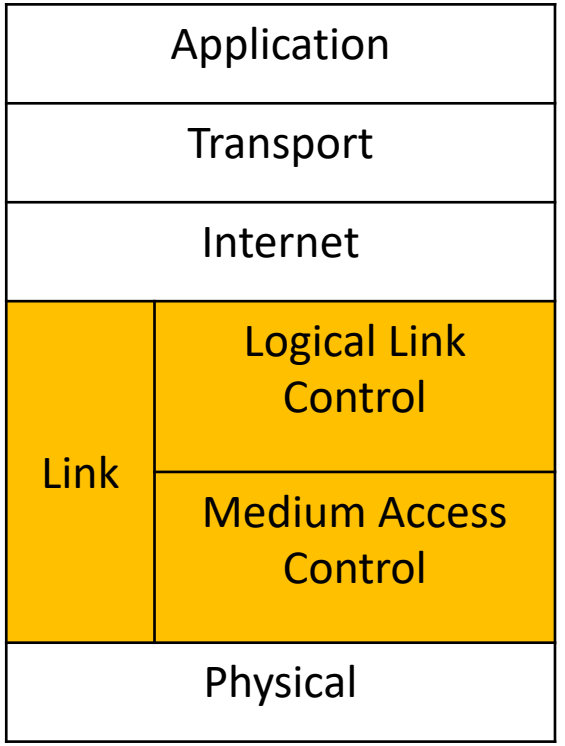
Dr Takfarinas SABER
takfarinas.saber@dcu.ie

CA169
Networks & Internet

Layer 2: Part 4 (and last)
Medium Access Control

Medium Access Control

- Link layer is responsible for flow and error control from a machine to a machine over a single link
  - Answers the question: How is data sent between a Sender and a Receiver?
- However, how to organise communications when multiple devices are on a single link?
  - Medium Access Control



IEEE Project 802

Notation

- When two or more nodes want to transmit at the same time, they are said to **contend** for the channel
- If two or more nodes transmit at the same time, usually the frames will **collide** and are destroyed
    - No transmission is successful
- Our goal is to avoid contention (best)
- Or detect and resolve collision (at least)

Contention Resolution

- There are 3 basic contention resolution strategies:
  - Divide the channel into **independent sub-channels** where one is used for each transmission
  - **Collision Resolution** allows the nodes to transmit whenever they like but they must check for collision
    - If a collision is detected each node waits a **random** amount of time before transmitting again
  - **Reservations**: a node must have a **token** before transmitting, when finished it sends the token to its neighbor
    - A token is a piece of data that signals permission to transmit
    - There is often a modification where the token can be passed to anyone in the network, as long as all nodes get a chance to transmit

Ethernet

- In the mid 1970s Xerox PARC developed first Ethernet to connect 100 computers on a 1 km cable

- It used a channel access method: CSMA/CD
  - Two components:
    - Carrier Sense Multiple Access (CSMA)
    - Collision Detection (CD)
  - to try to reduce the ***likelihood*** and ***effects*** of a collision

Carrier Sense Multiple Access

- CSMA: a node wishing to transmit must first **listen** to the channel
- If the channel is busy:
  - some other node has to be transmitting
  - ➢ our node must wait until it detects that the channel is idle
- When the channel is determined to be idle:
  - ➢ our node can transmit

Collision Detection

- During transmission, our node listens to the channel and if another transmission is detected
  - e.g., higher voltage level than expected for one transmission

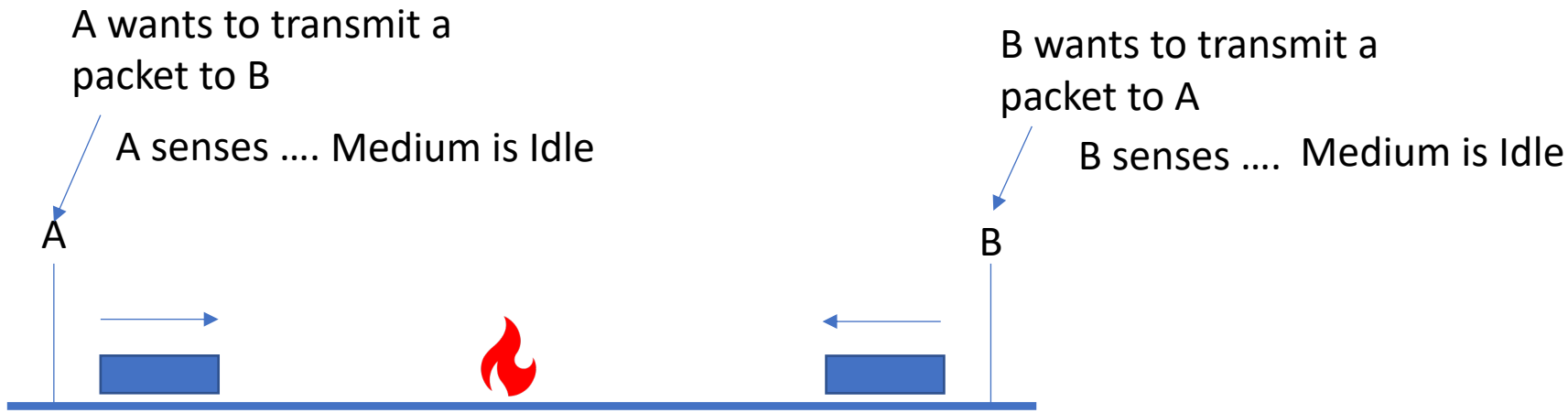
- Every node involved in the collision:
  1. stops transmitting immediately
  2. computes a **randomly-sized** time interval
  3. waits for that amount of time
  4. then begins the transmission attempt again (using CSMA)

CSMA/CD

- A basic problem with CSMA/CD is that, theoretically, a node wishing to transmit may ***never*** be able to
  - Especially if the Maximum Medium Access Time (MMAT) is high
  - Also, even with random waiting times, the node's transmission attempts may collide every time!

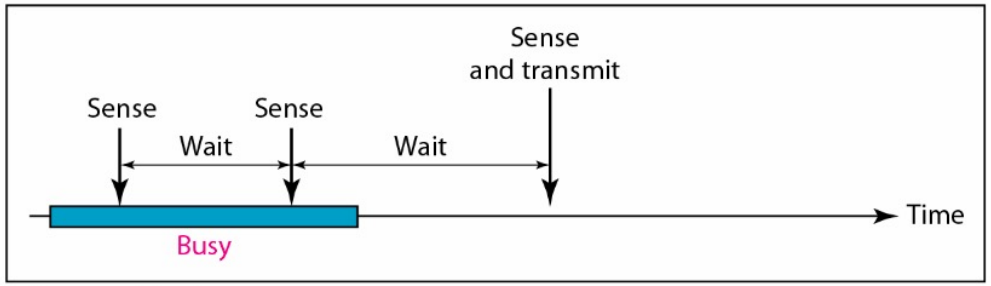
Collisions in CSMA/CD

- Collisions can still occur even with Carrier Sensing
  - because it takes non-zero time for a signal to propagate along the channel



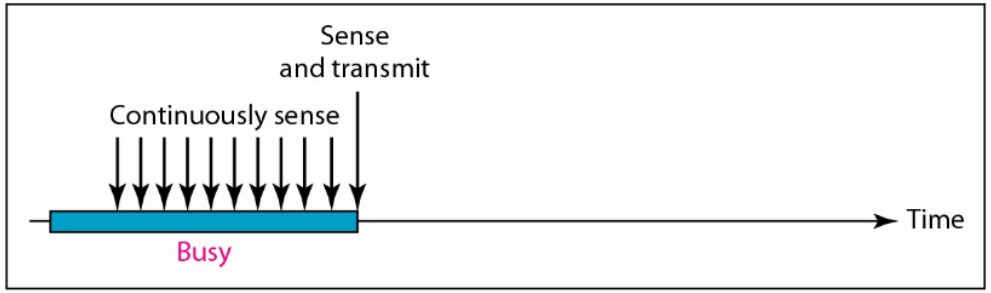
CSMA/CD Variants

- Non-Persistent CSMA
  - Wait a back-off period before sensing again
  - High efficiency, but high delay



b. Nonpersistent

- 1-Persistent CSMA
  - Start transmission as soon as the channel becomes idle
  - Low delay, low efficiency

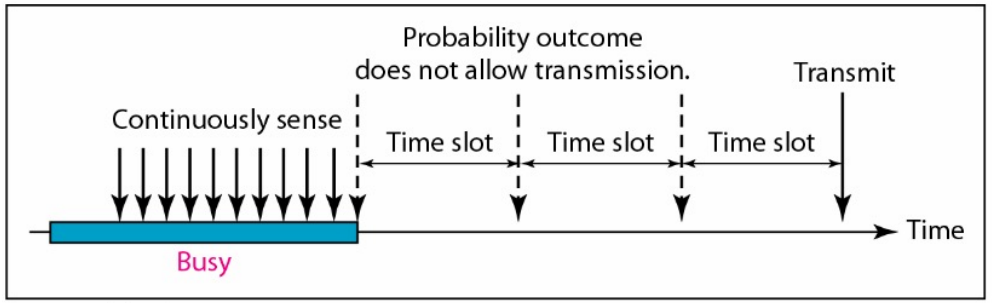


a. 1-persistent

P-Persistent

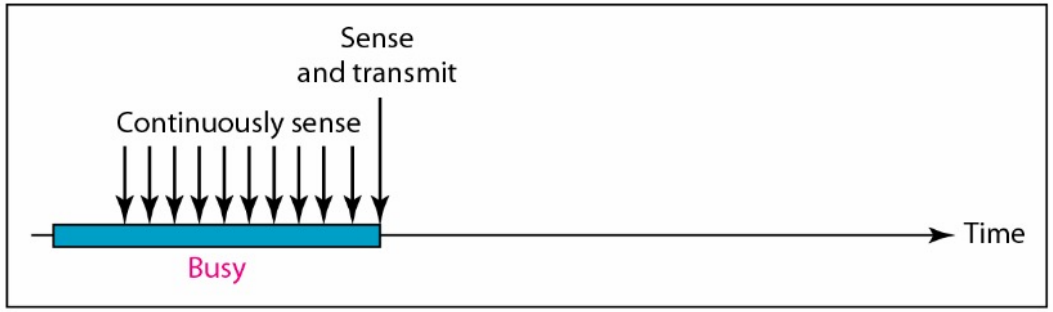
- Assume channels are slotted:
  - After each transmission period there will be a competition for the channel

1. Sense the channel:
   - If the channel is idle transmit with probability P
   - ➢ If the slot has been transmitted, go to step 2.
   - ➢ If the slot has not been transmitted, go back to step 1.
2. Collision?
   - If collision occurs while sending, wait a "backoff" period, go back to step 1.

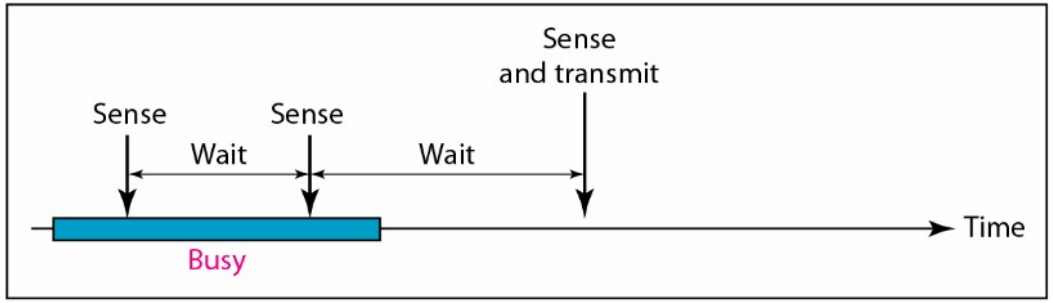


c. p-persistent

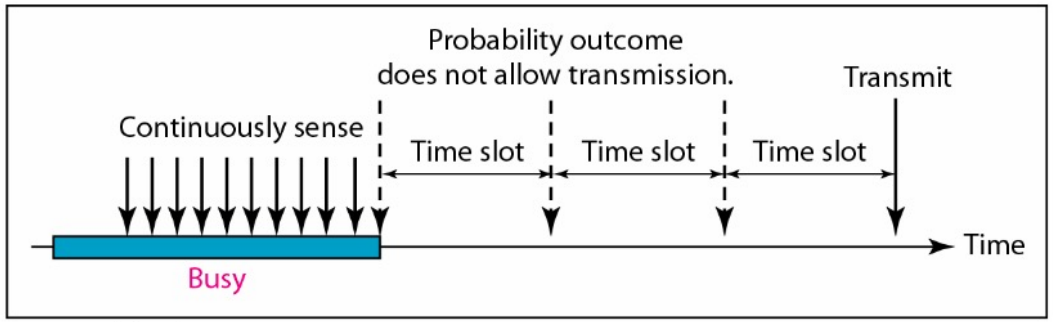
Summary of CSMA/CD variants



a. 1-persistent



b. Nonpersistent



c. p-persistent

CSMA in Radio Comms

- CSMA is often used for radio communications
  - notably WiFi

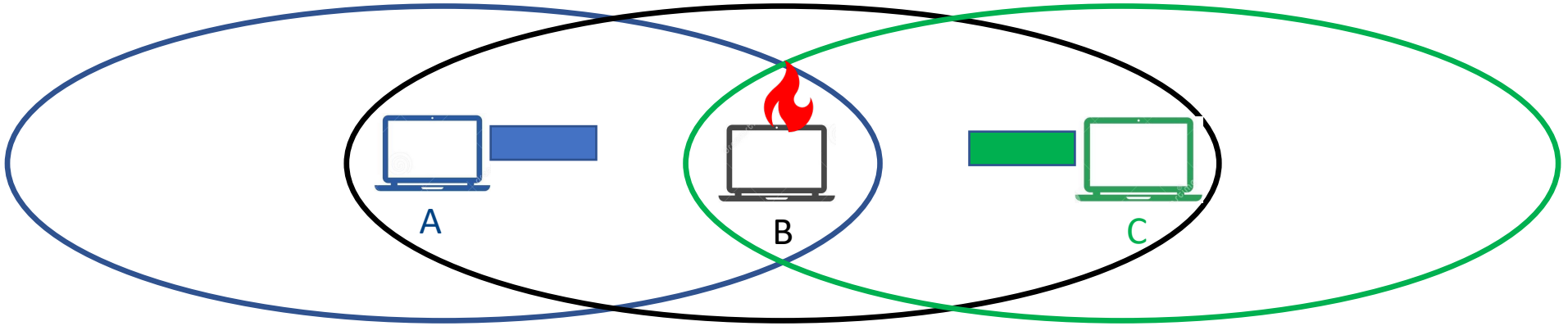
- We see a problem in this case known as the **hidden node problem.**

A wants to transmit a packet to B

A senses …. Medium is Idle

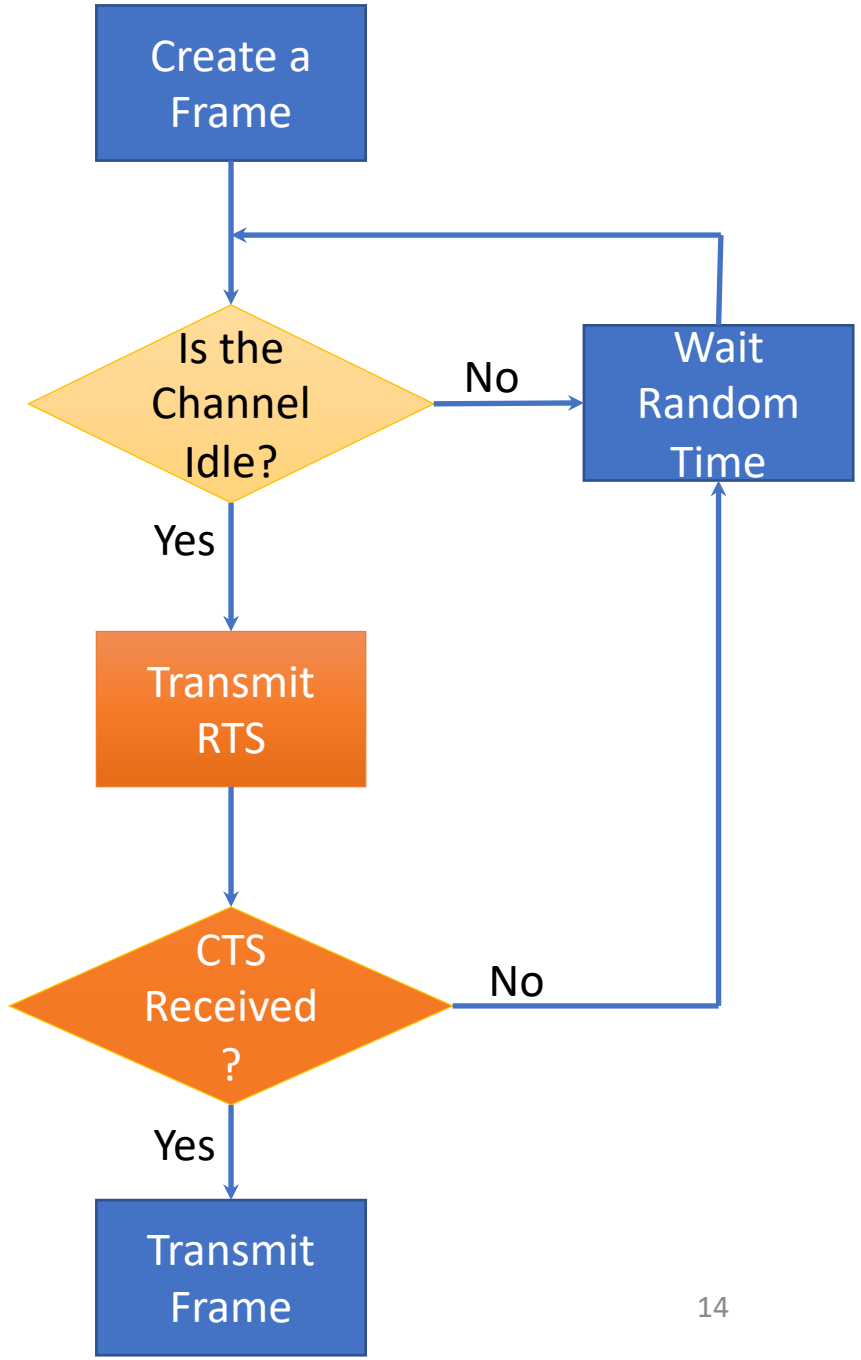
C wants to transmit a packet to B

C senses …. Medium is Idle



CSMA/CA

- We have to modify the CSMA strategy to account for this hidden node problem
- This CSMA variant is called CSMA/CA (Collision Avoidance)
  - Avoids collisions altogether
  - It uses Request To Send (RTS) and Clear to Send (CTS) packets



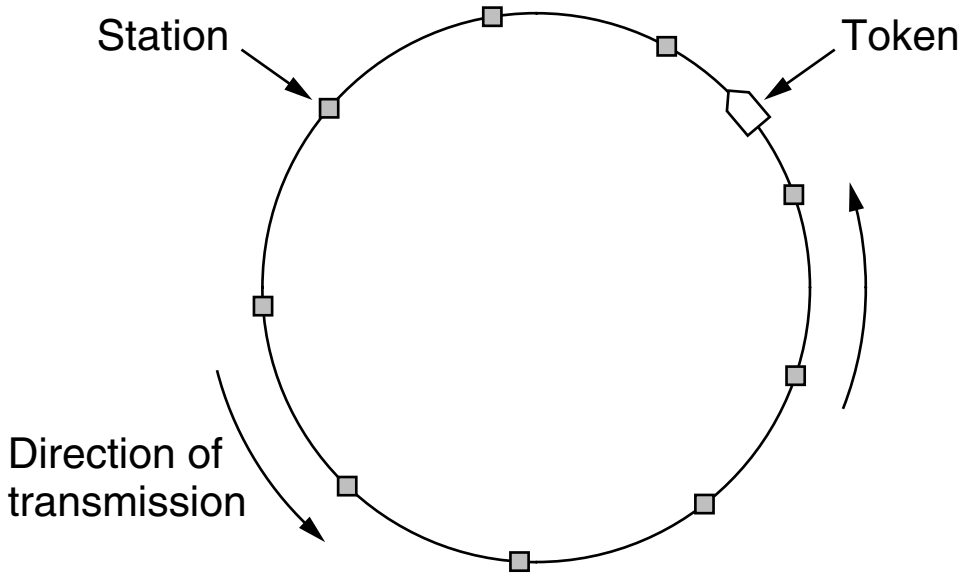
CSMA/CD Alternatives

- The potential problems with Ethernet led to the development of some alternative technologies in the early 80s
  - IBM chose a ***ring topology*** for office automation applications
    - Led to the Token Ring (802.5) standard
  - General Motors, and others interested in factory automation, chose a ***bus topology*** as a good match to layout of assembly lines
    - Led to the Token Bus (802.4) standard
- Key point in both of these cases: the Maximum Medium Access Time (MMAT) is **bounded**, assuming the network is working correctly

Token Ring Networks

- A **ring** is actually a set of point-to-point links that form a circle
  - A ring is (logically) unidirectional

- A **token** is a special frame passed from node to node
  - A node can only transmit when it has the token

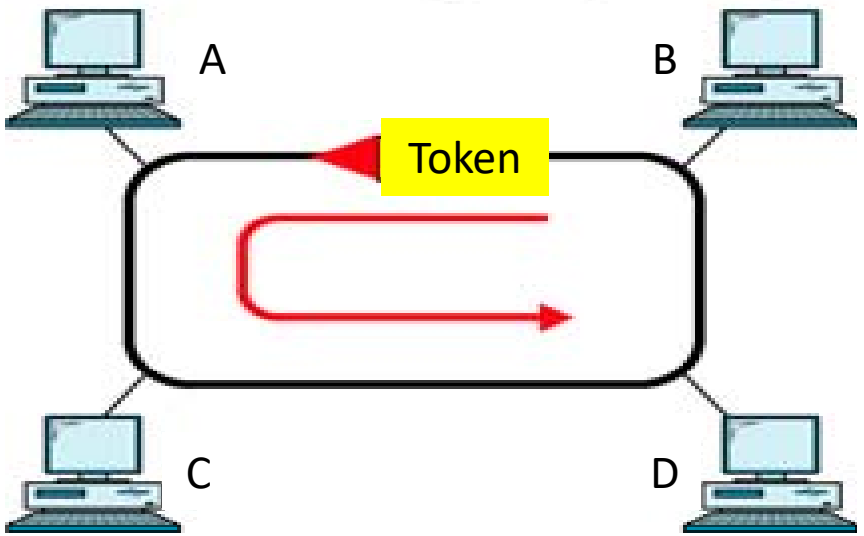


Token Ring Networks

- When a node receives the token, it can choose to transmit a frame
- This fame is then forwarded around the ring in the same direction as the token
- At some point the frame must be removed from the ring
  - This is usually done at the receiver or when it returns to the sender
- After the frame is removed, the token is put back on the ring

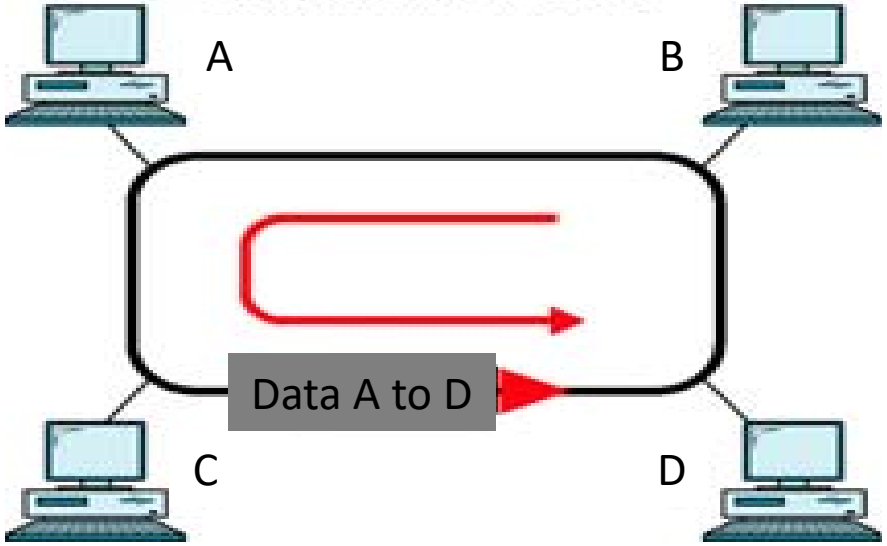
Token Ring Networks

Token is traveling along the ring.



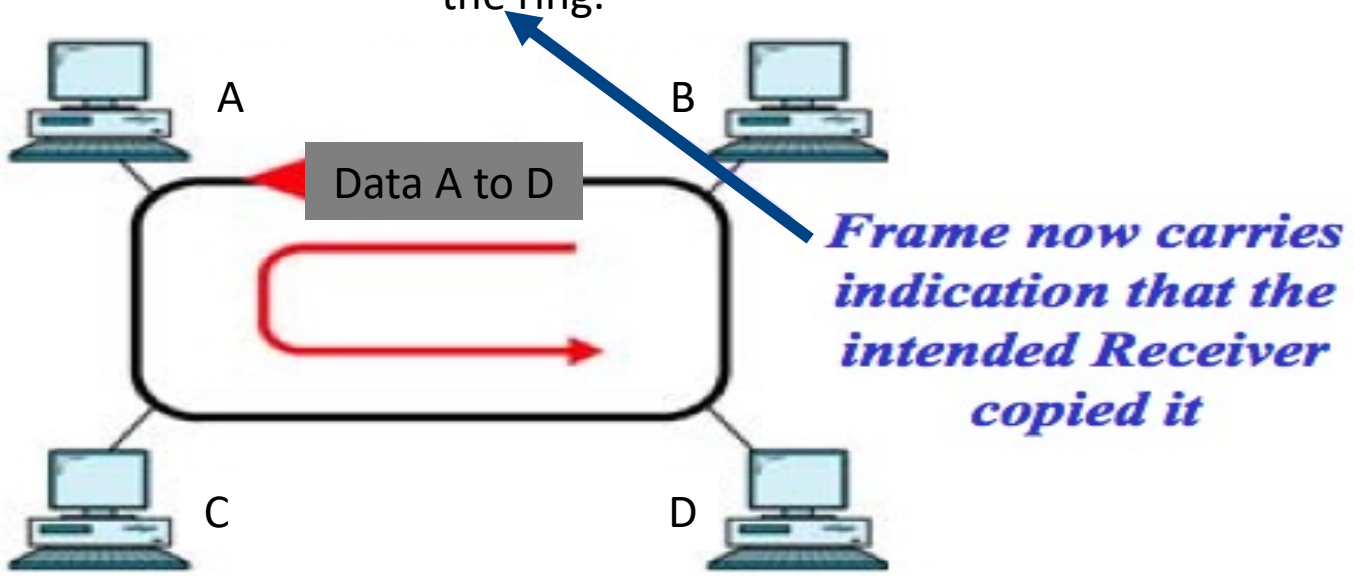
Token Ring Networks

Station A captures the token and sends its **data** to D.



Token Ring Networks

Station D copies the frame and sends the data back to the ring.



Token Ring Networks

Station A receives the data frame and releases the token.