MAC Sub-Layer

COMP90007 Internet Technologies

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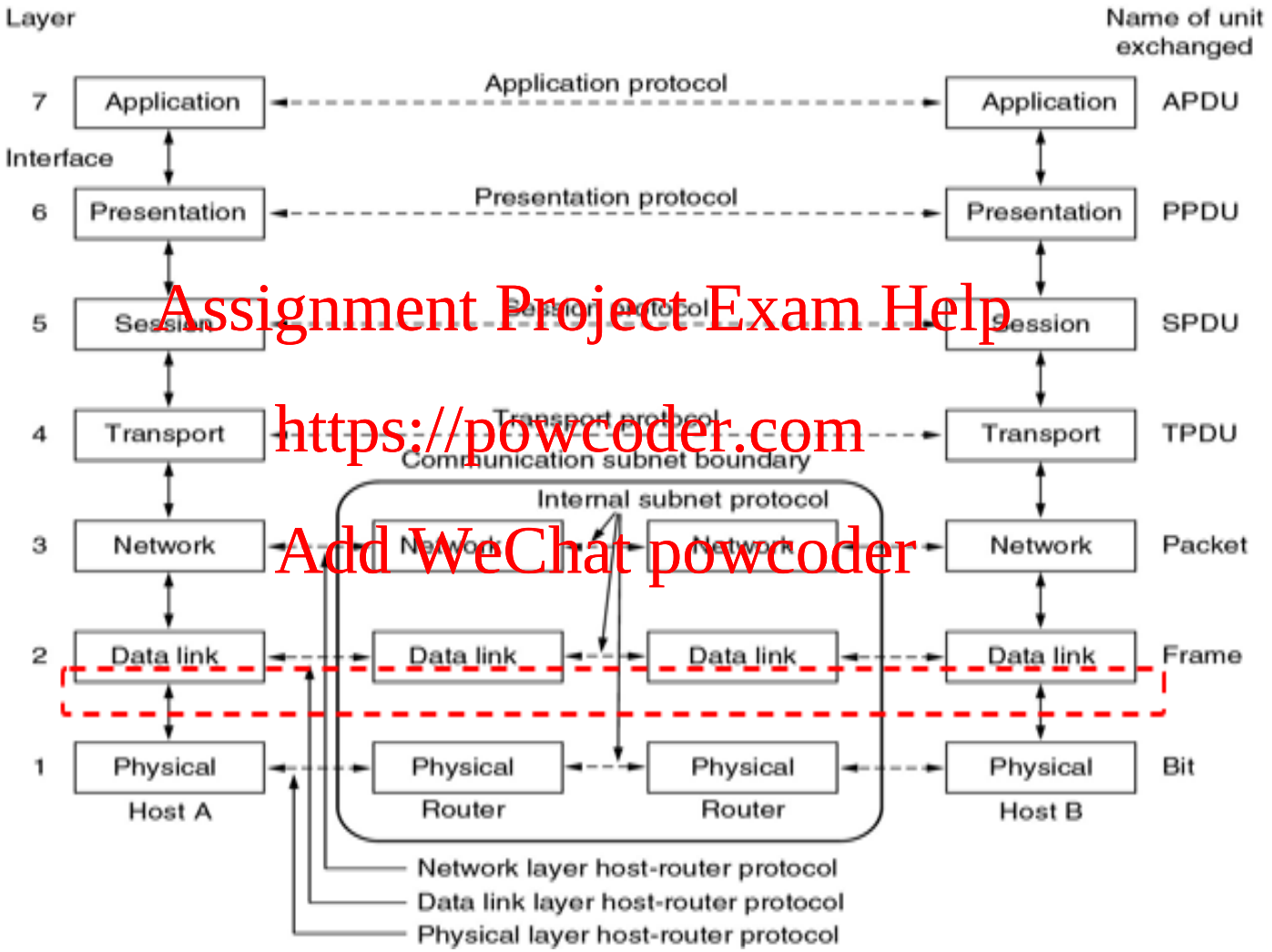
Introduction

- On **point-to-point networks**, there are only singular sender and receiver pairs, eliminating transmission contention
- On **broadcast networks**, determining right to transmit is a complex problem
- **Medium Access Control (MAC)** sub-layer is used to assist in resolving transmission conflicts

MAC Sub-layer



Types of Channel Allocation Mechanisms

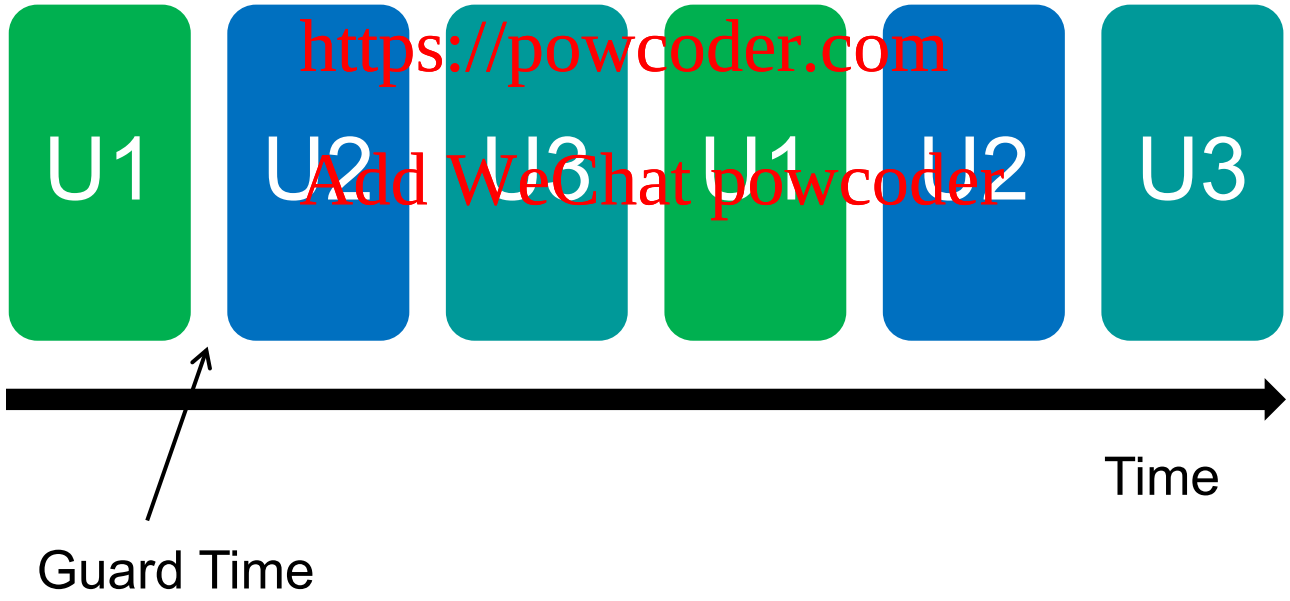
- Various methods exist for allocating a single broadcast channel amongst competing users
  - Static Channel Allocation
  - Dynamic Channel Allocation

Static Channel Allocation

- Arbitrary division of a channel into segments and each user is allocated a dedicated segment for transmission
  - Time Division Multiplexing (TDM)
  - Frequency Division Multiplexing (FDM)

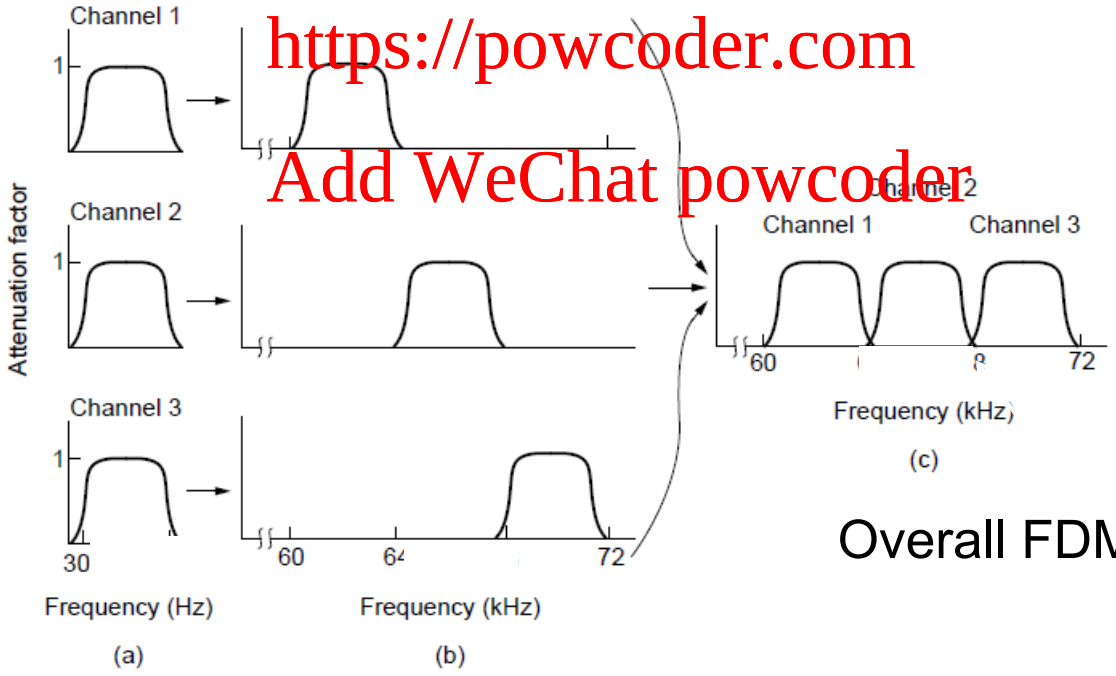
Time Division Multiplexing

- TDM: users take turns on a fixed schedule
- e.g. 2G mobile network



Frequency Division Multiplexing

- FDM shares the channel by placing users on different frequencies.
- e.g. TV and Radio; ADSL; 4G



Overall FDM channel

Static Channel Allocation

- Usually good for fixed number of users
- Significant inefficiencies arise when:
  - Number of senders > allocated segments
  - Number of senders is not static
  - Network traffic is bursty, but static methods TDM and FDM try to give consistent access to the network

Dynamic Channel Allocation (1)

- Channel segmentation and segment allocation are dynamic
- Assumptions for dynamic channel allocation:

1) Single channel for all communication

2) Independent transmission stations

3) Simultaneous transmission results in damaged frames (collision)

Dynamic Channel Allocation (2)

4) Time

- Continuous: Transmission can begin at any time
- Slotted: Transmission can begin only within discrete intervals

5) Carrier Sense

- Carrier Sense: Detection of channel use prior to transmission

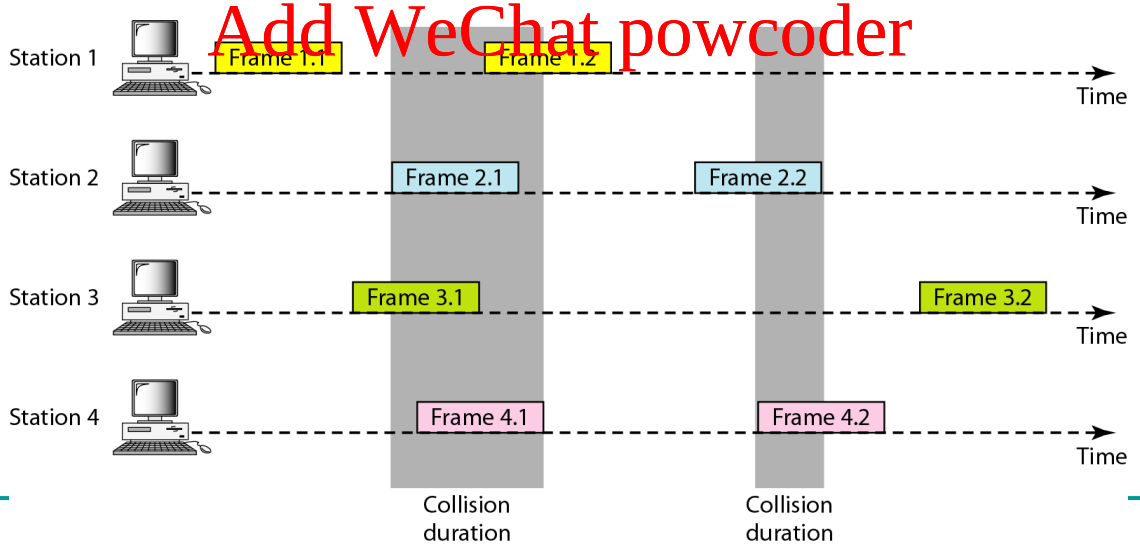
- No Carrier Sense: No detection of channel use prior to transmission

Multiple Access Protocols

- Contention
  - ALOHA, Slotted ALOHA
  - Carrier Sense Multiple Access
- Collision Free
- Limited Contention
- MACA/MACAW (for Wireless LANs)

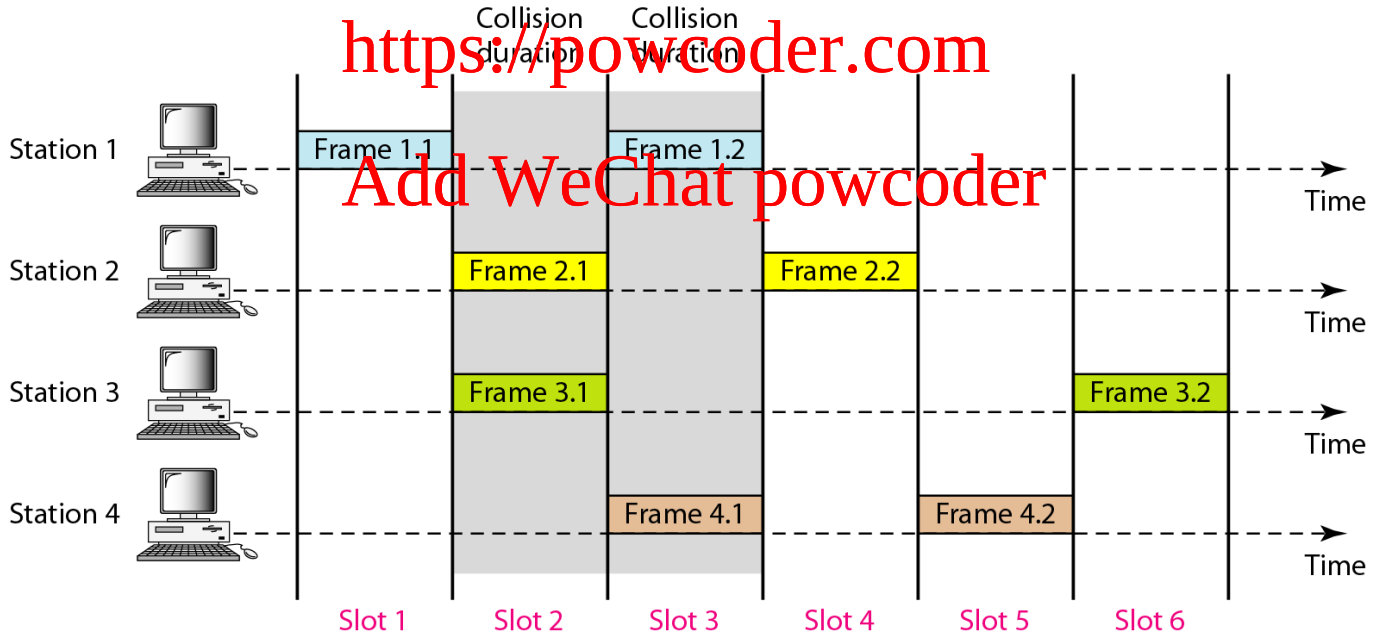
ALOHA

- Users transmit frames **whenever they have data**; **retry after a random time** if there are collisions (or no Ack is arrived)
- Requires **no central control mechanism**
- Efficient under low load but inefficient under high traffic loads



Slotted ALOHA

- Allows the users to start sending **only at the beginning of defined slots**.
- Increase efficiency of pure ALOHA by reducing possibility of collisions



Carrier Sense Multiple Access (CSMA)

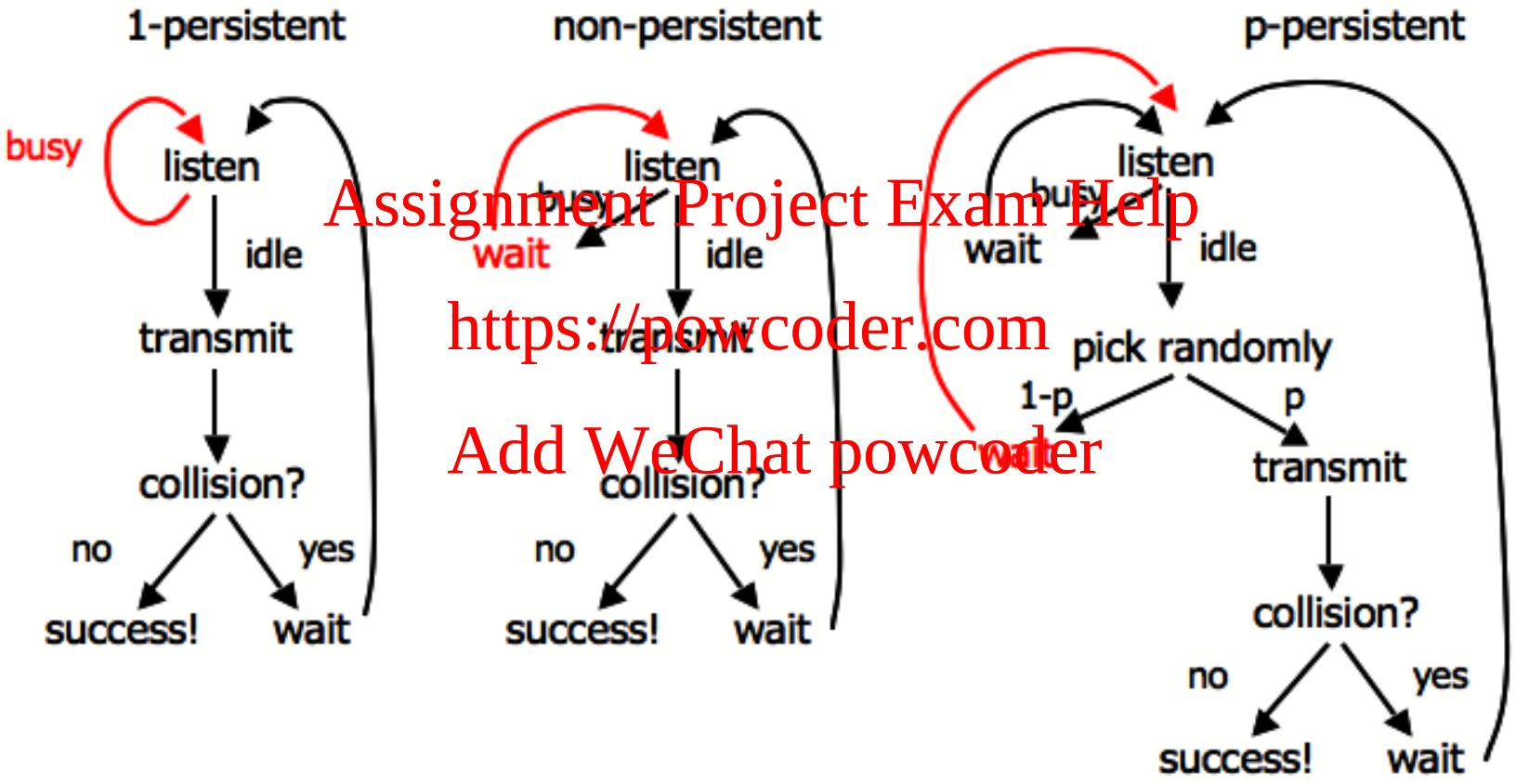
- **Require transmission state detection** to determine transmission rights dynamically, there are specific protocols which are used
  - Persistent and Non-Persistent CSMA
  - CSMA with Collision Detection

Persistent and Non-Persistent CSMA (1)

CSMA: when a sender has data to transmit, first check channel to detect other active transmission

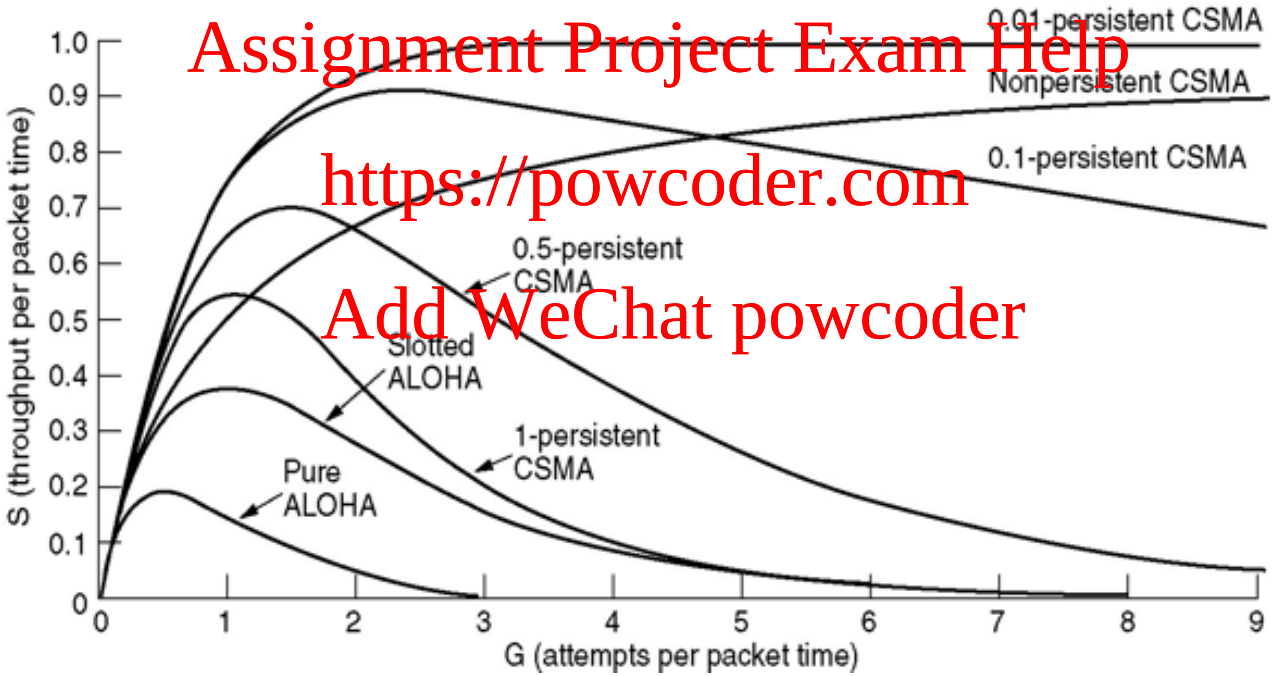
- **1-persistent CSMA**
  - Continuously check, and wait until channel idle; transmit one frame and check collisions; if collision, wait for a random time and repeat
- **Non-persistent CSMA**
  - If channel is busy, wait random period and check again; if idle, start transmitting
- **p-persistent CSMA**
  - If channel is idle, transmit with probability *p*, or wait with probability *(1-p)* and check again

Persistent and Non-Persistent CSMA (2)



CSMA Variants

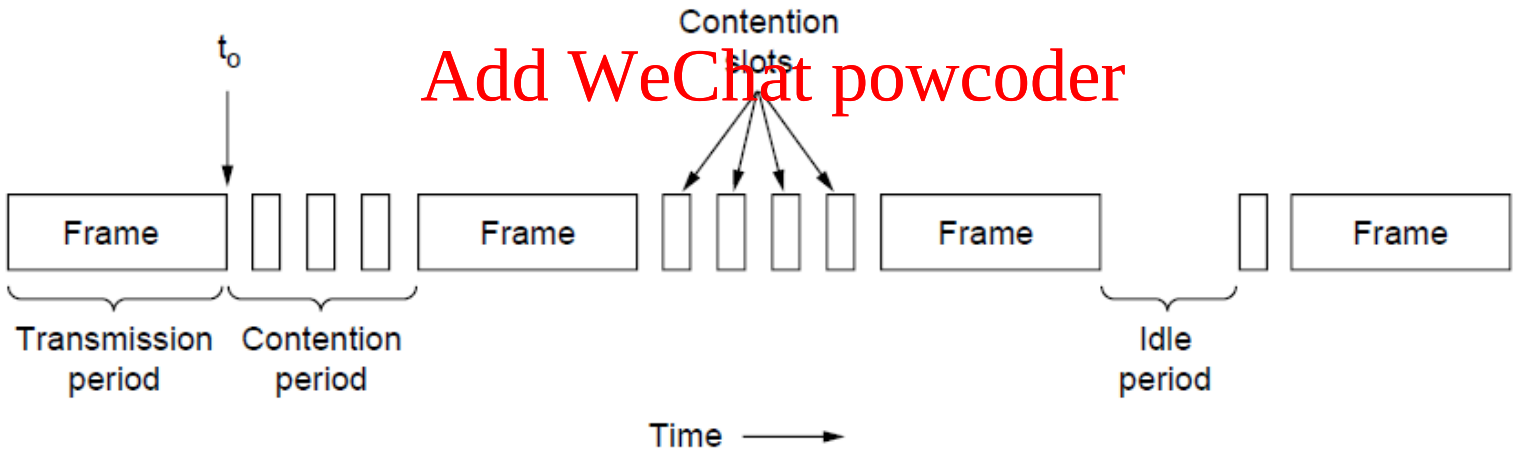
- Comparison of the efficiencies (channel utilisations) for various protocols



CSMA outperforms ALOHA, and being less persistent is better under high load

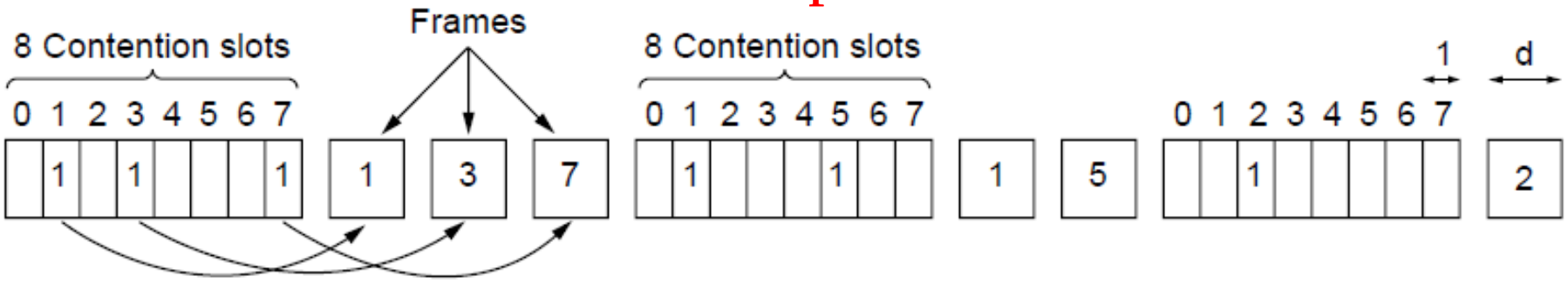
CSMA with Collision Detection

- Process: After collision detected, abort transmission, wait random period, try again
- Channel must be continually monitored
- Reduce contention times to improve performance



Collision Free Protocols (1)

- Bit Map Protocol
  - Reservation-based protocol
  - Overhead: 1 bit per station
  - Division of transmission right, and transmission event - no collisions

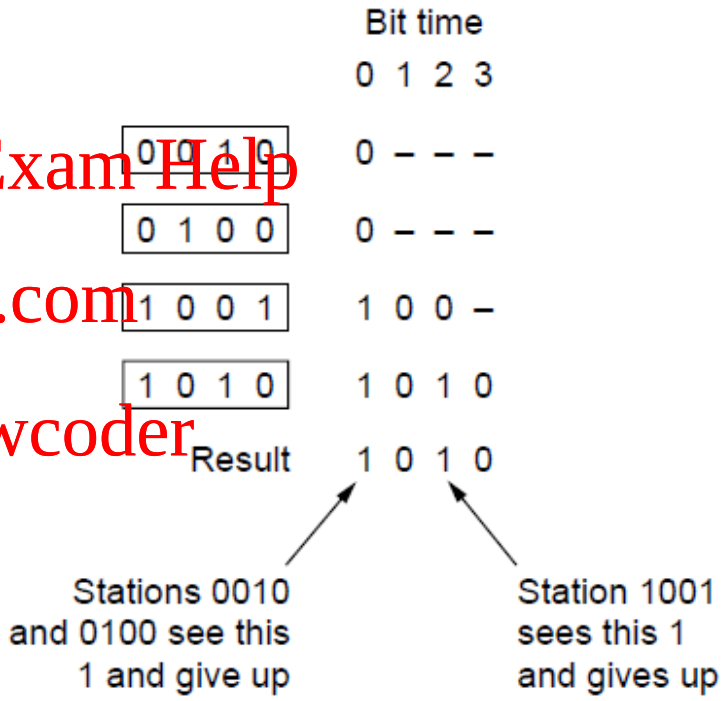


Collision Free Protocols (2)

- Binary Countdown Protocol
  - Defines transmission order based on the binary station addressing
  - Higher numbered stations have a higher priority - no collisions

Collision Free Protocols (3)

- Binary Countdown Protocol
  - Stations send their address from high-order bit in contention slots ($\log_2 N$ slots instead of N)
  - Channel medium ORs bits; stations give up when they send a "0" but see a "1"
  - The station that sees its full address is the next to send



Contention vs. Collision Free

- **2 strategies: contention** and **collision free**
  - Under **low loads** (collisions are rare), the collision free is less attractive due to the overhead.
  - Under **higher loads**, contention method is less attractive due to higher number of collisions.
- Both become inefficient at different points