Problems and Solutions (Chapter 14)

1. What happens if you use two house-hold cordless phones at the same time? Explain with appropriate reasons.

   [Solution]

   A cordless phone has two essential components: a base and a handset. The base converts the incoming electrical signal (in case of incoming call) to FM radio signal and broadcasts the signal, which is received by the handset. The base and handset work in duplex frequency mode. In 1998, FCC (Federal Communications Commission) opened up 2.4 GHz range (ISM band) for cordless phone use. These days digital spread spectrum (DSS) is used in cordless phones where the information is spread over several frequencies between the receiver and the base. If we have 2 cordless phones at the same time then, it may happen that at a particular instant both the phones are using the same frequency channel and hence may result in a collision. But since the band is very large and the frequency hopping sequence may utilize different hopping schemes, the possibility is lower.

2. You might have observed the following:

   (a) When you open your garage door, your next-door neighbor's door might also open.

   (b) Your neighbor complains sometimes that the TV channel is changing automatically.

   Can you think of ways to avoid such phenomena? Explain clearly.

   [Solution]

   (a) Garage door remotes controls use the typical frequency of around 400 MHz. A special digital coding system separates one system unit from another. Every garage door opener allows us to set the code in a series of small switches inside the garage. This code is a binary number, which is different from the neighbor's code. However, if we accidentally set the code to that of our neighbor and if both the systems are operating at the same frequency, then both the doors start operating at the same time. To avoid this we should use different binary codes.

   (b) In infrared remote controls which we generally use in TV and VCRs, we transmit the signal using pulses of infrared light. A special set of codes are used, depending upon the make and the model of the television which keep the various remotes from interfering with each other. Since infrared remotes use light, they cannot penetrate through walls, however they can make their way around corners. Thus, the TV channels of the neighbor might change sometimes. Different codes need to be used to avoid this.

3. A set of small robots needs to be equipped with wireless devices. Consider the usefulness of the following devices if used for a laboratory environment:

   (a) Infrared (IR).

   (b) Diffused Infrared (IR).

   Obtain information about infra-red communication from your favorite web site.

   [Solution]

   Diffused Infrared (IR) is an indirect and non-line-of sight communication. The diffused infrared signal, which is emitted from the transmitter, fills an enclosed area and uses the room's surfaces to bounce the optical signal between the transmitter and the receiver. The advantage of diffused IR links is that they provide robustness against shadowing and behave as RF (radio waves) within a room enclosure in comparison to basic infrared communication, which is a line of sight communication. Also using basic IR communication may result in disruption of communication in case robots are non-line-of-sight, which is not the case with diffused IR. The disadvantage of diffused IR is that it's signal uses the complete enclosed area so we need to use different code to identify different communications.

4. Repeat Problem 14.3, if the robots are employed for a field application.

   [Solution]

   In case of field application generally there is no enclosed area to diffuse the IR waves, so both IR and diffused IR will tend to have the same performance.

5. A set of small robots needs to be equipped with wireless devices. Consider the usefulness of the following devices if used for a laboratory environment.

   (a) WMAN

   (b) WLAN

   (c) WPAN

   [Solution]

   Both HomeRF and HiperLAN support peer-to-peer communication, which may be suitable for this kind of application where a given set of robots work independently. Bluetooth works in Master-Slave mode, which requires that one of the robot, should be selected as a master. Limiting range of Bluetooth and movement of master may result in frequent piconet reconfiguration.

6. Do Bluetooth devices and house-hold microwave ovens interfere? Explain.

   [Solution]

Bluetooth, which works in ISM band, typically hops faster (220 micro seconds) and employs shorter packets as compared to other systems operating in same frequency band. It limits the impact of microwave ovens and other sources of indoor disturbances on Bluetooth enabled devices by using fast frequency hopping technique.

7. What impact will Bluetooth devices connected to mobile units have on the piconet?

   [Solution]

   If bluetooth devices are connected to mobile units then the device may move out of the range of a particular master in the piconet, resulting in breaking of master-slave communication. If the master moves out of the range then it will result in the complete failure of the piconet.

8. In a hypothetical wireless system five adjacent frequency bands (f_1, f_2, f_3, f_4, f_5) are allowed for frequency hopping sequences. Enumerate how many different hopping sequences are possible and prove their correctness.

   [Solution]

   If we have 5 bands we can have $5! = 120$ hopping sequences.

9. In Problem 14.8 , it was decided to add five additional channels, (f_6, f_7, f_8, f_9, f_{10}) while keeping the frequency hopping sequence to five bands. Is it advisable to maintain frequency hopping within each of the channels (f_1, f_2, f_3, f_4, f_5) and (f_6, f_7, f_8, f_9, f_{10}) or it is better to select five channels among the bands (f_1, f_2, f_3, f_4, f_5, f_6, f_7, f_8, f_9, f_{10})? Explain your answer with some quantitative measures.

   [Solution]

   In the first case the number of hopping sequences we get will be: $2 * 5! = 240$.

   In the second case the number of hopping sequences we get will be $\binom{10}{5} * 5! = \frac{10!}{(10-5)!5!} * 120 = 37240$. Hence the second scheme is better.

10. A conference organizer decided to have eight separate groups of panels, A, B, C, D, E, F, G, and H to make decisions on eight parallel tracks for a professional meeting. To facilitate communication between six members of each group, a piconet is formed using Bluetooth enabled Laptops. The following hopping sequence is followed by a piconet of each group.

Group	Allocated Frequency Hopping Sequence							
A	f_1	f_5	f_9	f_{13}	f_{17}	f_{21}	f_{25}	f_{29}
B	f_2	f_6	f_{10}	f_{14}	f_{18}	f_{22}	f_{26}	f_{30}
C	f_3	f_7	f_{11}	f_{15}	f_{19}	f_{23}	f_{27}	f_{31}
D	f_4	f_8	f_{12}	f_{16}	f_{20}	f_{24}	f_{28}	f_{32}
E	f_{13}	f_{17}	f_{21}	f_{25}	f_{29}	f_1	f_5	f_9
F	f_{14}	f_{18}	f_{22}	f_{26}	f_{30}	f_2	f_6	f_{10}
G	f_{15}	f_{19}	f_{23}	f_{27}	f_{31}	f_3	f_7	f_{11}
H	f_{16}	f_{20}	f_{24}	f_{28}	f_{32}	f_4	f_8	f_{12}

If there is a collision, quantify the fraction of time such an interference may be present.

[Solution]

If the group operates in parallel then there may be 100% collision.

11. Assuming that the channel $f_i \neq f_j$ for $i \neq j$, find if there could be collision and interference in Problem 14.10, if :

    (a) Group (A, B, C, and D) or group (E, F, G, and H) are simulatneously operating due to overlapping of memberships between these groups.

    (b) All eight groups are communicating simultaneously.

    (c) Any six groups are operational at a time due to limitations on the availability of laptops.

    [Solution]

    (a) If group (A, B, C, D) or (E, F, G, H) are simultaneously operating then there will be no collision because all of them use different frequencies for hopping.

    (b) If all 8 groups communicate simultaneously then collision will be there.

    (c) If any 6 groups are operational then also there will be partical collision because some frequencies will be repeated, depending on which 6 groups are selected.

12. In Problem 14.11(a), group A may need to communicate with group B about a submission, overlapping between the two subject areas. How is it possible to establish such an interaction? Consider all possible feasibilities and explain with appropriate justifications.

    [Solution]

    Piconets A and B can communicate by forming a scatternet where they have to share one of their members and the member has to tune to a different hopping sequence (for A and B) at different time slots to transfer the information across the two groups.

13. The group of reviewers needs to be redistributed in the afternoon group (A, B, E, F) and group (C, D, G, H). Repeat Problem 14.11 for this new distribution.

    [Solution]

    (a) There will be collision because (A, B, E, F) or (C, D, G, H) use common frequencies among them.

    (b) There will be some collisions.

    (c) There will be collision.

14. What are the advantages and disadvantages of using "Bluetooth" based devices as a sensor network? Explain your answer from a possible feasibility point of view.

    [Solution]

    For a small set up, we can make use of Bluetooth based devices as a sensor network. For example in home if a fire is generated at a point and if the Bluetooth slave is able to sense it, then it can always communicate it to the master for emergency action. But in general inter and intra piconet communication, configuration and reconfiguration of scatternet, and inter piconet routing for sensor networks becomes a critical issue in using Bluetooth devices for sensor networks.

15. Forming a cluster of Bluetooth devices into a piconet is important. Can you think about any strategy to define members of a piconet? Justify your answer.

    [Solution]

    In Bluetooth system, a network with a master and at most 7 active slaves associated with it is known as a piconet. The master node has more responsibility than the slaves, such as maintaining the cluster, transferring the messages between slave nodes, controlling channel access with polling scheme etc. Therefore, in a cluster, the node having more resource and energy should be assigned as a master node and others could serve as slave nodes. The role of the master could be changed dynamically. Besides, the node located in center of the piconet ought to be favored as the master because it may offer a better coverage as the piconet use the star topology.

16. A bridge node provides access between two adjacent piconets. How can you schedule from one piconet to bridge to the second piconet so that information can be transferred? Explain.

    [Solution]

    A bridge node cannot be active at two piconets at the same time. Therefore, in order to transfer a message from one piconet to the other piconet, the bridge node first communicates in one piconet to get the message to be transferred. Then the bridge node tries to switch to the other piconet

and forward the message to destination. Then it switches back to relay more packets.

17. Can you apply different ad hoc network routing protocols to a scatternet? Explain clearly with suitable examples.

    [Solution]

    The different ad hoc routing schemes available are AODV, DSR, etc. All the schemes can be applied to scatternet if we assume every piconet to be a node in an ad hoc network. This is important to remember as there may be only one "bridge" node between two piconets and not all the nodes of a piconet may not have information about other piconets. Once the information is passed to a given node it can be distributed in the piconet using master-slave communication.

18. What is the rational behind using different slot sizes in Bluetooth? Explain clearly.

    [Solution]

    It is the channel quality. If channel quality is good, using multiply slots packets can provide higher throughput. On the other hand, in a noisy environment or if multiply piconets co-exist in the same area, system may have much more interference. If channel quality is not good, packets may easily get corrupted and retransmission of a large packet causes added retransmission delays. The small slots size can reduce the retransmission ratio and can get a better overall efficiency.

19. How do you ensure that two adjacent piconets do not use the same frequency hopping sequence? Explain.

    [Solution]

    In Bluetooth system, hopping sequence is computed according to Bluetooth device address and clock of the master node. Since there is a large range of address space and clock range is also large, so hopping sequences in different piconets are less likely to be the same.

20. Can you possibly use "orthogonal latic squares" to avoid the problem indicated in Problem 14.19? Find out details on "orthogonal latic squares" from web search. Explain clearly.

    [Solution]

    A Latin square is an n by n matrix with elements $a_{ij} \in \{1, 2, ..., n\}$ such that entries in each row and column are distinct. Specifically, a Latin square consists of n sets of the numbers 1 to n arranged in such a way that no orthogonal (row or column) contains the same number twice. Therefore, by using orthogonal Latin squares, we can ensure adjacent piconets do not use the same frequency hopping sequence in orthogonal (row or column) directions.

21. Compare HyperLAN with Bluetooth.

    [Solution]

    Bluetooth offers approximately 1 Mbit/s data rate in the 2.4 GHz band and is mainly intended as a cable replacement technology to connect peripheral devices mobile phones and PCs in the Personal Area Network (10 m), using the Master slave polling, time division duplex (TDD). The HiperLAN2 is a more cable replacement technology for Local Area Networks (100 m) supporting speeds up to approximately 54 Mbit/s in the 5 GHz band, using the Time Division Multiple Access (TDMA) in MAC layer.

22. Compare the usefulness and limitations of WMANs, WLANs, and WPANs.

    [Solution]

    WMAN, WLAN, and WPAN all aim to provide wireless data connectivity:

    Usefulness:

    A WMAN is meant to cover an entire metropolitan area;

    A WLAN provides similar services but covers a much smaller area (e.g., a building, an office campus, lounges)

    A WPAN is an extremely short-range network, formed around the personal operating space of a user. Typically WPAN are used to replace cables between a computer and its peripheral devices.

    Limitations:

    In WMAN, some operational spectrum, such as the $10-66$ GHz band in the IEEE 802.16 standard requires the precondition of LOS. The $2-11$ GHz band in the IEEE 802.16a uses the licensed and license-exempt spectrum, including the crowded 2.4 GHz frequency.

    WLANs transmit data via radio waves which can be blocked by metal. Also because the 2.4 GHz band is unlicensed, there are a lot of other devices which use the same band. The IEEE 802.11 standards family provide shared bandwidth; access points are bridges not switches. Also, Physical access point devices from different vendors are unlikely to interoperate across a distribution system due to the different approaches taken to distribution system design. In WPAN, the IEEE 802.15.X standards are also working in the crowded 2.4 GHz frequency.

23. What is the fundamental difference between the Ricochet solution and IEEE 802.16?

    [Solution]

    There are differences in operational spectrum, channel access etc. Refer to Table 14.2, Page 368.

24. Describe the wireless solutions that you would recommend for the following situations. Some situations may need multiple standards. Explain clearly.

(a) A person carries a PDA, laptop, bio-sensors and wrist watch that run applications that are collaborative in nature and communicate with the Internet.

(b) A salesman on the road needs to keep track of product inventories.

(c) A group of executives meet in a conference room and want to digitally exchange their business cards.

(d) A group of conference organizations need to take "conflict-of-interest" into acount while discussing conference submissions and making acceptance decisions.

[Solution]

(a) Use WPAN technology to communicate between the devices, and access the Internet using the WLAN or WMAN technology.

(b) Use WMAN technology, such as Ricochet to connect to the online product inventories.

(c) WLAN technology. By using IEEE 802.11 standard, we can build up the communication between their laptops or PDAs.

(d) We can try to integrate WLAN, WPAN, and cellular system, to set up a heterogeneous wireless network to satisfy the different requirement of different groups or persons