SYSC 5306: Mobile Computing Systems
Solutions to Final Exam, Winter 2004

Question 1. Frequency Reuse (10 marks)

Briefly explain the concept of frequency reuse that underlies cellular systems. Also explain why frequency reuse is necessary.

Answer:

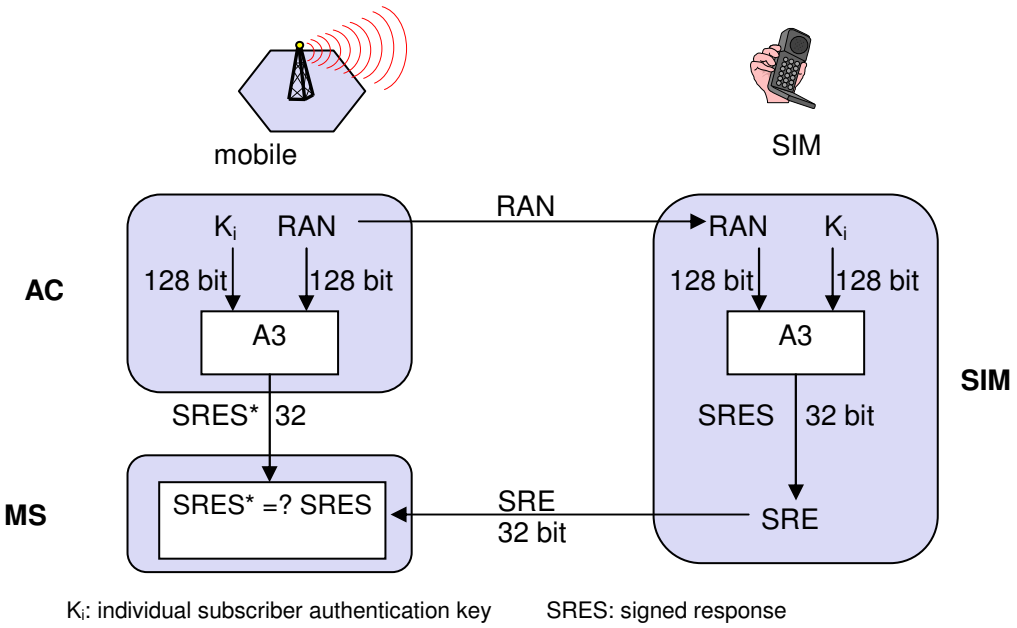
- Most cellular system cannot assign the same frequency to separate users at the same time (exception: CDMA). The use of the same frequency at the same moment by physically close senders leads to collision
- Typical solution: each cell uses only subset of frequencies, with different subset of available frequencies assigned to neighboring cells
- Each frequency set is reused eventually, frequency plan (assignment of frequencies to cells) typically follows a regular pattern such as 3, 4, or 7 groups of cells
- Reuse distance is distance between two cells that use same subset of frequencies. Distance should be such that transmissions in one cell will not cause interference in other cell (radio wave propagation attenuates with distance, empirical evidence suggests a proportionality factor of roughly r^{-4}).

Question 2. GSM (5 marks)

How are users authenticated in GSM? Explain all necessary steps, assuming that a user inserts his/her SIM into a new device in an unknown network and powers up the device.

Answer:

1. First the user has to authenticate him/herself to the SIM card, using a secret PIN
2. Next, the SIM card authenticates itself with the nextwork as follows:



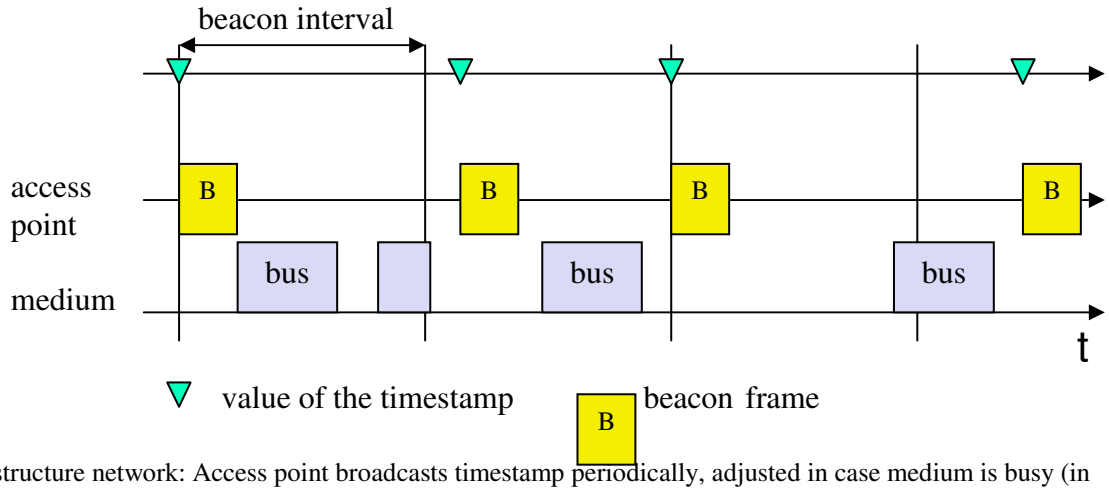
K_i: individual subscriber authentication key SRES: signed response

Question 3. IEEE 802.11 (15 marks)

Describe how clock synchronization and power saving is achieved in IEEE 802.11 for both Infrastructure Networks and Ad-hoc Networks.

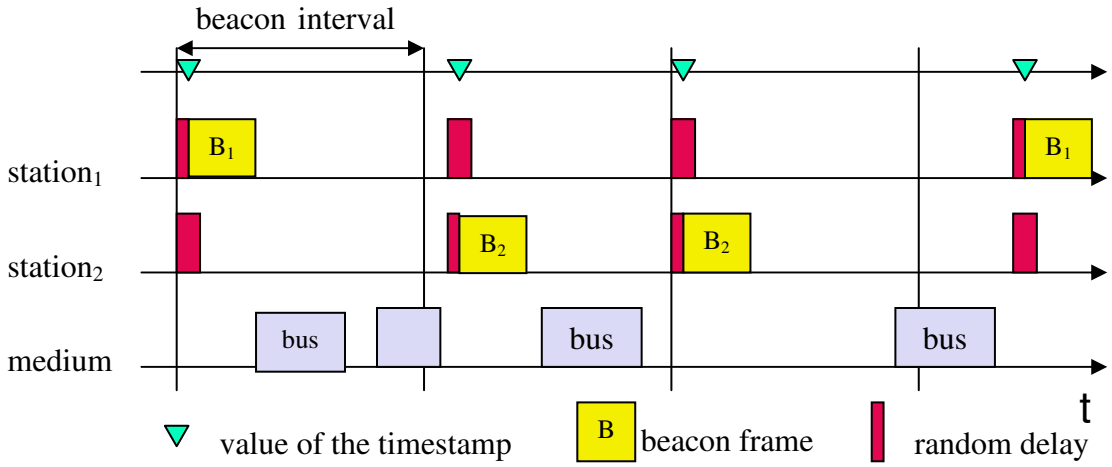
Answer:

1) Clock synchronization:

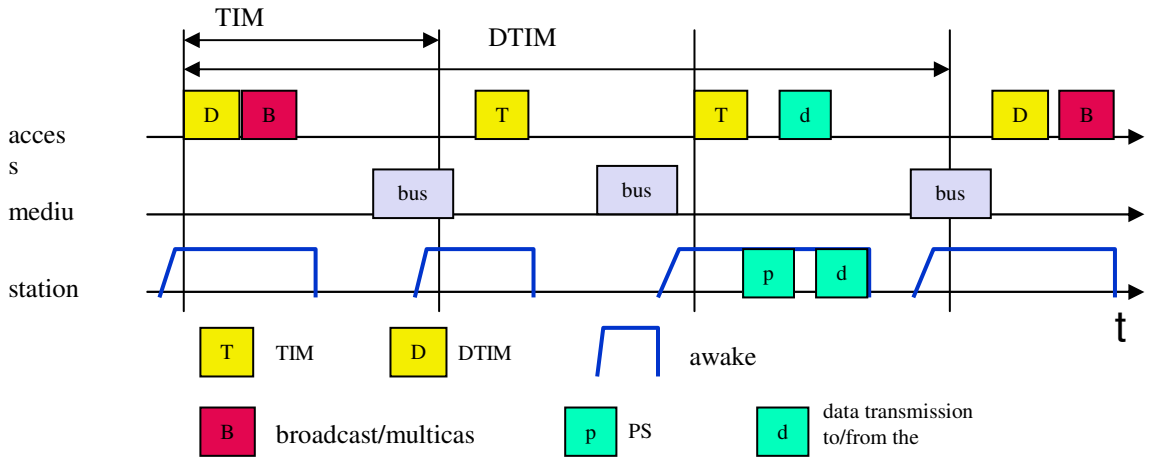


Infrastructure network: Access point broadcasts timestamp periodically, adjusted in case medium is busy (in the latter case, access point waits for medium to become idle and then broadcasts beacon, but resumes broadcasts at regular schedule….).

Without infrastructure network: stations compete to broadcast beacon with timestamp, station with shortest random interval wins (assuming medium is idle).

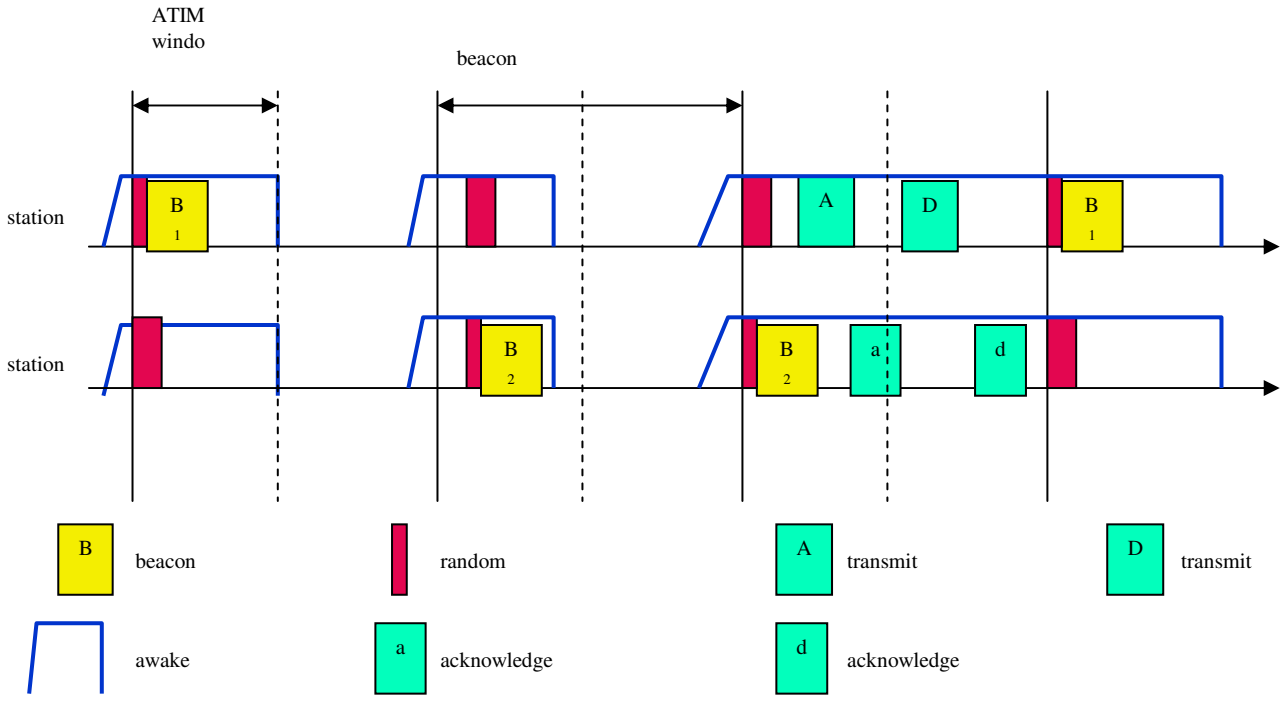


2) Power saving:



Infrastructure network: with every beacon, a traffic indication map (TIM) is sent. The TIM contains the list of stations for which unicast data frames are buffered in the access point. Mobiles have to wake up to listen to beacon/TIM. If TIM indicates a unicast frame for that mobile, station stays awake for transmission and responds that it is ready to received the frame (PS poll). Message exchange follows and the exchange can be duplex, afterwards station goes into sleep mode again. For multicast/broadcast message, mobile will also stay awake. Multicast/broadcasts are delivered every DTIM interval. As before, the beginning of an interval (TIM or DTIM) can be delayed if the medium is busy.

In ad-hoc networks, power management is more complicated: each station needs to buffer data it wants to send to a power-saving station. All stations announce a list of buffered frames during a period when they all wake up, in a structure called ad hoc traffic indication map (ATIM). The announcement window is called the ATIM window/interval.



Question 4. Snoop (10 marks)

Briefly describe

1. What problem(s) the SNOOP protocol solves (also make reference to the problems SNOOP does NOT solve)
2. How SNOOP works

Answer:

1. SNOOP is a network layer solution to address the problem of poor TCP performance over wireless links. It addresses packet loss due to transmission errors over the wireless link in the downstream traffic, and has limited support for upstream traffic and packet loss due to handoff. Also, SNOOP was not designed for multihop wireless communications.
2. Basic idea: modify network layer software at base station (so changes are transparent to MH and FH). SNOOP does not cause changes in TCP semantics (unlike I-TCP). Modifications are mostly in caching downstream TCP packets and performing local retransmissions across the wireless link by monitoring (*snooping*) on TCP ACKs from MH. These ACKs are also used to delete packets from SNOOP cache.

Question 5. System Support (10 marks)

1. What problems do distributed file systems face in a mobile environment?
2. How does CODA solve these problems?

Answer:

1. What problems do distributed file systems face in a mobile environment?

   Consistency:
   - are all views on data the same?
   - how and when should changes be propagated to what users?

   Limited Connectivity

2. How does CODA solve these problems?

   Consistency:
   - system keeps a record of changes in files and compares files after reconnection
   - if different users have changed the same file a manual reintegration of the file into the system is necessary
   - optimistic approach, coarse grained (file size)

   Limited Connectivity:
   - multiple client states to reflect the state of connectivity: strong, weak, or disconnected
   - if strongly connected, use hoarding to download many files to client to prepare for periods of disconnectedness:
     - user can pre-determine a file list with priorities
     - contents of the cache determined by the list and LRU strategy (Last Recently Used)
     - explicit pre-fetching possible
     - periodic updating