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Title(English)	Frequency Dependency Analysis of Geometry-Based Clusters in Indoor Environments at SHF Bands
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Thesis Outline

Frequency Dependency Analysis of Geometry-based Clusters in Indoor Environments at SHF Bands

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The study of the frequency dependency and physical interpretation of geometry-based clusters across wide frequency ranges are necessary for the improvement of channel model and deployment of the next-generation wireless system as it is expected that several frequency bands will be used simultaneously. However, to the best knowledge, such kind of study has not been done in the open literature.

Therefore, this thesis presents the frequency dependency analysis of geometry-based clusters (GBCs) in indoor environments at super-high frequency (SHF) bands measured at 3, 10 and 28 GHz. Firstly, measurement-based ray tracer (MBRT) was used to obtain scattering points (SPs) of each multipath component (MPC) estimated from the measured data. Secondly, the KPowerMeans (KPM) clustering framework, which is called SP-based KPM (SPKPM), was used to cluster the MPCs based on the SPs. Finally, clusters were recombined and tracked based on the distance between the current and previous spatial snapshots. Finally, their scattering intensities (SIs) were calculated and physical interpretation was conducted by the assistance of physical optics (PO).

The MBRT and SPKPM results showed that the geometry-based clustering method could also be applied to get reasonable scattering locations with sufficient accuracy at multiple frequencies. The frequency dependency analysis illustrated that there were three major cluster groups: 1. No frequency dependence (Reflection), 2. SI decrease with frequency increases (Scattering, Diffraction, Shadowing), 3. SI fluctuates with frequency increases (Fading). Group 1 was dominant in the hall environment because of the reflection on smooth and large cylindrical surfaces such as tubes and pillars. Group 2 comprised of scattering from brick, shadowing by tubes and pillars, and diffraction from the metal stud. Group 3 occurred due to phase and Fresnel zone difference fading. The phase difference fading occurred due to the constructive and destructive interference of several signals from several surfaces. In contrast, the Fresnel zone difference fading happened as different Fresnel zones of the signals were shadowed at different frequencies.

The findings in this thesis were used to improve the cluster frequency dependence of the 3GPP channel model. Clusters were divided into two types: 1. Roughly same SI across frequencies, 2. SI decreases as frequency increases. The comparison of the clusters derived from conventional and proposed models was done to clarify the validity of the proposed method and how the properties of the parameters change from the modification. The distribution types of type 1, type 2, and all clusters were mostly the same. However, the cluster properties varied greatly for each type and environment, and the frequency dependency trend of each type of clusters was the same as the assumption. These results implied that it is vital to generate two different types of clusters separately due to dissimilar properties to improve the frequency dependence of the channel model.

These studies also showed that the frequency characteristics and cluster properties across the SHF bands could change drastically for different environments as they contain dissimilar structures of scattering objects.