Local Area Networks
Token Ring

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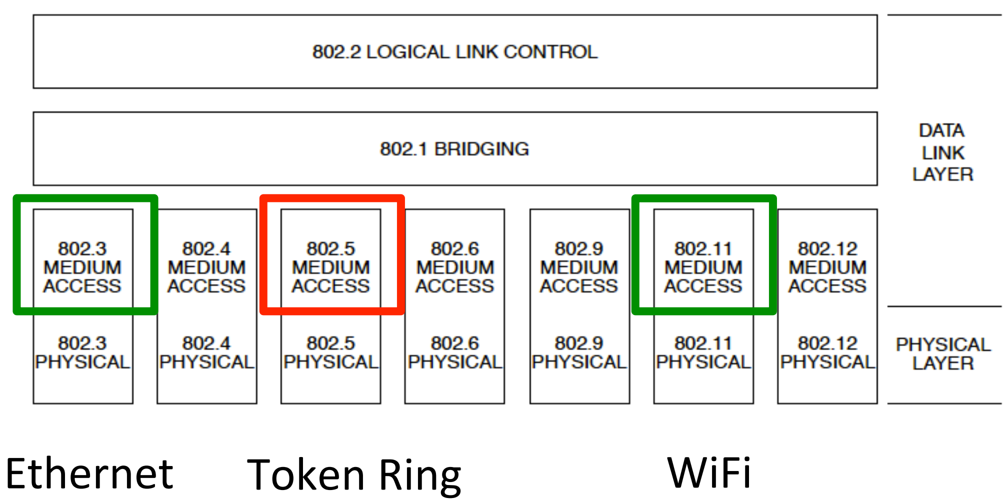
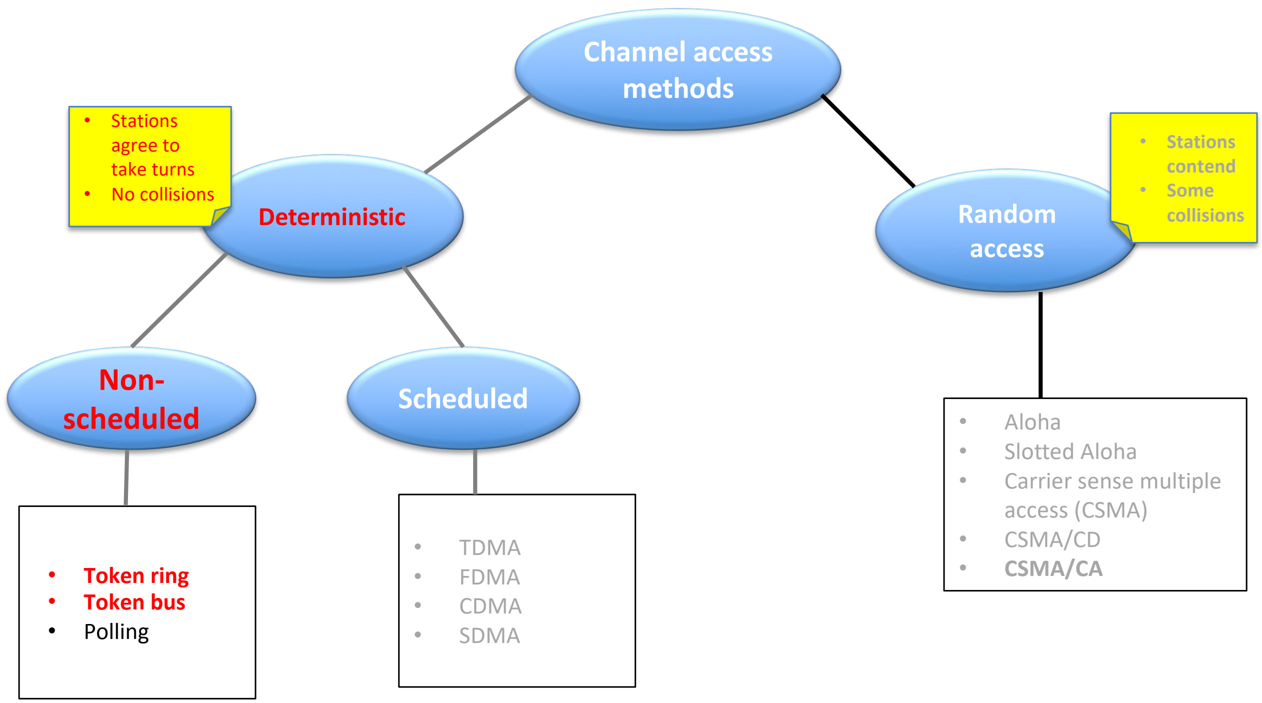
IEEE protocols family



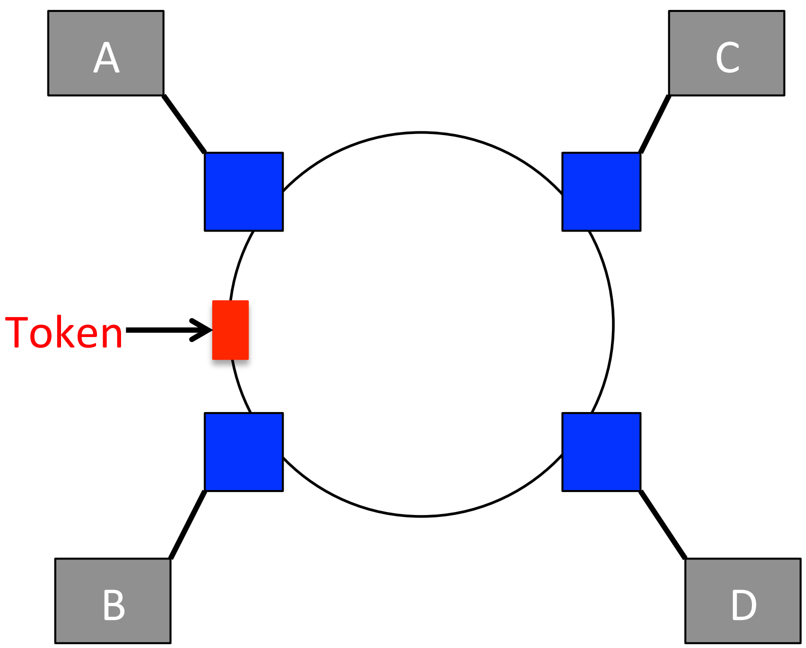
Recall:

- IEEE 802 family of standards deals with the physical and link layer
- Link layer is divided into two sublayers
  - LLC (e.g. HDLC)
  - Medium Access Control

IEEE 802.5 – Token Ring

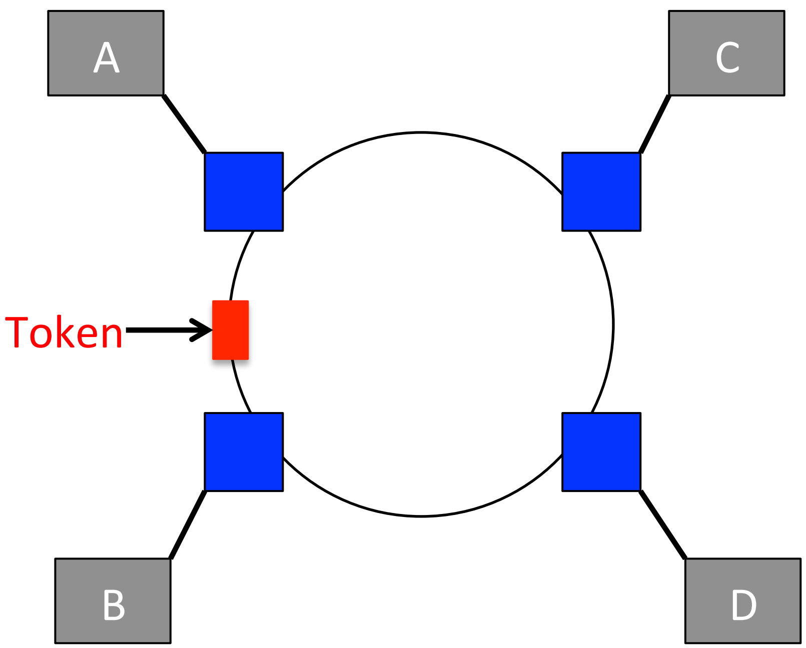


IEEE 802.5 – Token Ring



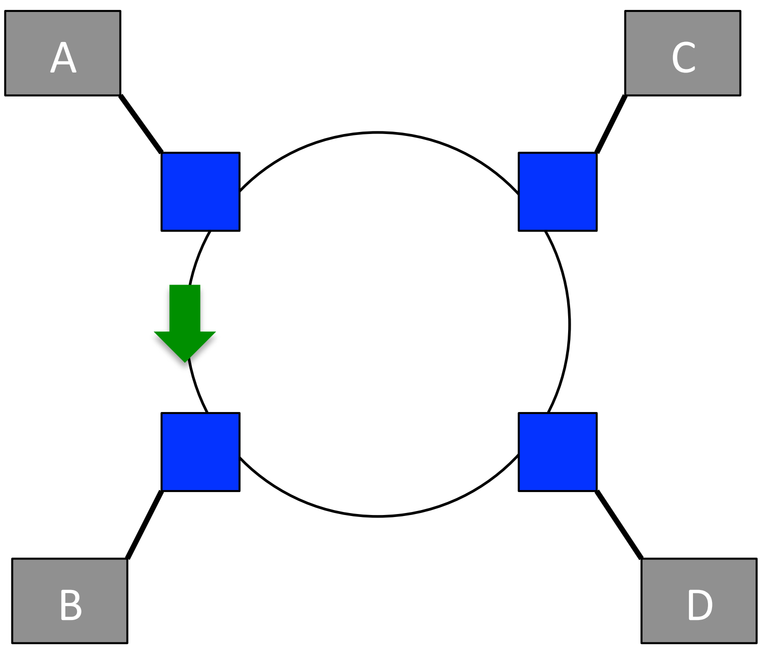
- A given station transfers information onto the ring, where the information circulates from one station to the next
- The addressed destination station(s) copies the information as it passes
- Finally, the station that transmitted the information removes the information from the ring

Medium access control



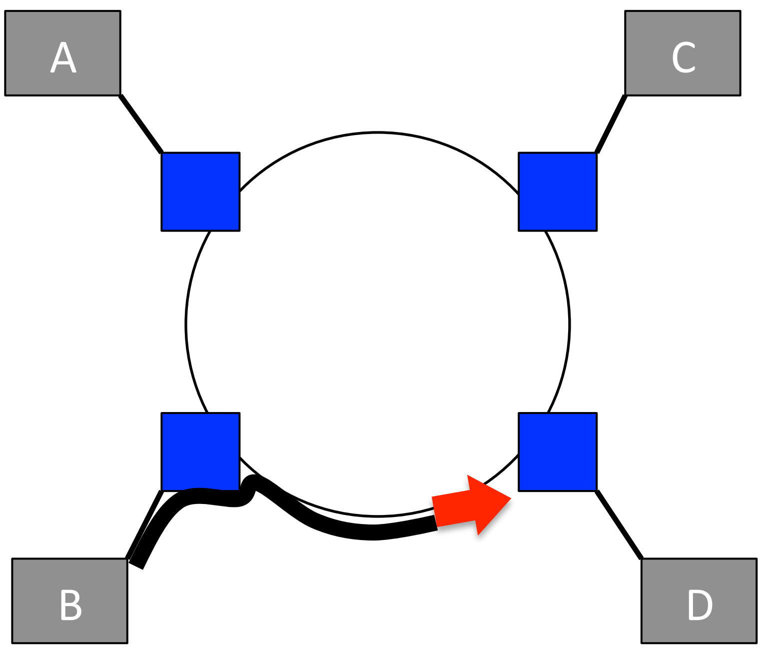
- Station gain the right to transmit information onto the medium using a token
- Any station, upon detection of a token, may “capture” it, send data and then “release” it

Data transmission



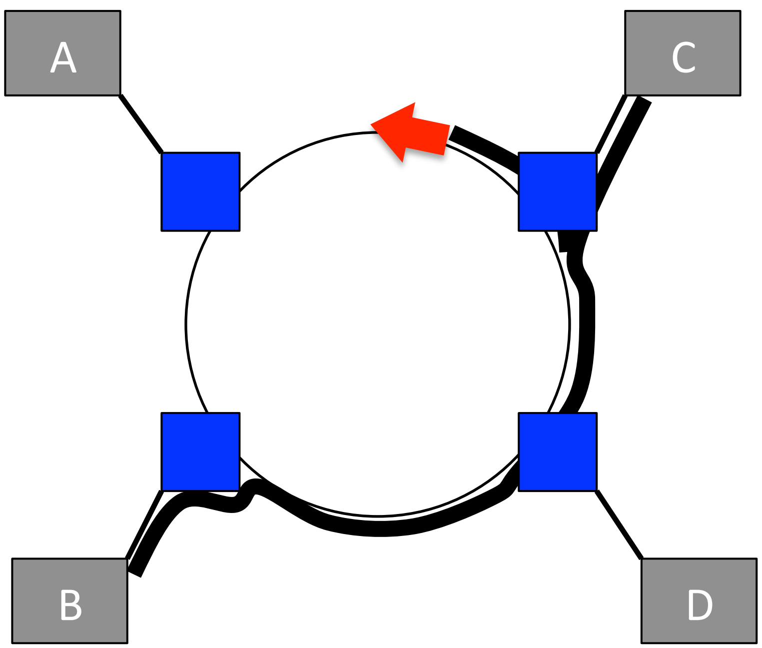
- B has data to transmit to C: it looks for a free token

Data transmission



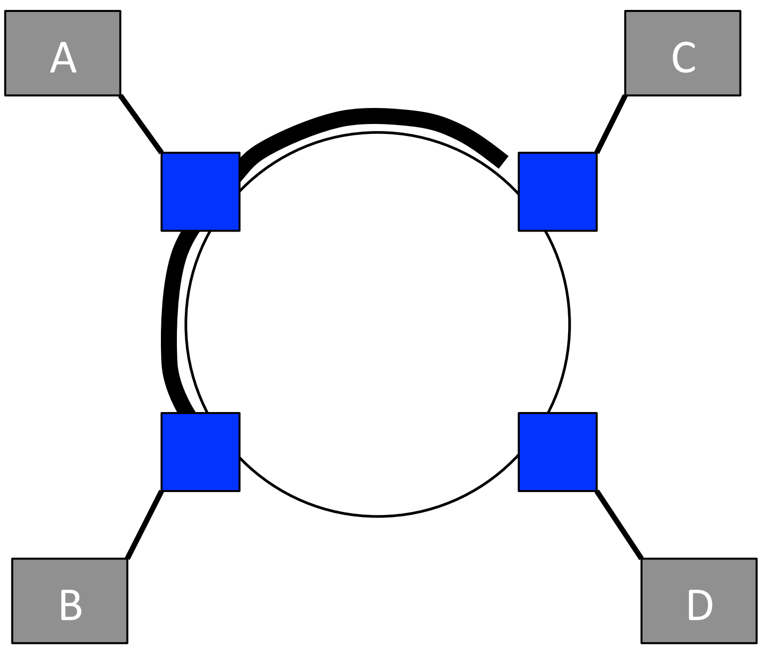
- It “captures” the free token, converts it into “busy” token
- Starts transmitting its data packet to C

Data transmission



- It “captures” the free token, converts it into “busy” token
- Starts transmitting its data packet to C
- C recognizes it is intended receiver and copies the data to its buffer
- The other nodes simply forward the data down the ring

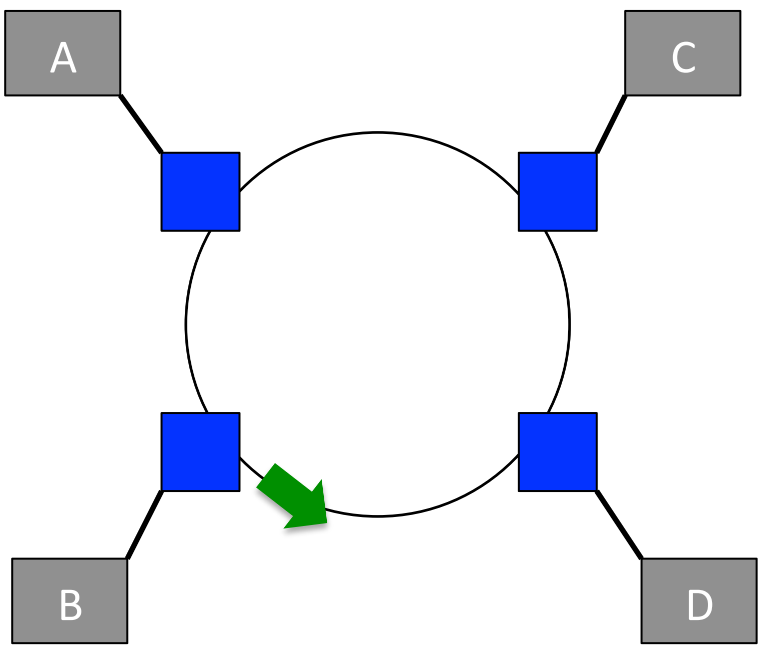
Data transmission



- The packet transmissions "wraps around" reaching B again

- B will check to see that C received the packet (C will flip a particular bit)

Data transmission

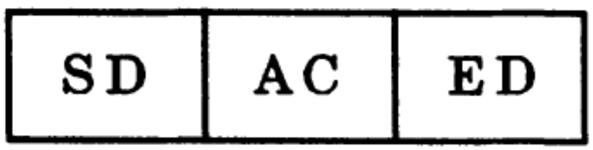


- If C received the packet, B will remove it from the ring
- It “releases” the token to the others

Questions

- What is the token?
- How does a station capture a token and for how long can it hold it ?
- How do a station know if they are the intended destination of a particular data?
- How does a transmitter know the intended receiver got the packet?
- Are all stations equal?
- What happens when things fail?

The token



SD = Starting Delimiter (1 octet)
AC = Access Control (1 octet)
ED = Ending Delimiter (1 octet)

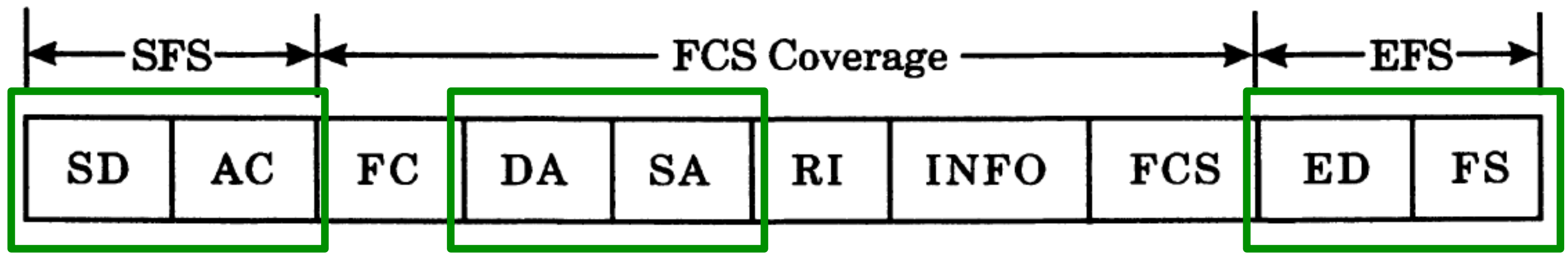
- A token is free/busy based on the value of the AC (access control field)
- Capturing/releasing the token consists of modifying the AC field

AC (Access Control) field

PPP = priority bits
T = token bit
M = monitor bit
RRR = reservation bits

- PPP: Token ring supports 8 priorities: 000 lowest, 111 highest
- T (token): 0 if token is free
  - Capturing the token means setting this bit to 1
- M: only the active monitor inspects/modifies (more later)
- RRR: Request modification to the PPP field (more later). Coded over 3 bits.

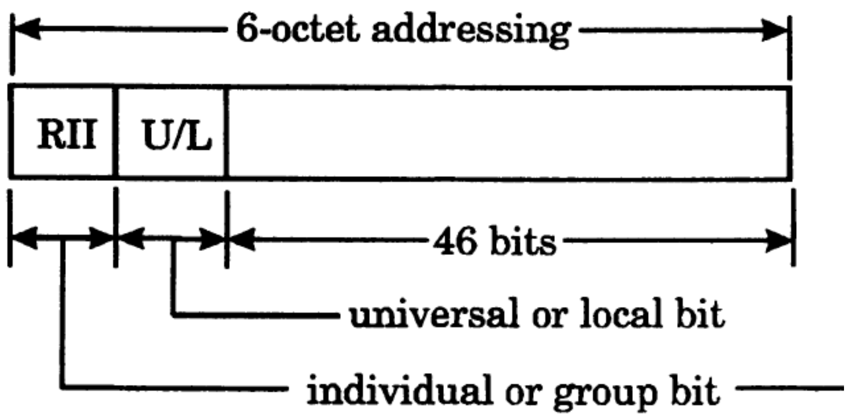
Data Frame



SFS = Start-of-Frame Sequence
SD = Starting Delimiter (1 octet)
AC = Access Control (1 octet)
FC = Frame Control (1 octet)
DA = Destination Address (2 or 6 octets)
SA = Source Address (2 or 6 octets)

RI = Routing Information (0 to 30 octets)[5]
INFO = Information (0 or more octets)[6]
FCS = Frame-Check Sequence (4octets)
EFS = End-of-Frame Sequence
ED = Ending Delimiter (1 octet)
FS = Frame Status (1 octet)

DA/SA Addresses



- Individual addresses identify a particular station on the LAN and have to be distinct
- Broadcast address: all bits set to 1

Ending delimiter (ED)

J	K	1	J	K	1	I	E

J = non-data J
K = non-data K
1 = one bit
I = intermediate frame bit
E = error-detected bit

- The E bit is set to 0 by the transmitter
- All stations on the ring check the FCS and if error is detected the E bit is set to 1

Frame status

A = address-recognized bits
C = frame-copied bits
r = reserved bits

- Transmitter sets A and C bits to zero
- A station recognizing the DA field as its own address will set A to 1
  - If it has available buffer it copies the packet and sets C to 1
  - Otherwise transmitter will know the receiver is congested

Priority operation

- Goal: enable service differentiation for quality of service (QoS) provisioning
  - Different kinds of traffics, e.g. voice, video, data have different requirements
  - Can benefit from a "one size fits all" network

Priority operation

P P P	T	M	R R R

- PPP = priority bits
- T = token bit
- M = monitor bit
- RRR = reservation bits

- Uses the PPP/RRR fields of the AC field present in token/data frames
- Fairness is maintained for all stations with a priority level

Priority operation

- At any point in time, the ring is assigned a "*current ring service priority*"
  - The PPP value of the AC field of packets circulating on the ring
- The current ring service priority needs to match the highest priority packet data unit (PDU) ready for transmission from some station on the ring
- Only packets whose priority (Pm) matches the current ring service priority can be transmitted

Setting the ring service priority

- A station that has the token and has a PDU with Pm higher than the current ring service priority does:
  - It stores the current priority in a local variable (Sr)
  - It generates a token with PPP set to Pm and RRR to 0 (changing the ring's service priority)
  - Stores the new service priority in a local variable (Sx)
  - Becomes a ***stacking station*** (it's his responsibility to change the service priority to the old lower value once there are no more PDUs with the higher priority)
  - Why *stacking*? A station can raise the service priority several times: it will need to stack several Sr/Sx values

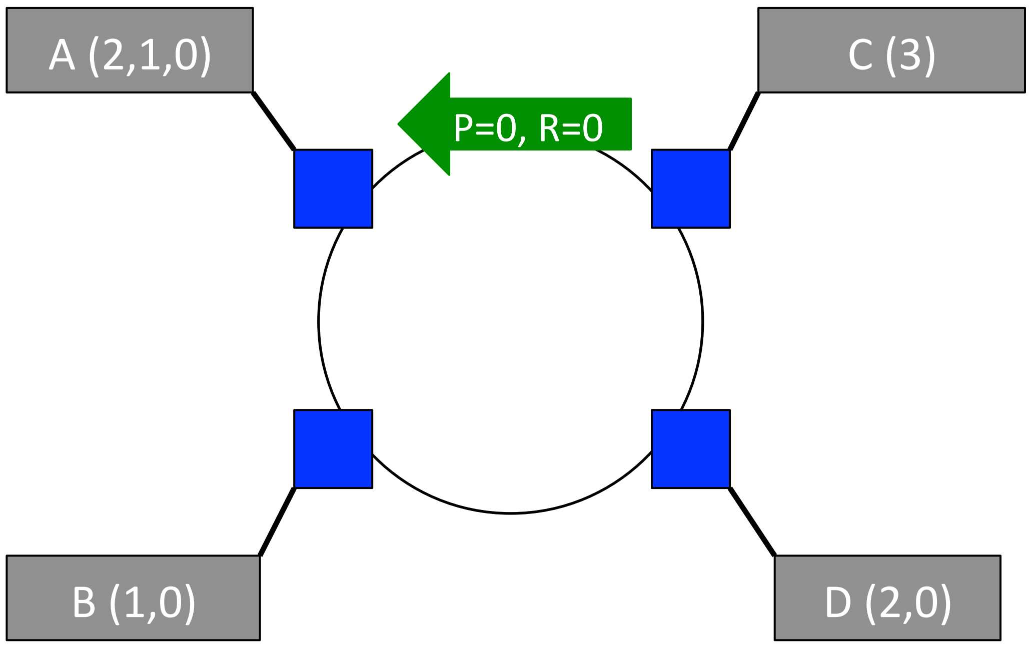
The stacking station

- It examines the RRR field of every frame for the purpose of raising, maintaining, or lowering the service priority of the ring
- If the new RRR value is greater than Sr:
  - Set Sx to RRR, PPP to RRR, RRR to 0
- If the new RRR values is equal to or less than the value of the Sr:
  - Set PPP to Sr (priority back to the old value)
  - Sr and Sx are removed (popped from the stack)
  - If no other Sr, Sx values left in the stack, the station discontinues its role as stacking station
- Obviously, a stacking station can transmit PDUs with Pm equal to the current service priority

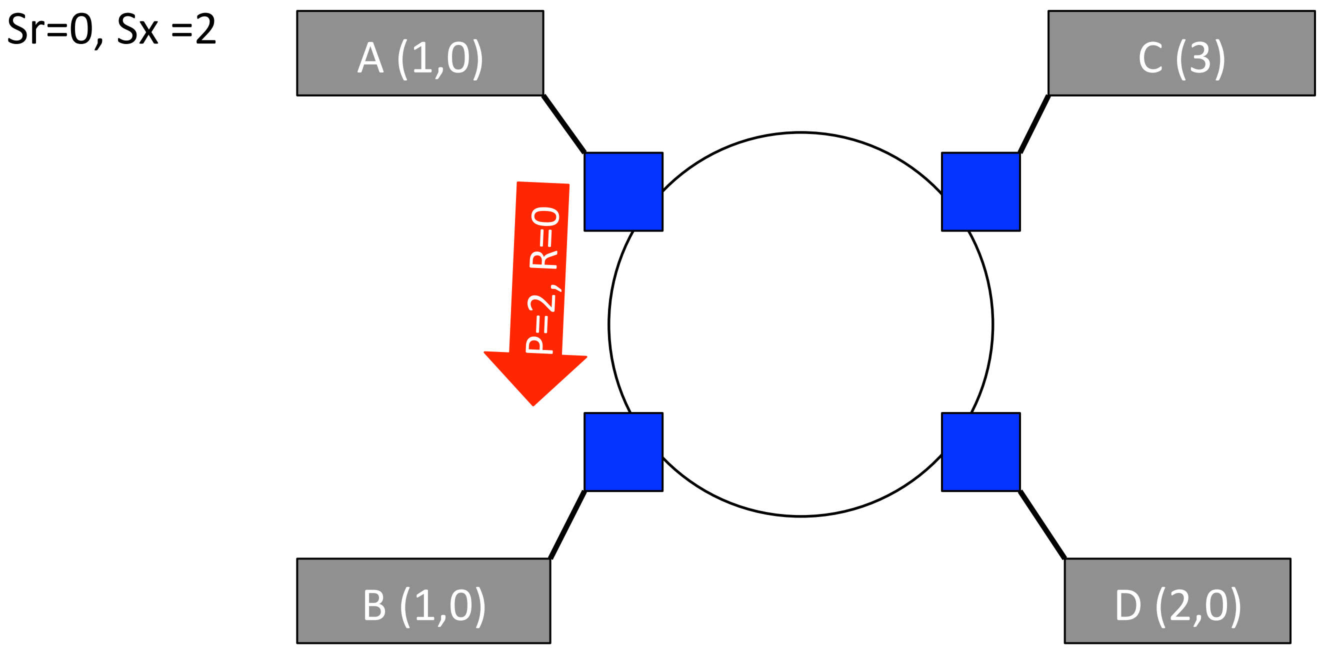
Non-stacking stations

- If the Pm of its PDUs is equal to the current service level it seizes the token and transmits packets
  - If no more packets to transmit at this PM , it sends a token with PPP and RRR at the current service level
- If Pm is less than the service level the station can try to make a reservation
  - If Pm > RRR than it sets RRR to Pm
- If Pm is greater than the current service level it becomes a stacking station (slide 25)

Illustration

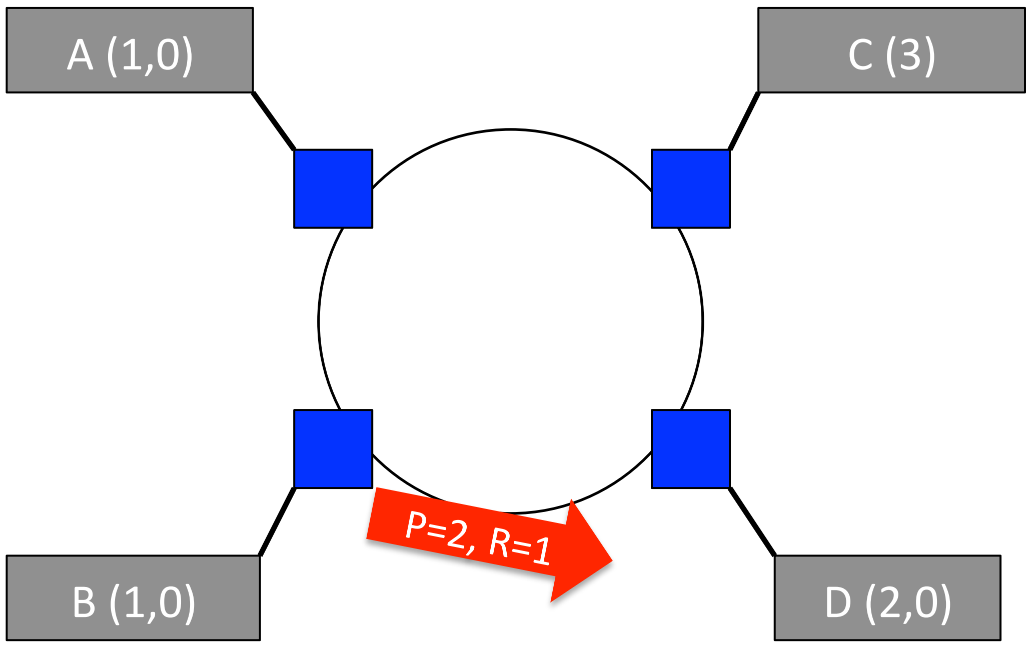


Station A increases priority to 2

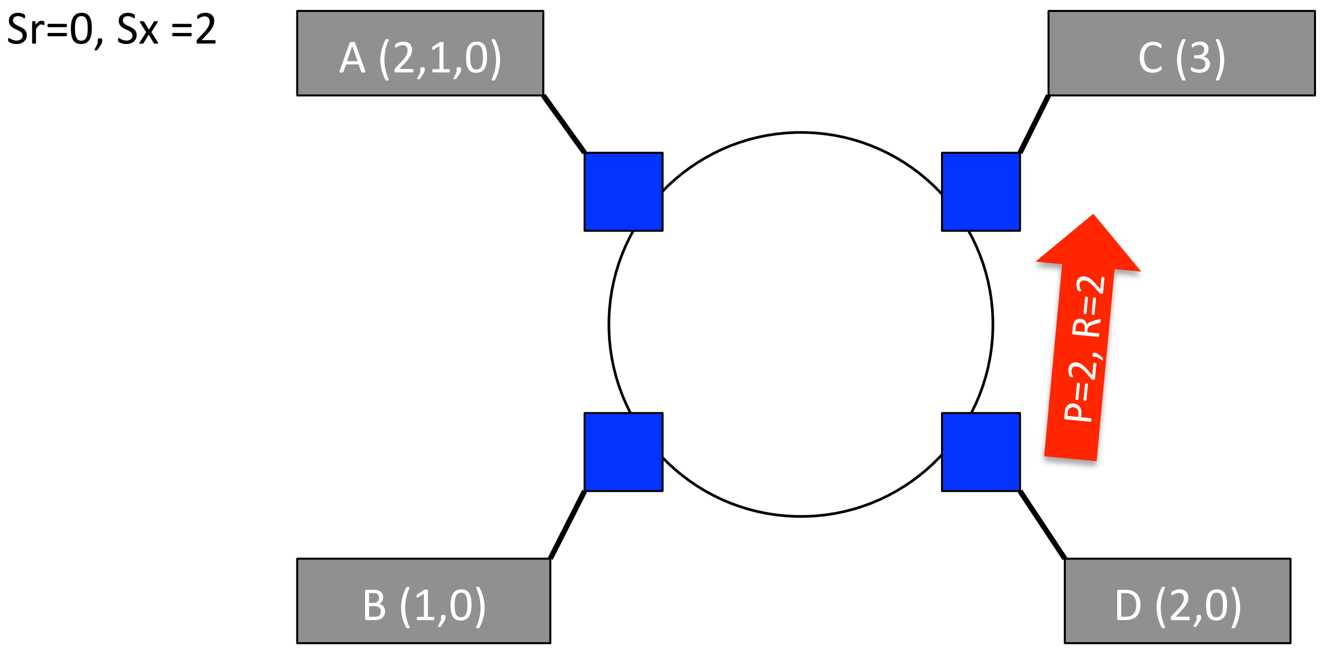


B makes a reservation

Sr=0, Sx =2

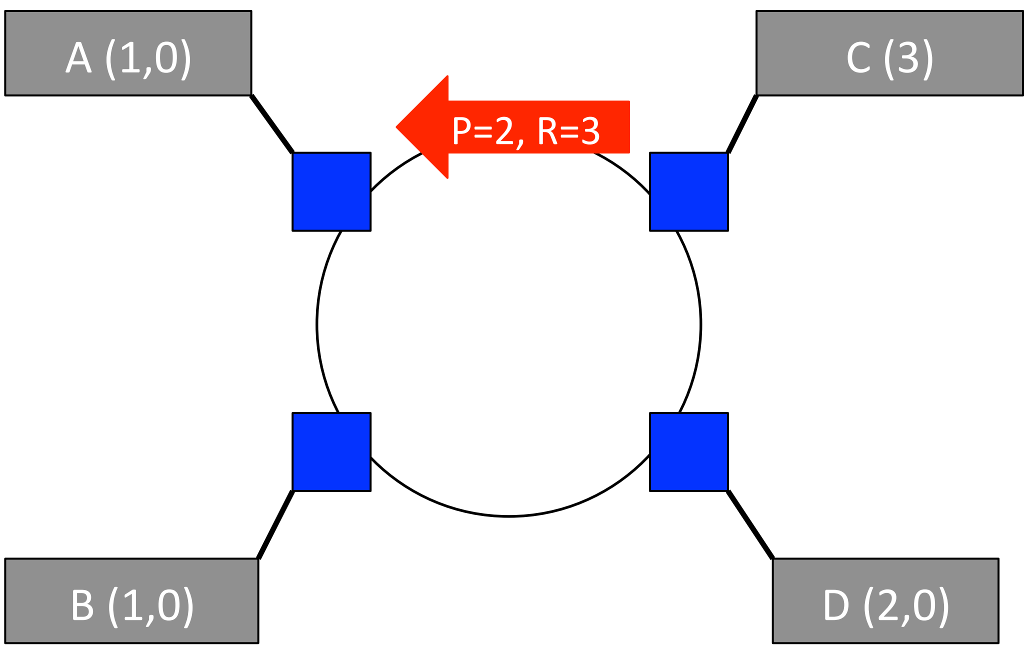


D makes a reservation



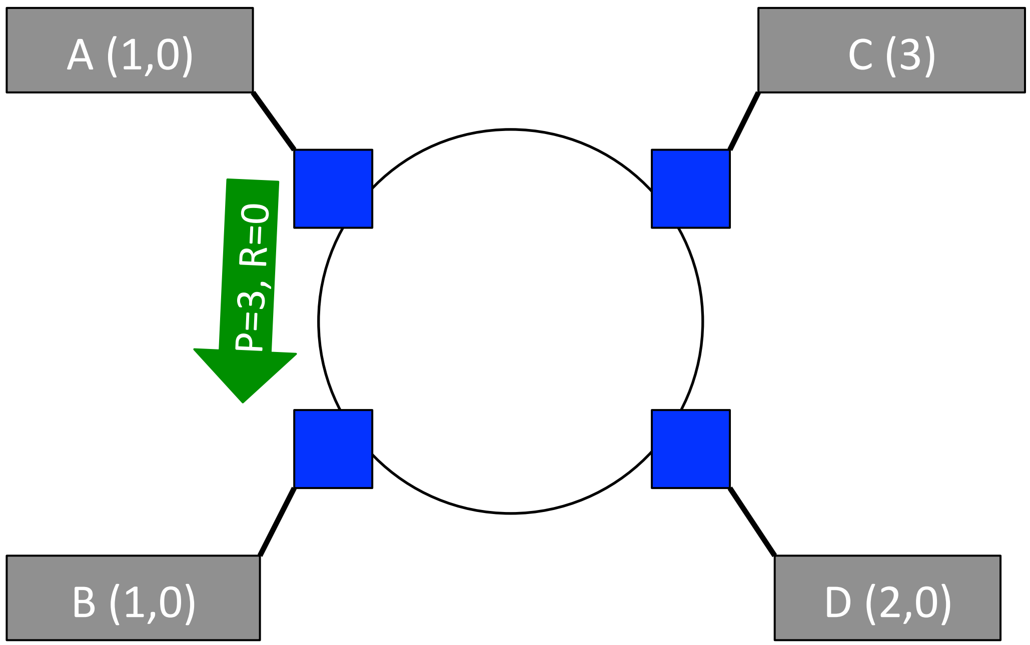
C makes a reservation

Sr=0, Sx =2



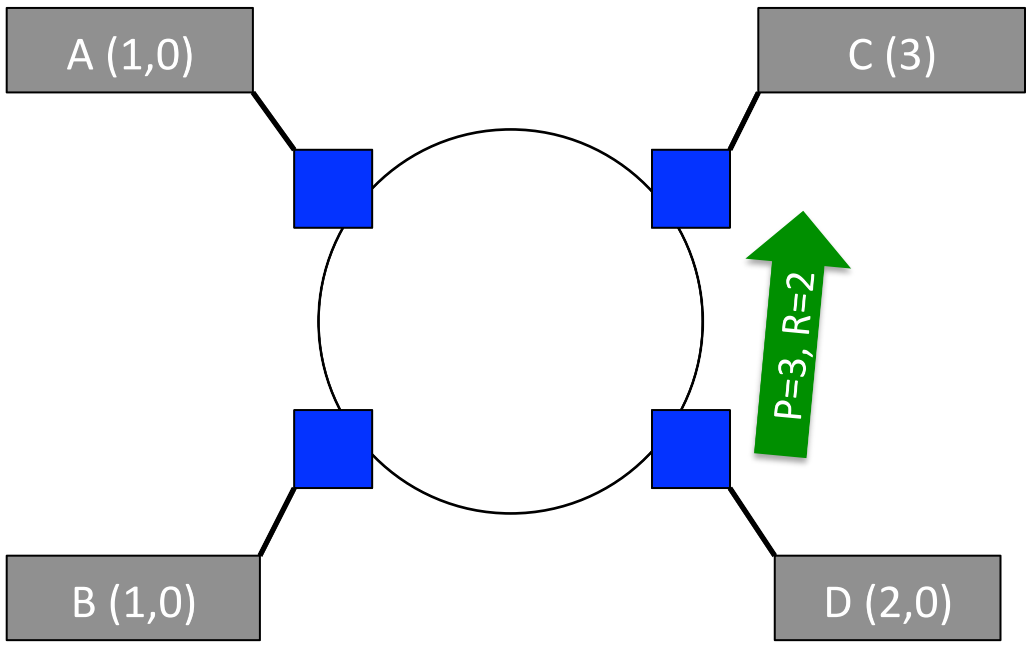
A raises priority to 3, free token

Sr=2, Sx =3
Sr=0, Sx =2



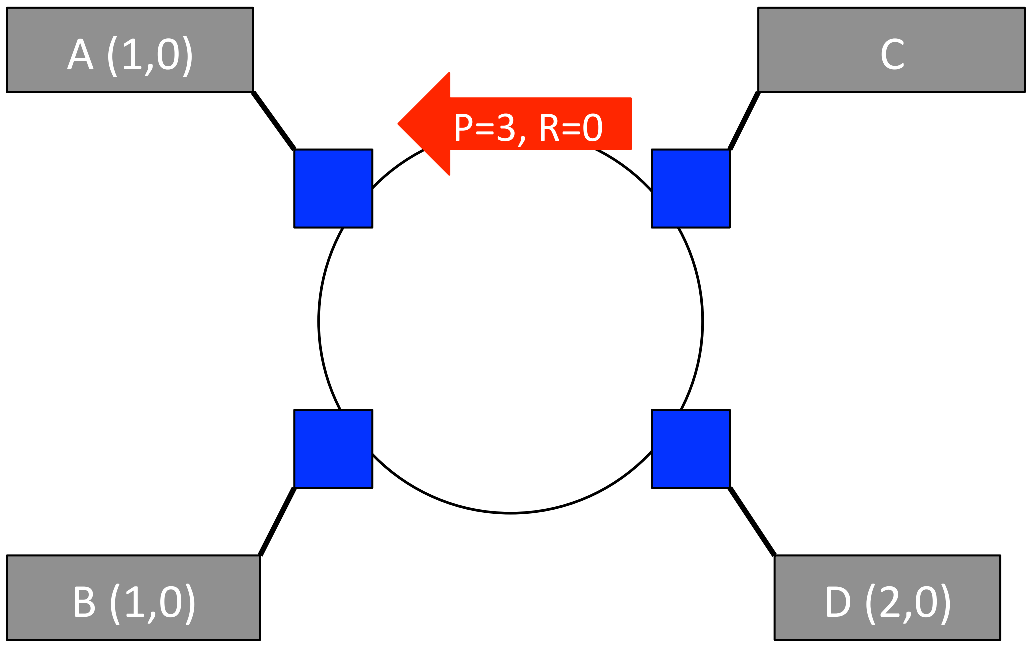
Station with lower priority make reservations

Sr=2, Sx =3
Sr=0, Sx =2



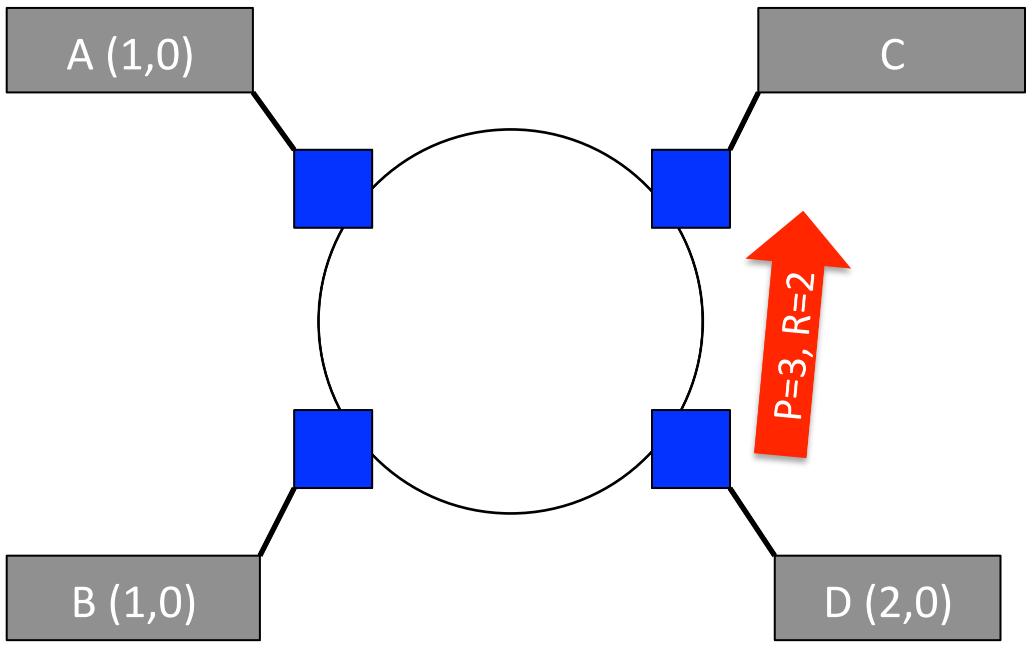
C ceases token and transmits PDU

Sr=2, Sx =3
Sr=0, Sx =2

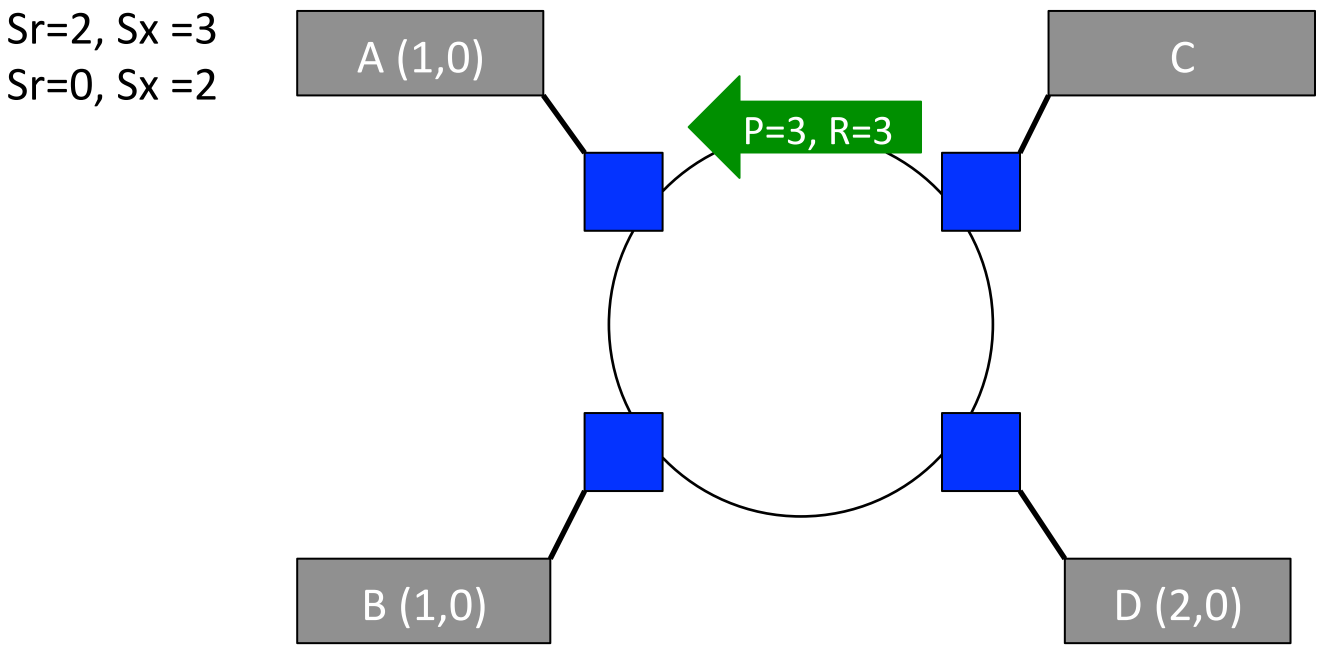


Other stations make reservations

Sr=2, Sx =3
Sr=0, Sx =2



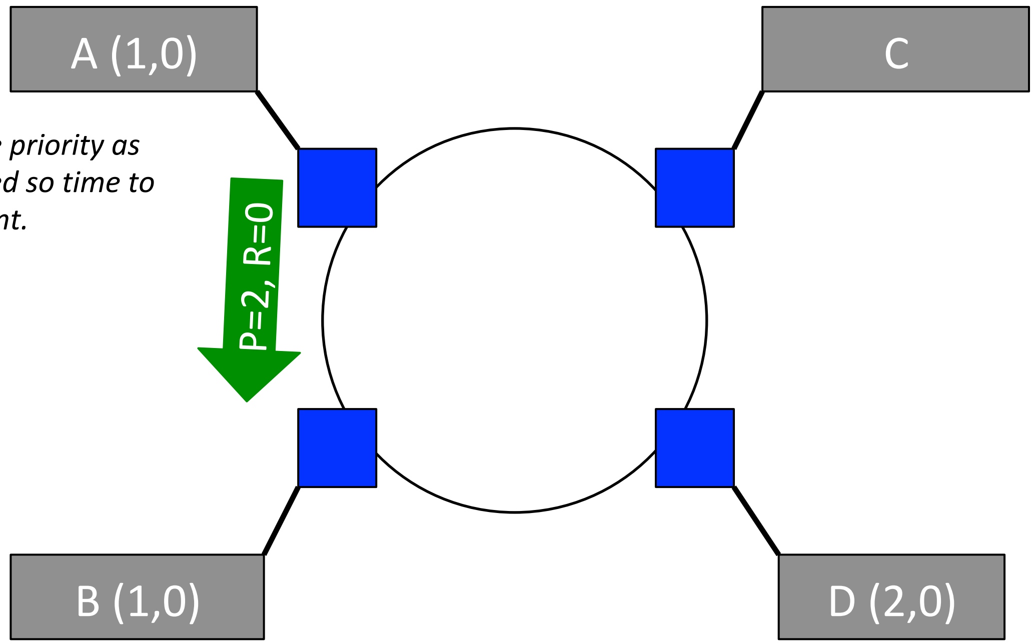
C sends a free token



A lowers service priority

Sr=0, Sx =2

A sees a free token with same priority as the one it sent. No one claimed so time to lower by "popping" an element.



Failures

- A node sends a packet and then goes down
  - The packet can circulate forever, preventing anyone else from transmitting
- One station has special status: active monitor
  - All nodes are capable of being an active monitor
  - It is selected based on a bidding process (highest MAC address wins)
- Its job is to recover from various error situations
  - It will remove packets circulating for a long time for example by making use of the M bit