Source:	Nokia
Title:	Complexity issues in system level channel modeling
Document for:	Discussion

1. INTRODUCTION

The aim of this document is to facilitate discussion on some of the issues related to system level channel modeling activity. In particular, the implementation complexity of the model, and the interface between link level results and the system level simulation are discussed.

2. OVERVIEW OF CURRENT CHANNEL MODEL PROPOSAL

The current proposals [1],[2] for ray-based channel modeling broadly consist of the following steps:

- Calculating correlated values of AS, DS and LN.
- Fixing a certain number of distinguishable temporal paths N(= 6).
- Randomizing delays and associated powers for the N paths.
- Randomizing mean AOD's from the BS for the N paths.
- Selecting K (=20) sub rays to represent the Laplacian angular spread around each mean AOD. Angles associated with sub-rays are also selected at random.
- Similary address AOA at the UE
- Generate channel realization.

3. COMPLEXITY OF SIMULATION

The proposed spatial channel model is regarded to be too complex and time consuming to be attractive for extensive system level simulations. This is especially true in comparison with today's system level simulations, where the propagation model in many cases is modelled via simple lookup tables to generated power delay profiles, shadowing etc. Nokia does therefore believe that the current proposal needs to be simplified further in order to have a model which enables the users to run system simulations with MIMO within a reasonable time period. In evaluating the time required to simulate the propagation environment of the new SCM system model, it is furthermore important to keep in mind that the computations required for interference calculations, packet scheduling actions, traffic modeling, etc, typically requires more resources and time than the propagation related calculations and lookups. Given this starting point, we suggest methods for further simplifying the proposed model in [1]-[2], in an attempt to make the model more attractive from a complexity point of view.

The proposed modeling requires the generation of 20x6 = 120 complex exponentials for each user, each of which are randomly selected for each drop. It is well known that the generation of sinusoids is computationally intensive. One of the time-saving mechanisms used in system-level simulations is to generate fading realizations in advance, and to read them from storage as necessary. The complete randomization of the channel modeling makes this procedure untenable, thus increasing the computational load of the system level simulation tremendously.

In [1]-[2] it is furthermore proposed to randomly select values of the AS, DS, and LN for each simulation drop. These values are sampled from independent pdf's and afterwards filtered to impose the correct cross-correlation between the variables. Using this approach requires a large number of simulation drops in order to make sure that the we have sufficient statistics to compare results from two system level simulations. In order to further reduce the required simulation time, we propose to simplify the random selection of AS, DS, and LN for each simulation drop. It is suggested define a relative small number of possible discrete joint values of the AS, the DS, and the LN, where each set of values is assigned a selection probability (i.e., defining a discrete joint pdf of the AS, DS, and LN). An example is provided in Table 1. By using this approach, the number of required simulation drops to obtain sufficient statistics can be reduced significantly. This is especially true if we limit the size of Table 1 to contain, for instance, 10 cases only, where the probability for each case is larger than 1-5%. It should be possible to agree on the values in Table 1 within the SCM group by using the more advanced and accurate models proposed in [1]-[2].

AS	DS	LN	Probability
10 deg	1.2 ms	-5 dB	10%
2 deg	0.2 ms	+4 dB	22%
…			

Table 1: Example of specification of a discrete joint pdf of AS, DS, and LN.

As we cannot neglect the complexity of the SCM system level model, it is suggested that the proposed models are benchmarked in the furture by comparing the required simulation time. We believe that it is important to more seriously address the trade-offs between the accuracy of the propagation model, the modeling accuracy of other functionalities like the packet scheduler, traffic models, and the simulation time.

4. INTERFACE TO LINK LEVEL RESULTS

The other big issue related to MIMO channel modeling is the interface between link level and system level simulations. In previous standardization efforts [3], AWGN link level curves have been used, along with some penalty functions, as input to the system level simulations. This methodology carries with it, an implicit quasi-static fading assumption, which might be useful for extremely short frames only. Hence, there is a necessity to explore other methods of mapping.

One suggested mechanism is to use the *Actual Value Interface* (AVI) curves [4], which use the averge Eb/No in a reference. These AVI curves are generated from link level simulations, and these are substituted for the AWGN curves used in mapping to the system level. The use of AVI curves, however, brings a complication. Different AVI curves will have to be obtained under different spatio-temporal conditions for the same transmission scheme. This is because of the fact that the correlation between antennas, and also the frequency selectivity of the channel, have a distinct effect on the performance of the algorithms. But from the randomization of the systel level model, we can see that there are infinite possible spatio-temporal combinations. The reduction in the multiplicity of system level scenarios will by itself help to reduce the corresponding number of link level scenarios. Further reduction may be possible by other means.

It is relevant to note there that the translation from link level BLER and BER curves into AVI curves is dependent on the MIMO scheme. For some schemes, this translation may be a function of Eb/no only, while other schemes might require additional input parameters such as the per-TTI rank of the channels correlation matrix, the power ratio from dominant interferer to the total interference, etc. Whenever new MIMO schemes are proposed, it is the responsibility of the proponent to also provide as well as justify the corresponding AVI specifications (i.e. defining the input parameters), and also provide the AVI curves thus produced for the system level simulations.

5. CONCLUSIONS

Based on the issues raised in sections 3, 4, it is recommended that the group proceed in the direction of rationalizing the system level channel model, so that the computational load of the simulations is manageable. Some possible steps can be:

- Convertion some of the random parameters in the proposal into deterministic ones.
- Discretization of the angles (say, to the nearest degree), which will facilitate the storage-retrieval method of channel realization.
- Many-to-one mapping of system level scenarios to link level scenarios.

6. REFERENCES

[1] Lucent Technologies, SCM-042, “Wideband system level model and statistics”, August 2002.
[2] Motorola, SCM-029, “Correlated System Level Spatial Channel Model”, June 2002.
[3] 1X-EV-DV Evaluation Methodology, 3GPP2 WG2 Evalation AHG, 2001.
[4] Lucent Technologies, R1-01-0304, “System simulations for MIMO enhancements to HSDPA”, contribution to 3GPP RAN-WG1.