Multiple Access Control

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Overview

Multiple Access Control

MAC

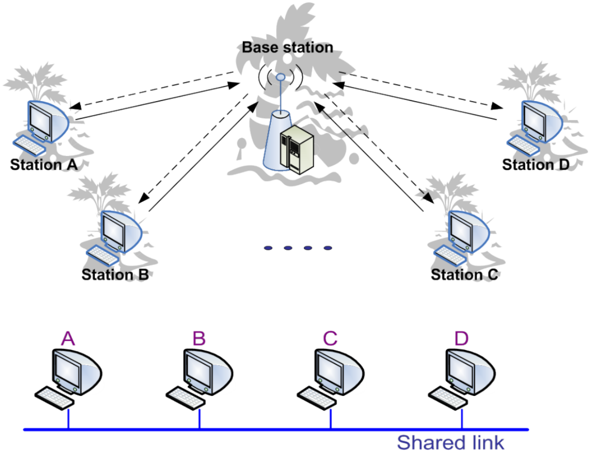

Figure: Multiple Access Control (MAC) allows to share communication resources among multiple users.

MAC

1. Resources
   - Time
   - Frequency
   - Code
2. Allocation
   - Static
   - Dynamic
3. Control
   - Central
   - Distributed

Static Allocation

Static TDMA

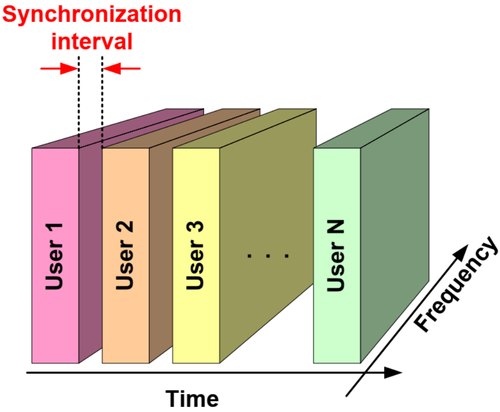

Figure: Static Time Division Multiple Access (TDMA) divides time into time frames and further divides each time frame into N time slots, each devoted to a user. Static TDMA wastes resources when a user has no data to transmit. TDMA eliminates collisions and is perfectly fair; however, it creates unnecessary delay to get the assigned time slot.

Static FDMA

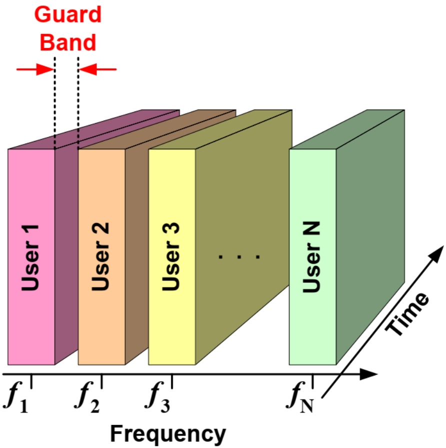

Figure: Static Frequency Division Multiple Access (FDMA) divides divides the available frequency band into N sub-bands and allocates the sub-bands to each of N user. Static FDMA wastes resources when a user has no data to transmit. FDMA eliminates collisions, is perfectly fair, and does not impose unnecessary delay to get the assigned frequency sub-band.

Static CDMA

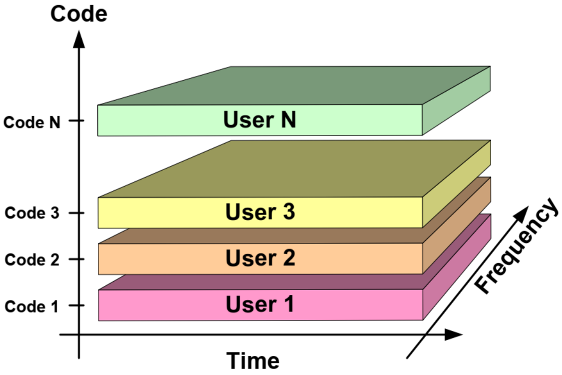

Figure: In Static Code Division Multiple Access (CDMA), each user is assigned a unique code. Static CDMA wastes resources when a user has no data to transmit. CDMA eliminates collisions, is perfectly fair, and does not impose unnecessary delay to get the assigned time and frequency resources. The assigned codes are usually orthogonal.

Static CDMA

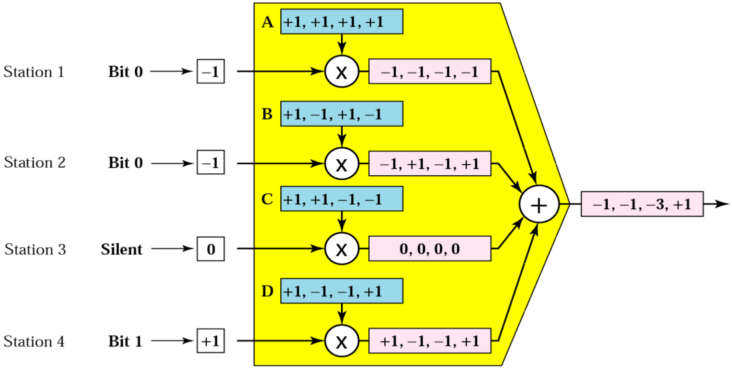

Figure: In CDMA, each bit time is subdivided into M short intervals called chips. Each user is assigned a unique M-bit code called a chip sequence (user code). All chip sequences are pairwise orthogonal. To transmit a 1 bit, a station sends its chip sequence. To transmit a 0 bit, it sends the negation of its chip sequence. A user can be silent and transmit nothing.

$$\boldsymbol{S}_k.\boldsymbol{S}_{k'} = \frac{1}{M}\sum_{i=1}^{M} S_{k,i}S_{k',i} = 0, \quad \mathsf{S}_k.\mathsf{S}_k = \frac{1}{M}\sum_{i=1}^{M} S_{k,i}S_{k,i} = 1$$

Static CDMA

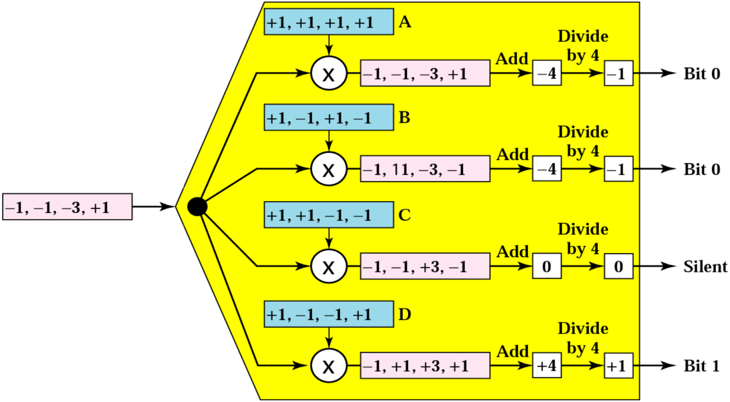

Figure: When two or more users transmit simultaneously, their bipolar sequences add linearly. To recover the bit stream of an individual user, the receiver calculates the normalized inner product of the received chip sequence and the chip sequence of that user.

$$\boldsymbol{R} = \sum_{k=1}^{K} b_k \boldsymbol{S}_k, \quad \boldsymbol{R}.\boldsymbol{S}_N = \frac{1}{M} \sum_{k=1}^{K} b_k \boldsymbol{S}_k.\boldsymbol{S}_N = b_N$$

Dynamic Allocation

Pure ALOHA

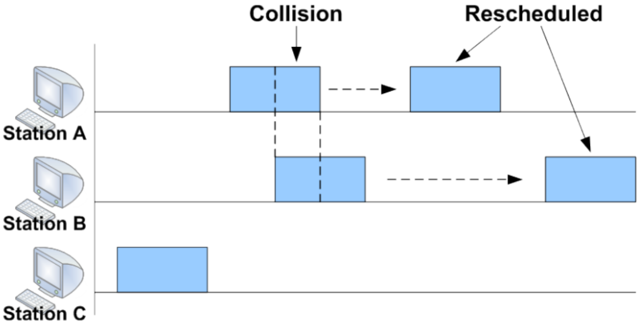

Figure: In pure ALOHA system, users transmit whenever they have data to be sent. Whenever two frames try to occupy the channel at the same time, there will be a collision and both will have to be retransmitted later. When the frames are equal-length, a frame generated at time t_0 experiences no collision if no other frame is transmitted within $[t_0 - T, t_0 + T]$, where T is frame duration.

Slotted ALOHA

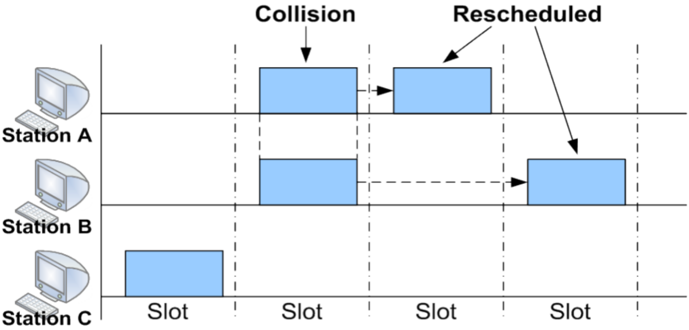

Figure: In slotted ALOHA system, users transmit at specified time instances. Whenever two or more users transmit at the same time instance, there will be a collision and the collided frames will have to be retransmitted later. When the frames are equal-length, no collision occurs if only one user transmits at a time instance, which happens when only one user has something to transmit within a frame time T. The slotted aloha experiences less collision.

The End