Introduction of TG3c channel model and beyond

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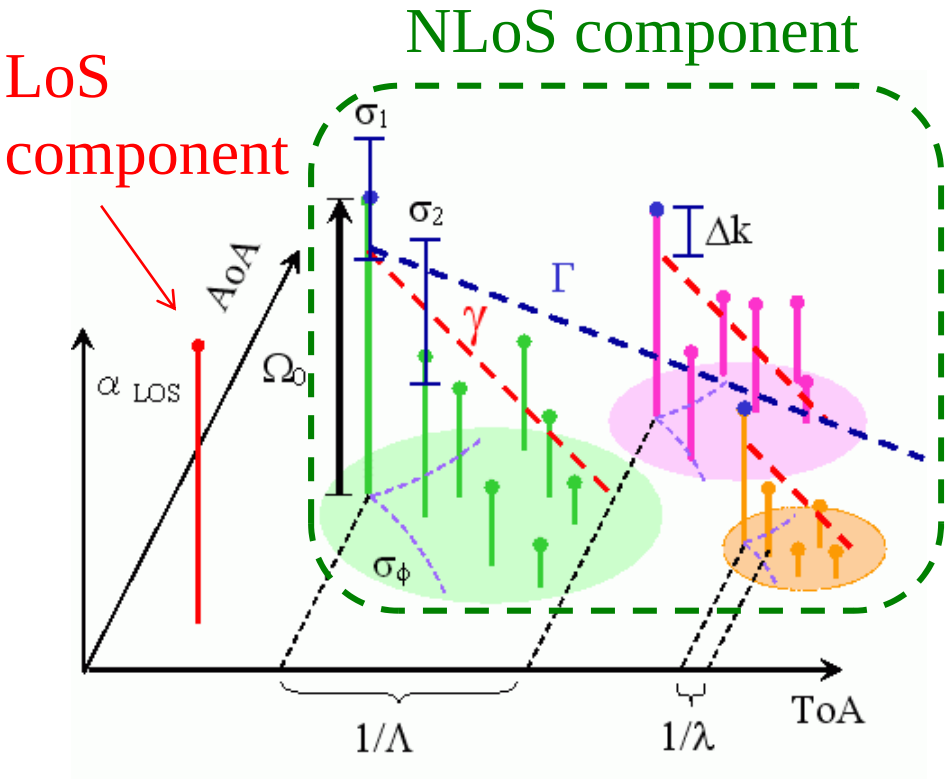
Outline

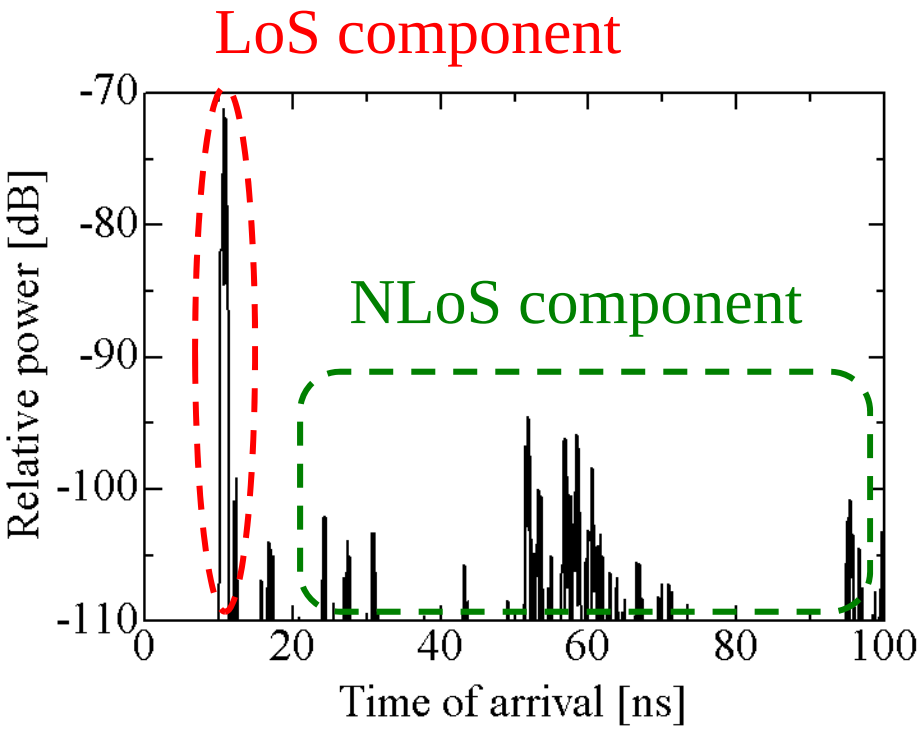
- Introduction of TG3c channel model
- Comments on TGad channel model requirements (P802.11-09/323r0)
- Comments on channel models for 60 GHz WLAN systems (P802.11-09/336r0)
- Reusability of TG3c intra-cluster parameters
- Introduction of recent propagation measurement

Introduction of TG3c channel model (1)

- TG3c channel model is statistical channel model
- The model merging statistical two-path and SV-model
- AoA, ToA at Rx side were included, however, AoD at Tx-side was not adopted, good enough for non-beam forming systems
- Line of sight component is very strong comparing with non-line of sight components

Introduction of TG3c channel model (2)





- Graphical representation of the CIR(complex impulse response) as a function of ToA(time of arrival) and AoA(angle of arrival)
- LoS component and NLoS component are merged

For NLoS environment

- NLoS channel models for “ Desk top” and “ Residential” were developed By removing LoS component from LOS channel models to save channel model development time
- A number of measurements carried out for real NLOS environments later on and confirmed this “short-cut” approach is good enough

Introduction of TG3c channel model (3)

Channel Model	Scenario	Environment	Descriptions
CM1	LOS	Residential	Typical home with multiple rooms and furnished with furniture, TV sets lounges, etc. The size is comparable to the small office room. The walls/floor are made of concrete or wood covered by wallpaper/carpet. There are also windows and wooden door in different rooms within the residential environment.
CM2	NLOS		
CM3	LOS	Office	Typical office setup furnished with multiple chairs, desks, computers and work stations. Bookshelves, cupboards and whiteboards are also interspersed within the environment. The walls are made by metal or concrete covered by plasterboard or carpet with windows and door on at least one side of the office. Cubical, laboratory, open and closed office can be treated as a generic office. Typically these offices are linked by long corridors.
CM4	NLOS		
CM5	LOS	Library	Typical small size library with multiple desks, chairs and metal bookshelves. Bookshelves are filled with books, magazines, etc. Some tables and chairs were interspersed between the bookshelves. At least one side of room has windows and/or door. The walls are made of concrete.
CM6	NLOS		
CM7	LOS	Desktop	Typical office desktop and computer clutter. Partitioning surrounded this environment
CM8	NLOS		
CM9	LOS	Kiosk	Typical kiosk server with human body holding a portable device. The portable device is pointed to the kiosk server.

by NICT contributions

Comments on TGad channel model requirements (P802.11-09/323r0)

802.15.3c Channel Model Discussion (1)

- We believe the general approach used to create the channel models, based on the extended time-angular S-V model, is valid. Some of results obtained by the IEEE 802.15.3c channel modeling group may be reused in the 60 GHz TGad channel model.
- Yes: By reusing the TG3c channel model parameter will reduce the measurement time for development of TGad channel model
- However, the reuse of the IEEE 802.15.3c channel modeling results is complicated by the fact that *no raw channel measurement data, except for the IMST company data* used to generate the library model, are available [2].
- No: NICT provided raw channel data for LoS residential and NLoS office environment. There are on IEEE server. Document numbers are 802.15-06/12r1 and 06/13r2

802.15.3c Channel Model Discussion (2)

- 802.15.3c channel model provides limited support for evaluating beamforming performance:
  - Angle-of-Departure (AoD) is not included in the .15.3c channel models and the AoA model only describes the azimuth angle (no elevation information)
- TG3c channel model developments focused on not so high gain antenna systems and resulted in relevant channel models for low to medium gain antenna systems. The channel model developments on high gain antenna systems such as the systems deploying beam forming technology may result in a channel model close to AWGN.

802.15.3c Channel Model Discussion (2)

- There is no support for polarization characteristics:
  - As was shown in [3], the degradation due to polarization mismatch can be as high as 20 dB
- Only vertical polarization was adopted for TG3c channel models, since reflection waves from floor and ceiling are reduced with vertical polarization. If the polarization is taken into account, it is difficult to keep the independence of room since reflection coefficient depends on incident angle.
- There is no support for non-stationary, human body blockage effects which can have a strong impact on 60 GHz devices
- A loss of human body blockage over 40dB has been confirmed by experiments, it can be dealt as NLoS environment or by reducing the number of clusters.

802.15.3c Channel Model Discussion (3)

- Due to differences in the approaches to statistical channel modeling, 802.15.3c decided to prepare golden data sets (instead of Matlab code) for the channel realizations that were used in proposal evaluation.
- No. TG3c Matlab code was provided to generate whole channel realizations. Golden data sets were also provided for non-Matlab users for easy simulation.

802.15.3c Channel Model Discussion (3)

- The golden sets were prepared for only a subset of the channel models (CM1, CM2 and CM3) that included some “extraordinary” realizations that produced a BER “floor” for some channels [4, 5].
- The Golden sets were prepared for all channel models required for system simulation and they are not only a subset. Extraordinary responses are fatal problem of statistical channel models (modified S-V). Thus 10% worst responses were removed from PHY simulations in 15.3c as well as 15.4a. NICT proposed an improvement method to solve this problem (Doc.P802.15-06-0453r0), however, it was withdrawn due to the limited time line for “call for proposal”.

Propagation Environments of Interest for TGad

- Three environments are considered in accordance with the evaluation methodology proposal [6]:
  - Residential living room
  - Conference room
  - Cubicle environment
- The residential environment was measured. The parameters of TG3c desktop environments can be used as another measurement data of conference room environment for TGad. New measurement only for cubicle environment will be required.

Propagation Environments of Interest for TGad

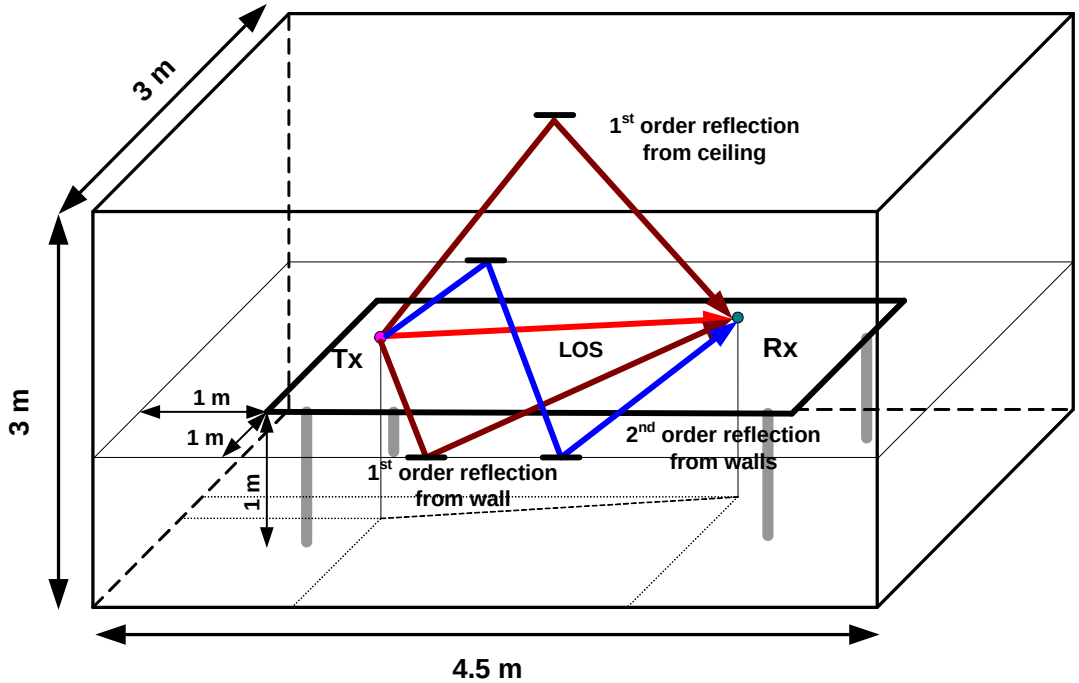
- Adding more environments may unnecessarily complicate the channel model development:
  - Most of the TGad usage models [7] can be related to the above three environments
  - Measurements may not be available for other environments
- If other environments are required for new usage, TG3c channel models have possibility to support them.

Comments channel models for 60 GHz WLAN systems (P802.11-09/336r0)

$$h\left(t,\varphi_{tx},\theta_{tx},\varphi_{rx},\theta_{rx}\right)=\sum_{i}A^{(i)}C^{(i)}\left(t-T^{(i)},\varphi_{tx}-\Phi_{tx}^{(i)},\theta_{tx}-\Theta_{tx}^{(i)},\varphi_{rx}-\Phi_{rx}^{(i)},\theta_{rx}-\Theta_{rx}^{(i)}\right)$$

$$C^{(i)}\left(t,\varphi_{tx},\theta_{tx},\varphi_{rx},\theta_{rx}\right)=\sum_{k}\alpha^{(i,k)}\delta\left(t-\tau^{(i,k)}\right)\delta\left(\varphi_{tx}-\varphi_{tx}^{(i,k)}\right)\delta\left(\theta_{tx}-\theta_{tx}^{(i,k)}\right)\delta\left(\varphi_{rx}-\varphi_{rx}^{(i,k)}\right)\delta\left(\theta_{rx}-\theta_{rx}^{(i,k)}\right)$$

Ray Tracing Model for Conference Room



Comments on channel models for 60 GHz WLAN systems (P802.11-09/336r0)

- Direct wave is considered as a separated component from other clusters of reflection waves
- Cluster parameters (large scale parameter) are simulated by ray trace method
- That is a good idea to reduce the measurement time for three dimensional AoD and AoA information
- Only intra-cluster parameter is extracted from measurement result
- A channel model of conference environment is proposed

Reusability of intra-cluster parameter

- TG3c channel model has intra-cluster parameters in many environments

  λ, intra-cluster (ray) arrival rate
  γ, intra-cluster (ray) decay rate
  σ_r, ray lognormal standard deviation
  σ_ϕ, angle spread

- By reusing these parameters, the measurement time will be reduced

Summary

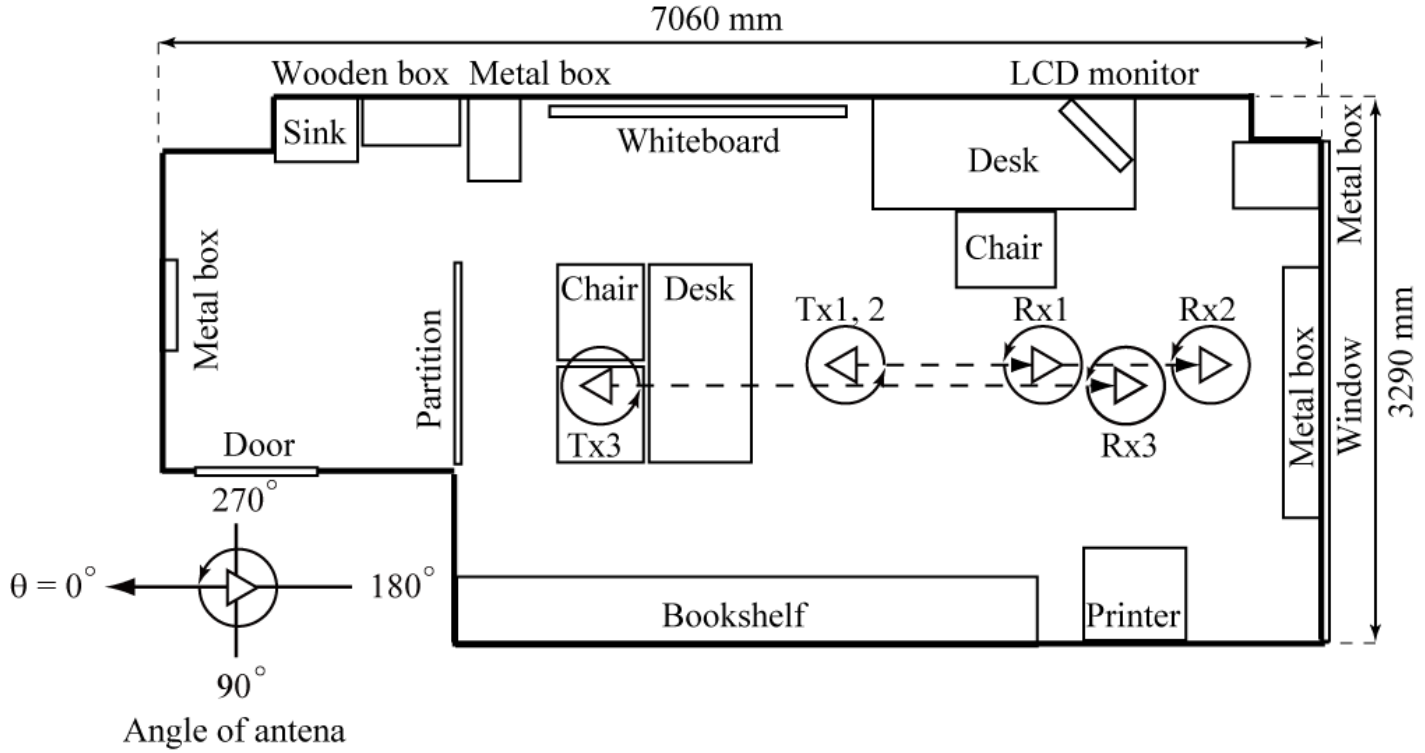
- TG3c channel model is introduced for development of TGad channel model
- To reuse TG3c intra-cluster parameter is proposed to reduce new measurement

Discussion

- How to compromise Ray tracing as a good propagation analysis tool and modified S-V model for easy system simulation
- How to reuse existing data including TG3c intra-cluster parameters
- How to validate developed channel models (RMS delay spread, Excess delay, etc.)

Introduction of recent propagation measurement work

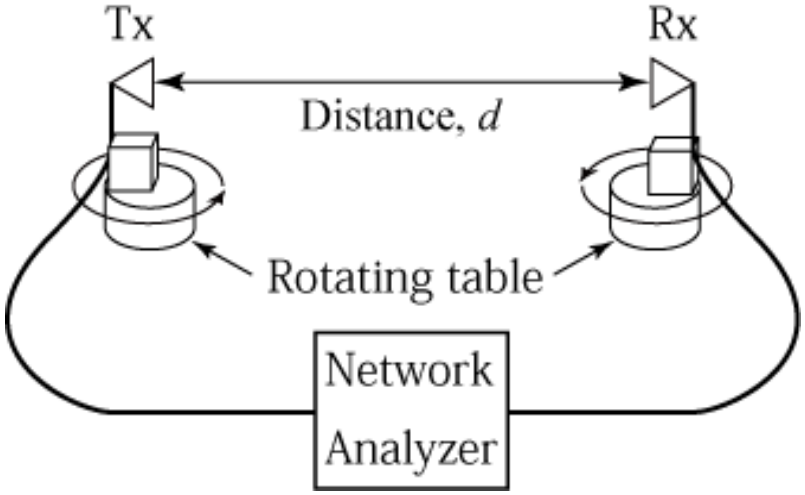
- Double directional propagation measurements in office environment have been done



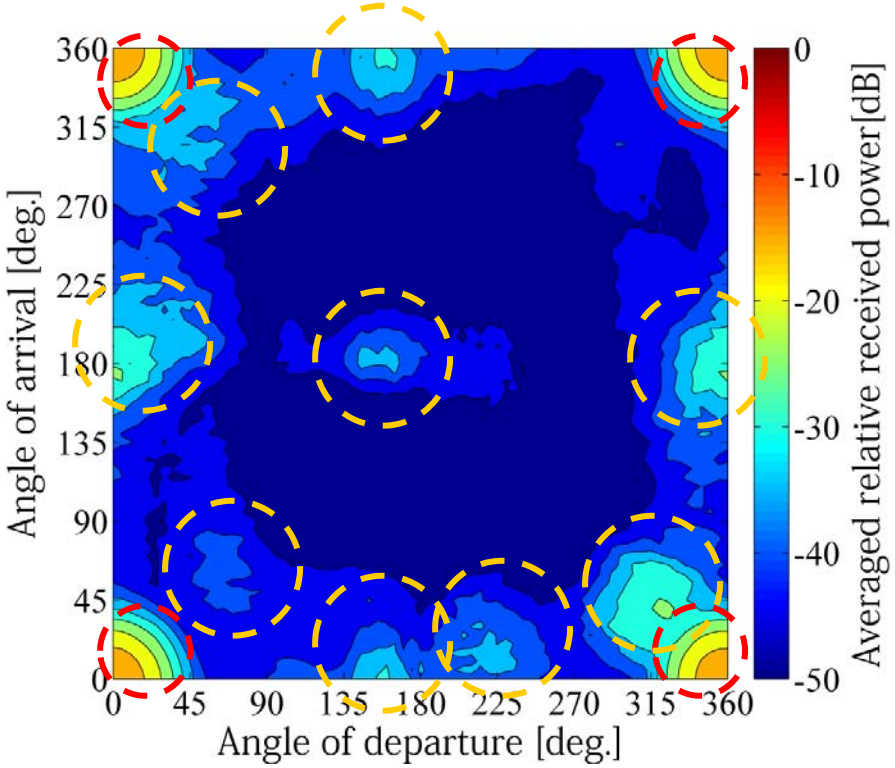
Floor plan of office environment

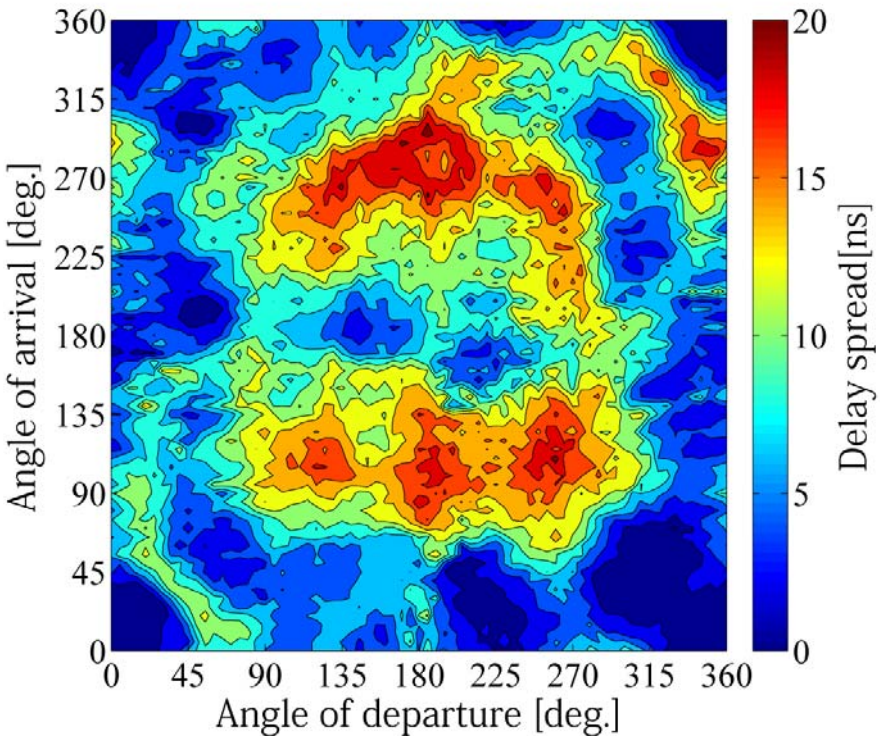
Detail of propagation measurement

Instrument	HP8510C VNA
Center frequency	62.5 GHz
Bandwidth	3 GHz
Tx and Rx antennas	Conical horn antenna (16dBi) Beam width: 30 degrees
Rotational step angle	5 degrees
Distance between Tx and Rx	d =1, 2, 3m



Example of measurement results (distance:3m)





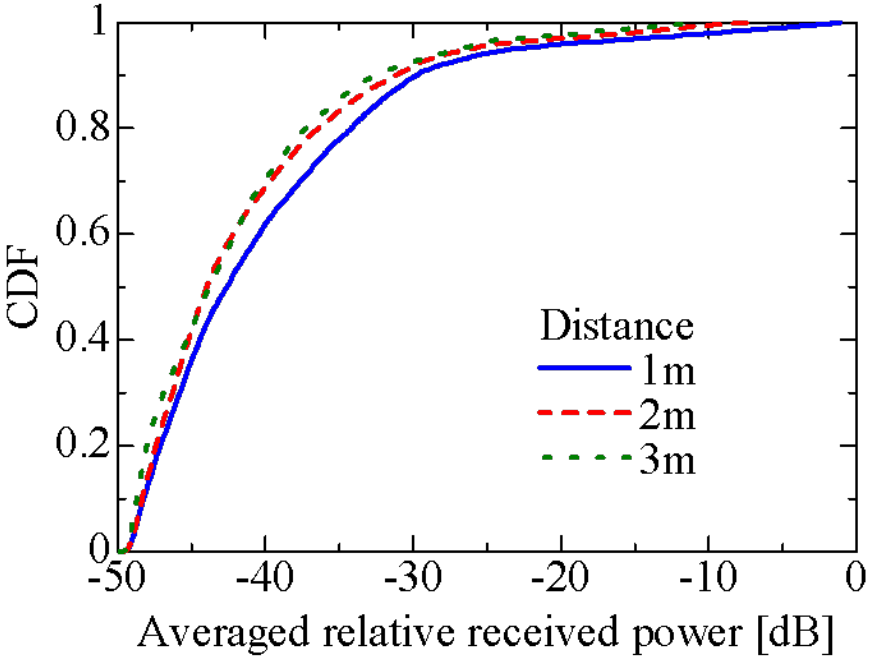
Averaged relative received power

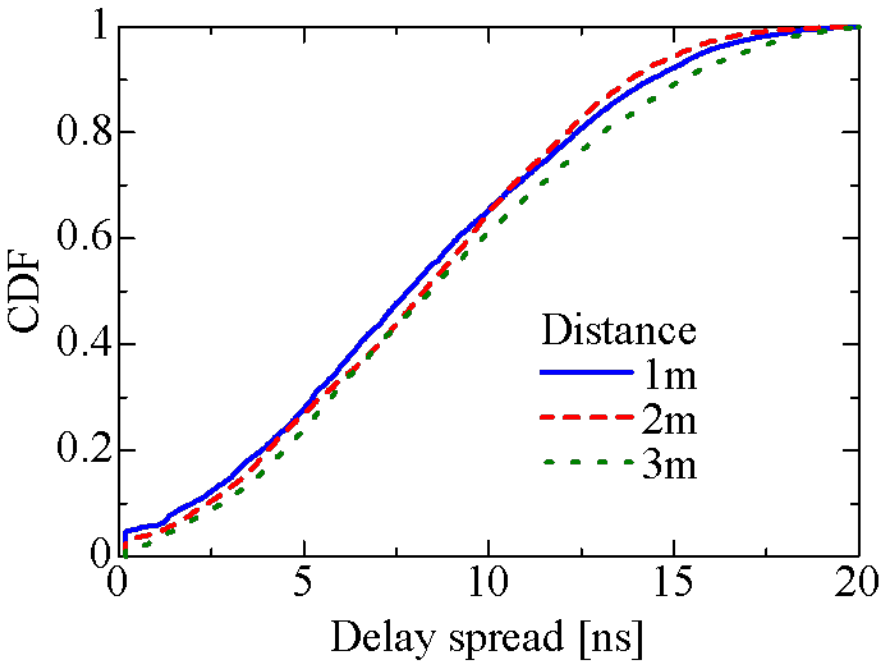
Delay spread

Direct wave

Reflection wave clusters

Statistics of measurement results example





Averaged relative received power Delay spread

- Development of double directional channel model from measurement result is future work