## Subscriber mobility modeling: location updates (+paging)

**Motivation**

Introduction of connected cars as a part of Intelligent Transportation Systems (ITS) changed substantially the user behavior and mobility models. As before only human-to-human communications took place, the average speed, mobility and traffic patterns of the users were different. The differences in these parameters have a big influence on the signaling. At the same time more complex procedures and detailed policing and charging led to the signaling “storm” in the LTE core network [1], [2] or signaling “explosion” [3] . The vendors investigate and measure the signaling load, but the values are not comparable [2], [4], [5], [6]. In the scientific world LTE signaling was seen from different perspectives, for example, authentication procedures [7], [8]. Some of the authors approached location management from the point of view of different protocols, GTP vs. PMIP, [9], OCS signaling overhead [10] or different policy realization [11]. *State-of-the-art to be completed*

There was an attempt in [12] to compare the overall core signaling load from the Release 99, where SS7 is used, and Release 5, where SIP and IMS were introduced. Although, it was interesting to see the overall increase of signaling in Release 5 compared to Release 99, a number of drawbacks could be identified:

* Signaling assessment depends on concrete release 🡪 more generic approach needed
* No consistent user behavior model (data from 1998) 🡪 how does user traffic look like now? What procedures does it trigger?
* The used average message sizes have no clear derivation 🡪 more generic approach with clear assumptions and probabilities
* Signaling is shown overall core network with no breaking down for each element 🡪 [2] shows that the signaling load is not equally distributed between the elements
* No Diameter signaling evaluation

Understanding the signaling load is crucial for correct network dimensioning. The areas of network dimensioning are:

* Signaling contributes/defines node dimensioning: MME, HSS, DEA, AAA, OCS, PCRF are dimensioned based on transactions per second
* Signaling contributes to LTE links dimensioning

Thus proper signaling models are vital for correct network planning and cost evaluation.

**Thesis description**

Thesis aims at creating LTE subscriber mobility signaling model, i.e., Location Updates. The focus of the research lies on the core network signaling, RAN is not considered. The outcome of the thesis shall be the signaling model, for which the input is variable and consists of four modules described in the Table 1 Input modules and output of the mobility signaling model. The output of the model is mobility signaling dimensioning, see Table 1. First, the appropriate input is researched/created and mathematically described in probabilistic models. Second, the numerical calculations in Matlab provide with an output.

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| **Input** | **Output** |
| Location Update scheme, e.g.:   * Static (GSM+UMTS) [13] * Tracking Area Lists (TAL), LTE [14]:   + Active and idle mobility   + Release specific parameters, 3GPP 23.4014 and 24.301: triggers, timers, procedures, conditions, default TALs, #of msgs   + TAL allocation reference schemes: see what happens if TA is not one cell | * Signaling load due to location updates per element as [2] showed that core signaling is not a direct mapping from RAN one:   + MME, HSS, GWs, OCS   + Comparison with NSN trends [2] * Answer to the question under how much mobility management (LUs) signaling would ITS users add? Dependencies on   + Parameters & conditions   + TAL scheme * Differences to H2H behavior * **Analysis of TAL adaptation for ITS mobility** |
| Mobility model:   * Analyze and adapt existing approaches, e.g., [15] * Travelling speeds and patterns specific for ITS:   + start with public as more deterministic (check works for railway)   + private * Random walking model adaptation   Define basic mobility model ([Veins](http://veins.car2x.org/documentation/), [SUMO](http://www.dlr.de/ts/en/desktopdefault.aspx/tabid-9883/16931_read-41000/)) |
| Reference model for comparison:   * Conventional H2H model, from for example [12] or [15]   Define or find/adapt for comparison reasons of H2H and ITS cases |

Table Input modules and output of the mobility signaling model

**Tools and prerequisites:**

1. Probability theory/statistics
2. Matlab (flexible, could be python, java or c++): numerical analysis and plotting
3. Basic LTE knowledge

**Future work or extensions:**

* Add paging analysis for the full mobility picture (paging could be considered as RAN signaling)
* More detailed mobility model
* Include

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