Mobile Communications
Problem Set 12

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1. What limits the maximum number of simultaneously active users in TDM / FDM systems in comparison to a CDM system?

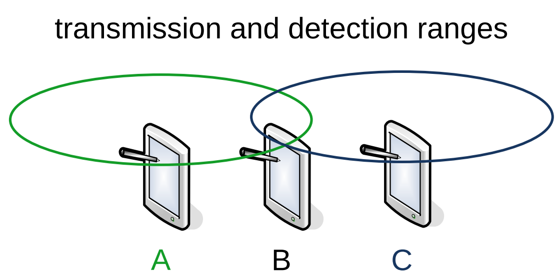
   Solution:

   - TDM: Number of time slots
   - FDM: Number of frequency bands
   - CDM: The signal to noise ratio (SNR). In CDM systems additional users add to the noise such that new users are only admitted as long as the SNR is sufficient for signal decoding.

2. Explain the problems known as "Hidden station" and "Exposed station" using a sketch.

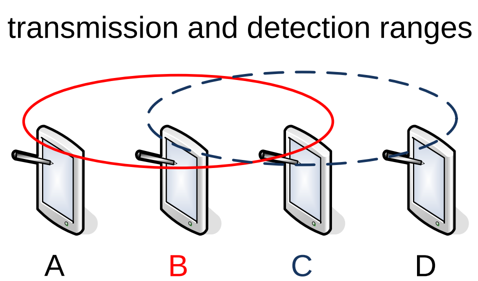
   Solution:

   Hidden station problem:



   At B a collision occurs because A is hidden from C and C is hidden from A. A senses free medium and starts sending to B. In the same time C cannot hear A. Then C senses free medium and starts sending to B. Since A cannot hear C both are sending at the same time to B. A collision occurs at B.

   Exposed station problem:



C is exposed to the transmission of B, i.e., C cannot send to D as long as B is sending to A. This happens because B and C both want to send data and both can detect the transmission of each other. So B starts sending to A before C starts sending. C listens to the medium and detects that it is busy and does not start sending to D. However, since D is outside the transmission range of B it would have been able to correctly detect the signal from C without any collisions.

3. Consider the project of covering a large hall (dimensions: 250m x 450m) with Wifi. We use Wifi Hotspots with transmission power of 63 mW and 2 dB antenna gain. The handheld devices using Wifi want to achieve the highest possible data rate, i.e., the highest modulation and coding scheme which is supported at a sensitivity of -65 dbm. Calculate the maximum radius R of one Wifi cell given a path loss coefficient of $\gamma = 2.5$. Hint: Remember that Wifi uses a frequency of 2.4 GHz. Now that we know the radius R of one Wifi cell we can calculate the signal to interference ratio (in dB) assuming that we use 12 Channels (i.e., cluster sizes of $N = 12$).

   Solution:

   - wavelength $\lambda = c/f = 0.125$ m

     $$85dB = 25 \log(4\pi R/\lambda)$$

     such that $R = 25$ m.
   - using $D/R = \sqrt{3N}$ we get $D = 150$
   - The signal to interference ratio is then given by

     $$\frac{S}{I} = 10 \log \left(\frac{1}{6} \left(\frac{D}{R} \right)^{\gamma} \right) = 11.67dB$$

4. Consider two stations using a slotted reservation ALOHA system. The considered simplified system contains one short reservation slot of length x followed by a corresponding transmission slot of length $10x$. This pattern is repeated continuously. A station makes a reservation in the reservation phase with probability p. Assume statistically independent stations. In case of a successful reservation a station obtains the corresponding timeslot. Use the renewal reward theorem to calculate the long term throughput of the system.

   Solution:

   Considering the renewal reward theorem, the solution S is given by the relation of the average reward $E(R)$ and the mean inter-arrival time $E(X)$:

$$S = \frac{E(R)}{E(X)}$$

The probability of one station accessing the medium is $2p(1-p)$. Since it then gets all 10 transmission slots, the average reward is $E(R) = 2p(1-p)10$. The inter-arrival-time consists of the reservation slot and the 10 transmission slots and thus is given by $E(X) = 11$. Thus, the long term throughput is given by

$$S = \frac{2p(1-p)10}{11}.$$

5. An AWGN channel with a bandwidth of 500 kHz should be dimensioned for a data transmission. Is error-free data transmission with 10 Mbps over the AWGN channel possible, if the signal-to-noise ratio is 15 dB? Justify your answer.

   Solution:

   To answer the question, we consider the Shannon bound for AWGN channels. It states that

   $$C = B \log_2 \left(1 + \frac{S}{N}\right),$$

   where C is the data rate in Bps, B the bandwidth in Hz and S/N the signal-to-noise ratio. Rewriting the equation in terms of the signal-to-noise ratio gives

   $$\frac{S}{N} = 2^{\frac{C}{B}} - 1.$$

   Inserting the given values for C and B we obtain

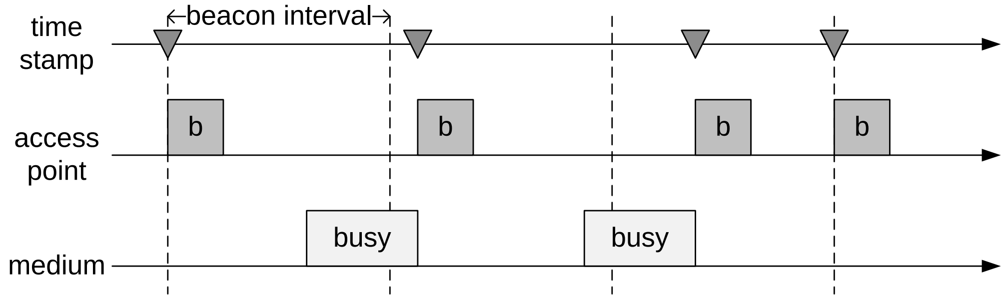
   $$2^{\frac{C}{B}} - 1 = 1048575.$$

   This results in approximately 60 dB for the signal-to-noise ratio which is much higher than the given 15 dB. Error-free data transmission thus is not possible in this scenario.

6. What function do the beacon frames perform in an IEEE 802.11 network in the infrastructure mode?

   Solution:

Beacon frames are used for synchronization. They are quasi-periodic and contain a timestamp to which nodes adjust their local clocks. In addition they include a traffic indication map (TIM) that contains a list of stations for which data is available. Hence, stations can sleep and wake up at the right time (power management!).



- Beacon frames are transmitted according to a fixed schedule
- A beacon may be delayed if the medium is busy, however, the future schedule is not changed
- The timestamp transmitted in the beacon is the actual time of sending the beacon

7. Can we completely eliminate collisions, if we use the DCF with RTS/CTS?

   Solution:

   No, we cannot completely eliminate collisions, since the RTS/CTS scheme only avoids collisions of data. RTS messages might still collide.

8. The performance of the wifi network can be influenced by changing the size of the contention window. What influence on the performance has a too large value for CW? Explain your answer briefly.

   Solution:

   The size of the contention window is a parameter for calculating the random backoff value. If the contention window size is too high, the resulting high average backoff value will cause a very low throughput.

9. Is it possible that a bluetooth device has the role of a master device in two different piconets? Why?

   Solution:

No, this is not possible, since the master device defines a unique hopping sequence for one piconet. If it would have the master role in two piconets, both would follow the same hopping sequence and thus the data would be corrupted.

10. In GSM networks who is responsible for synchronization and why is the synchronization of the utmost importance?

    Solution:

    Generally, the physical layer is responsible for synchronization. Synchronization is achieved by training sequences contained in bursts within TDMA frames. Since TDMA is used, synchronization is crucial for avoiding overlap of frames and thus possibly corrupted data.

11. What are the advantages and disadvantages of HSCSD?

    Solution:

    The main advantage of HSCSD is the achievement of higher data rates by bundling several Traffic Channels (TCH). It uses the connection-oriented mechanisms of GSM, which fits well for continuous constant bit rate streams. Yet, it usually wastes a lot of scarce radio resources considering the bursty and asymmetrical nature of typical computer data traffic (e.g. web browsing).

12. What function do the following system components have in GSM?

    BSC, GMSC, VLR

    Please, write down the full name for each abbreviation.

    Solution:

    BSC: Base station controller

    GMSC: Gateway mobile-services switching center

    VLR: Visitor location register

    The BSC is responsible for managing the base transceiver stations (BTS). Its tasks include reservation of radio frequencies, handling the handover from one BTS to another within the base station subsystem (BSS) and performing paging of the mobile station (MS).

    Whereas a regular MSC is only responsible for the management of one or more BSCs, the GMSC has additional connections to other fixed networks. It is a high-performance digital ISDN switch with gateway functions.

    A VLR is associated to one MSC. It stores all necessary information that is needed for the MS users currently who are currently in the location area associated with the MSC. It copies all relevant information about new users entering the corresponding location area from the home location register (HLR).