CSCI-UA 480: Computer Networks Assignment 4

Kai Liao

November 16, 2020

1 Written Questions

1.1 Different router architectures

1.1.1

It needs to support N enqueues and N dequeues in order to handle worst case scenario such that there is a packet for each input port and output port.

1.1.2

It needs to support N enqueues and 1 dequeue per tick, and we have N such memories with one for each output port.

1.1.3

It needs to support 1 enqueue and 1 dequeue per tick. N enqueues does not make sense since packet comes in once for each input. N dequeues does not make sense either since it's unusual to forward a packet to multiple output ports. There are N such memories, with one for each input port.

1.1.4

Shared memory could dynamically allocated memory to diffferent output ports, and thus does not suffer from the head-of-line blocking issue in input queueing [1]. However, shared memory needs to support up to N enqueues and N dequeues per tick which is demanding.

1.2 The ALOHA protocol

1.2.1

Assume each user transmits with a fixed probability p, the probability that exactly one user transmits out of N is given by,

$$N \cdot p \cdot (1-p)^{N-1} \tag{1}$$

To find optimum, we take derivative of the above formula with respect to p and set that to 0,

$$N \cdot (p \cdot (-1)(N-1)(1-p)^{N-2} + (1-p)^{N-1}) = 0 \tag{2}$$
$$p \cdot (N-1)(1-p)^{N-2} = (1-p)^{N-1} \tag{3}$$
$$p \cdot N - p = 1 - p \tag{4}$$
$$p = \frac{1}{N} \tag{5}$$

1.2.2

Assume each user uses the optimal transmission probability, we substitute $p = \frac{1}{N}$ into equation (1),

$$N \cdot \frac{1}{N} \cdot (1 - \frac{1}{N})^{N-1} = (1 - \frac{1}{N})^{N-1} \tag{6}$$

1.3 Differences between ALOHA, WiFi, and Ethernet

1.3.1

In ALOHA, a user could not detect other users who are transmitting at the same time (no carrier sense). WiFi, on the other hand, cannot transmit and receive (check for collisions) at the same time, but it can detect other users' transmissions before transmitting data (carrier sense) [3].

1.3.2

ALOHA uses a contention based protocol since there is no carrier sense. It assumes each user is independent of each other and adaptively determines transmission probability p. For WiFi MAC protocol, it exploits carrier sense by avoiding collision before transmitting data.

1.3.3

Physical layer of WiFi is more vulnerable to the problem called interference such that EM waves from senders could arrive at the same time and "destroy the reception of signal", which appears as collision in the link layer. Interference is not a problem for Ethernet as sender is isolated from one another. Besides, a WiFi user cannot transmit and receive at the same time, since EM waves interfere with each other making it impossible to decode transmission from others while transmitting [3].

1.3.4

A WiFi user cannot transmit and receive at the same time, and therefore the whole packet must be transmitted in order to determine if there is a collision. The MAC protocol for WiFi tries to avoid collision by waiting for I (sampled from 1 to CW) idle slots before transmitting the packet.
For Ethernet, it can transmit and receive at the same time. Therefore, it transmit bits, detects collision, and acts accordingly if there is a collision.

1.4 Other questions on MAC protocols

1.4.1

Carrier sense refers to a user knows that another user is transmitting on the shared medium [1].

1.4.2

The user can measure current voltage level on the wire and check if that exceeds some threshold [3].

1.4.3

Two laptops A and C transmit packets to Access Point B. A and C cannot see each other but can both see the access point. There is collision when the packets arrive at B at the same time. However, both A and C will be unaware of each other who is transmitting to B.

1.4.4

The user, instead of transmitting data directly to Access Point, sends Request-to-Send (RTS) message. The AP responds to the user with earliest arriving RTS by broadcasting Clear-to-Send (CTS) response, such that the other user will also receive this signal and stay silent for the period specified by CTS. The user whose RTS arrives first gets to transmit now without collision [3].

1.4.5

In TDMA, each user uses the medium for a fixed amount of time before releasing it to the next user in round-robin order. In FDMA, each user on the shared medium gets a "slice of the frequency range" [2].

1.4.6

TDMA: In High Performance Computing Center, each user gets to use some compute nodes for certain amount to time before releasing the resource.
FDMA: For radio channels, each channel gets to use a certain frequency range.

1.4.7

TDMA and FDMA requires the existence of a central authority to manage the distribution of shared medium, which is not suited for WiFi or Ethernet. The MAC protocols for WiFi and Ethernet interact with the shared medium and react to the "response" from the medium (collision for Ethernet and timeout/ACK for WiFi) accordingly, instead of asking some authority to do the work.
TDMA and FDMA are also not suitable for nowadays network with burst activities. Therefore, ALOHA is a contention based protocol, such that transmission probability for each user is adaptively determined.

References

[1] Sivaraman Anirudh. *Lecture 12: Input and output queueing*. 2020.

[2] Sivaraman Anirudh. *Lecture 13: Medium Access Control, the ALOHA protocol*. 2020.

[3] Sivaraman Anirudh. *Lecture 14: Carrier sense*. 2020.