A Simple Speed Estimation Algorithm for Mobility-Aware SON RRM Strategies in LTE

Transversal Projects and Innovation - Telefónica I+D

J. Lorca, A. M. Sierra {jlh,asd}@tid.es

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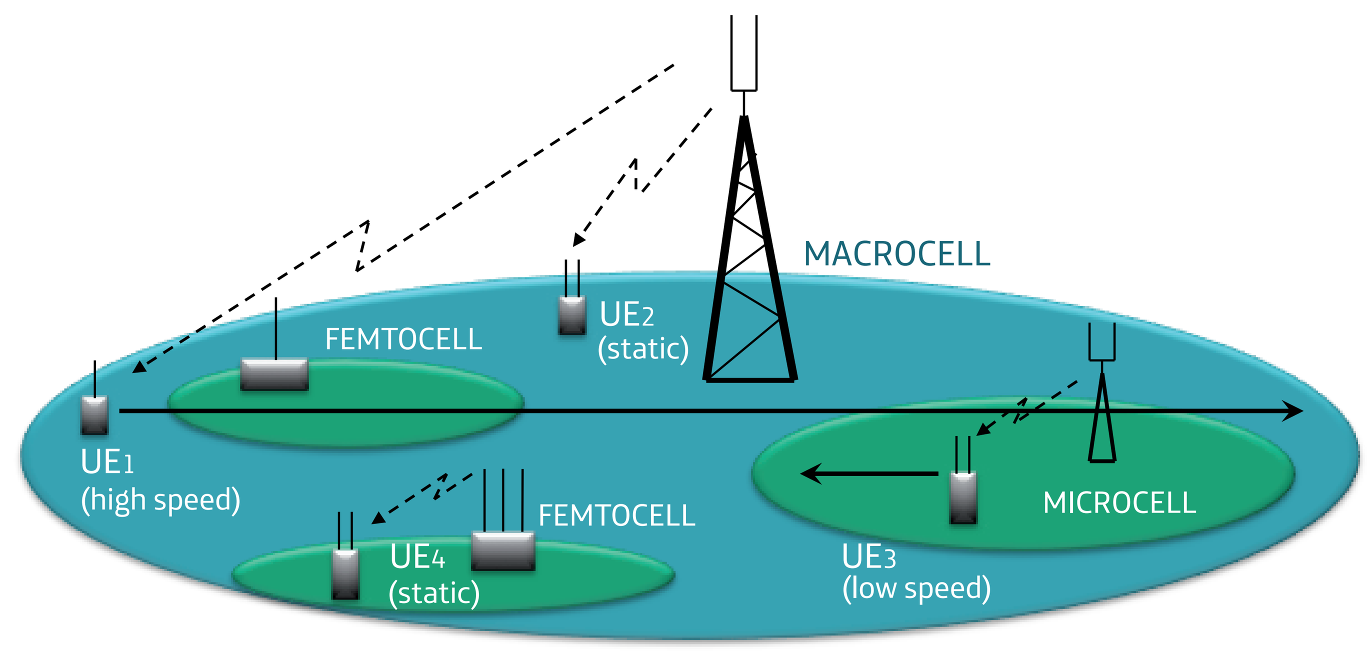

Fig.1: Scenario for application of mobility-aware RRM strategies

1. MOBILITY-AWARE RRM STRATEGIES

- Mobility management becomes a complicated issue in Heterogeneous Networks comprising several cells with different sizes (Fig. 1).
- Users with different mobility from high-speed to static demand speed-specific strategies for cell reselections and handovers.
- The following RRM strategy is proposed:
  - Base Stations broadcast “CELL_SIZE” parameter representing a relative measure of the cell size taking into account transmission power and frequency.
  - Idle users estimate their own speed and perform cell (re)selection according to user speed, cell sizes and signal levels from all detected cells.
  - Connected users report user speed and neighbour cell sizes to the serving cell, so that handover can take user mobility and neighbour cell sizes into account.

2. SPEED ESTIMATION BASED ON DOPPLER SPECTRUM

- A simple structure for velocity estimation is proposed (Fig. 2) based on Doppler power spectrum estimation
- The circular buffer stores the channel transfer functions over N time intervals (separated ΔT) and L frequencies (separated Δf).
- Speed can be obtained from the width of the estimated Doppler power spectrum F given an FFT of the autocorrelations:

$$F[p]=\sum_{k=0}^{N-1} R^{(M)}[k]e^{-j2\pi\frac{k}{N}p}$$

where p denotes the discrete Doppler frequencies and R[k] denotes the autocorrelations of the time-variant channel transfer function H.

- Autocorrelations can be calculated with the expressions (Fig. 3):

$$R^{(m+1)}[k]=\frac{L(N-k+m)R^{(m)}[k]+\sum_{l} P_{ijl}[k]}{L(N-k+m+1)}$$

where the partial products Pijl are defined by:

$$P_{ijl}[k]=H_l^{*}[i]H_l[j], \text{such that } j-i=k$$

and the autocorrelations in the first iteration are given by

$$R^{(0)}[0]=\frac{1}{LN}\sum_{i,j,l} P_{ijl}[0],$$

$$R^{(0)}[1]=\frac{1}{L(N-1)}\sum_{i,j,l} P_{ijl}[1],$$

$$\vdots$$

$$R^{(0)}[N-1]=\frac{1}{L}\sum_{i,j,l} P_{ijl}[N-1].$$

The width of the Doppler power spectrum pmax determines the UE speed (where fc is the carrier frequency):

$$v=\frac{cp_{\max}\Delta f}{f_c}$$

After M iterations the algorithm stops to ensure a given difference in accuracy between the minimum and maximum Doppler frequencies.

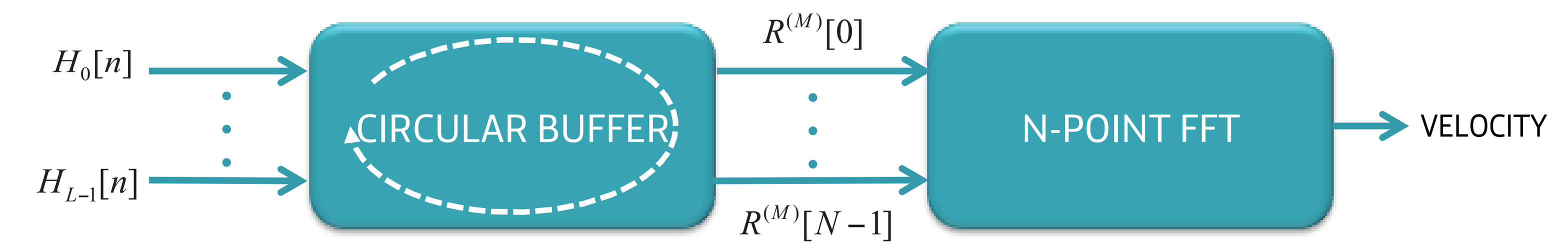

Fig. 2: Proposed structure for velocity estimation

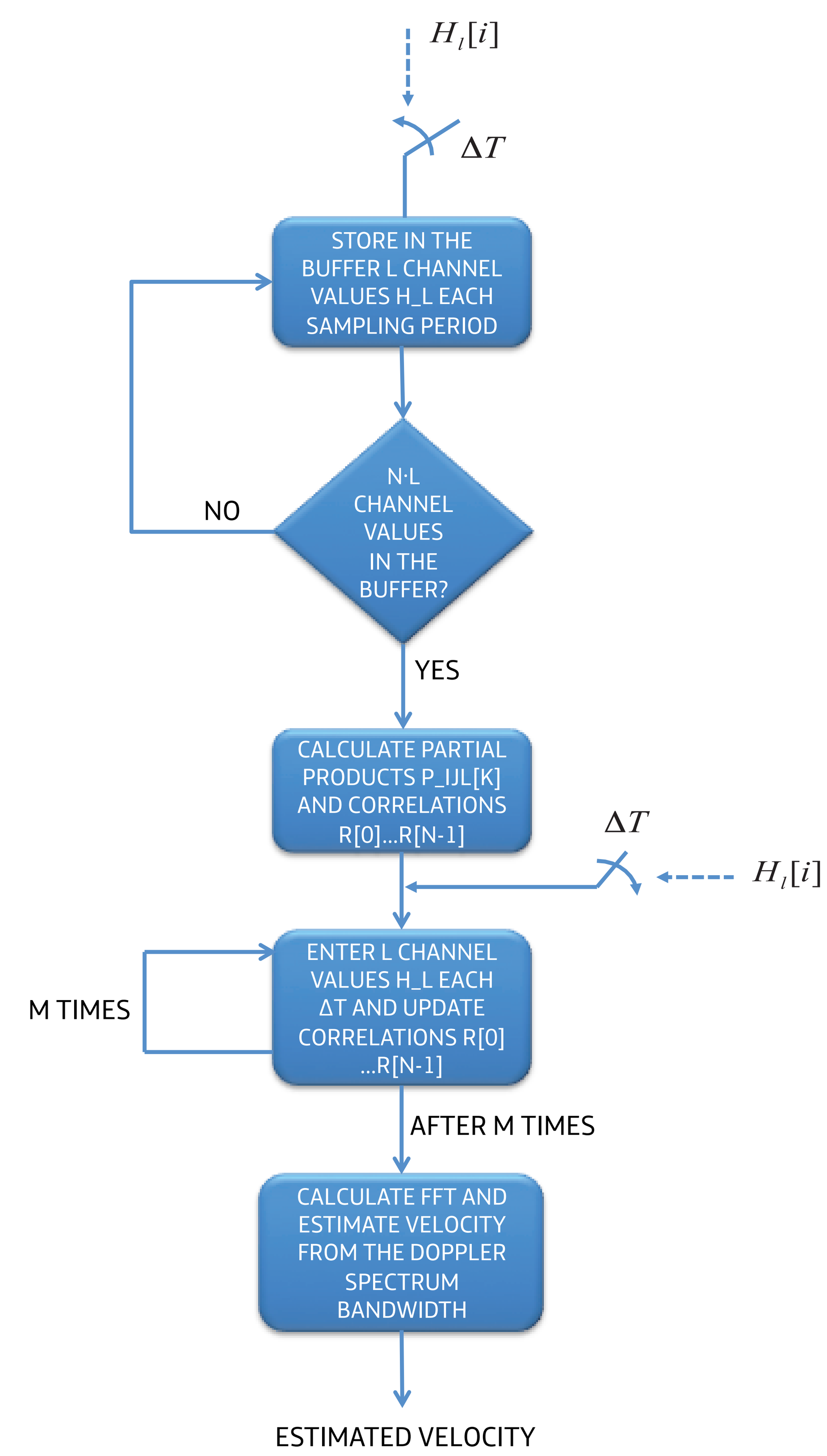

Fig. 3: Flow diagram for the speed estimation algorithm

3. SIMULATION RESULTS

- The performance of the algorithm was assessed with an in-house LTE link-level simulator (Fig. 4).
- The algorithm was relatively insensitive to SNR after choosing the appropriate values of N, M, L, ΔT and Δf.
- In all cases the rms errors are below 10% except for 3 km/h (with 26% rms error), where the Doppler spectrum is so narrow that width estimation is more tricky.
- The algorithm yields a velocity estimation every 2.8 sec, making it appropriate for application in cell reselection or handover strategies

4. CONCLUSIONS

- A simple procedure for velocity estimation is proposed based on signal analysis and not relying on GPS receivers.
- Results are accurate enough even in low SNR conditions.
- The algorithm poses low complexity and can be parameterized for a variety of speed limits and computational complexities.

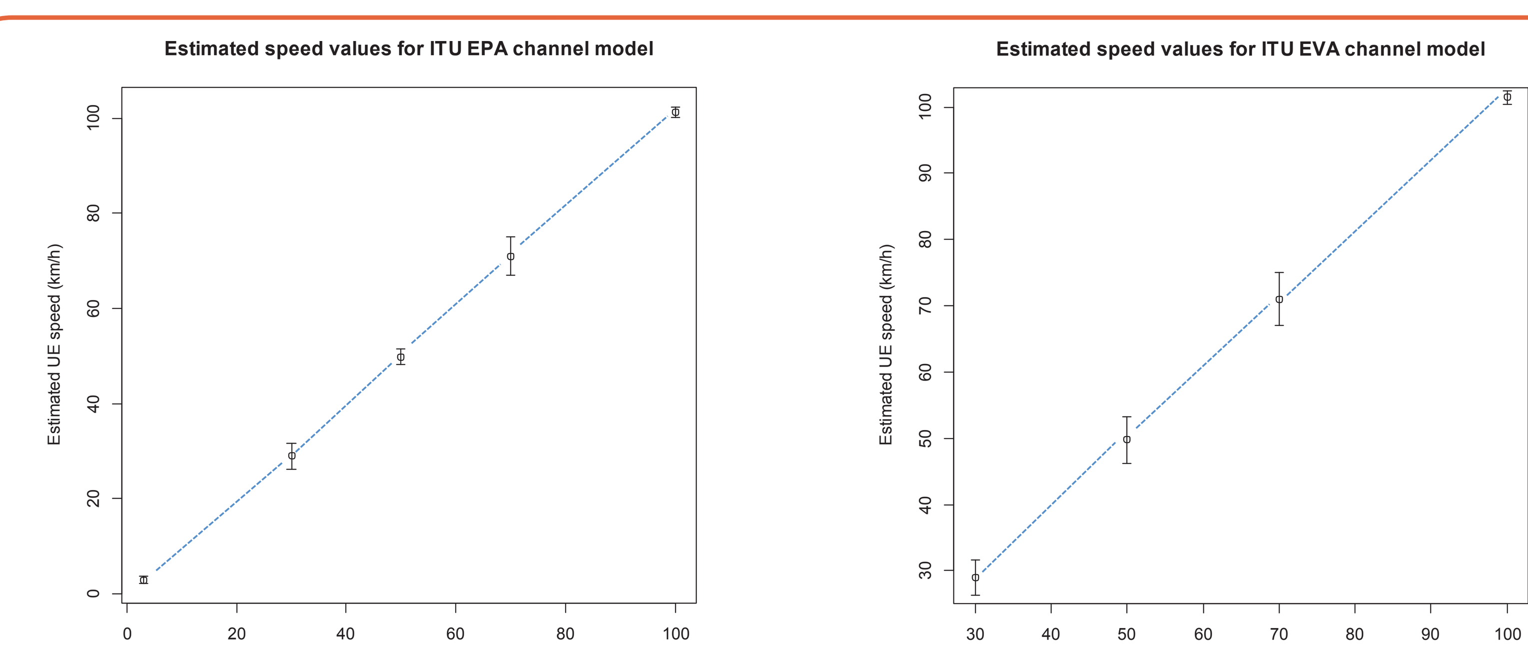

Fig. 4: Simulation results for ITU EPA and EVA channel models