# Problems and Solutions (Chapter 6)

1. What is the key issue for contention-based access protocols? How is it solved? Give an example to explain your answer.

   **[Solution]**

   The key issue for contention-based access protocols is the collision problem. This problem can not be completely solved due to the nature of the protocols. However, this kind of protocol can reduce the collisions by random backoff. By choosing a random backoff period the probability of collision is reduced. For example, CSMA/CA use the exponential backoff scheme. It picks a random backoff period within its contention window.

2. How does slotted ALOHA improve the throughput as compared to pure ALOHA?

   **[Solution]**

   In slotted ALOHA packets must be transmitted within a slot. If a terminal has a packet to send , it waits until the beginning of the next slot. Hence, slotted ALOHA has no partial collision. Therefore, it can improve the throughput by reducing the contention period.

3. Is it impractical to use ALOHA or slotted ALOHA for MSs to access control channel associated with the BS? Explain clearly.

   **[Solution]**

   It is practical. In fact, aloha and slotted ALOHA are designed for accessing the access control channels associated with the BS. BS has the preallocated channels, using any of the TDMA , FDMA or CDMA schemes. When MS wants to make a call, it need to send access request to the BS. Only one control channel is used to accept the access request. Thus we need a contending protocol to manage these access requests and they are ALOHA or slotted ALOHA.

4. What is meant by a collision in data transfer and why is it not possible to decipher information from collided data? Explain clearly.

   **[Solution]**

   A collision of data transfer means that there are more than one terminal transmitting data on the shared medium at the same time. It is not possible to decipher information from the collided data because the signals get garbled and cannot be separated or interpreted by the nodes accurately.

5. In a given system with shared access, the probability of "$n$" terminals communicating at the same time is given by

$$p(n) = \frac{(1.5G)^n e^{-1.5G}}{(n-1)!},$$

where $G$ is the traffic load in the system. What is the optimally condition for $p$?

**[Solution]**

The optimal condition for $p$ is when $n = 1$

and then

$$p(1) = (1.5G)e^{-1.5G}.$$

At this condition, there is only one terminal is transmitting at a time so that no collision occurs.

6. What are relative advantages and disadvantages of persistent and non-persistent CSMA protocols? What makes you select one over the other? Explain clearly.

**[Solution]**

Advantages of persistent CSMA:

The terminal will keep listening to the medium when it senses the medium busy. Then it will capture the channel immediately after the medium becomes idle. Thus, 1-persistent CSMA will have good channel utilization when traffic is light. The $p$-persistent CSMA works better when traffic is heavy.

Disadvantages of persistent CSMA:

When traffic is heavy, 1-persistent will bring more collisions because it is highly possible that more than one terminal sense the medium immediately after the medium becomes idle.

Advantages of non-persistent CSMA:

It can reduce the collisions by waiting for a random time to sense the medium again after it senses the medium is busy. It is especially useful when traffic is heavy.

Disadvantages of non-persistent CSMA:

It may waste the channel by waiting for an unnecessary random time to sense the medium again due to light traffic.

Therefore, choosing the 1-persistent CSMA when traffic is light, and non-persistent CSMA or $p$-persistent CSMA when traffic is heavy.

7. Describe the advantages and disadvantages of 1-persistent CSMA and $p$-persistent CSMA respectively.

**[Solution]**

Advantages of 1-persistent CSMA:

It will have good channel utilization when traffic is light because it will transmit immediately when the medium becomes idle.

Disadvantages of 1-persistent CSMA:

It will bring more collisions, especially when the traffic is heavy.

Advantages of $p$-persistent CSMA:

It provides a balance between 1-persistent and non-persistent schemes.

It can reduce the collisions by transmitting with the probability $p$ instead of 1 when the medium becomes idle. It is very useful when traffic is heavy.

Disadvantages of $p$-persistent CSMA:

It may waste the channel by waiting unnecessarily, especially when the traffic is light.

8. Can we use CSMA/CD in cellular wireless networks? Explain your answer with solid reasoning.

   **[Solution]**

   We cannot use CSMA/CD in wireless networks. Because the sender node cannot detect the collisions during its transmission.

9. What are the major factors affecting the throughput of CSMA/CA?

   **[Solution]**

   Traffic load; number of users; the minimum contention window; data packet length.

10. What is the difference between collision detection and collision avoidance?

    **[Solution]**

    Collision detection means if a collision is detected during the transmission, the terminal aborts its transmission immediately and the terminal attempts to transmit later after waiting for a random time. Collision detection protocol is mainly used in Ethernet.

    While collision avoidance does not abort the transmission but tries to avoid collisions in advance. Collision avoidance is implemented by an additional waiting time of DIFS and backoff time. Collision avoidance is used in wireless LANs.

11. What are the purposes to use RTS/CTS in CSMA/CA?

    **[Solution]**

    RTS/CTS is used for:

    (a) Solving the hidden terminal problems;

    (b) Reducing the collision period.

12. What are the relative advantages and disadvantages of basic CSMA/CA and CSMA/CA with RTS/CTS protocols? What makes you select one over the other?

    **[Solution]**

Due to RTS/CTS packets the overhead of data transmission increases. If we have small DATA packets then it is not worth using the RTS/CTS packets which may increase the overhead. However if the DATA packets are bigger in size and the channel is heavily loaded then using RTS/CTS can prove effective.

13. What in your opinion should be the criteria to select the value of the contention window? Also explain how you will decide the value of the time slot for CSMA/CA.

    **[Solution]**

    We should allow the nodes to choose the contention window value randomly over a large range of values. The range of values should be more than the nodes present in the network. Otherwise collisions will be certain. When the traffic load is heavy then the contention window should be large. When load is less and number of nodes is also less then we can use smaller contention window.

14. In a CSMA/CA scheme, a random delay is allowed whenever a collision occurs. What is the guarantee that future collision between previously collided terminals will not occur? Explain the rational behind your answer.

    **[Solution]**

    CSMA/CA cannot guarantee that the future collisions will not occur due to the nature of CSMA/CA. But it can reduce the future collisions by using backoff scheme whenever a collision occurs. Because collision terminals randomly select a backoff counter within the contention window, the future collisions can be reduced but it is still possible that two or more terminals select the same backoff counter so that there still exist collisions.

15. Why does contention window need to be changed sometimes? Explain clearly.

    **[Solution]**

    In order to give priority to different nodes we should let the nodes choose the contention windows from different ranges. Higher priority nodes should be able to choose lower contention window. Also after a collision we double the contention window range in order to decrease the probability of choosing the same slot by two or more nodes.

16. In CSMA/CA, why do you need a contention window, even after DIFS? What is the typical size of the contention window?

    **[Solution]**

    The purpose of the contention window is to reduce or avoid the collisions. The typical size of the contention window is 32, 64, 128, 256,....

17. Suppose the propagation delay is $\alpha$, SIFS is $\alpha$, DIFS is $3\alpha$, and RTS and CTS are $5\alpha$, respectively for CSMA/CA with RTS/CTS.

(a) What is the earliest time for the receiver to send the CTS message?

(b) If data packet is $100\alpha$ long, what is the shortest time for the receiver to send the ACK signal?

(c) Explain why SIFS is kept smaller than DIFS period?

(d) Can you make SIFS $= 0$?

**[Solution]**

(a) If a terminal has a packet ready to transmit, it will sense the medium first. If the medium is idle for DIFS, it will transmit RTS, then wait for the CTS from the receiver. Therefore, the earliest time for the receiver to send CTS massage is:

$$3\alpha + 5\alpha + \alpha + \alpha = 10\alpha.$$

(b) When the sender receives the CTS from the receiver, it waits for SIFS, and then sends its data packet. Therefore, the shortest time for the receiver to send the ACK signal is:

$$3\alpha + 5\alpha + \alpha + \alpha + 5\alpha + \alpha + \alpha + 100\alpha + \alpha + \alpha = 119\alpha.$$

Note that we should include the propagation delay also.

(c) This is to give priority to some packets. For example after transmitting the DATA packets the receiver should be allowed to send ACK packets without any collisions. To accomplish this, we transmit the ACK packets immediately after SIFS time interval before any other node can transmit and interrupt the ACK packet.

(d) No. SIFS is the turnaround time required to change from transmit (receive) mode to receive (transmit) mode. Thus it is compulsory to have finite SIFS time.

18. In an experiment, the persistent value $p$ is varied as a function of load $G$, from 1 to 0.5 to 0.1 to 0.01. For what value of $G$, would you have such a transmission? Is there any specific advantages of having such changes? Be specific in your answer.

**[Solution]**

The persistent value $p$ should be carefully selected to reduce the collisions. When the traffic $G$ is heavy (e.g., $> 10$), we should choose the small value of $p$ (e.g., 0.01) so that the packets can be separated enough to reduce the collisions. When the traffic $G$ is light (e.g., $< 0.1$), we should choose the large value of $p$ (e.g., 1) because at this time, it is not necessary to waiting for another additional time. Similarly, we can appropriately select the value of $p$ between 0.1 and 0.5 when the traffic is medium.

19. Under the CSMA/CA protocol, suppose there are $n$ users and the contention window for each user is $W$, then what is the collision probability?

    **[Solution]**

    Assuming all n users transmitting:

    There can be 3 cases:

    $N = 1$: This means only one user is present and there is no possibility of collision.

    $N > W$: In this case no way a collision can be avoided and collision probability is 1.

    $N < W$: The collision probability is

    $$1 - \frac{W!}{(W-N)!}W^n.$$

20. The IEEE 802.11x is the popular CSMA/CA protocol employed for wireless LANs and ad hoc networks. Briefly describe all the current 802.11 standards and explain clearly how each is dis tinct from the other.

    **[Solution]**

    There are different standards under the IEEE 802.11. For more information please refer the IEEE 802.11 standard. The IEEE 802.11a uses 5 GHz unlicensed spectrum to achieve bandwidths of around 54 Mbps. The IEEE 802.11b uses 2.4 GHz ISM band and achieves bandwidths up to 11 Mbps. The IEEE 802.11g uses the 2.4 GHz ISM band and achieves 54 Mbps with the help of OFDM.

21. Look at your favorite Web site and find out, what is meant by the hidden terminal problem and the exposed terminal problems? Explain clearly, how can you address them?

    **[Solution]**

    Hidden terminal problem occurs when a node other than the receiver is hidden from the transmitter. This way the node cannot detect any ongoing communication and may interrupt the data reception at the receivers. In exposed terminal problem, nodes that are not participating in an ongoing transmission have to stay idle for some time period before the transmission completes. To address these issues we have RTS and CTS packets which may help in knowing ongoing transmissions.