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Agenda Item: Ad Hoc 29
Source: Siemens AG
Title: Simulation results on TDD LCS
Document for: Discussion

1 Introduction

This document provides further simulation results on the location services for the TDD mode. It focuses on the trade-off between accuracy and number of measurements and on the accuracy that can be achieved with different T1P1 channel models.

2 Simulation parameters

The used parameters and assumptions for the simulations are almost the same as for the simulations that have been presented at the WG1-meeting #17 [1] and are given in the following.
Figure 1 shows a hexagonal layout of seven cells for the LCS simulations. All measurements are performed on the midambles of length 512 chips.

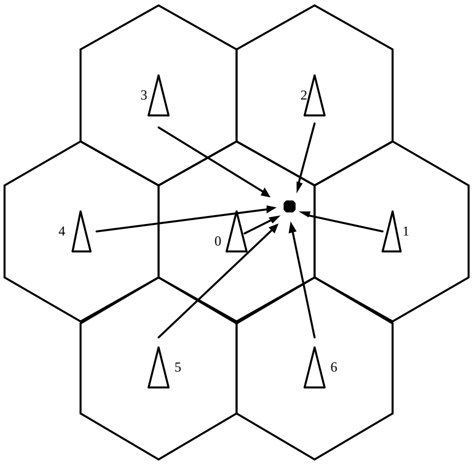

Figure 1: Cell configuration

The UE is located at random locations with uniform distribution over the centre cell. For each random placement, the path losses is computed from the UE to each of the seven NodeBs. The model for path loss computation is inverse fourth power law with an additional lognormal shadow fading component with 8 dB standard deviation. Because of the assumption of idle periods there are two phases for each measurement. In the first phase, all NodeBs transmit midambles but the UE only correlates against the midamble code for the serving cell. In the second phase all NodeBs except the serving NodeB transmit midambles and the UE correlates against the six relevant midamble codes.
For both phases for each position location, several measurements (the range is from one measurement up to 5 measurements) are repeated in time to provide a diversity element in the determination. It is assumed that the serving NodeB provides timing advance based on the earliest path so that position determination can be based on time of arrival measurements rather than time difference of arrival.

The path from each NodeB to the UE is treated as a T1P1 channel with independent fading for every measurement. The general simulation assumptions are as follows:

Parameter	Value
Range Law	$N = 4$
Propagation Standard Deviation	8 dB
Channel	Urban A/B, Suburban, Rural, Bad Urban
Time Diversity	1-5 Measurements
Receiver Sample Rate	2 samples/chip
Cell Radius	1000 m
NodeB Sync Error Standard Deviation	100 ns

Rather than specifying a transmitter power, the relative noise level has been computed to relate to an effective transmitter power providing a normal service. Because LCS will be based on existing signals, it is assumed that the service, provided through this signal, has a coverage of 98% with an Eb/No = 8 dB at the edge of the cell.

The coverage at the cell corner is based on an assumption of equal nominal path loss from the three nearest NodeBs with independent lognormal shadowing and selecting the best NodeB. For 8dB lognormal shadowing this corresponds to a shadow fading margin of about 5 dB.

The measurements are performed in two phase, as indicated earlier. During the first phase, the UE correlates only against the midamble of the serving NodeB. The correlation powers over a window of 50 chips are computed. This process is repeated over the diversity period, and the powers are added together. Based on this result, the earliest strongest path is determined. In the second phase, the delays from surrounding base stations is performed in the same way as during the first phase, but now with idle periods in the serving cell. This leads to 6 correlation results, each representing the strongest earliest path received from each NodeB. From these paths the three strongest are selected and ranked into a descending order of the magnitude.

At this stage a total of four time of arrival measurements are available. It is assumed, that a timing advance measurement has been performed for the serving cell. Because the cells are synchronised this means, all measurements can be treated as time of arrival measurements.

Finally the position of the UE is computed using all four measurements based on a minimum mean square error computation. If the position of the UE can not be computed then the centre of the serving cell will be the estimate of the UE's position.

It has to be noted, that four measurements are needed for reliable positioning. It might be expected that this requirement would degrade the statistics of measurement since the probability of all three surrounding cells falling within the necessary power window would be reduced. However, this is not the case. Generally only three measurements actually contribute to the result. The reason for needing to handle four measurements is to increase the probability that the three used are those which form a triangle around the UE's position. Where the UE is outside the triangle the measurement errors can become very big - in fact so much so that the UE can appear to be inside the triangle even when it is not. Thus the reason for needing four measurements is to include a nearer NodeB even when shadowing makes a more distant NodeB provide a stronger signal. Thus we need all four measurements because we cannot determine a priori which subset of three will provide the better result.

3 Simulation Results

Figures 2 to 6 show the range error distributions for the T1P1 channel models (Urban A, Urban B, Suburban, Bad Urban and Rural). The different curves in each figure represent the diversity order, i.e. the number of measurements that have been averaged for one position calculation. The trade-off between accuracy and number of measurements is shown. For all channels, the best performance is achieved by averaging over 5 measurements, but this number can be reduced to 3 without loosing much accuracy. In some environments (Urban B, Suburban and Rural) even the average of only two measurements is sufficient.

Table 1 summarises the probabilities for the position error of 100 and 300 m for all channel models if 3 or 5 measurements are used. It can be seen, that an average position error (average over all channels) of maximal 100 m is achieved with a probability of nearly 80% and 90% for an error of 300 m.

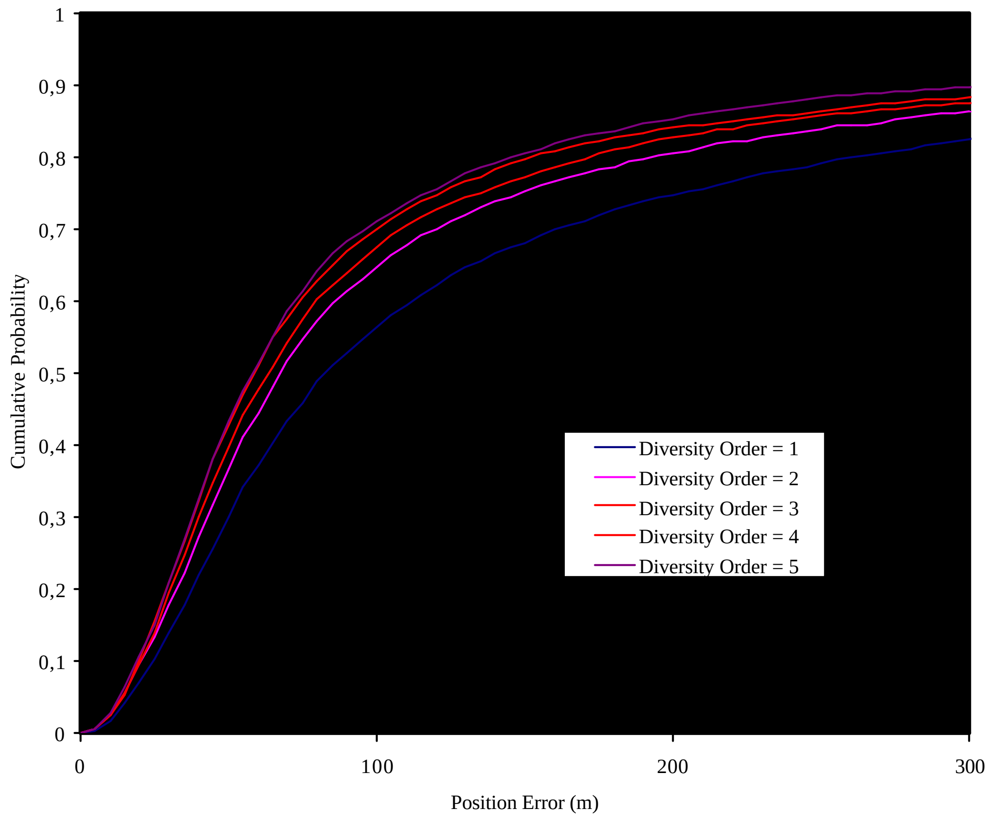

Figure 2: Range error distribution for the Urban A channel

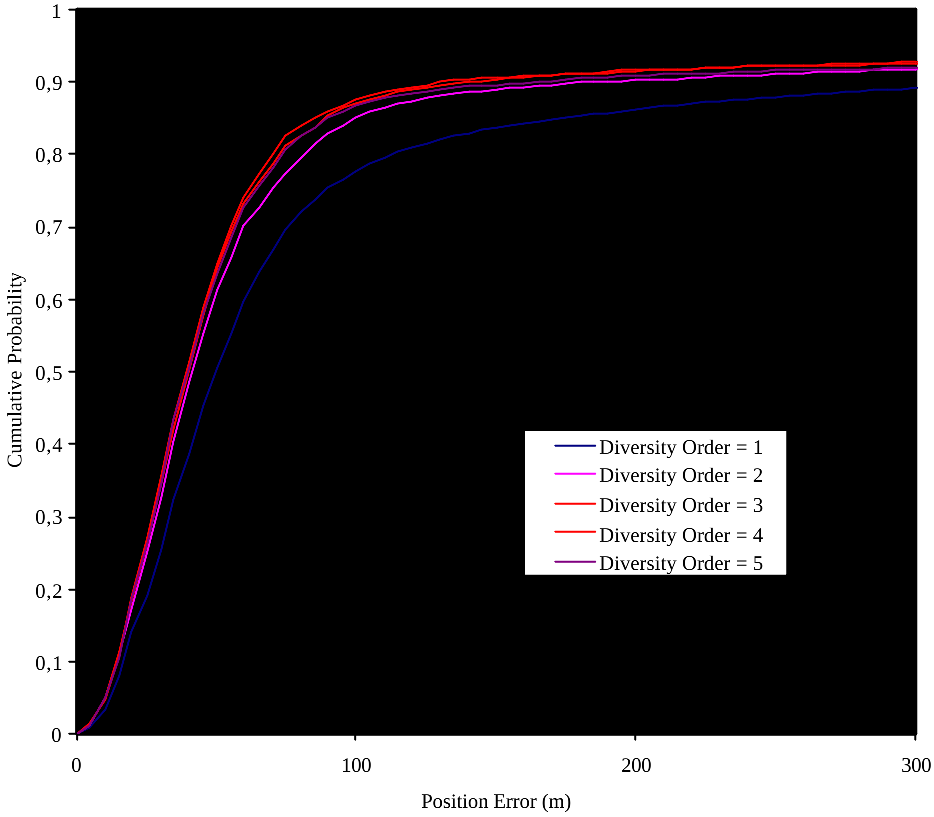

Figure 3: Range error distribution for the Urban B channel

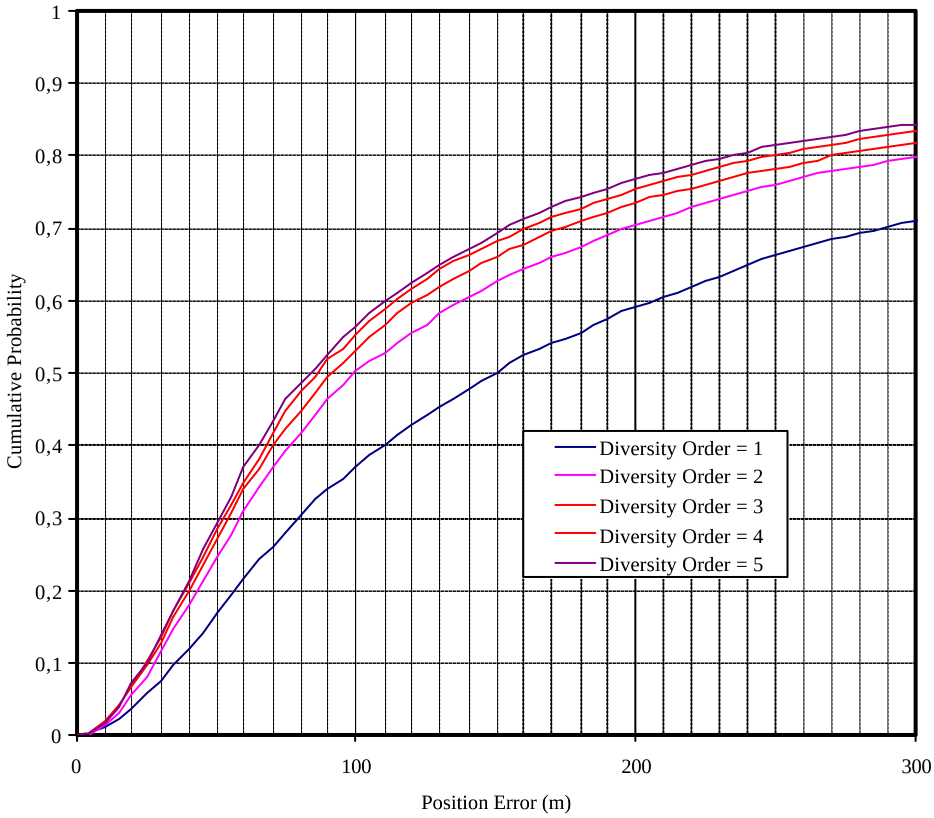

Figure 4: Range error distribution for the Bad Urban channel

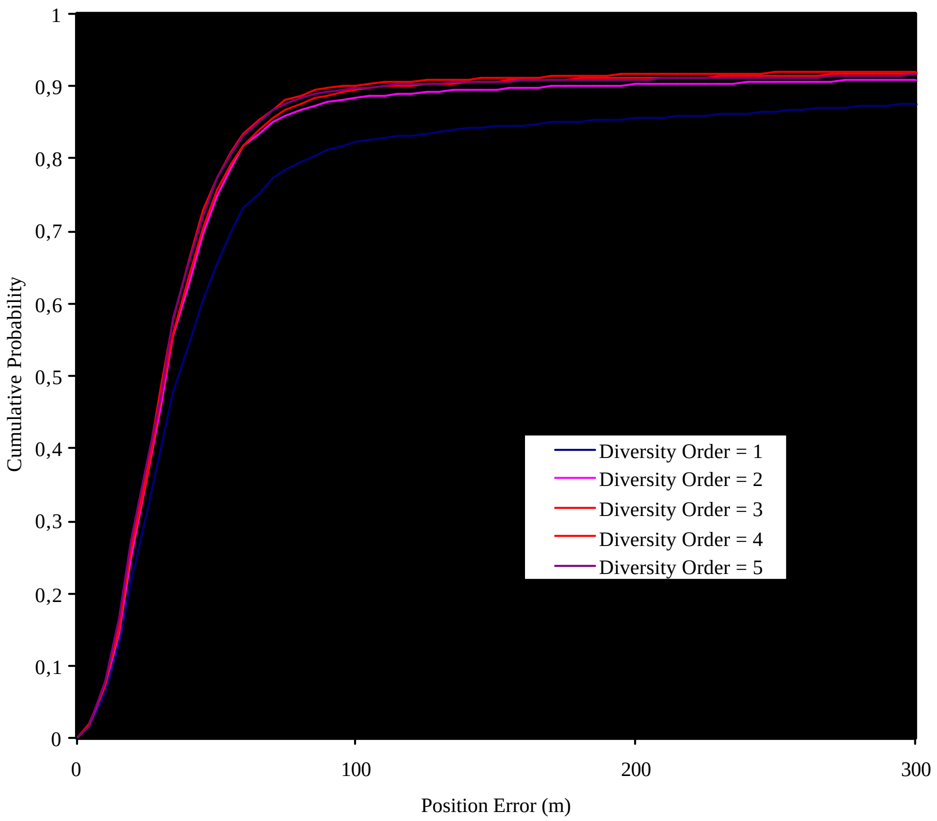

Figure 5: Range error distribution for the Suburban channel

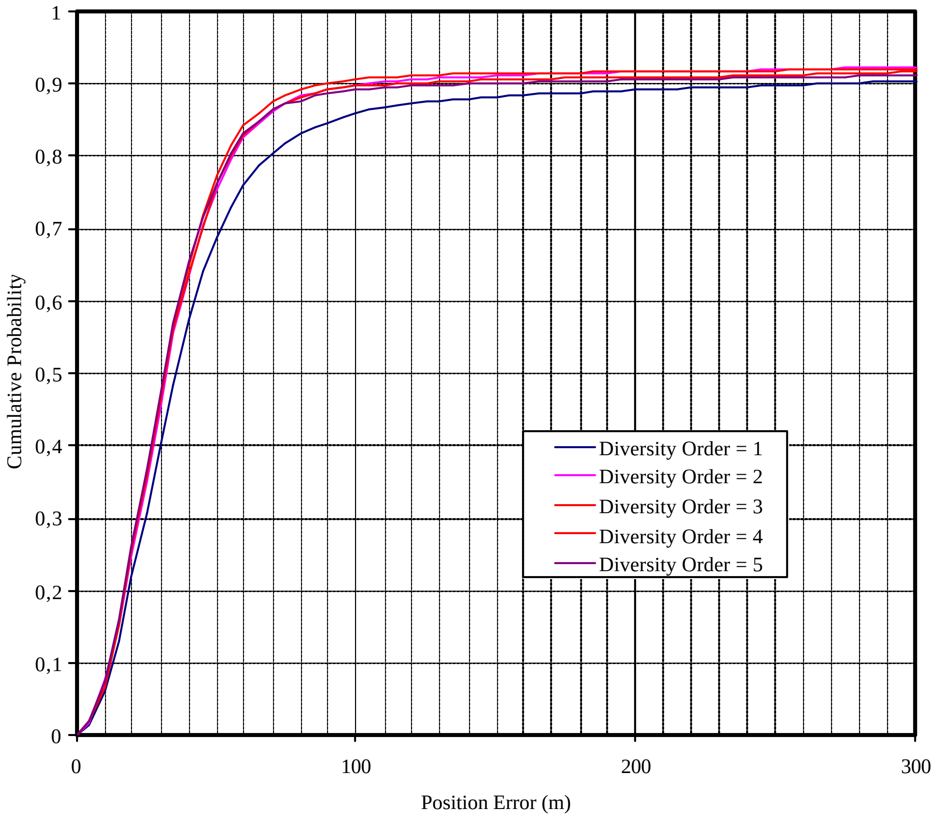

Figure 6: Range error distribution for the Rural channel

Channel	100 m @ 3 measurements	100 m @ 5 measurements	300 m @ 3 measurements	300 m @ 5 measurements
Urban A	0.67	0.71	0.88	0.90
Urban B	0.87	0.87	0.92	0.92
Bad Urban	0.53	0.56	0.82	0.84
Suburban	0.90	0.90	0.92	0.92
Rural	0.89	0.89	0.91	0.91
Average	0.77	0.79	0.89	0.90

Table 1: Probabilities of position errors

4 Conclusions

It has be shown that a sufficient accuracy is achieved with an average of 3 measurements and the proposed IPDL scheme for TDD provides enough accuracy and coverage for LCS.

5 References

[1] Tdoc R1-00-1355: LCS for 3.84 Mcps TDD, source: Siemens