# Paper reading Sammerize

## Goal

1. Design algorithm that minimize the overall effort for both Location Update & Paging
2. Suggest a generic analytical simulation platform for both location update and paging schemes with following modules in this platform
   1. A realistic / parameterized model for user mobility model
   2. A realistic geographic context (SUMO & Openstreet Maps)
   3. A realistic / parameterized model for call behaviors(call patterns)

## State of Art

1. Various location update and paging schemes have been proposed in the literature
2. Due to different models and assumptions during performance evaluation, so relative performance of all these schemes was not yet clear (not comparable)

## Steps to take

1. Design a simulation/performance analysis platform for both location update and paging
2. Using the simulation platform so designed, determine a series of scenarios, which will help finding out under which circumstances each of the location management schemes performs best
3. Present and discuss simulation performance evaluation results for a representative sample of location management schemes

## Focus

* Location Management Schemes
* User Mobility Model
* Call patterns
  + WE COULD MAYBE MODELING THIS

## Location Management Schemes

1. **Paging Schemes**
   1. Cost
      1. Proportional to number of polling cycles & number of cells in each cycle
   2. Types
      1. Blanket polling: all cells within the location area are polled simultaneously
      2. Sequential Paging: the current location of the mobile is predicted based on its location probability distribution
2. **Location Update schemes:**
   1. Standard TA schemes:
      1. Cells are grouped into mutually disjoint sets, each being a TA, a cell belongs to exactly one TA, and each UE is registered to only one TA
      2. While network conditions change, this approach is not effective, in other words, it does not meet the diverse traffic and mobility characteristics of different UEs.
      3. No matter how the TAs are designed, the Ping-Pong effect exists between two neighbor TAs, and sometimes even between three neighbor TAs of a corner.
      4. Standard TA could not solve the problem of high traffic due to simultaneous Updates of a large number of UEs crossing a TA boundary.
   2. TAL
      1. Reconfiguration of static TA results service interruption, however thanks self-organizing network (SON) capability of LTE, there is a possibility to change the TAL assigned to each cell in short time intervals without any cost of service interruption
      2. TAL could solve the most significant problems, which faces standard static TA schemes
      3. TAL scheme design:
         1. Design TA for UEs (user specific) : the network assigns each UE with a TAL proper to that UE’s mobility behavior
         2. Design for cells (cell specific): based on the aggregated movement patterns and call arrival rates of the UEs
      4. Several optional “user-specific schemes” could be taken into account:
         1. Location-area based schemes
         2. Distance-based schemes
         3. Movement-based schemes
         4. Direction based schemes
      5. Consideration during TAL scheme selection:
         1. Which one results in the lowest signaling overhead (TAU + Paging) ?
         2. Which one is more practical one to be applied in a large-scale network?
   3. TAU conditions:
      1. In active mode: cell handover
      2. In idle mode:
         1. Cell reselection with TAU
         2. Periodic TAU

## User Mobility Model

* Users classification :
  + Local users : local residents of the current region, they often follow an ordered pattern to haunt several fixed sites, so that their mobility exhibits strong regularity
  + Global UEs : not local residents of the current region with weak regularity
* Important aspects to consider by modeling:
  + Individual movement behavior based mobility model : Gaussian, Markov, Random Walk & activity based …
  + aggregate movement behavior of users: aggregate traffic congestion, velocity profiles …
  + speed, direction recording of history movement
* Elements included in the model , here I take an example for an individual movement based mobility model – Activity based model
  + Number of activities of interest for a user, which generally take place at different spatial locations
  + Time zone for each activity (for example, movement towards work places)
  + Time periods where certain population resides at certain attractions (working places, shopping hours)
  + Activity duration profile : survey or set by analyst
  + Activity sequential profile
  + Geographic location of activities : location can either be estimated using the geographic distribution of the different movement attraction points (MAPs) or randomly distributed one
  + Optional : recording of movement history
* Classification of Uses: people, people in the any kind of cars/trains

## Call patterns model

* Assume the call arrival to the UE follow a Poisson distribution
  + Fix the number of calls
    - Could maybe copy the daily call traffic profiles as observed in published data from telephone network
  + Distribute them over a specific time interval
  + During the day generally higher than in the night
  + Alternative uniform distribution is used to compare

## Questions

* Question 1: Considering dynamic TAL schemes: each optimal scheme is obtained periodically using specific algorithm, which is generally based on measured UE mobility and traffic characteristics of Users during the last time interval, and then it would be adopted for next time interval.
  + The Question is, would it be still effective for the next time interval? If not, do we need to design a new algorithms based on statistical data processing?
* Question 2: in our case, do we still to consider our user mobility model presented above?
* Question 3: is there some other aspects that I have not mentioned in this summary?

# Second Update

User individual is better than that of aggregate-cell specific

* + Cell-specific neglect the mobility and traffic characteristics of individual UEs.
    - It is intuitive that UE s with high mobility should perform LUs less frequently, as in this case the LU cost dominates the total signaling cost.
    - Whereas for UEs with low mobility, frequent LUs are beneficial in reducing the paging costs, because in this case the paging cost dominates the total signaling cost.
  + Therefore, a cost-effective scheme needs to take into account the mobility and traffic characteristics of individual UEs.

Discuss about popular RA/LA/TAL schemes:

Movement-based location update (MBLU) & distance-based location update (DBLU) scheme:

1. Using MBLU scheme: an optimal movement threshold for TAL allocation based on the mobility and traffic characteristics of individual UEs should be derived.
2. Using DBLU scheme: the UE updates its location when the distance (in terms of the number of cells) between the last interacted cell and the current cell of the UE
3. Drawbacks:
   * Papers adopting these two schemes considered that a TAL is a concentric ring consisting of TAs. In this case, when the optimal movement/distance threshold is large, may even violate the 16-TA upper bound.
   * For DBLU: the UE is required to have the knowledge of the cell topology information (i.e. the distance relationship between cells), which cannot be practically implemented in a real network.

Focus : Location area based TAL schemes

Reference papers:

1. M, Hughes, H.Dancs „Dynamic Location Area Management“
2. Z.Lei, C.Rose, “adaptive individual location areas for PCS systems”, 1998
3. A. Pal, D. Khati, “Dynamic location management with variable size location areas”, 2001

**NOTE**: The 3G LA-based location update is a special case of the LTE-TAL based-location update when the size of an LA if equal to that of a TAL and the TA in TAL only contains only one cell or the TAL only contains one TA. Therefore, under the assumption that TA in TAL only contains one cell (flexible size could be taken into account), then all schemes from RA in GSM or LA in 3G could both be implemented in TAL in 4G.

### Dynamic Location Area Management:

* + The size of location areas for each user is not fixed but optimized according to its current arrival rate and mobility; thus, under the user-variant and time-variant arrival rates, it performs much better than the fixed schemes does.

Scheme description:

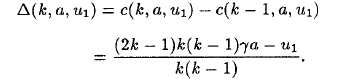
A cell covers an L\*L square area, and a location area covers a square area with k\*k cells, which is referred as size k location area.

Optimization procedure:

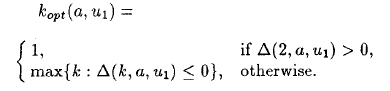
* Modeling user mobility and calculate cost function



* Define a cost difference equation between the system with size k and the one with size k-1(k>=2)



* Calculate optimum k by which the cost reaches the minimum :



### Adaptive individual location areas for PCS systems

* + Most previous problem work (the paper above for example) discussed only the sizing problem of LAs – how many locations (cells) should be put into a LA, without considering the problem of **LA shape** with respect to different movement and call patterns
  + Compared with dynamic location area management above:
    - An improved individual mobility modeling techniques, namely Brownian motion with drift model was chosen
    - Investigate the influence of the directional motion and motion uncertainty of an individual user on the size and shape of its LAs
    - Shaping of LA: while a user is moving in a given direction the probability of user location is also moving along in the same direction, therefore the position of each new LA relative to the current location of the user should be shifted in the same direction to attain the maximum possible probability of user location

Optimization procedure:

* The boundaries of the one dimentional LA be given as B1 and B2: B2-B1 is the size of LA, Lc is the cell size.
* Number of cells in the LA region [B1, B2] could be optimized, which is influenced by the average movement velocity, location uncertainty and mean call arrival rate of the user.

### Dynamic location management with variable size location areas

* LA is defined based on subscriber’s mobility history.
* The speed and call arrival probability of the subscriber is considered to define the LA size.

Basic concepts:

* Parameters to use:
  1. S\_Time: time when the subscriber entered the LA
  2. E\_Time: time when the subscriber left the LA
  3. Cells\_crossed : number of cells crossed within LA
  4. Prev\_Speed: previous speed of the mobile device
  5. Cur\_Speed: current speed of the mobile device
  6. PrevCallArrProb: previous call arrival probability
  7. CurCallArrProb
  8. LAp: location area size in the pth updation
  9. LAdef: default location area size.
  10. Speed calculation: [Cells\_Crossed/(E\_time-S\_Time)]
  11. SpeedDiffRatio=(Cur\_speed-Prev\_Speed)/Prev\_Speed
  12. CallArrDiffRatio=(CurCallArrProb-PrevCallArrProb)/PrevCallArrProb
* LA size calculation: LAp=LAp-1\*(1+SpeedDiffRatio-CallArrDiffRatio)
* The user profile will be stored as a graph where the nodes represents visited cells and the link represents transition between cells. The value of the node indicates the traversal frequency of that node. If the user traverses a new cell but the new node cannot be added to the graph, then a replacement policy can be used like least traversed node can be replaced by the newly visited node.