Wireless Networks

Problem 09 Solutions

P9.2

You have temporarily moved to a new area and you would like to use your cell phone. What alternatives do you have if:
(a) There is no service provider in that area?
(b) There is no agreement between your wireless phone service provider and the service provider in the new area?
(c) The area is covered only by a satellite phone service?

[Solution]
(a) It is impossible to use a cell phone where no service provider (including satellite phone service) exists.
(b) If there is no agreement, there is nothing you can do in the new area. You can register your cell phone to the new service provider in the new area, if that employs the same technology and reprogrammed for new frequency band and/or code.
(c) Subscribe your cell phone to a satellite phone service provider, if it is capable to use the satellite frequency band.

P9.6
Asssume that you just got out of the airplane and you switched on your cell phone. If the closest BS is located at a distance of 5 kms, what is the minimum and the maximum delay before a contact is established between your cell phone and the nearest BS, given the BS transmits beacon signals every one second?

[Solution]
The registration process including:
$T1$: Beacon signal exchange between BS and MS
$T2$: MS request for registration
$T3$: Visiting BS send authentication request to home BS
$T4$: Home BS send authentication response back to the visiting BS
$T5$: Visiting BS send the authentication/rejection back to MS
Suppose $T3$ and $T4$ are fixed, then the minimum delay is

$$T_2 + T_3 + T_4 + T_5 = 2 * (\frac{5 \text{ km}}{3 * 10^8}) + T_3 + T_4,$$

and the maximum delay is

$$1 + T_1 + T_2 + T_3 + T_4 + T_5 = 1 + 3 * (\frac{5 \text{ km}}{3 * 10^8}) + T_3 + T_4.$$

P9.9
In a wireless network, the radio signal is broadcast through the air. Therefore, what is the significance of multicasting in this context? Explain in detail.

[Solution]
When a wireless network use a common channel, only stations in the radio range of the sender can receive the signal. Multicasting implies formation of group members beyond the radio range so that all can receive intended message

P9.10
What is meant by bidirectional tunneling? Why do you need HA-FA in addition to HLR-VLR pair? Explain clearly.
[Solution]
The bidirectional tunneling approach is that when an MS moves into a foreign network, a binding update is sent to the HA, which then responses with a binding acknowledgement. After that, a bidirectional tunnel is created by HA to the FA that is currently serving the MS and HA encapsulates the packets for the MS

Wireless Networks

Problem 10 Solutions

P10.2

What are the differences between OSI and TCP/IP protocol models? Explain clearly.
[Solution]
These are the differences between OSI and TCP/IP protocol models:
- The OSI model consists of *7* layers, whereas the TCP/IP model consists only *5* layers.
- In the TCP/IP protocol suite, the application layer serves the purpose of the three combined layers of application, presentation and session. The OSI model made a clear distinction between the top
three layers. Each application in the TCP/IP suite has to independently implement the session and presentation layer functions.
- The OSI suite was put forward before the protocols were invented whereas in the case of TCP/IP, the model was a description of the existing protocols.
- The OSI model supports connectionless and connection-oriented communication in the network layer, and only connection-oriented in the transport layer. TCP/IP supports only connectionless communication in the network layer, and provides a choice of both connectionless and connection-oriented communication in the transport layer

P10.7
With suitable examples? Explain the differences between a connection-oriented and connectionless protocols.
[Solution]
A connection-oriented protocol needs the client and the server to establish a connection with the help of control packets, before the transmission of any data packets. This is termed as a handshake between the client and the server. The handshake procedure serves to negotiate certain parameters such as determining the ‡ow control so as to prevent the receiver from being overwhelmed, establishing the sequence numbers between the two parties etc.
A connectionless protocol does not involve any handshaking mechanism between the two parties before data transfer. The sender can directly send a data packet to the receiver irrespective of whether the receiver is ready to accept it or not.
The advantage of a connectionless protocol is that it does not require the overhead involved with establishing a connection, thereby improving the time required for the first packet to be received by the receiver. This is useful when the sender needs to intermittently send a few packets, and so the time spent on establishing the connection is not justified.

P10.11
What are the particular advantages and disadvantages of using a split TCP approach for wireless networks?
[Solution]
The advantage of the split TCP approach for wireless networks is that it hides the mobility of the receiver from the sender. Its disadvantage is that the TCP connection between the sender and the receiver gets split at the intermediate BS and does not maintain end to end.

P10.16

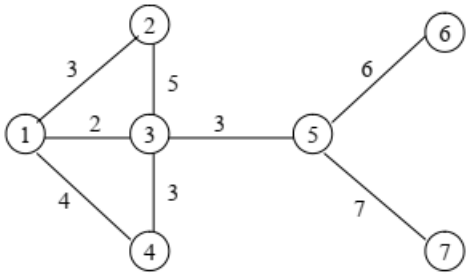
Both I-TCP and M-TCP are split TCP approaches to improving the performance of wireline TCP over wireless networks. What is the difference between these two approaches?

[Solution]

In M-TCP, the receiver can make the sender enter the persist mode by advertising a zero window size in presence of frequent disconnections. In I-TCP, all the support needed for handling the mobility related problems, is built into the wireless side of the interaction. Handoff between two differences MSRs is supported on the wireless side without having to re-establish the connection at the new MSR.

P10.19

How many iterations are needed to calculate the shortest path to all nodes from node 3? Find the shortest distance to each node and what is the path used for each one of them?



2 iterations are required to calculate shortest paths from node 3.

The shortest paths from node 3 are:

Destination Node	Distance	Path using Nodes
1	2	3-1
2	5	3-2
4	3	3-4
5	3	3-5
6	9	3-5-6
7	10	3-5-7

Wireless Networks

Problem 12 Solutions

P12.1.

What are the major differences between 802.11a and 802.11b protocols? Explain clearly.

[solution]

802.11a and 802.11b use different radio technologies and portions of the spectrum, they are incompatible with one another.

P12.4.

An AP covers an area of 50000 m^2. An area of area of 10000000 m^2 is to be covered by many Aps. How many Aps will be needed if deployed in a mesh topology?

[solution]

$$\frac{10000000}{50000} = 200$$

P12.11.

What is the operational difference between 802.11b and 802.11n?

[solution]

802.11n use MIMO which has multiple separate receive and transmit paths and OFDM modulation which has better performance

P12.15

in a given large institution, there are two types of APs, pre-installed 802.11g APs and newer 802.11n APs. What are the advantages and limitations of such a deployment? Explain clearly.

[solution]

Different types of APs allow different coverage area as well as different bandwidth. So, they can be tailored in the areas based on underlying requirements. Off course, not all users can experience the high data rate of new APs.

13.1 What are the differences between cellular and ad hoc networks?

Answer:

Cellular network model supports the needs of wireless communication by installing BSs as access points. Communications between two mobile nodes completely rely on the wired backbone and the fixed base stations. In an ad hoc network, no such infrastructure exists and the network topology may change dynamically in an unpredictable manner since nodes are free to move in an arbitrary direction with a random speed.

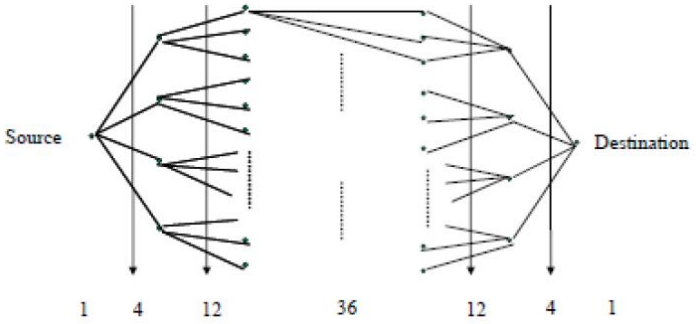
13.5 In Problem P13 .4, if the destination node is located at 5 hops apart from a given source node, what is the maximum possible value of

(a) tbe number of alternate paths of length of 5 hops?

(b) alternate disjoint paths of length of 5 hops?

Answer:

(a) Alternate paths means a source node S can take A-B-C to destination D, it also can take M-L-N to destination D if the formal link fails. If the destination node is located at 5 hops apart from a given source node, every node is connected to exactly 4 adjacent node, therefore, source can connect with four adjacent node, among these four adjacent nodes, every node mostly can connect with another 3 nodes, then from 4 nodes arrive to destination. Therefore, there would be 4*3*3*1*1 = 36 alternate paths (maximum).



(b) (b) For disjoint-ness, no intermediate node should be common among the paths. One simple way is to have a unique path between 12 nodes after 2 links from either source or destination, giving 4 x3x1x4 = 48 disjoint paths (maximum).

13.11 Consider an ad hoc network in which communication (message or packet transfer) is to take place from node X to node Y. The route has already been established, and a data packet is to be transferred over *n* hops. To transfer the packet, the kth node uses the following medium access protocol :

- **It waits for time *t(k)* after which the channel becomes free. *t(k)* = kαtime units.**
- **It transfers the data packet to the next hop. This takesαtime units.**
- **It receives an acknowledgment. This takes another α/2 time units.**

The time *t(k)* before the kth node actually transmits the data packet is given by *t(k)* = kαtime units.

(a) Find an expression for time taken for the data to cover *n* hops

(i.e., from node 1 to node n+1).

(b) If the time taken to traverse *n* hops is $T = 2n\sqrt{n\alpha}$, what is the value of *n*?

Answer:

(a) For node I, it waits for time t(i) = i *α time units, then it transfers the data packet to node (i+1), this takes α time

units. Then it waits for acknowledgement, which takes α /2 time units. Therefore: from node 1 to node n + 1, there would be

$(\alpha + \alpha + \alpha/2) + (2\alpha + \alpha + \alpha/2) + (3\alpha + \alpha + \alpha/2) + \ldots\ldots (n\alpha + \alpha + \alpha/2) = (n^2/2 + 2n)\,\alpha$

(b) n = 4

13.15 What are the advantages and disadvantages of reactive and proactive protocols? Which one would you prefer and why? Explain with specific conditions.

Answer:

Reactive protocols:

Advantages:

(a) The routing protocol is active only when data is required to be transmitted between nodes.

(b) Storage of all routes not required.

Disadvantages:

(a) Latency involved when data needs to be transmitted due to non-availability of routes.

(b) Useful Scenarios: Light traffic scenarios, where proactive protocols would incur high overhead. Attractive for large networks.

Proactive protocols:

Advantages:

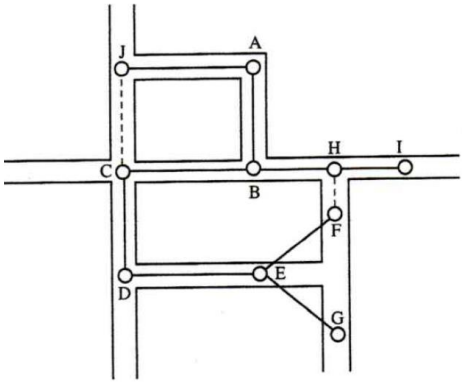
(a) Data does not face any latency due to route updates and can be sent fast.

Disadvantages:

(a) Protocol is active at all times, even when data is not being transmitted.

(b) Storage of all routes required.

13.21 A VANET in a city area is shown in Figure 13.15. What is the transmission path you would select to send a message from device G to device A?



Answer:

There are three possible solutions such as:

- G E F H B A
- G E D C J A
- G E D C B A

14.1 What are the similarities and differences between ad hoc networks and sensor networks? Explain clearly

Answer:

Ad hoc networks have characteristics of band width-constrained, and energy-constrained operation. Wireless sensor networks also have such characteristics. While ad hoc networks have dynamic topologies, nodes are free to move, the mobility of nodes in a sensor network is very limited. Wireless sensor networks are 'data centric', unlike traditional networks where data is requested from a specific node. A wireless sensor network is a collection of tiny disposable and low power devices. The routing protocols proposed for all the traditional networks are point-to point and so these protocols are not well suited for wireless sensor networks.

14.3 In a sensor network, the energy consumed by different functions by a sensor is as follows:

Mode	Energy Consumed (in nJ/bit)
Sleeping mode	0
Sensing or idle mode	0.5
Aggregation	5
Communication to cluster head	100
Cluster head to BS	1000

Assume the total number of nodes as *P*, the number of cluster heads to be *m*, the number of sensor nodes which send their data to different cluster heads as *n*, and the frame size to be *B* bits.

(a) Find the power consumption, during a frame time period if sensing and communication is done during every frame, assuming the other half of the nodes are sleeping at that time.

(b) Find the power consumption in the idle frame when sensing and communication to the CH is done in every alternate frame. Remember that power is consumed even in the sleeping mode of the cycles, when sensing is not carried out.

(c) Find the total power consumption in different frames if sensing is done every other cycle, while transmission to CH is done every fourth frame.

(d) Repeat part (b) if there are 10 clusters, with each cluster consisting of 8 sensor nodes and aggregation done by CH every 8 frames while CH to base station communication takes place every 16 frames.

Answer:

In a sensor network, the energy consumed by different functions by a sensor, is as follows:

-Sleeping mode is 0:

-Sensing mode is 0:5:

-Aggregation is 5:

-Communication to cluster head is 100:

-Cluster head to BS is 1000:

-Energy consumed is in nJ/bit.

Assume total number of nodes is P.

Assume number of non-cluster nodes is N.

Assume number of cluster heads is M.

Assume size of frame in bits is B.

(a) Sensing and communication is done during every frame, assuming other half nodes are sleeping at that time. Assuming that half of both cluster and non-cluster nodes are active at any time. Therefore, the power consumption during a frame time period is

0:5 *(N +M) * 0:5 + 5 * 0.5 *M + (0.5 * N *100 + 1000 *M) *B

= 0.25 *N + 2.75 *M + 50 * N * B + 1000 *M * B:

(b) Sensing and communication to CH is done in every alternate frame.

Remember that power is consumed even in sleeping mode of the

cycles, when sensing is not carried out. Therefore, the power consumption in the idle frame is 5 *(N +M).

(c) There are 4 types of frames

- Idle frames: 5 *(N +M) or 500 nJ
- Sensing frames: 0.5 *(N +M) or 50 nJ (When the sensing and transmission do not coincide)
- Transmission frames: 100 * N * B (When the sensing and transmission do not coincide)
- Sensing and transmission frames: 0.5*(N +M)+100*(N +M) (When the sensing and transmission do coincide)

(d) There are 4 kinds of sensing frames

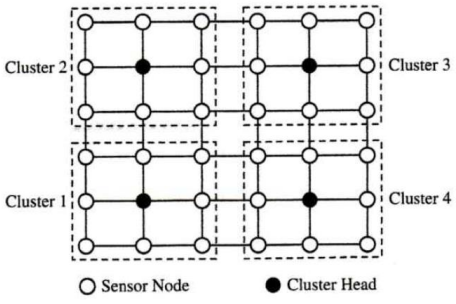
- Sensing frames: 0.5 * (N +M) or 40 nJ (When the sensing, aggregation and transmission do not happen)
- Sensing frames with aggregation: 0.5 *M + 5 *M = 5.5 *M or 27.5 nJ (Only the cluster heads before sending to BS)
- Sensing frames with communication to BS:
  0.5 *M + 1000 *M or 5002:5 nJ
- Sensing frames with aggregation and communication to BS:
  0.5*M + 1000*M + 50*B or 10005 nJ +50* B nJ.

14.8 Using the energy consumption by different functions in a sensor of Problem P14.2 , determine the energy consumption in the following topologies:

(a) How much energy is consumed for transmission to the CH?

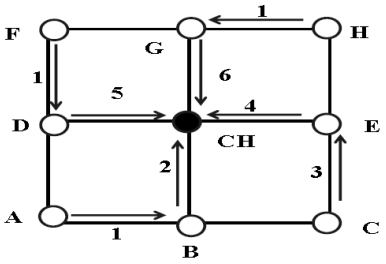
(b) How much energy is consumed to send data to the BS?

(c) What is a good location of the BS? Justify your answer.



Answer:

Each cluster has 8-sensors with each CH. All these 8-sensors need to send data to the CH located at the center as shown in the Figure.



(a)100 * 8 * 4 = 3200(nJ)

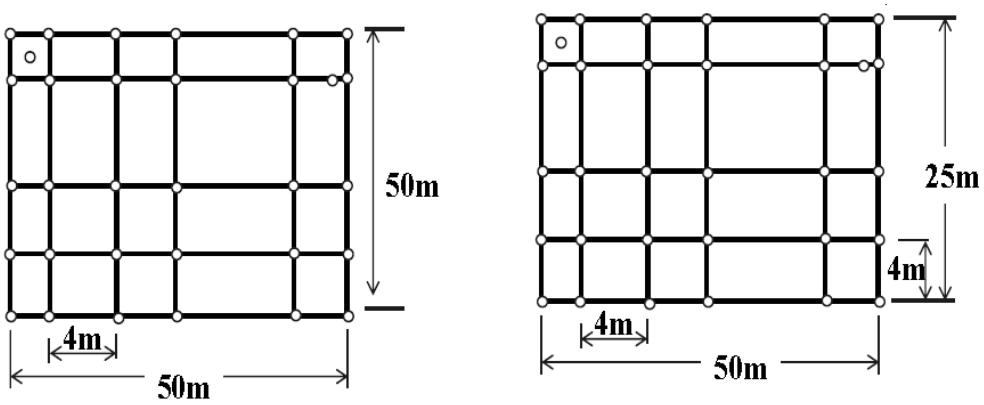
(b)1000 * 4 = 4000(nJ)

(c) It should be placed in the middle of the 4 CHs, so that the distance between the 4 CHs and the BS is as equal as possible.

14.13 A wireless sensor has a transmitter/receiver range of 2 m, and many such sensors need to be installed in a nuclear plant building of size 50 mx50 m with the height of 25 m. Can you think of an efficient arrangement of the sensor arrays assuming sensors can be placed anywhere in the plant? Explain clearly.

Answer:

We arrange the sensors as shown in the following Figure where we would have complete coverage of all of the nuclear plant building sensing all kinds of attributes. The distance between two adjacent sensors is 4 m.



The total sensors we need is:$(\frac{50-2}{4}+1)(\frac{50-2}{4}+1)(\left\lceil\frac{25}{4}\right\rceil+2)$=1521

14.17 Why do you use a "data-centric" approach in a sensor network?

Answer:

Data centric approach is used in sensor networks to save energy with the help of aggregation. In this approach instead of the traditional address centric approach we follow the data centric approach for establishing the routes.

15.6 Do Bluetooth devices and household microwave ovens interfere with each other? Explain.

Answer:

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.

15.8 In a hypothetical wireless system , five adjacent frequency bands (f1, f2, f3, f4, f5) are allowed for frequency-hopping sequences. Enumerate how many different hopping sequences a re possible and prove their correctness.

Answer:

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.

15.10 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, quantity the fraction of time during which such an interference may be present.

Answer:

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

15.14 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.

Answer:

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.

15.18 What is the rationale behind using different slot sizes in Bluetooth? Explain clearly.

Answer:

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.