

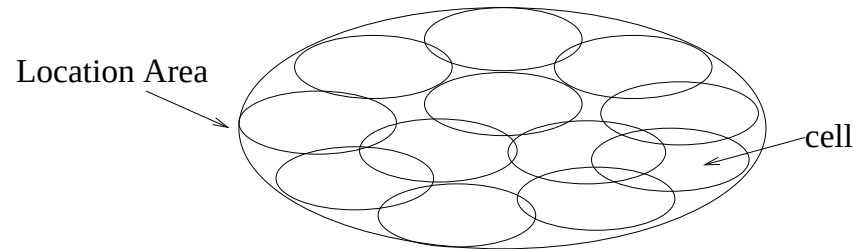
Analysis of Location Updates

Outline

- Impacts of Location Updates on Radio Resource Occupancy
- The Number of MSC/VLR Transactions

Location Updates in GSM

- A network is divided into a number of *location areas* (LAs), each of which has a unique LA identifier and comprises a number of cells.



- A mobile generates its location updates each time it detects an LA crossing. Nevertheless, if no communication has occurred between the mobile and the network for a fixed period (eg, an hour), the mobile generates a location update.
- A MSC/VLR may manage multiple LAs

Types of Location Update Procedures

- intra-VLR LU
- inter-VLR LU using TMSI (Temporary Mobile Subscriber Identity)
- inter-VLR LU using IMSI (International Mobile Subscriber Identity)

Rate of Location Updates

- Since periodic LUs occur less frequently in comparison to LA crossing LU, it can be assumed negligible.
- Omitting its derivation, the average number of crossings per hour in an LA perimeter cell is given by :

$$\lambda = \frac{v\rho L}{\pi}$$

where:

ρ = average population density in the region (MSs/ km^2)

v = average MS velocity (km/hr)

L = length (km) of the cell exposed perimeter
(ie, perimeter being part of the LA border)

Cell Exposed Parameter (L)

- Omitting its derivation, L is given by:

$$L = 6R \left[\frac{1}{3} + \frac{1}{2\sqrt{3N} - 3} \right]$$

where

R = the cell radius

N = the number of cells per LA

Number of Cells on the LA Perimeter

- In order to quantify the impact of the location updates on RF usage in a LA, we need to know N_p , the number of cells located on the perimeter of one LA . Omitting its derivation, it is given by

$$N_p = 6\sqrt{\frac{N}{3}} - 3$$

Resource Occupancy in the j -th Cell

- Using the definition of traffic intensity $A = \lambda/\mu$, the SDCCH/SACCH resource occupancy in the j -th cell due to MS LUs is given as:

$$Tr_{LU}^{(j)} = \lambda_{LU}^{(j)} \left[\sum_{i=1}^3 P_{LU}^{(i,j)} t_{LU}^{(i)} \right] \text{ (Erlangs)}$$

where

$P_{LU}^{(i,j)}$ = percentage of LUs belonging to type i for the j -th cell

$t_{LU}^{(i)}$ = average duration of type i LU

$Tr_{LU}^{(j)}$ = resource occupancy in the j -th cell due to the MS LUs

$\lambda_{LU}^{(j)}$ = number of location updates in cell j per hour

Transactions due to LUs at a MSC/VLR

Let N_{LA} be the number of LAs managed by MSC/VLR. The total number of transactions due to LUs generated in $N_{LA}N_p$ perimeter cells and processed per hour by the MSC/VLR is given as:

$$TTN_{LU} = \sum_{j=1}^{N_{LA}N_p} \lambda_{LU}^{(j)} \sum_{i=1}^3 P_{LU}^{(i,j)} T N_{LU}^{(i)}$$

where

$T N_{LU}^{(i)}$ = number of transactions processed by the MSC/VLR
due to a type i LU

TTN_{LU} = total number of transactions due to LUs

Example

Problem Statement

Use the following data for DCS-1800 and evaluate the impact of LUs on the radio resource and calculate MSC/VLR transaction load.

- Density of MS in the cell = 10,000 MS/km²
- Cell radius = 500 m
- Average moving velocity of an MS = 10 km/hour
- Number of cells per LA = 10
- Number of LAs per MSC/VLR = 5
- Number of transactions and duration of the transactions to MSC/VLR per LU for different LUs are given in the following table

Transaction Type	No. of Transactions/LU	Duration of a Transaction
Intra-VLR LU	2	600 ms
Inter-VLR LU with TMSI	14	3500 ms
Inter-VLR LU with IMSI	16	4000 ms

Radio Resource Occupancy in a Perimeter Cell

We consider two cases :

Case 1: An optimistic situation in which generated LUs in a cell are only intra VLR LUs.

Case 2: A pessimistic situation where generated LUs in a cell are inter-VLR LUs. Assume that 80% of LUs are with TMSI and 20% of LUs are with IMSI.

Solution of Case 1:

We consider the j -th cell located at the border of two LAs related to the same VLR. In this case, only intra-VLR LUs are processed in the cell.

$$L = 6R \left[\frac{1}{3} + \frac{1}{2\sqrt{3N} - 3} \right] = 6 \times 500 \left(\frac{1}{3} + \frac{1}{2\sqrt{3 \times 10} - 3} \right) = 1.377 \text{ km}$$

$$\lambda_{LU}^{(j)} = \frac{vL\rho}{\pi} = \frac{10 \times 1.377 \times 10,000}{\pi} = 43,831 \text{ LUs per hour}$$

$$Tr_{LU}^{(j)} = \lambda_{LU}^{(j)} \left[\sum_{i=1}^3 P_{LU}^{(i,j)} t_{LU}^{(i)} \right] = \frac{43,831 \times (600/1000)}{3600} = 7.3 \text{ Erlangs}$$

This requires 14 channels at 1% blocking (from Erlang B table) or $14/8=2$ TCH.

Solution of Case 2:

Consider the j -th cell located at the border of two LAs related to two different VLRs. In this case, only inter-VLR LUs will be processed in the cell.

$$Tr_{LU}^{(j)} = \frac{43,831}{3600} [0.8 \times 3.5 + 0.2 \times 4.0] = 43.83 \text{ Erlangs}$$

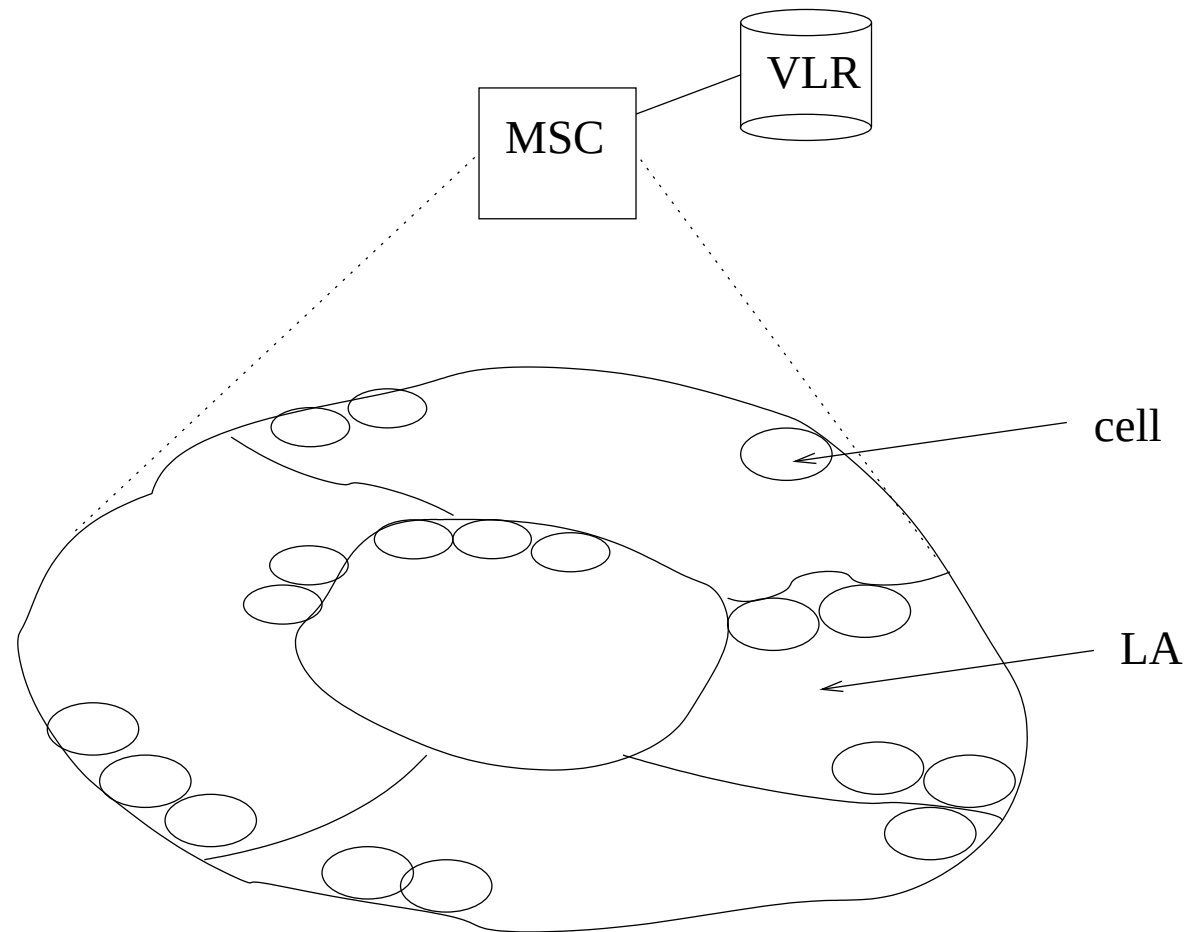
This requires 57 channels at 1% blocking or $57/8=8$ TCH.

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MSC/VLR Transaction Load

We assume that one LA is in the center of the area and the remaining four LAs are on the border of the area (see the figure in the next slide). We also assume that, in all the perimeter cells belonging to the center LA and in half of the perimeter cells at the border LAs, only intra-VLR LUs are generated. For the other half of the perimeter cells of the border LAs only inter-VLR LUs are generated. Furthermore, we assume that among the generated inter-VLR LUs, 80 percent are LUs using TMSI and 20 percent are LUs using IMSI.



The number of cells where intra-VLR LUs are generated is given by

$$N_p + \frac{4}{2}N_p = 3N_p = 18\sqrt{\frac{N}{3}} - 9 = 18\sqrt{\frac{10}{3}} - 9 = 23.86 \approx 24$$

Similarly, the number of cells where inter-VLR LUs take place will be:

$$\frac{4}{2}N_p = 2N_p = 12\sqrt{\frac{N}{3}} - 6 = 12\sqrt{\frac{10}{3}} - 6 = 15.9 \approx 16$$

Therefore,

$$\begin{aligned} TTN_{LU} &= \sum_{j=1}^{N_{LA}N_p} \lambda_{LU}^{(j)} \sum_{i=1}^3 P_{LU}^{(i,j)} T N_{LU}^{(i)} \\ &= 43,831[2 \times 24 + 16(0.8 \times 14 + 0.2 \times 16)] \\ &= 1.22 \times 10^6 \text{ transactions at peak hour} \end{aligned}$$