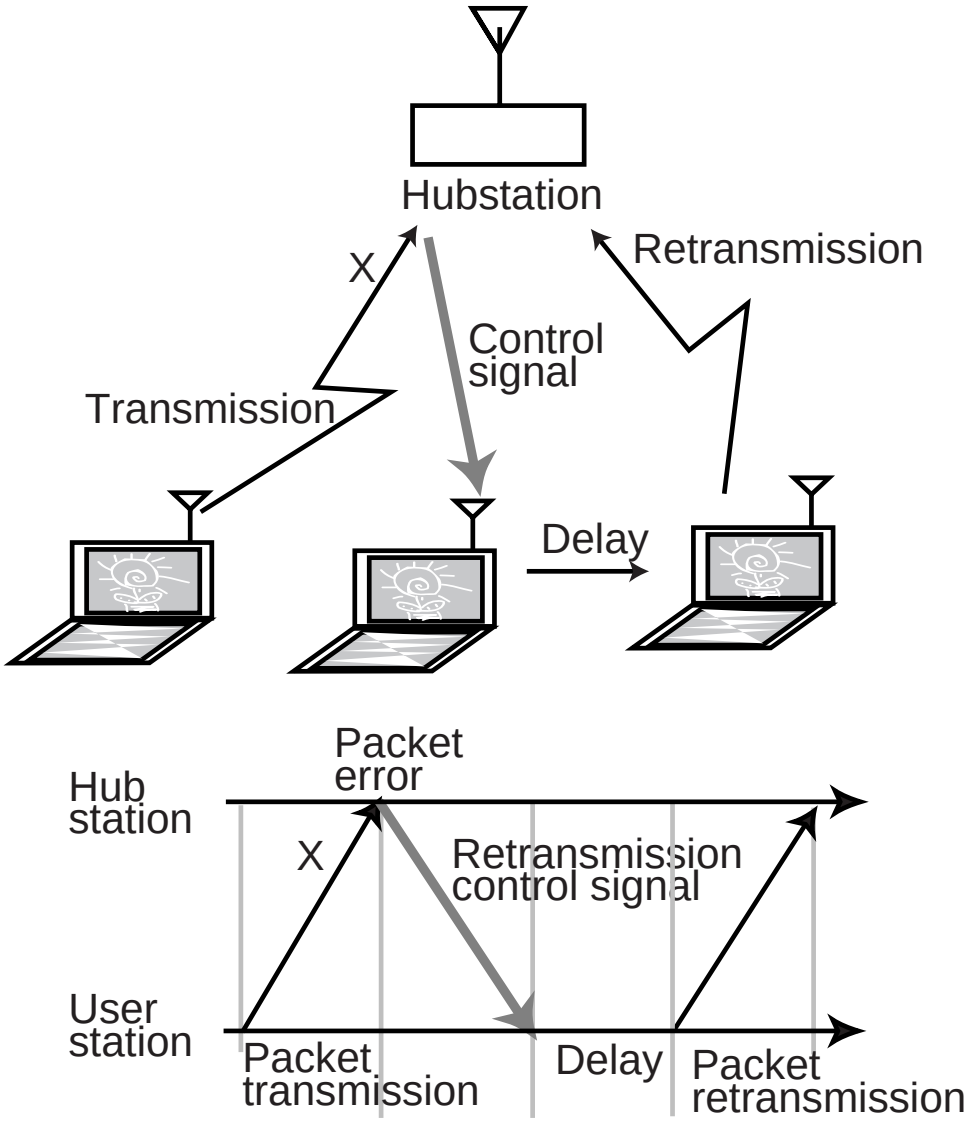
- Hub-station estimate the offered traffic load, G.
- According to the estimated G, the hub-station broadcast the probability, Ptr.
- Ptr is obtained so that actual offered load is set to the value which gains the maximum throughput.
- User transmits his packets according to Ptr

Throughput of CDMA ALOHA with MCLSP



- Maximum throughput is the same as one without access control.
- Robustness against access timing delay

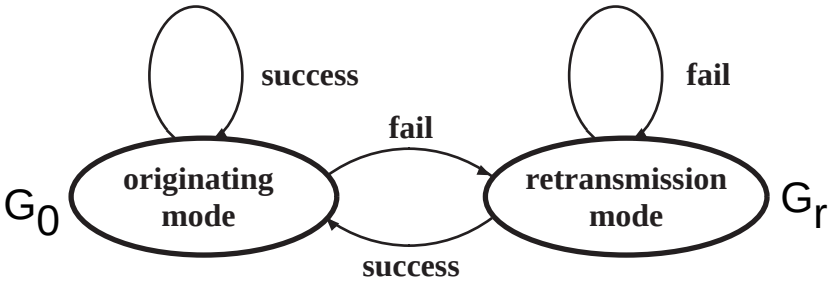
Retransmission Control Protocol



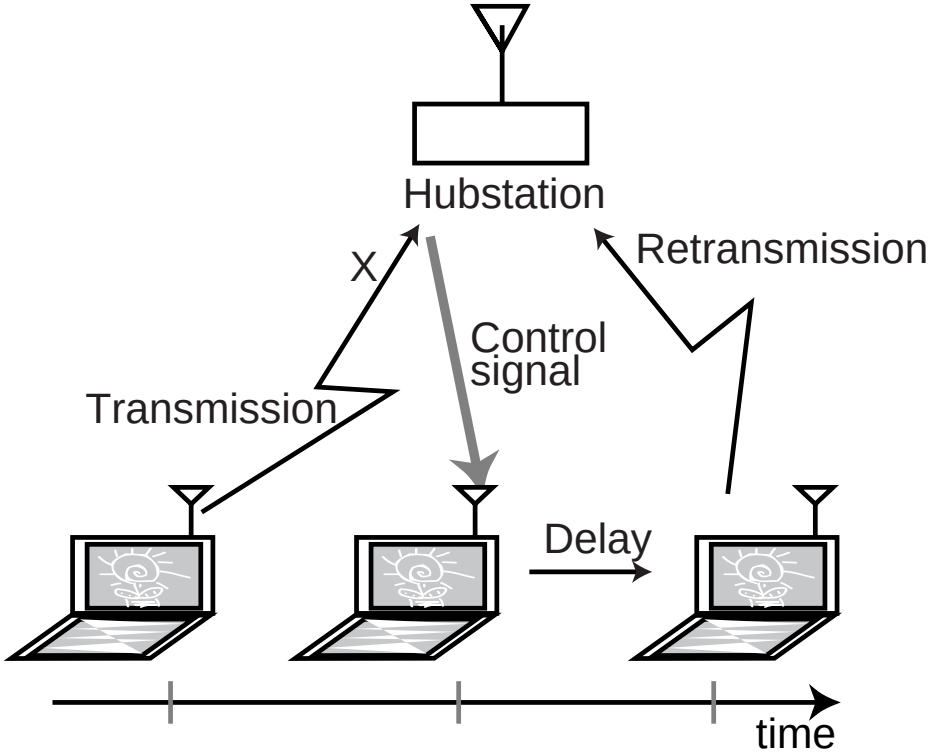
- If packet error occurs, a user schedules the packet at a later time according to a delay distribution
- This distribution is calculated and broadcast by a hub-station

3. Packet retransmission control (PRC)

Packet Retransmission Control (PRC)

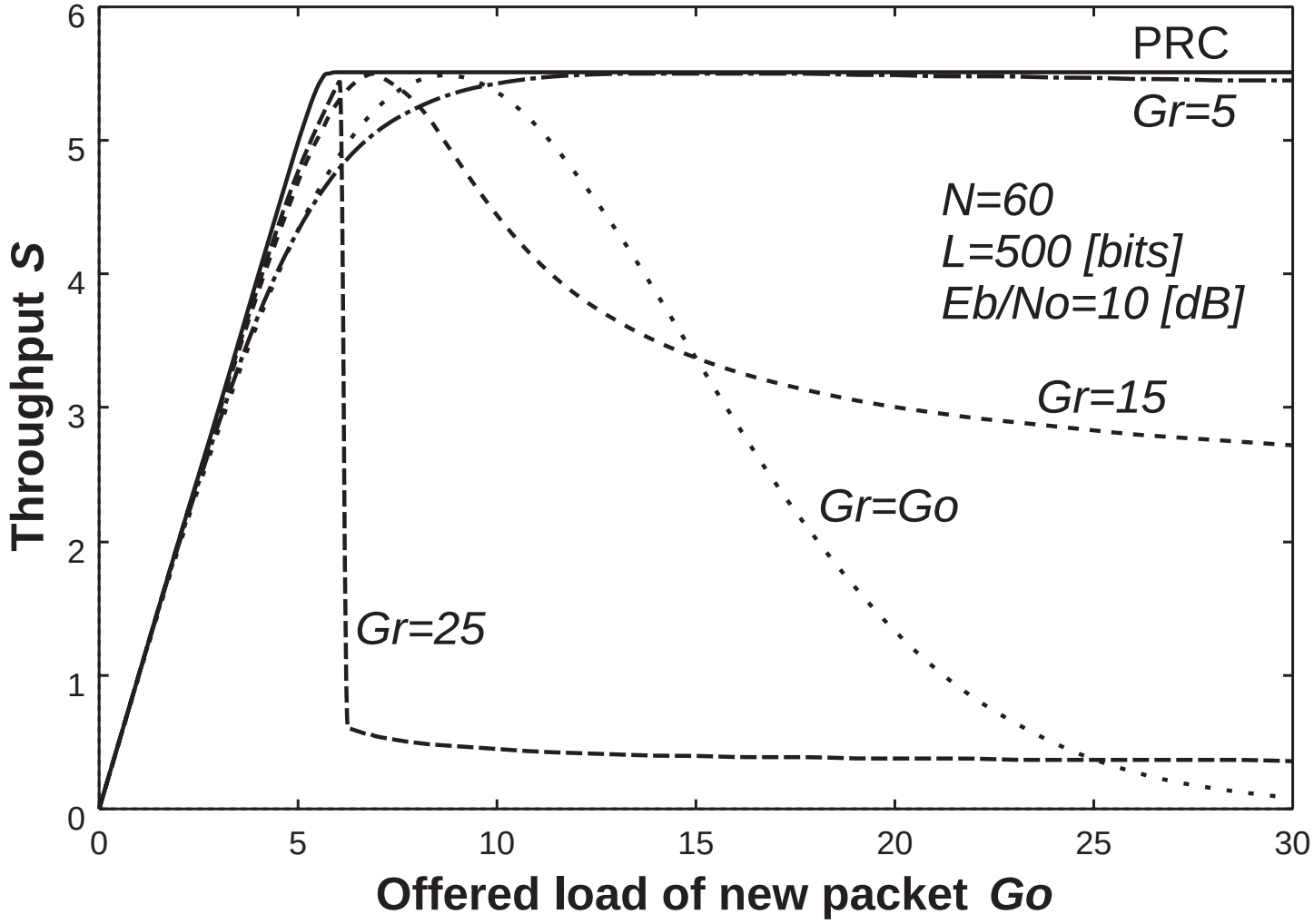


Transition of users between the originating mode and retransmission mode



- Appropriate distribution of delay is calculated and broadcast
- The distribution is obtained by a observation of channel load
- PRC is equivalent to a control of retransmission offered load, Gr

Throughput of CDMA ALOHA with PRC



- Maximum throughput is the same as one without access control.
- Throughput is almost same as MCLSP
- Robustness against access timing delay

What is the optimum access control?

Channel Load Sensing Protocol (CLSP)

- Higher throughput
- Weakness to access timing delay

Modified CLSP (MCLSP)

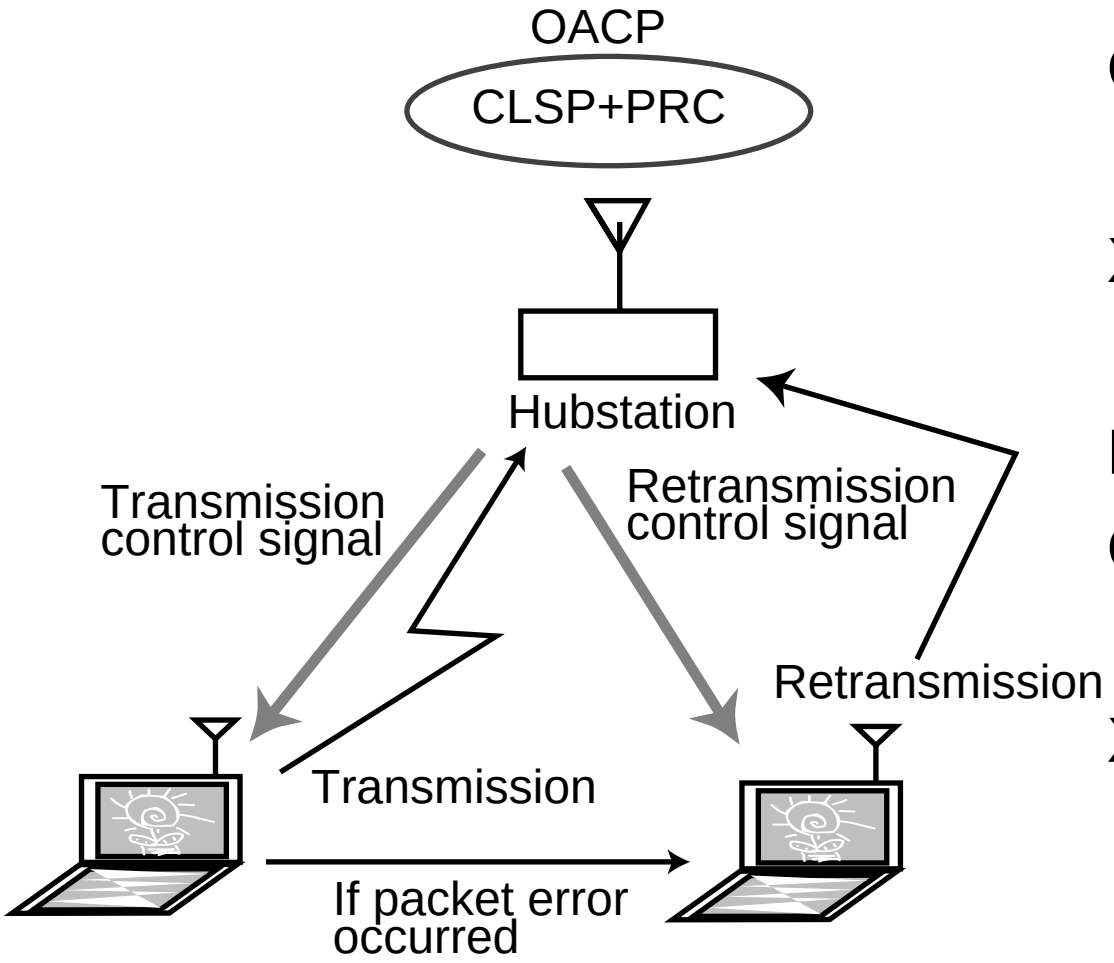
- Robustness against access timing delay
- No gain in maximum throughput

Packet Retransmission Control (PRC)

- Robustness against access timing delay
- No gain in maximum throughput

?

Optimal Access Control Protocol (OACP)



CLSP :

O Improvement in maximum throughput

X Weakness against access timing delay

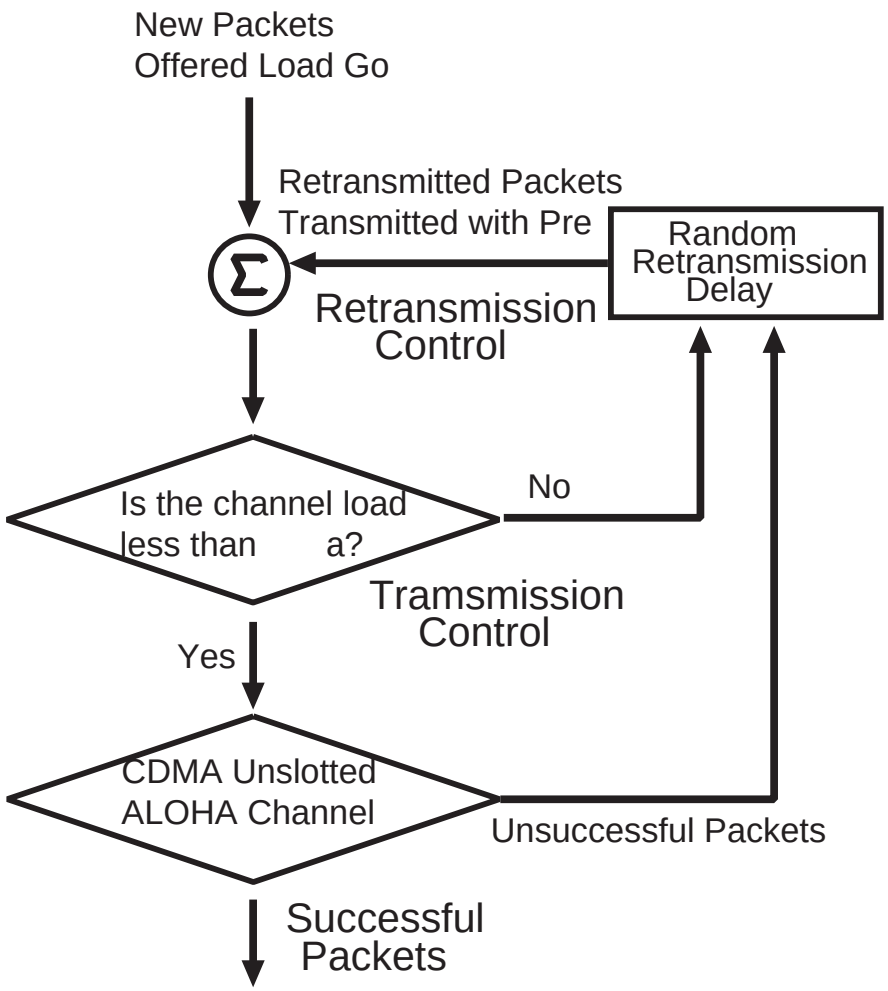
PRC :

O Robust against access timing delay

X No improvement in maximum throughput

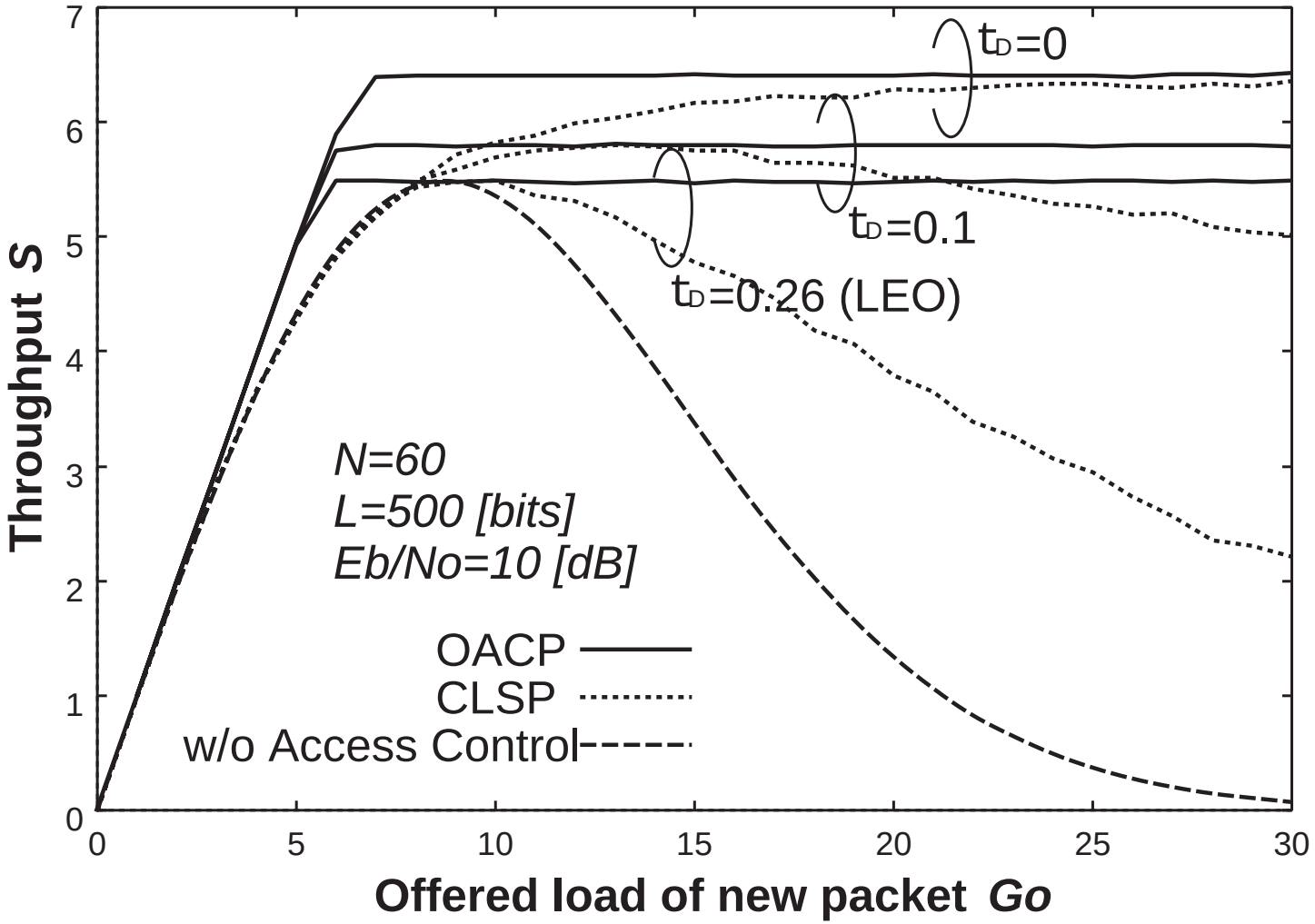
CLSP + PRC = Optimum

Optimal Access Control Protocol (OACP)



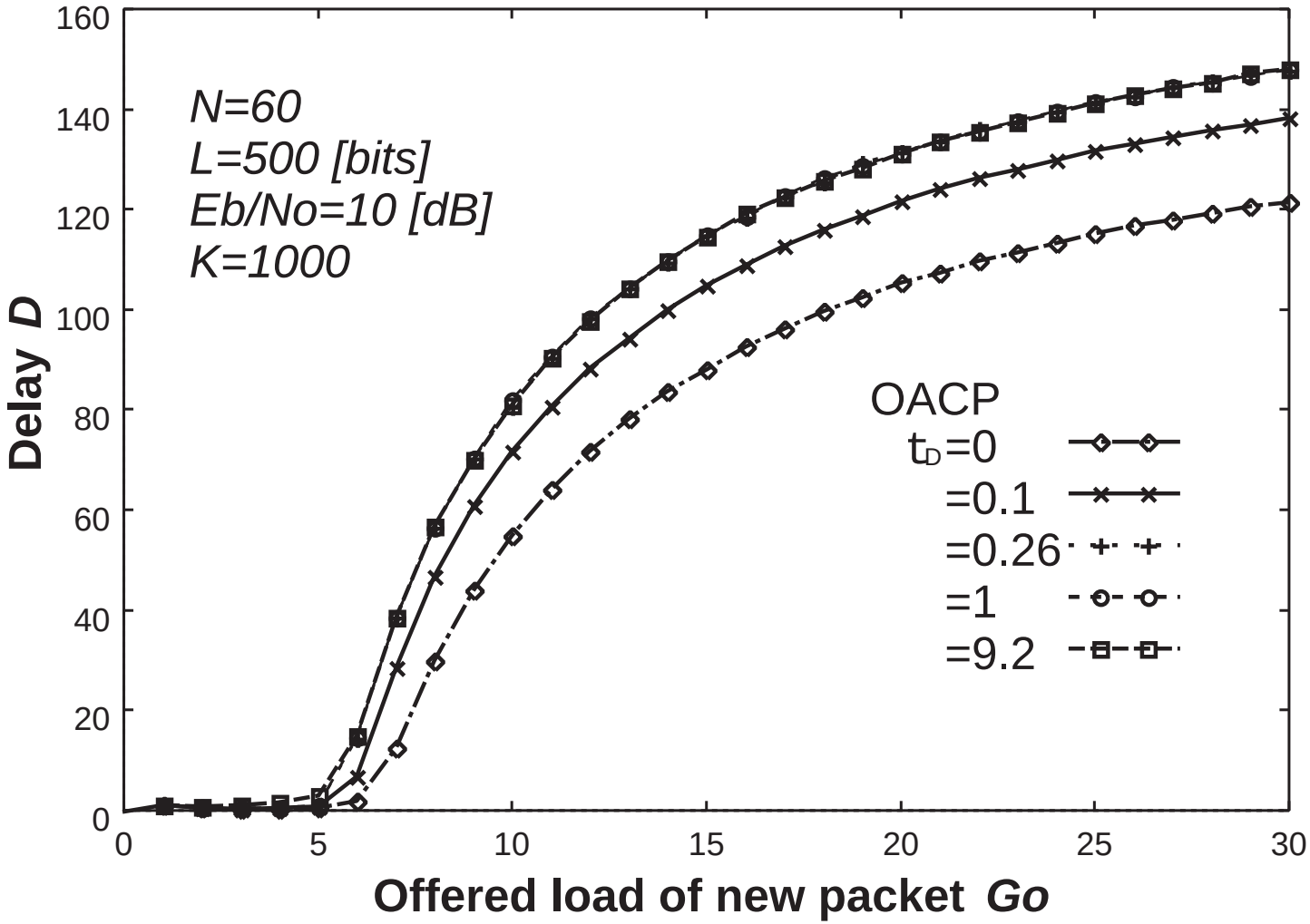
- Hub-station estimate the offered traffic load, G.
- If the channel load is below a, then packet transmission is allowed. Otherwise, the users move into retrans-mission mode (CLSP).
- Backlogged packet is controlled according to the retransmission probability broadcast from the hub-station (PRC).

Throughput of CDMA ALOHA with PRC

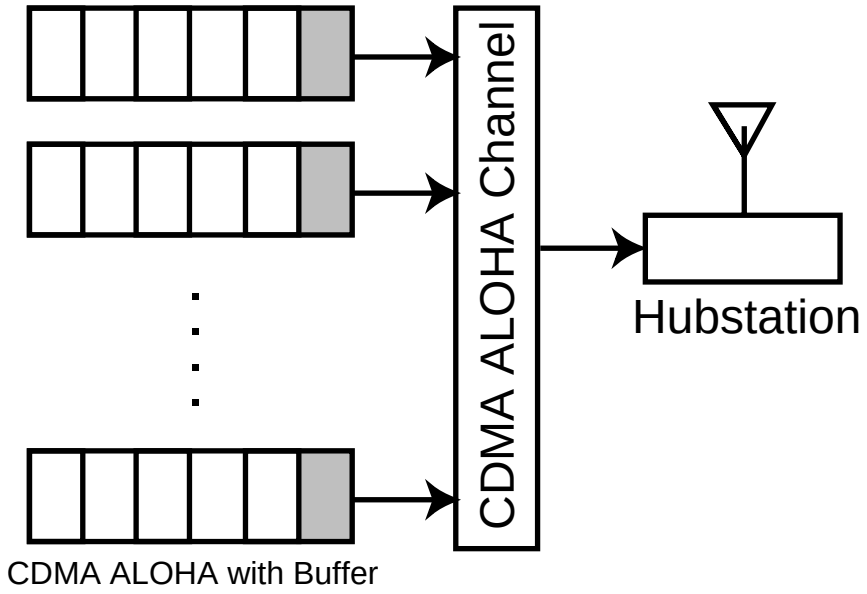


- Maximum throughput is the same as CLSP if access timing delay is negligible
- Robustness against access timing delay

Delay performance of CDMA ALOHA with OACP

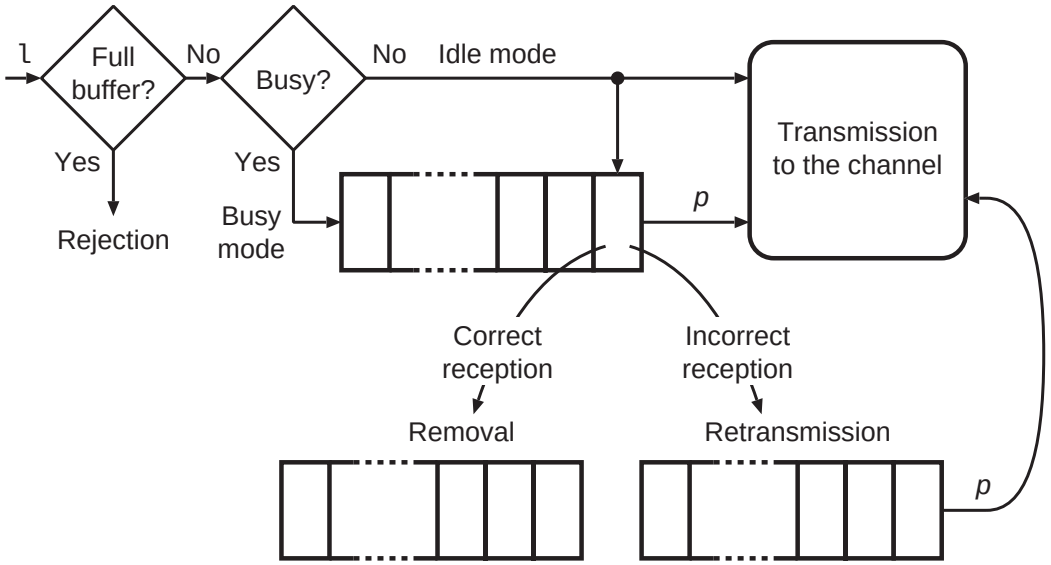


CDMA Unslotted ALOHA with Buffers



- Each user is equipped with a certain size of queueing buffers.
- Retransmission packet can be managed by each of users.
- Autonomous control of packet transmission may be possible.

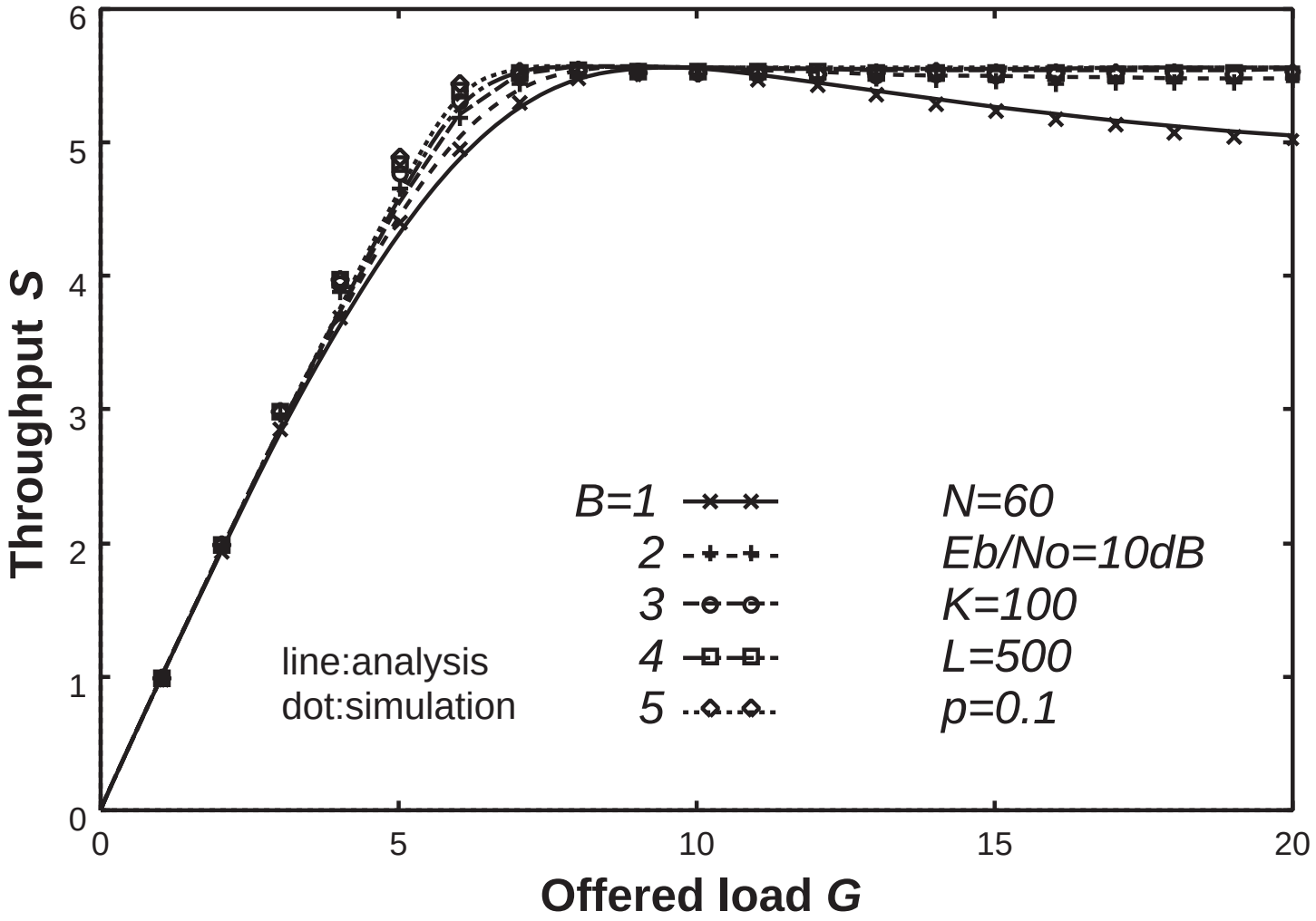
CDMA Unslotted ALOHA with Buffers



Schematic of packet flow at each user station

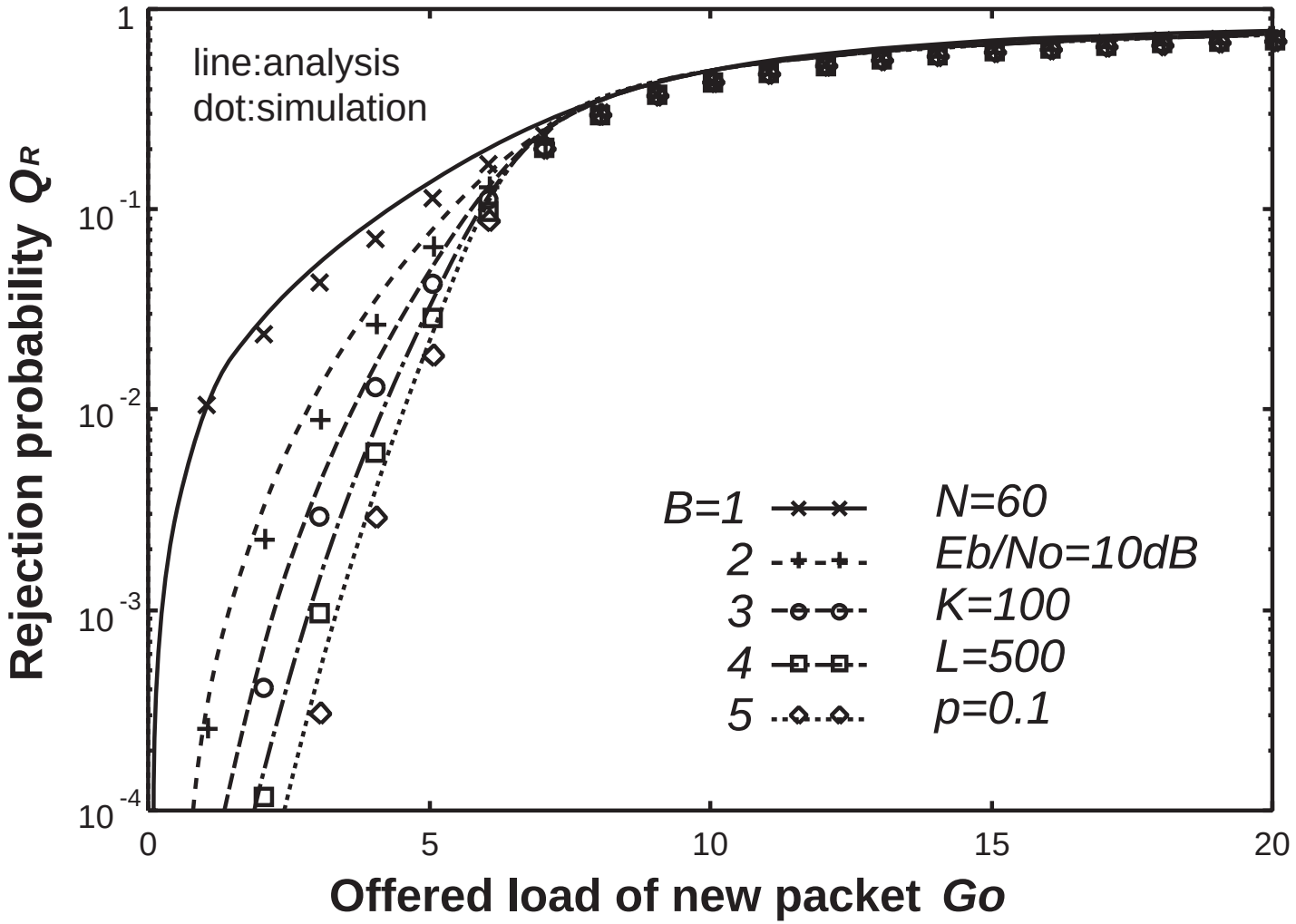
- Each user is equipped with a finite buffer capacity of B packets.
- Packet arriving at an idle status is transmitted immediately.
- Packets are served in a first-in-first-out (FIFO) discipline.
- Busy user attempt to transmit packet with rate *p*.

Throughput of CDMA U-ALOHA with Buffers



- The larger buffer size a user has, the more rapidly the throughput is increasing.
- Throughput is almost same as MCLSP or PRC

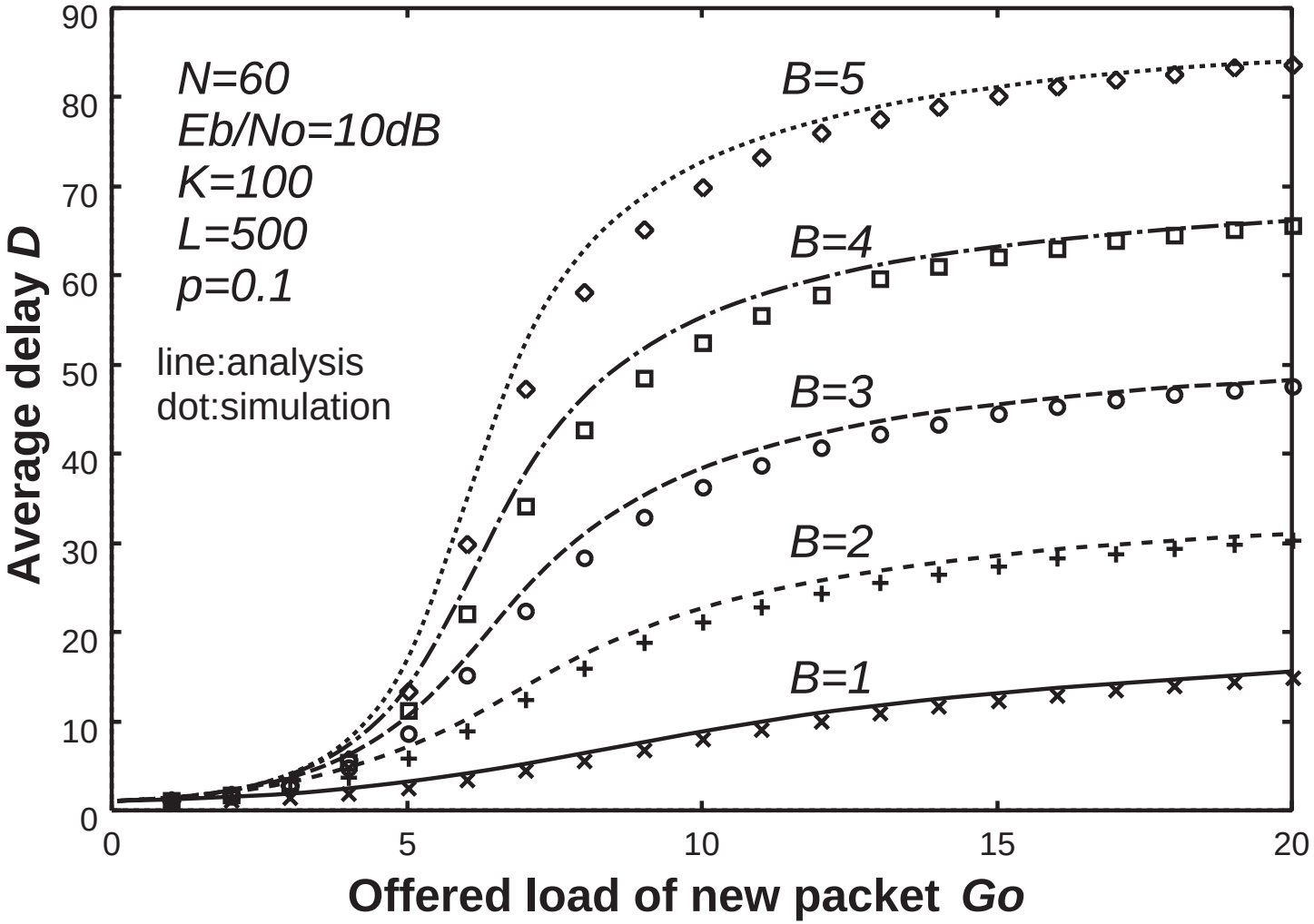
Rejection Probability



X If a packet arrives at a user with a full buffer, this packet is rejected

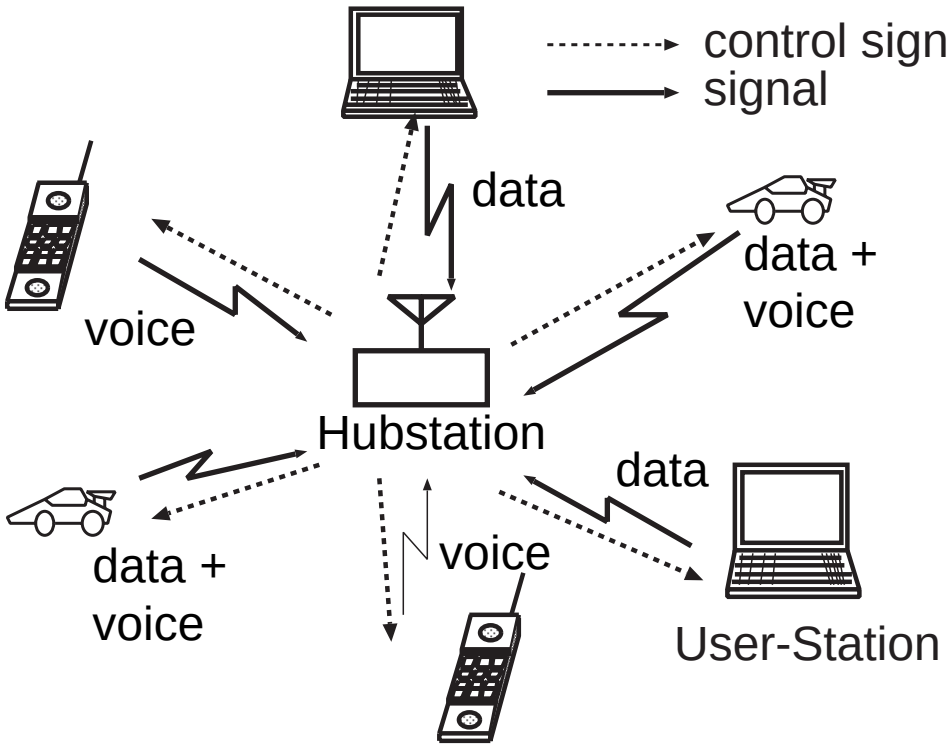
- The larger buffer size a user has, the less rejection probability is

Delay Performance



- The number of busy user increases by increasing the buffer size.
- Average delay increases in compensation for reduction of the rejection of packet transmission.

CDMA ALOHA for Multimedia signals



Access control for multimedia signals

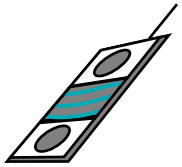
- Different media which have different characteristics are handled simultaneously
- CDMA is suitable for handling multimedia signal
  - Multi-rate CDMA
  - Multi-code CDMA

1 Integrated voice and data system

2 High and low bit rate data transmission

1. Integrated Voice and Data System

Voice : Real time delivery → Circuit switch mode (Reservation mode)

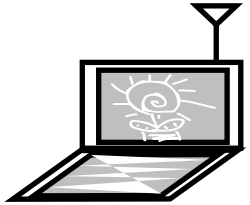


Voice users have to reserve the channel before they transmit their signals by sending a reservation packet.

Once they get the reservation, they continue to transmit their signal until voice call ends.

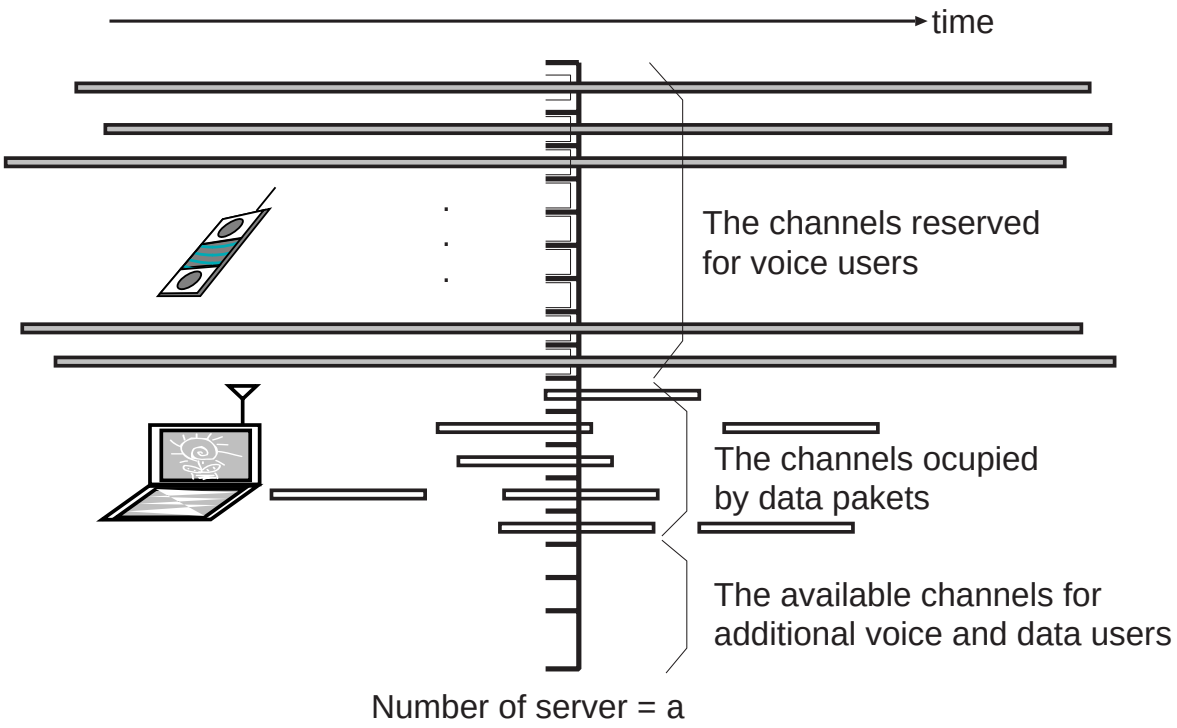
If the number of simultaneous established users reaches to a certain threshold, voice users cannot access to get the reservation.

Data : Some tolerance to transmission delay → Packet switch mode



Data users transmit thier packets on the CDMA Unslotted ALOHA .

Integrated CDMA Voice Signal & CDMA Data Packet (CDMA unslotted ALOHA)



Channel load status seen at hubstation

- Interference from both media
- Priority of voice medium (continuous voice call until call ends)

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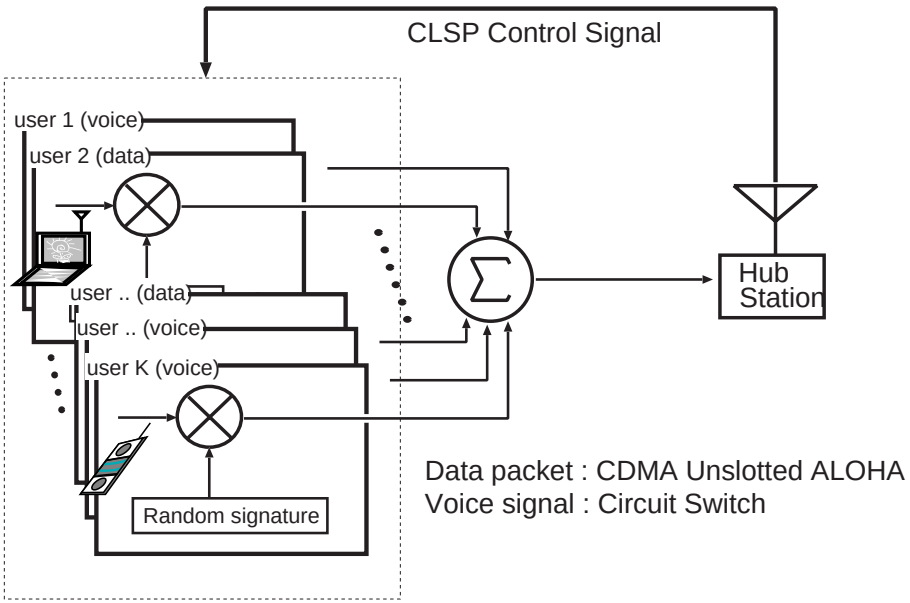
Necessity of traffic control

System Model



- Total bandwidth
  W = 20MHz
- Band expansion factor
  N = 312 (=W/R)

Voice signal :

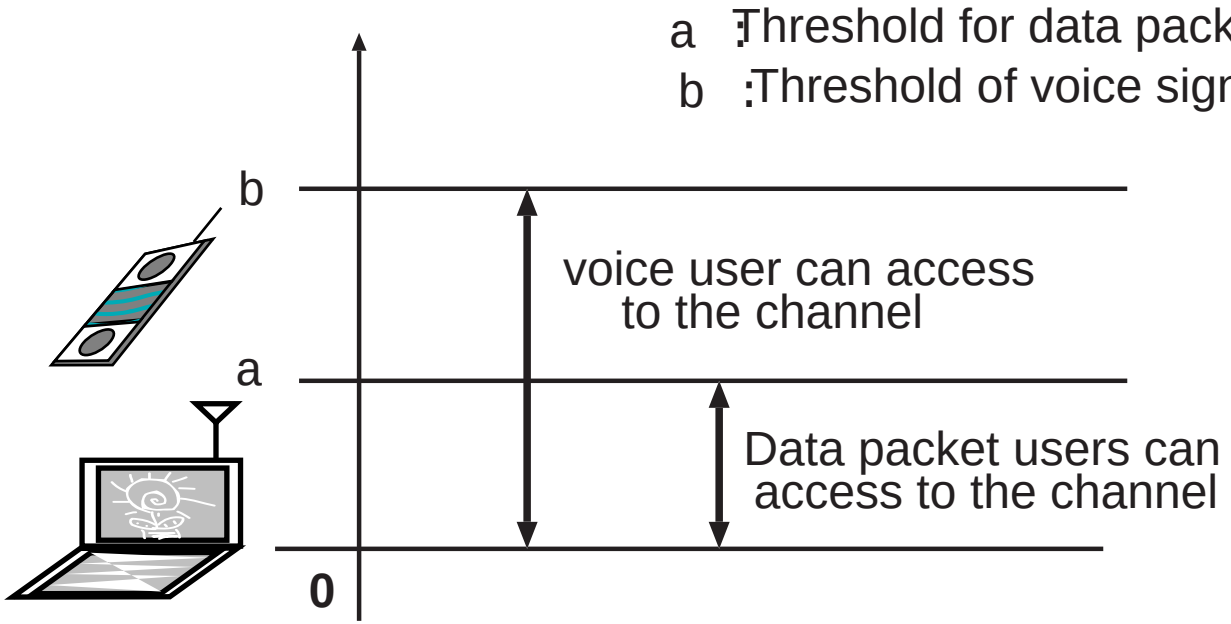
- Poisson generation
- Bit rate : R = 32k [bps]
- Exponential signal length
  Length 60.0 [sec]
  Silence period 1.7 [sec]
  Talk spurt 1.0 [sec]

Data packet :

- Poisson generation
- Bit rate : R = 32k [bps]
- Fixed packet length
  L = 500 [bit] (0.01 [sec])

Traffic Control for Voice and Data Media

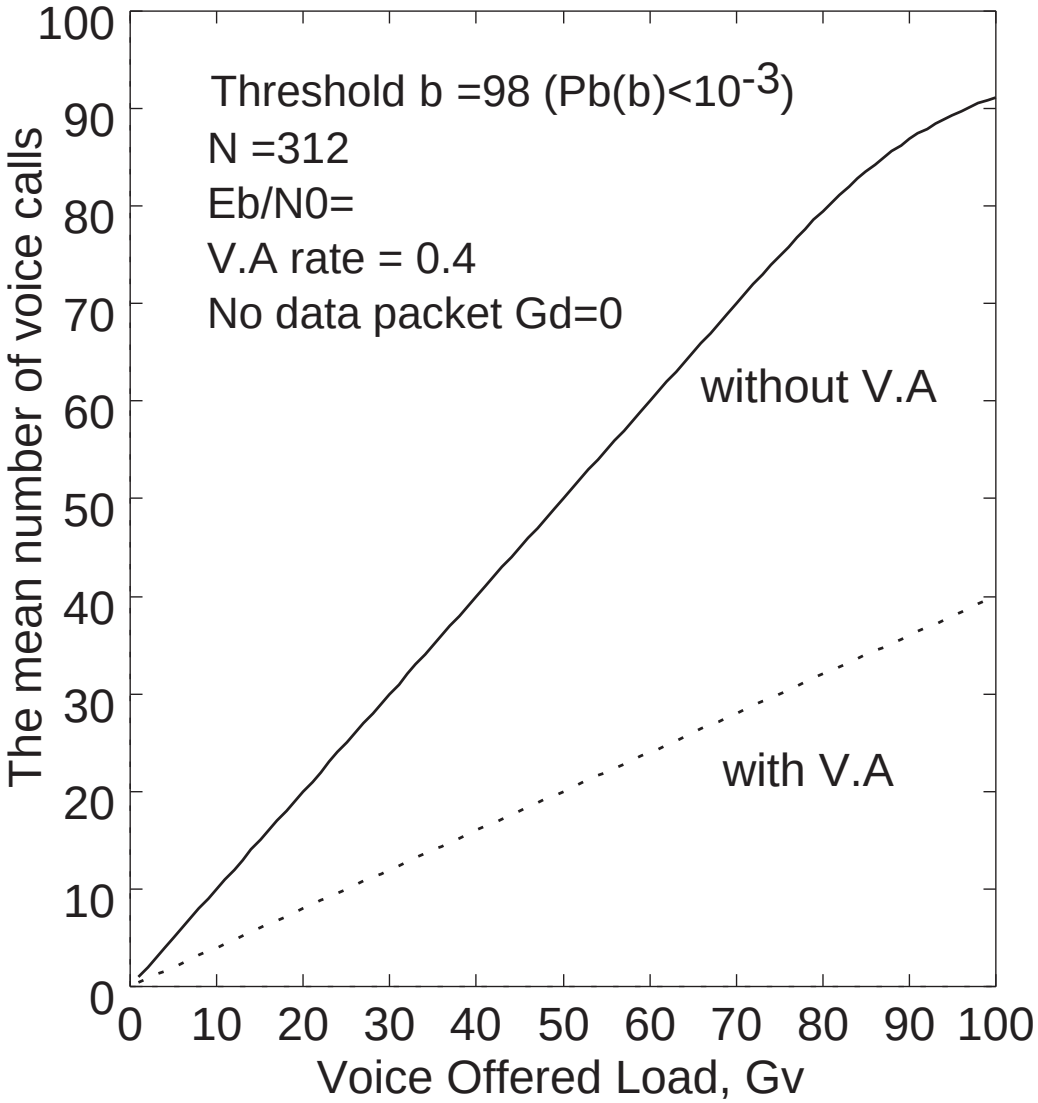
The number of simultaneous voice and data signals, k



Why b > a ?

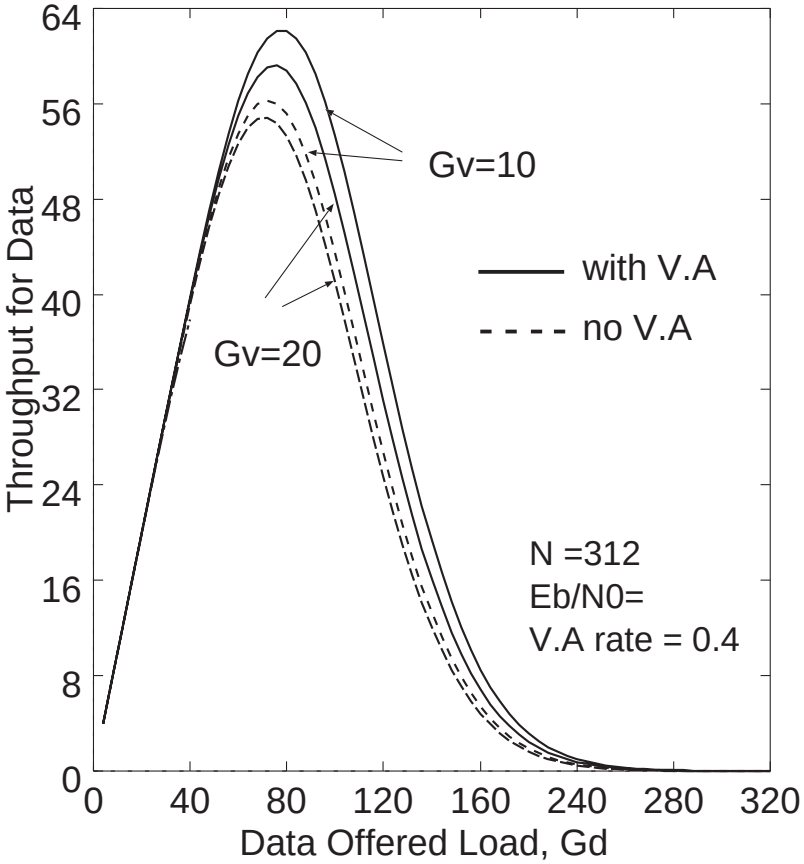
- The required signal quality of voice < that of data packet
- The signal quality must be guaranteed for voice signals

Mean Number of Voice Call

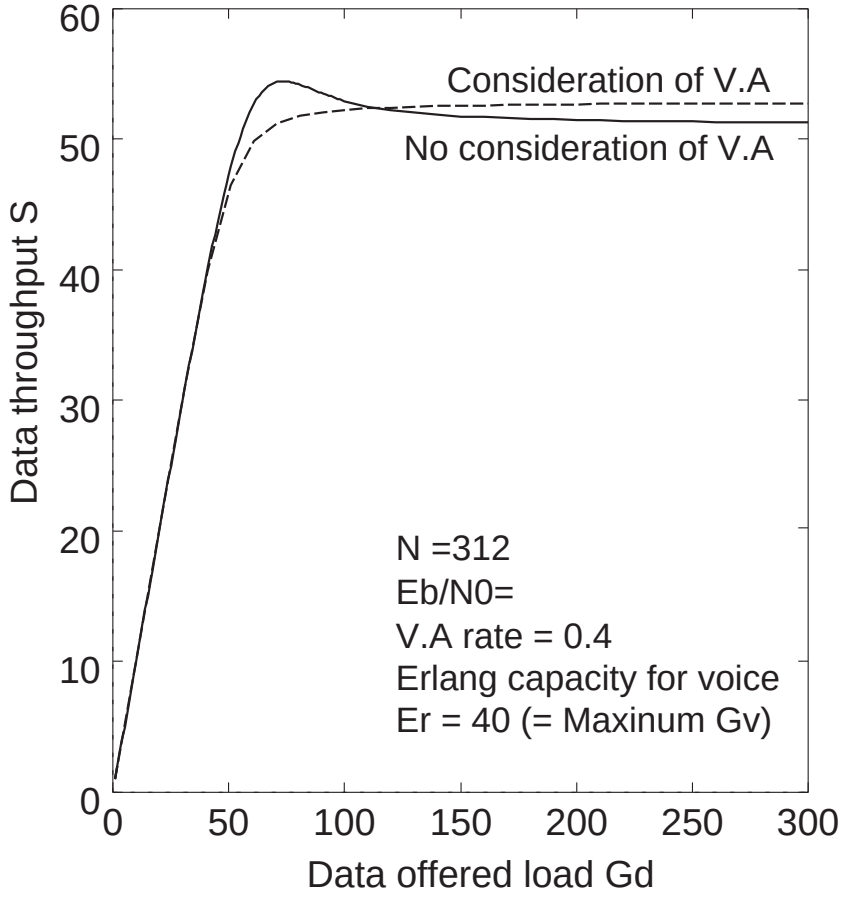


- Voice activity (V.A) improves the number of simultaneous call.
- Access control by counting the number of talk spurt of voice signal

Data Throughput

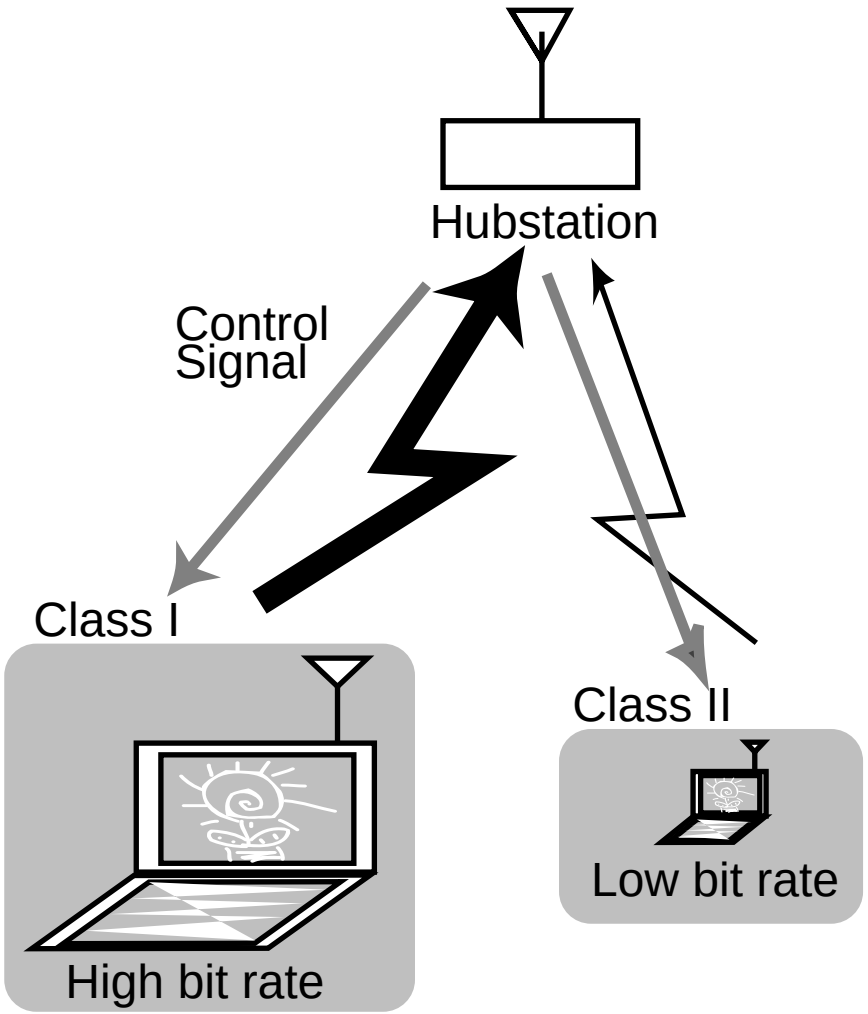


Without access control



With access control

2. High and Low Bit Rate Data Transmission

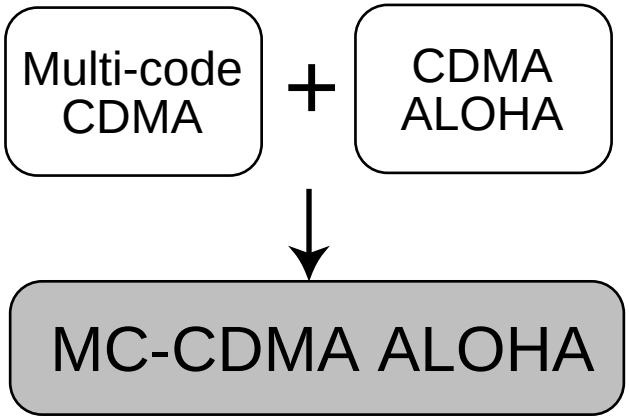


Class I : High-bit-rate packet

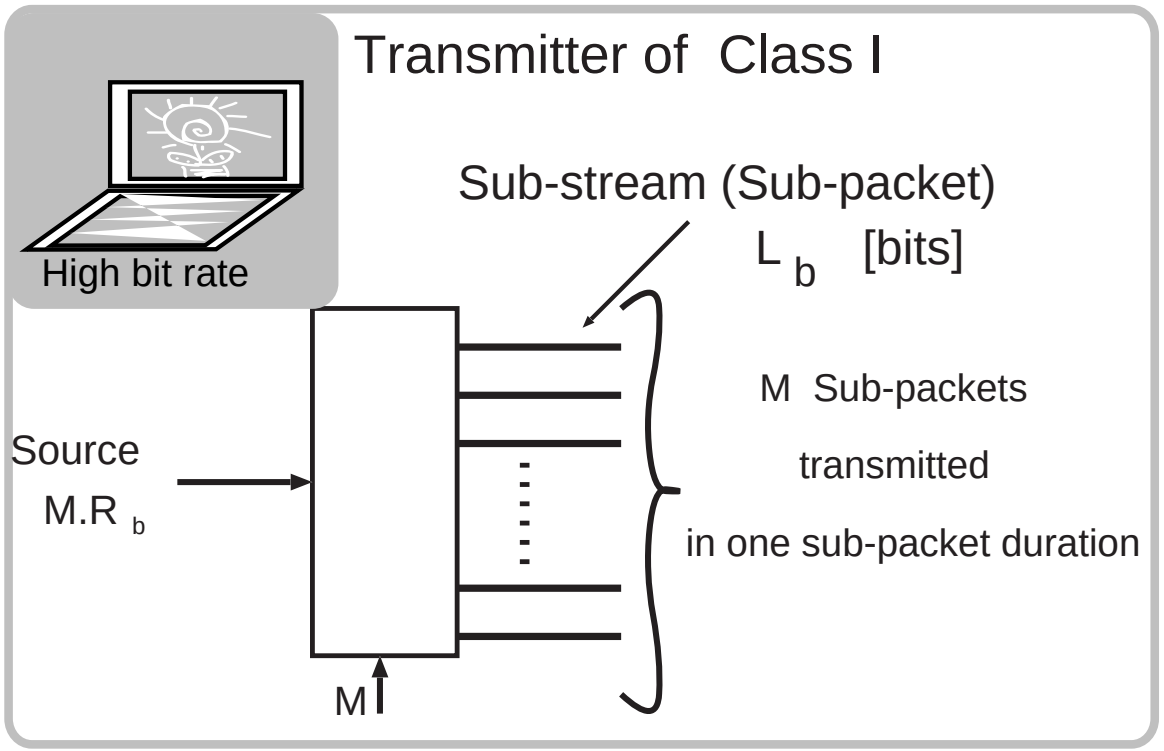
Class II: Low-bit-rate packet

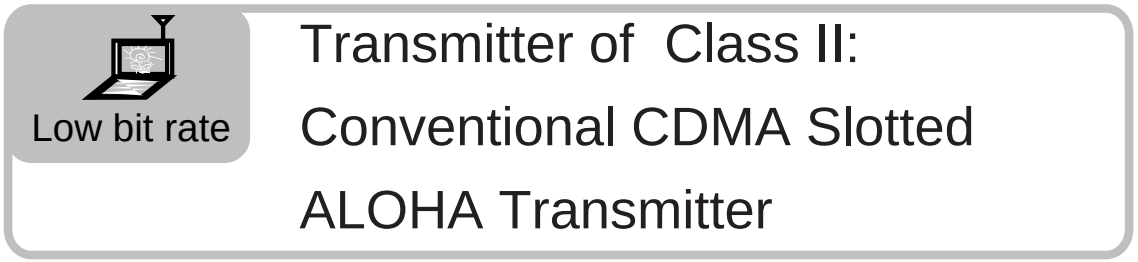
Multi-rate CDMA system

- O Multi-code
- Multi-processing gain
- Multi-modulation



System Model





Class I :

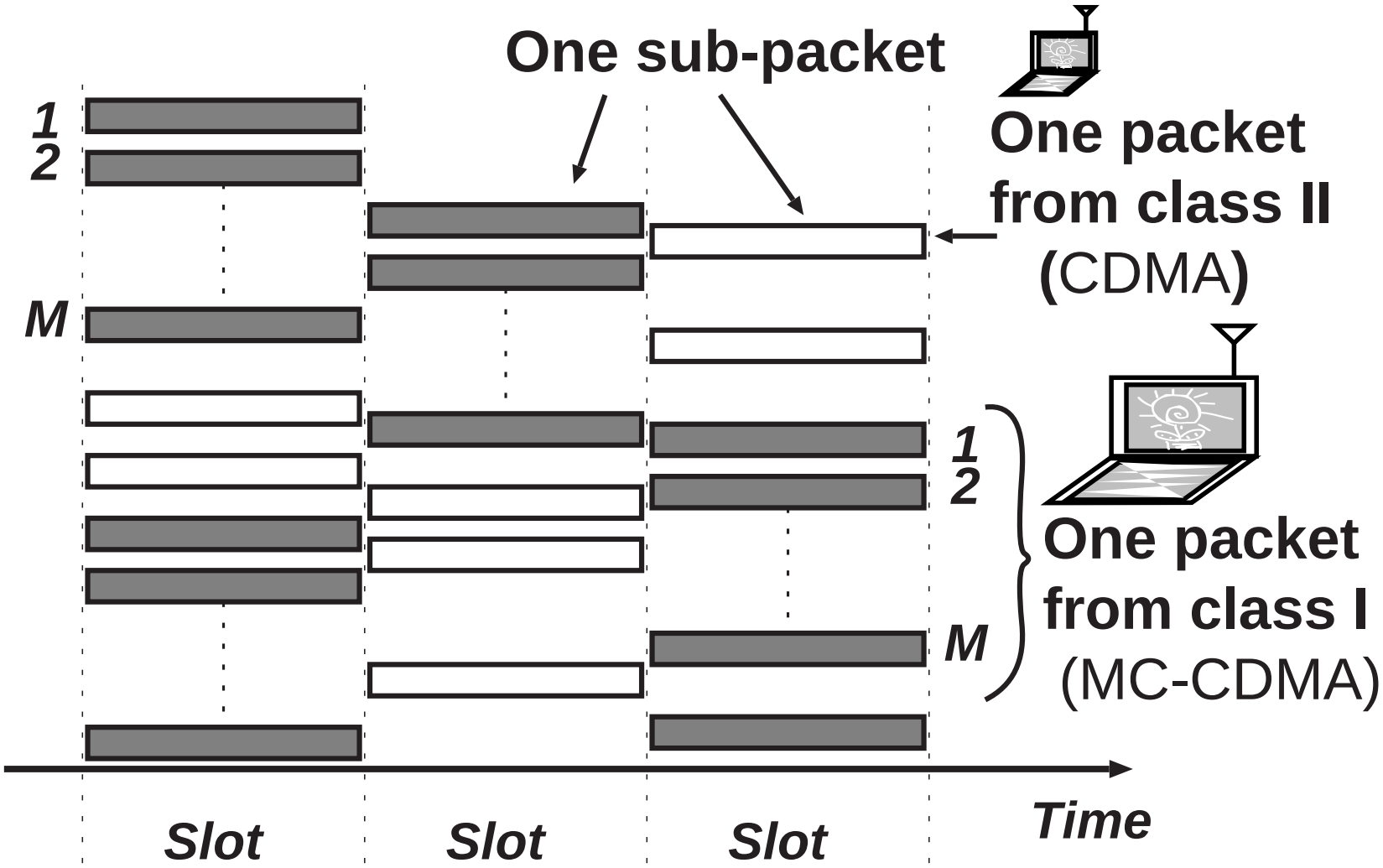
- Poisson generation
- Bit rate MRb [bit/sec]
- Fixed packet length MLb [bits]

Class II:

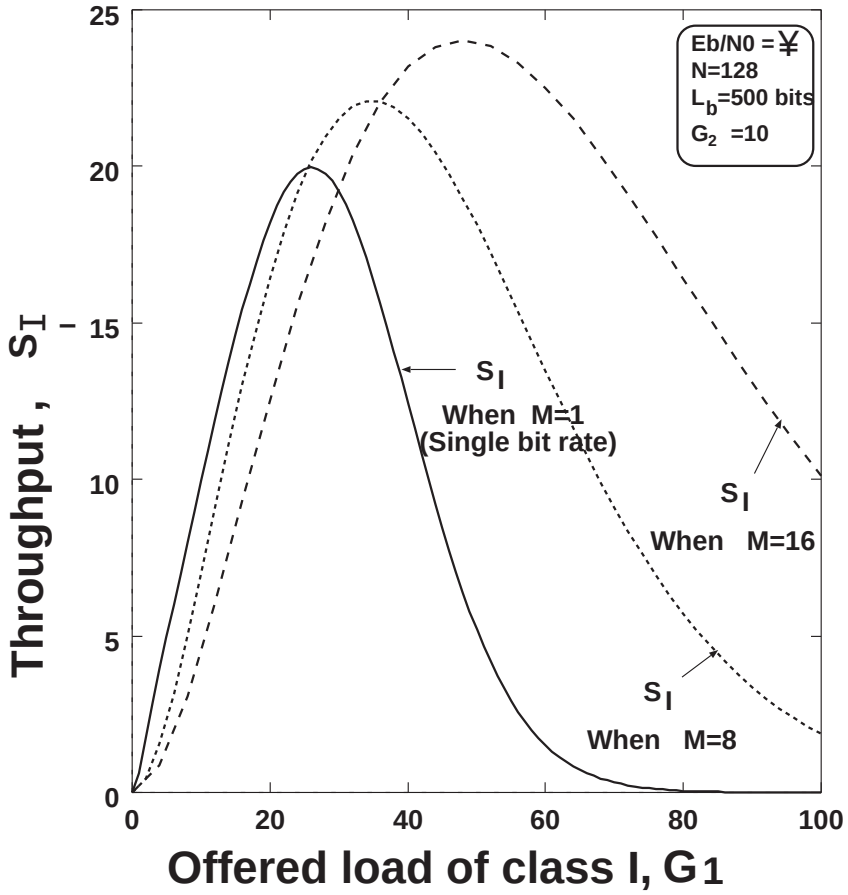
- Poisson generation
- Bit rate Rb [bit/sec]
- Fixed packet length Lb [bits]

Class I has priority over Class II

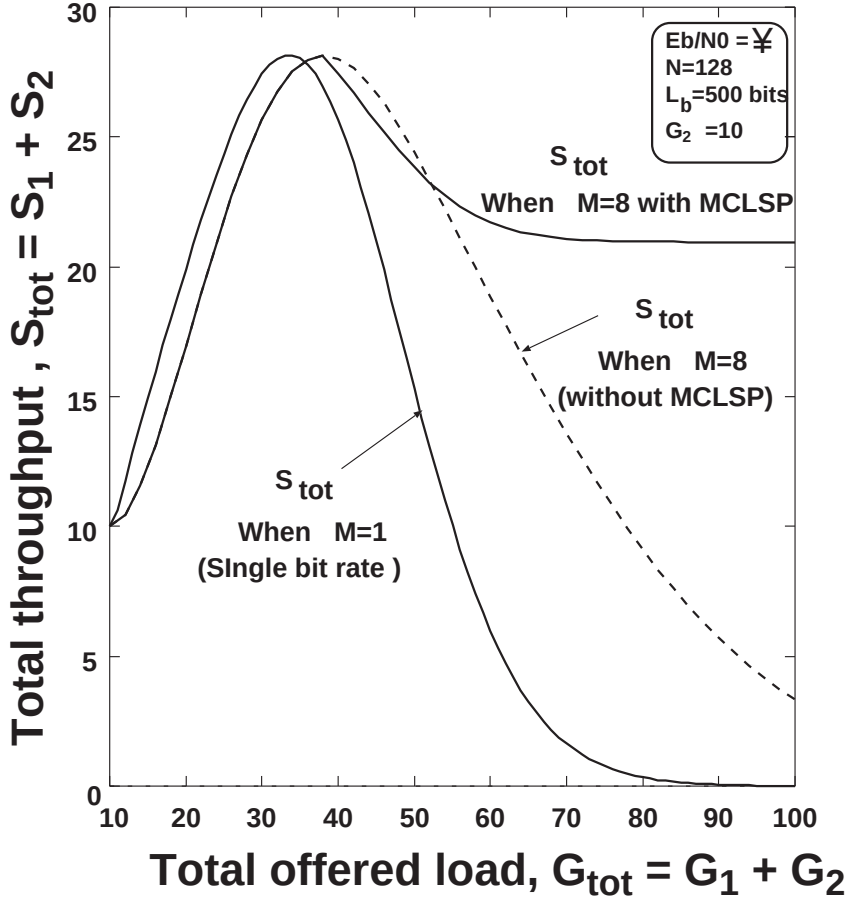
Channel Status at Hubstation



Throughput performances



MC-CDMA Slotted ALOHA
(Only class I user)



MC-CDMA Slotted ALOHA
with MCLSP (class I and II)

Conclusions

Fundamentals of CDMA ALOHA

- Throughput analysis of CDMA ALOHA
- CDMA ALOHA v.s. Narrow Band ALOHA

Access control techniques for CDMA ALOHA

- CLSP, MCLSP, PRC, OACP
- CDMA ALOHA with Buffers

Multimedia signal transmission using CDMA ALOHA

- Integrated voice and data system
- Multi-rate transmission using MC-CDMA