LOS Probability Modeling for 5G Indoor Scenario

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Abstract **– Indoor hotspot has been reorganized as an important part of 5G deployments. To satisfied the new requirements on 5G deployment and facilitate the evaluation of 5G candidate technologies, LOS (line of sight) probability model has been studied in this paper. Compared with the existing models, the new model introduced in this paper fits the propagation in indoor hotspot newly defined for 5G best of the four models evaluated. And it can improve the deficiency of ITU model.**

Index Terms **— 5G, Indoor hotspot, LOS probability.**

1. Introduction

In January 2015, the ITU published a work plan for IMT-2020 standardization [1]. This signifies that the global arena of 5G standardization is beginning in earnest. From some studies it is estimated that some 80% of data traffic deployment will be for indoor environments [2]. Technically, ensuring a high availability and quality of the connectivity experience for indoor access is always a challenge. For 5G in bands, achieving this requires a good understanding of indoor signal propagation and coverage.

LOS probability is an important aspect of indoor propagation characteristics. It will have influence over the coverage capability evaluation for indoor 5G radio access system. So far the mostly used LOS probability models can be found in [3]~[5]. But LOS probability is sensitive the deployment scenarios. For 5G, some new requirements on indoor hotspot deployments have been proposed in [6]. The density of the base station and its deployment in typical indoor hotspot has been changed. It is necessary to investigate the LOS probability considering these changes. And also some deficiency of existing LOS probability model for indoor hotspot in [4] should be addressed. The flat tail of the model in [4] can introduce over optimistic LOS probability.

In this paper, the LOS probability for indoor hotspot has been investigated based on newly defined 5G deployment requirements. To solve the deficiency of the existing models, a new model is proposed and validated by ray-tracing simulation.

2. LOS probability modeling

LOS probability model is an important part in system level evaluation on 5G candidate technologies. So far, the LOS probability models used for system level evaluation activities can be found from ITU-R IMT-Advanced evaluation methodologies [3] and WINNER II channel modeling report [4]. These models have been developed and used for about 10 years. Due to the change of the requirements on 5G deployments, these models may not be the best fit of new requirements any more.

Take the ITU InH LOS probability model as an example, the flat tail of the model can introduce over optimistic LOS probability after the distance exceed certain threshold. To evaluate the deficiency in ITU model, ray-tracing simulation has been conducted based on the definition of the InH scenario in [4]. The results are in Fig. 1.

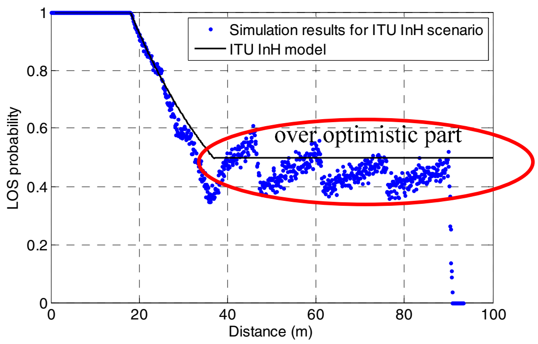

Fig. 1. InH LOS probability model of ITU

To improve the accuracy of the LOS probability and facilitate the evaluation work for 5G candidate technologies, a new LOS probability model is introduced in this paper. For comparison, the models investigated are all included in Table I, including the new model.

TABLE I
Summary on LOS probability models

Model	Description
(1).ITU model	$P_{LOS}=\begin{cases}1, & d\le d_{1\_1}\\ \exp(-(d-d_{1\_1})/d_{1\_2}), & d_{1\_1}<d<d_{1\_3}\\ a_1 & d\ge d_{1\_3}\end{cases}$
(2).WINNER II model (B3)	$P_{LOS}=\begin{cases}1, & d\le d_{2\_1}\\ \exp(-(d-d_{2\_1})/d_{2\_2}), & d>d_{2\_1}\end{cases}$
(3).WINNER II model (A1)	$P_{LOS}=\begin{cases}1, & d\le d_{3\_1}\\ 1-a_2(1-(b-c\log10(d))^3)^{1/3}, & d>d_{3\_1}\end{cases}$
(4).New model	$P_{LOS}=\begin{cases}1, & d\le d_{4\_1}\\ \exp(-(d-d_{4\_1})/d_{4\_2}), & d_{4\_1}<d<d_{4\_3}\\ \exp(-(d-d_{4\_3})/d_{4\_4})\cdot a_3, & d\ge d_{4\_3}\end{cases}$

3. Evaluation on LOS probability models

According to the most recently defined deployment scenario for indoor hotspot in [6], it is suggested a 20m ISD should be adopted for indoor hotspot. An open office of

120mx50m, deployed with 12 TRPs (Transmission Reception Point), is suggested as a typical example office. In [7] a sketch for illustration was provided and this is reproduced here in Fig.2. Compared with what has been used for LTE-Advanced/IMT-Advanced in [4], the TRP density and deployment locations have been changed greatly in this new model (Fig.2).

To further study typical open offices, including "cubical" deployment, another case is shown in Fig.3. In this case, the height of cubical isolation is 1.5m. It will be helpful to consider both types of deployment to derive LOS probability.

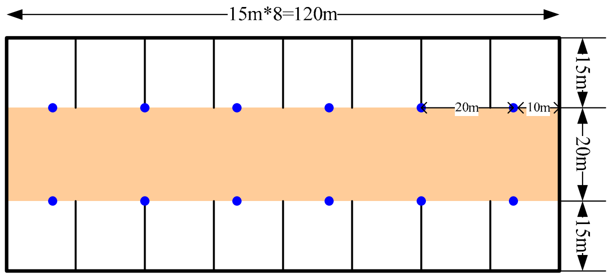

Fig. 2. Sketch of InH deployment: case 1

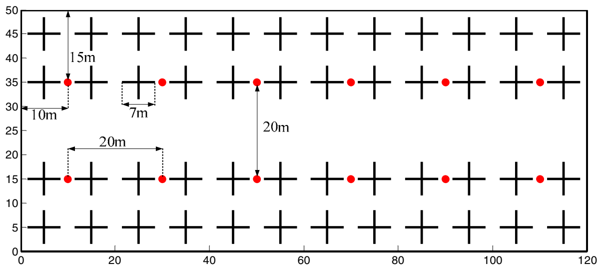

Fig. 3. Sketch of InH deployment: case 2

To derive the parameters for the LOS probability models in Table I, the two deployment cases in Fig.2 and Fig.3 were considered. Ray tracing simulation was conducted to develop the LOS probability distribution along with distance for both cases. In the simulation, 300000 UE positions were randomly chosen in a uniform distribution within the 120mx50m area. The twelve TRP locations at a height of 3m were investigated in each case. To evaluate different UE placement situations, e.g. hand-held or on the desktop, the UE heights were randomly chosen between 1m to 1.5m with a uniform distribution.

The weighted minimum MSE (mean square error) was used as criteria for optimal parameterization. The simulation data for both cases were treated with equal weight. The evaluation results can found in Fig.4. The parameterization results are summarized in Table II. Compared with original results in [3] and [4], the parameters are changed due to the change of the deployment scenario. The new model proposed in this paper ((4) in Table II) fits the propagation in indoor hotspots newly defined in [6] best of the four models evaluated. And it can improve the deficiency of ITU model.

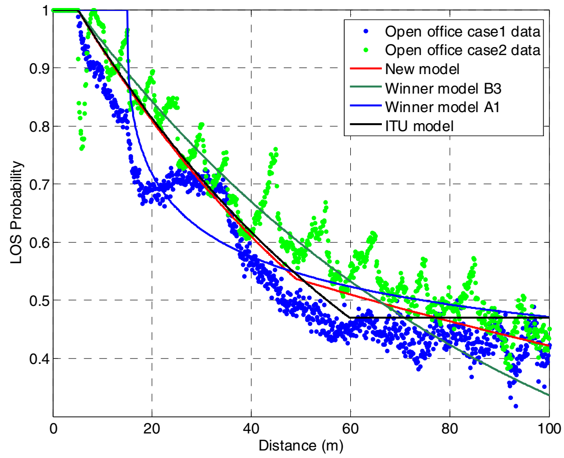

Fig. 4. Indoor open office LOS probability modeling

TABLE II
Summary on parameterization results

Model	Results	MSE
(1)	$\begin{cases} 1, & d \le 5 \\ \exp(-(d-5)/72.6), & 5 < d < 59.8 \\ 0.43 & d \ge 59.8 \end{cases}$	0.0034
(2)	$\begin{cases} 1, & d \le 5 \\ \exp(-(d-5)/87.3), & d > 5 \end{cases}$	0.0051
(3)	$\begin{cases} 1, & d \le 15 \\ 1-1.82(1-(1.01-0.01\log 10(d))^3)^{1/3}, & d > 15 \end{cases}$	0.0056
(4)	$\begin{cases} 1, & d \le 5 \\ \exp(-(d-5)/70.8), & 5 < d < 49 \\ \exp(-(d-49)/211.7)\cdot 0.54, & d \ge 49 \end{cases}$	0.0031

4. Conclusion

In this paper, LOS probability for 5G indoor hotspot has been studied. A new model is introduced. It fits the propagation in indoor hotspot newly defined for 5G best of the four models evaluated. And it can improve the deficiency of ITU model.

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