Agenda Item: 8

Source: ZTE, Sanechips

**Title:** Support of IIOT by map-based hybrid model

# Introduction

This document discusses the necessary changes made for map-based hybrid channel model to support the IIOT channel model, including the additional features such as absolute time of arrival.

# Changes needed by map-based hybrid channel model

***References to stochastic parameter tables in Section 7 (stochastic model)***

In the current map-based hybrid channel model, the channel between one TX and one RX contains both deterministic clusters and random clusters, where the deterministic cluster is completely generated by ray-tracing algorithm and the random cluster is generated with its delay and power being somehow random on one hand but dependent on the generated deterministic clusters on the other hand. The randomness in the random cluster share the same random number generation parameters used for stochastic channel model, for example, the RMS delay spreads for different scenarios including UMa, UMi, indoor office and etc. When supporting of IIOT is added to stochastic channel model, the parameters for random component generations are either added to the existing parameter tables or put in the new parameter tables. If it is the latter case, the references to the new tables should be added in the map-based hybrid channel model section.

***Proposal 1****: If one existing parameter used to generate random component in stochastic channel model has its separate value defined in new table for IIOT modeling, and this parameter is already used in current map-based hybrid model, the new table reference should be added to map-based hybrid channel model.*

***Modeling of absolute time of arrival***

As mentioned earlier, the deterministic cluster in the map-based hybrid model is generated based on ray-tracing. The following 38.901 text for map-based hybrid channel model shows that the absolute time of arrival for deterministic cluster is already derivable as ray-tracing output:

*- for each deterministic path (-th path sorted in ascending order of path delay):*

*- ….*

*- the normalized path delay  and the first arrival absolute delay (with  to be the real absolute propagation delay of the path);*

*- ...*

*The  deterministic paths are sorted by normalized path delay () in ascending order. That is to say, = 0.*

For the n-th random cluster, its normalized cluster delay is generated and denoted as  according to the following procedure mentioned in TR 38.901:

* *Draw random delays  for n = 0,…, *
* * for n = 0,…, *
* *The n-th random cluster is removed if n=0 or  for any of 1≤lRT≤LRT*
* *Denote  for 1≤n≤LRC as the delays of the LRC random clusters that remain after the cluster removal.*

It can be seen that both (*1≤lRT≤LRT*) and ** (*1≤n≤LRC*)represent the normalized delays that are relative to the first arrival cluster, which corresponds to *= 0* and . In addition, both  and ** behave the same way in the later steps for cluster power generation. Given the absolute delay for deterministic cluster is *=+*, it is natural to assign the absolute delay for n-th random cluster as *+*.

***Proposal 2****: In the map-based hybrid channel model, the absolute time of arrival is derived as  for* $l\_{RT}$*-th deterministic cluster and +for n-th random cluster.*

* *Include the CR text as in Appendix into the final batch CR for IIOT channel model SI.*

# Conclusion

This contribution concludes with the following proposals:

***Proposal 1****: If one existing parameter used to generate random component in stochastic channel model has its separate value defined in new table for IIOT modeling, and this parameter is already used in current map-based hybrid model, the new table reference should be added to map-based hybrid channel model.*

***Proposal 2****: In the map-based hybrid channel model, the absolute time of arrival is derived as  for* $l\_{RT}$*-th deterministic cluster and +for n-th random cluster.*

* *Include the CR text as in Appendix into the final batch CR for IIOT channel model SI.*

# References

1. TR 38.901, v15.0.0

# Appendix A. CR text to support absolute time of arrival

## 8.4 Channel generation

The radio channels are created using the deterministic ray-tracing upon a digitized map and emulating certain stochastic components according to the statistic parameters listed in Tables 7.5-6 to 7.5-10 [Note: Not all parameters listed in these tables are used in hybrid model]. The channel realizations are obtained by a step-wise procedure illustrated in Figure 8.4-1 and described below. In the following steps, downlink is assumed. For uplink, arrival and departure parameters have to be swapped.

**<Unchanged parts are omitted>**

Step 5: Generate delays (denoted as {**}) for random clusters.

 Delays are drawn randomly according to the exponential delay distribution

  (8.4-1)

 where , *Xn* ~ uniform(0,1), and cluster index *n* = 0,…,  with  to be configurable. A recommended value for  is the number of clusters given in Table 7.5-6.

 , where *rτ* is the delay distribution proportionality factor given in Table 7.5-6.

 Normalise the delays by subtracting the minimum delay and sort the normalised delays to ascending order:

  (8.4-2)

 where  is the additional scaling of delays to compensate for the effect of LOS peak addition to the delay spread, and is depending on the heuristically determined Ricean K-factor [dB] as generated in Step 4:

  (8.4-3)

 For the delay used in cluster power generation in Step 6, the scaling factor  is always 1.

 The *n*-th random cluster is removed if *n=0* or  for any of *1≤lRT≤LRT*, where *τth* is given by , and is the configurable probability for cluster inter-arrival interval to be less than *τth*. For example, set =0.2 to obtain *τth*=0.223.

 Denote  for *1≤n≤LRC* as the delays of the *LRC* random clusters that remain after the cluster removal.

 As an add-on feature, the absolute time of arrival of a cluster is derived as:

* , if the cluster is the -th deterministic path obtained in Step 3 for *1≤lRT≤LRT*;
* +, if the cluster is the n-th random cluster for *1≤n≤LRC.*

Step 6: Generate powers (denoted as for *1≤i≤LRC*) for random clusters.

 Cluster powers for the random clusters are calculated assuming a single slope exponential power delay profile. First, the virtual powers (denoted as  for *1≤i≤LRC*) of random clusters and virtual powers (denoted as  for *1≤j≤LRT*) of deterministic clusters are calculated as following.

 Denote:

  (8.4-4)

  (8.4-5)

 where *Zi,RC* and *Zj,RT* are the per cluster shadowing terms in [dB] and meet distribution of *N(0,)*. Then,

  (8.4-6)

  (8.4-7)

 *In the case of LOS condition*, *A=KR* with *KR* being the Ricean *K*-factor obtained in Step 4 and converted to linear scale; otherwise, *A=0*. The real power (including effects of pathloss) per random cluster in *k*-th frequency bin is given by

  (8.4-8)

 for *1≤i≤LRC* and . Similar to path power of deterministic cluster, the path power of *i*-th random cluster is calculated as

 . (8.4-9)

**<Unchanged parts are omitted>**