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# BLG609E - Special Topics: 4G Wideband Wireless Network Architectures

(Spring 2012)

## Homework-4: Location Management

1. Determine which radio frame number (SFN) i.e (SFN mod T) and which subframe within the SFN the UE monitors for page message, from Slide 10, given the following parameters (5 POINTS)

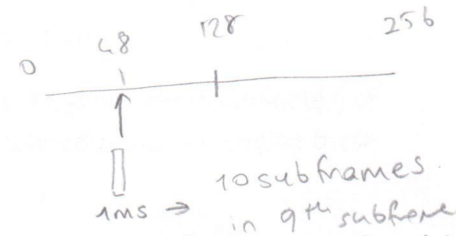
$T_{ue}$ = 128 frames ( UE specific paging cycle )
$T_c$ = 128 frames ( cell specific paging cycle )
$N_f$ = 0.25 (1/4), i.e every 4th radio frame contains 1 paging subframe (number of paging subframes in a radio frame that is used for paging)
IMSI = 172

MME
| page request (last 10 bits are used!)
eNB (not full IMSI)

- System Frame Number calculation:

$T = \min\{T_c, T_{ue}\} = 128$

N : number of paging frames within the paging cycle of the UE
$= \min\{T, \text{number of paging subframes per frame} * T\}$
$= \min\{128, \frac{1}{4}128 = 32\} = 32$

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$SFN_{modT} = \frac{T}{N}\,(UE_{id\,modN}) = \frac{128}{32}\,172_{mod32} = \frac{128}{32}\,12 = \mathbf{48}$

10 subframes
in 9th subframe listens for its page message.

- Subframe # in SFN where UE monitors for page message:

Note: Pages may only be present in the subframe { 0, 4, 5, 9 }

Ns: max { 1, $N_f$ } = { 1, 0.25 } = 1.

$i_s$ : index to a table containing the subframes with a radio frame used for paging
$= \left\lfloor \frac{UE_{id}}{N} \right\rfloor_{modNs}$
$= \left\lfloor \frac{172}{32} \right\rfloor_{mod1} = 0$

Subframe number : **9** (slide 12 in [1])

2. Propose one scheme for location update and paging, which is not a static location update scheme (i.e not a single-cell scheme or fixed location area update scheme). This scheme can be one of the schemes discussed in class. For the proposal: (5 POINTS)

   1. Describe the location update scheme, i.e what is the shape of the location area and when the UE will perform location updates. Explain how your scheme handles the case when the UE is stationary. [The network wants to keep track if the UE is "alive", i.e ON and able to communicate with the network, by getting a heart-beat from the UE every, 10 hours (say), without having to page the UE].

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R L.A.

will not the radius always be 'R' here

you probably may want to take Δt into account for allocate 'R'.

**Location update scheme:** A simple profile based scheme is proposed: the last 2 locations of a MU is kept and the location update area set is given as: cells that fall in a circle having current location as center and distance between last two locations is the radius. The idea behind this profiling is that user will protect its speed but may not protect its direction. (Similar to a random walk model)

**Location Area**: Location area is thought to be consisting of non overlapping TAs.

**Location update**: At each update, UE is informed with a set of TAs calculated with a new and dynamic range (that is calculated as difference of its last known two locations). The UE will make a TAU if he passes to another TA that is not existing in the list.

**Paging:** intelligent paging based on user last two locations. User is first paged in cells within a circle centered at its last known location and the radius of two last locations' difference (in the set previously proposed to UE). Then will expand the paging area.

why do you need to expand this?

**UE stationary case:** intelligent paging then will compute a distance of 0 (last two known locations are the same) and will page only last known TA.

2. Describe a basic paging scheme to locate the UE, i.e in what cells will the UE be paged.

   Paging is described above.

3. Describe what data is stored in the MME for such a paging scheme.

   MME has to keep track of last known two locations (not just their $TA_{ID}$s but also coordinates) of UE. And nearby cell boundaries to decide which cells fall in calculated radius for paging these cells.

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4. Describe an optimization (paging or location updating) to your scheme if the MME keeps track of the last n (say 5) cell ids where the UE performed location update and the time when the UE made these updates, i.e ({xi,yi},ti), i=n, n-1, n-2, n-3, n-4, where n is the latest location update, {xi,yi} is the (lat,lon) of the cell from which the UE performed the i-th location update and ti is the time of the i-th location update. Also, explain how your optimization performs in the two extreme cases (a) UE is stationary, and (b) UE is moving very fast in a linear direction.

   **Optimization proposed on location update:** Calculte the average speed from these 5 points. And try to guess the sixth speed (can be taken equal to the average as simplest case). Also try to guess the sixth direction from last known 4 movements (e.g. think a linear movement direction and guess in a subset of directions). Propose a set of TAs that covers possible locations of UE according to previously made guesses on speed and direction.

   **UE stationary case:** Algorithm will guess a zero speed and no direction, therefore will propose a set of containing exact id of the TA UE is in.

   **UE moving fast:** Algorithm may easily catch a fast speed trend from last 5 locations and since the movement is linear, if directions are guessed properly. Even basic 4 directions of noth, east, south and west, the set algorithm will propose will most likely cover the sixth position of the UE.

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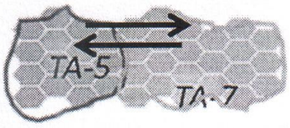
3. Consider a static location area scheme with two location (tracking) areas shown below. Each hexagon in the figure is a cell, i.e coverage area of a base-station.

1. Explain what is the problem with the "cell ping-pong effect" as described in the paper "Location Management in Cellular networks" B. Sidhu, H. Singh? (**1 POINT**)

   A mobile user can move along between similar cells (2, 3 or more but relatively small number of cells) and result in being in same cells for most of its travel. However, if the static location update scheme with location areas and boundary crossing principle is applied, he will make excessive locaiton updates. This effect is named after cell ping-pong effect [2]. For the two cell (or TA in example): a mobile user can switch between TA-5 and TA-7 repeatedly with respect to its mobility pattern. Even if the number of different locations he has been is 2, it performs excessive location updates (# of transpassings) since every time he passes a cell boundary he performs a location update according to the update scheme.




2. Now consider the following figure where there is an overlap in the tracking areas. The cells in the overlap advertise both TA-5 and TA-7. Explain how the ping-pong effect is reduced by using the TA overlap scheme. (**3 POINTS**)

   Considering a mobility pattern visualized in figur a) below, a mobile user will need to update when he transpasses further TA-5 bundary and further TA-7 boundary in return. This is the same problem in previous case and no reduce in ping pong effect. However if the mobility is within a smaller range and is like shown in below figures b or c, the mobile user does not need to make any update since its stays within the same TA (5 or 7). And the ping pong effect is reduced with the help of these kind of users.

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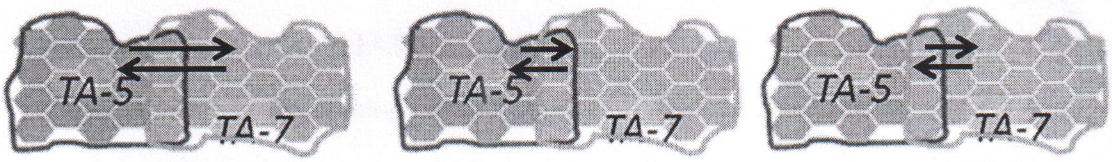


a)Mobility Pattern 1 b) Mobility Pattern 2 c) Mobility Pattern 3

3. What is one of the disadvantages of using overlapping tracking areas. (**1 POINT**)
   One of the disadvantages is the increased paging cost for the nodes that stays in the intersection area of the overlapping tracking areas. The paging is performed on both tracking areas for these users.

   → more TAs to cover an area

- REFERENCES:

[1] Ali, I. and Yegin, A. (2011). Power Management and Location Management for Wireless Networks [PowerPoint slides]. Retrieved from http://groups.yahoo.com/group/BLG609E-2012/files/

[2] B. Sidhu and H. Singh, "Location management in cellular networks," in In Proceedings of World Academy of Science, Engineering and Technology, 2007, pp. 314–319.