Problems and Solutions (Chapter 11)

1. What is the rationale behind using highly elliptical orbits? Explain.

   [Solution]

   In an elliptical orbit the earth is situated at one of the focuses of the orbit and the satellite moves quicker at perigee (the point of the orbit that is nearest to the earth), than in apogee (the point of the orbit that is the most distant from the earth). Such highly elliptical orbits are used for satellite telecommunication. Unlike the geostationary orbit, the satellites on elliptical orbits can "see" the poles of the earth. At apogee, the satellite moves slowly and hangs there for several hours. During these several hours, the satellite provides stable telecommunication, and then its place is taken by another satellite. Thus, several satellites in elliptical orbit are used to provide more stable telecommunication.

2. What will be the propagation delay between a satellite and an earth based mobile station, if the satellite is located at a distance of 850 kms and if its inclination angle is 35°?

   [Solution]

Distance of the Satellite	$h = 850$ kms
Inclination angle	$\theta = 35$ degrees
Radius of the Earth	$R = 6,370$ kms
Speed of light	$c = 300,000$ kms

   $$\text{Propagation delay between the satellite and earth} \tag{3}$$
   $$= \frac{1}{c}\left[\sqrt{(R+h)^2 - R^2\cos^2\theta} - R\sin\theta\right]$$
   $$= 0.00454655 \text{ sec}$$

3. The beam foot print depends on the inclination angle. What will be the impact on the coverage if the angle is changed from 35 degree to 30 degree? Explain clearly.

   [Solution]

4. What should be the velocity of the satellite if it orbits around the earth at a distance of 1,000 kms and weighs 2,000 kgs?

   [Solution]

Distance of the satellite from earth	$r = 1000$ kms
Radius of the Earth	$R = 6,370$ kms

$$\text{Velocity of Satellite, } V = R * \sqrt{\frac{g}{r}}$$
$$= 6370 * \sqrt{\frac{0.00981}{1000}}$$
$$= 19.95 \text{ km/s}$$

5. If the isoflux area boundary is fuzzy, what should you do and what will be an overall impact on the system performance? Explain clearly.

   [Solution]

   The quality of the signal may be influenced greatly if the MS is in the boundary area of the isoflux.

6. Setting up a path for a satellite phone subscriber requires a comprehensive hand shaking mechanism between the MS, the satellite, and the BS. Prepare the steps that are desirable in setting up such a path and comment on how you could possibly minimize traversal of signals between the satellite and the MS/BS?

   [Solution]

   The steps involved in setting up a path for a satellite phone subscriber are:

   For an incoming call:

   (a) The gateway helps to reach the closest BS from the PSTN.

   (b) It then uses the HLR-VLR pair to indicate the satellite serving the most recently known location of the MS.

   (c) The satellite employs a paging channel to inform the MS about an incoming call and the radio resource to use for the uplink channel.

   For a call originating from an MS:

   (a) The MS accesses the shared control channel of an overhead satellite.

   (b) The satellite in turn informs the BS for authentication of the user/MS.

   (c) The BS then allocates a traffic channel to the MS via the satellite and also informs the gateway about additional control information, if it is necessary to route the call through the backbone.

7. What is the information content if an average of 2-way diversity is used in a satellite system for 10 % of time by 50 % of the traffic and 5 % of time the rest of the traffic?

   [Solution]

2-Way diversity is used for 10% of the time by 50% of the traffic and 5% of the time by the rest of the traffic. The time diversity is used $= (10 * 0.5 + 5 * 0.5)\% = 7.5\%$.

If the total data transmitted is X then the information content

$$\begin{aligned} I &= \frac{X}{\left(\frac{7.5X}{100}\right) * 2 + \frac{92.5X}{100}} \\ &= \frac{X}{\frac{15X}{100} + \frac{92.5X}{100}} \\ &= 0.93 \end{aligned}$$

8. In Problem 11.7, if (128, 32) code is used for error correction, what is the fraction of information contents?

   [Solution]

   (128, 32) code is used for error correction.

$$\begin{aligned} \text{Information Content } I &= 0.93 * \frac{32}{128} \\ &= 0.232558 \end{aligned}$$

9. A code (n, k, t) is defined by k information bits and $(n - k)$ redundant bits so as to correct t errors in the resulting word of n bits. Given a channel bit error rate of p, what is the word error rate (WER)?

   [Solution]

$$\text{WER} = \sum_{i=t+1}^{n} \binom{n}{i} p^i (1-p)^{n-i}.$$

10. What are the differences between orbital and elevation angles of a satellite? Explain.

    [Solution]

    The elevation angle is the angle between the satellite beam and the surface of the earth. Orbital angle is the angle between the equatorial plane and the plane of satellite orbit.

11. What are the advantages and disadvanges of LEO and GEO?

    [Solution]

    LEO:

    Advantage:

    - Reduced launch costs to place in low Earth orbit.

- Much reduced pas loss,
- Much shorter transmission delays.

Disadvantages:

- When in the low orbit, satellite lifetime dramatically educed.
- Short visibility from any point on earth demands large constellations.
- Radiation effects reduce electronics lifetimes.

GEO:

Advantages:

- Need no ground station tracking since its stationary.
- It is permanently in view, no inter-satellite handoff.
- Larger area of earth surface in view of one satellite, three satellites give full earth coverage
- Almost no Doppler shift.

Disadvantages:

- Long transmission latencies
- Weak received signal
- 3Dost not provide good coverage at high latitud

12. How do you compare delays in a satellite system versus a cellular system, versus an inter-terrestial satellite system? How about the power level, coverage area and transmission rates?

    [Solution]

    The one-way delay in a satellite system involves the transmission from the mobile station to the satellite and the satellite to the earth station. In cellular system, the delay is much smaller, since the wireless transmission is from the mobile station to the base station, and the distance is much shorter. Inter-terrestrial satellite system involves the transmission from the mobile station to the satellite, from the satellite to the earth station, from the earth station to another earth station, from earth station to the satellite, from the satellite to the destination mobile station and could be substantially large.

13. How is the call setup in a satellite system different from a cellular system? Explain.

    [Solution]

    The call setup in satellite system is similar to a cellular system. The difference is in satellite system where the call setup involves the earth station. The earth station assigns the channel and connects to the gateway.

14. In the satellite system, there is some degree of free space loss. Beside this loss, does it have any other source of loss, explained?

    [Solution]

    Yes, there are feeder losses, antenna misalignment losses, fixed atmospheric and ionosphere losses and effects of rain.

15. Why can there be more than one satellite orbiting in a single orbiting path of GPS?

    [Solution]

    The GPS system is divided into six orbital planes with four satellites in each orbital plane covering the entire earth under its signal beams. The spacing of the satellites is arranged such that at least five satellites are in view at any given time, from any point on earth.

16. Why are errors inherent in the triangulation technique? Explain clearly.

    [Solution]

    Triangulation is based on the range estimation using wireless signal. Since wireless channel is dynamic, and fading exists in the wireless path, there is error in the range estimation based on wireless signal. Thus, triangulation inherently has errors.

17. Is it possible to find a precise location inside a building or a room where GPS will not work? Explain.

    [Solution]

    While sometimes we can get a position inside a building when close to a window, the GPS antenna normally will not receive sufficient signal strength from the satellites to acquire from inside a building. It does not take much at all to obscure the high frequency and relatively low power GPS transmissions and a tin roof is more than enough to block the signals. Atmospheric conditions and satellite positions also affect reception, therefore we may find that sometimes we can get a position with an antenna mounted inside or another poor location, but at other times of day we do not. One way of achieving this indirectly is to use an external GPS observeable object as a reference and use the relative distance between the reference and the object inside the room (This has to be done by other wireless techniques).

18. From your local wireless service provider, find out if emergency 911 service is provided in your area and what kind of technique is used in location determination.

    [Solution]

    Find out from a local wireless service provider.

19. What are the different alternative techniques for determining location using cell phones? Explain the role of beacon signals.

    [Solution]

    Yes, the techniques used by satellites, can also be used by the cell phone BSs in determining the location of a MS. This implies that the MS needs to be observeable by at least 3 adjacent BSs (preferably 4). Relative distance, angle, or phase of the signal from a MS to 3 BSs can be used to compute the obsolute location of the MS and beacon signals can help measuring these parameters.

    Designing a geolocation system could be much easier if the receiver knew roughly where it was and what signals it should be looking for. Hence, assisted GPS system has recently been proposed to handle the need to locate cell phone within a few tens of meters.

    Assisted GPS leverages the following facts

    (a) the nodes have a means to communicate with an outside server

    (b) the position of node relative to the outside server is roughly known and

    (c) it is possible and inexpensive to build high quality GPS receivers to the ouside servers to assist in determining the location of the node.

    The most had problem is finding the satellite's signal in the background noise. Yet if the rough location of the node relative to the server is known, the server could calculate the signal that receiver should see. With this added information, the receiver's search space is much smaller and the receiver can actually make intelligent guesses about where the signal is. In the cell phone system, the system roughly to switch between cells. The BS would know the visible satellites and their Doppler frequency shift, which could be fed to the receivers to make it easier from them to find the needed signals. Other isses include the need of synchronization between BS clock and MS clock and elimination of multipath signals.

20. How is the location of packets/parcels updated by United Parcel Sservice (UPS) or Federal Express (Fedex)? Explain clearly.

    [Solution]

    Both UPS and Fedex employ wireless devices based tracking system that is updated in a distrbuted manner.

21. What are some of possible uses of GPS?

    [Solution]

    Some unusual uses of GPS are:

    (a) Some people install a GPS in their model airplanes. Later, after the flight is over they can download a track of the path taken.

(b) You can search for confluences. These are spots on the earth where the latitude/longitude numbers all zero out to an exact whole degrees. There are people that think these are fun places to find! One can also look for government survey markers scattered around the world.

(c) Future location of buildings won't include any traditional addresses but only latitude/longitude coordinates.

(d) Golfers can use a GPS to display the distance to the pin. Useful for picking the right club to use.

22. How do you compare the functionality of an earth station with the corresponding unit the cellular system?

[Solution]

The corresponding unit in cellular system is base station subsystem (BSS). In cellular system, BSS includes base station and mobile switching center (MSC). Mobile station communicates with the base station and the base station connects to the MSC which connects to the PSTN. Base station controls and allocates the wireless channels. In satellite system, a mobile station communicates with the satellites and the earth station connects to gateways which connect to the PSTN. Earth station also provides control and allocation for the wireless channels. Earth Station also includes HLR/VLR functionalities, which provide mobility management.