Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [A new LOS kiosk channel model based on TSV model]
Date Submitted: [February, 2007]
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Abstract: [This contribution describes LOS kiosk channel model based on TSV model.]

Purpose: [Contribution to mmW TG3c meeting.]

A new LOS kiosk channel model based on TSV model

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Summary

- Current kiosk environment (UM5) employs LOS office channel model (CM3)
- Some channel model users claimed that the channel model for UM5 has too strong reflections
- We re-measured propagation characteristics for kiosk environment and created a new channel model
- We suggest to use the new channel model to replace the current model (UM5)

Problem of kiosk (UM5) channel model

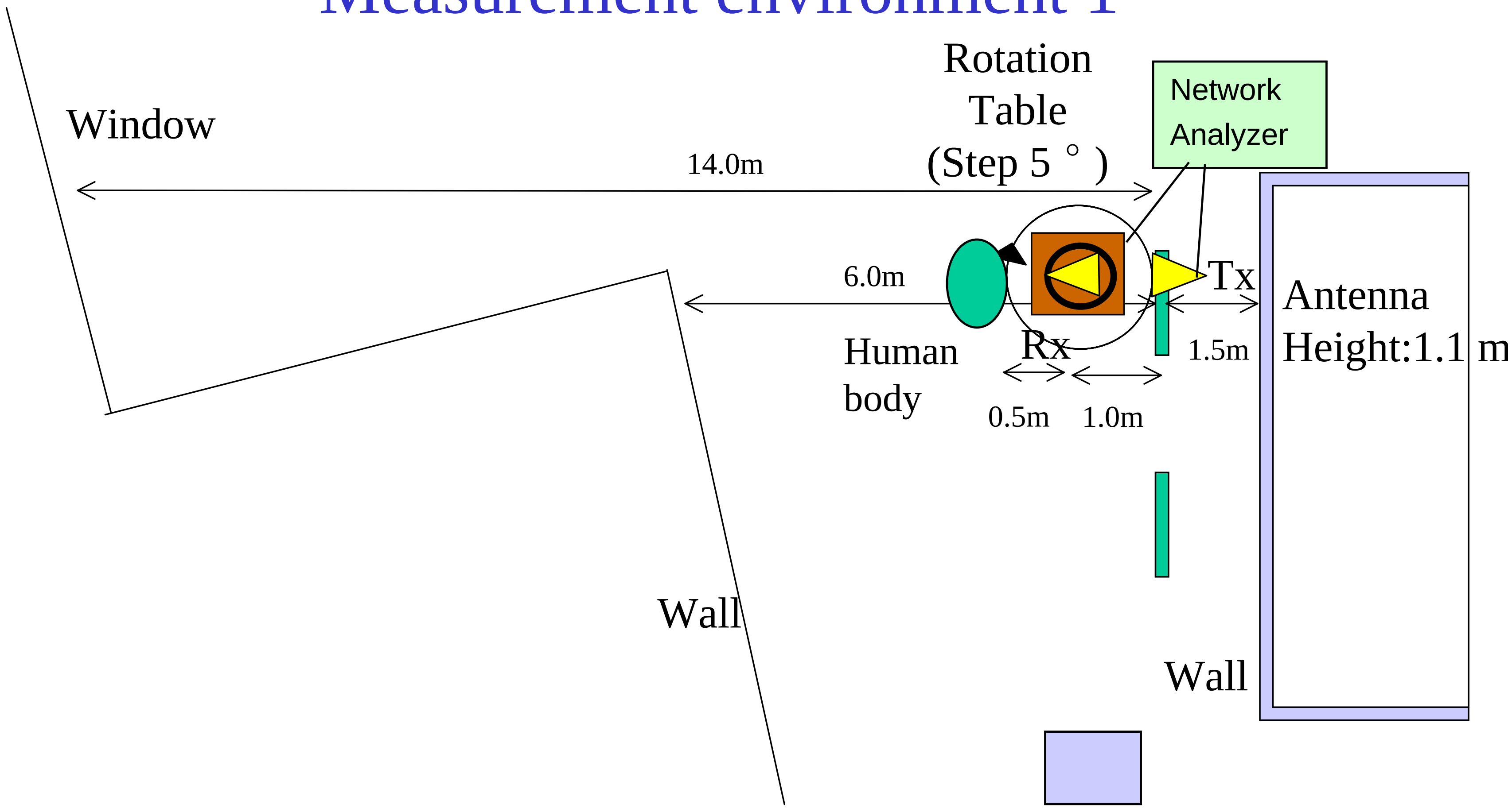
- Kiosk and office environments are found to be quite different environments
- Metal walls in office rooms cause the strong reflection, however, this is not the case of kiosk usage
- In kiosk environments, distance between server and PDA is 1m and human body will block large delay reflection waves, so that the delay spread will be smaller than that of LOS office environments
- More suitable channel model for kiosk environments is required

Measurement environment 1

Entrance hall of building

- With Objects that looks like kiosk server
- With Human body

Measurement environment 1



Floor plan of LOS kiosk environment

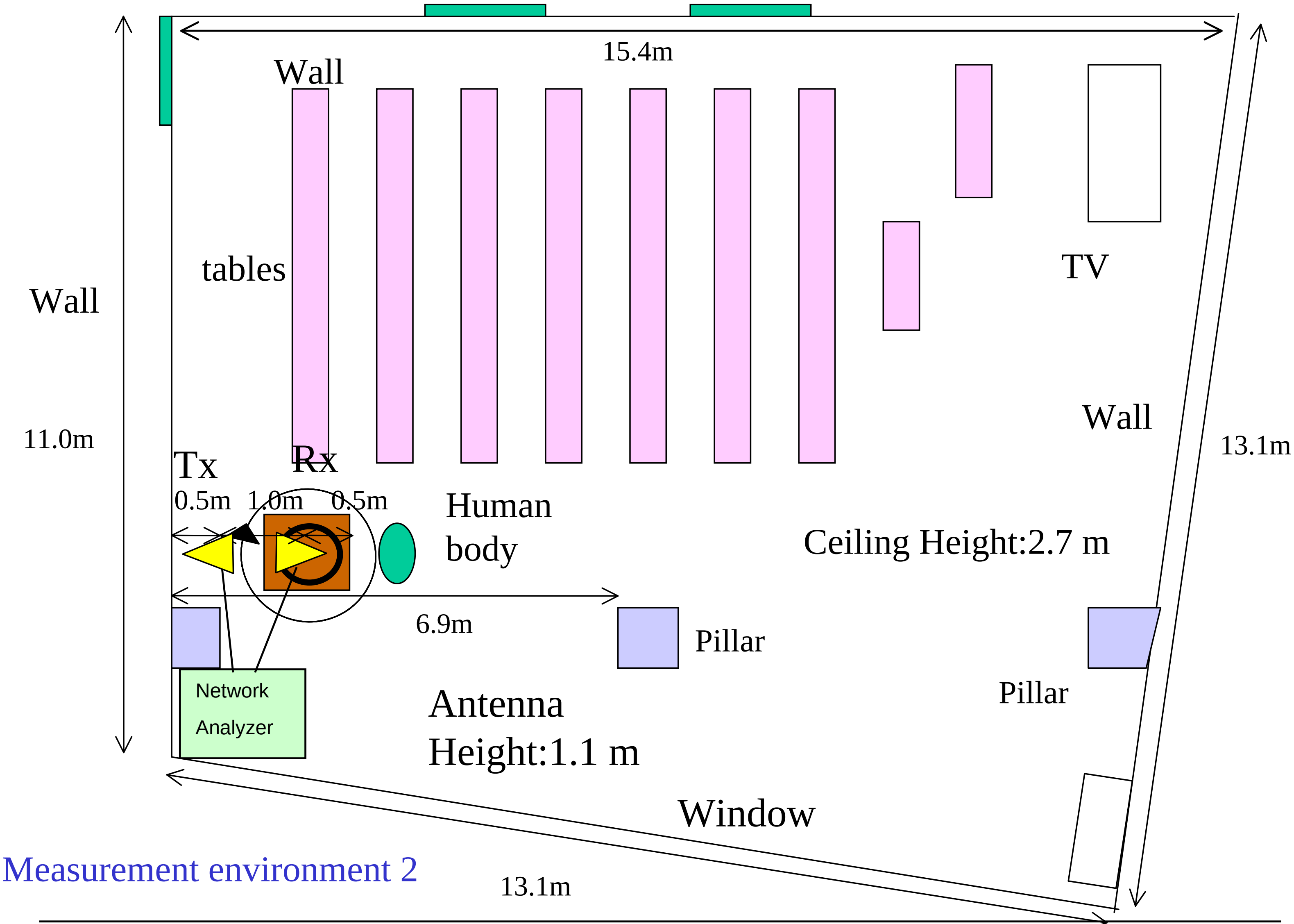
Measurement environment 2

Large room of building:11.0mx15.4m

(situation in such as convenience store)

•Surrounded by plaster board and glass window

•With Human body



Measurement environment 2

Measurement conditions

Instrument	HP8510C VNA
Center frequency	62.5 GHz
Bandwidth	3 GHz
Time resolution	0.333 ns
Distance resolution	19.1 cm
# of frequency points	801
Frequency step	3.75MHz
Times of average	128 times

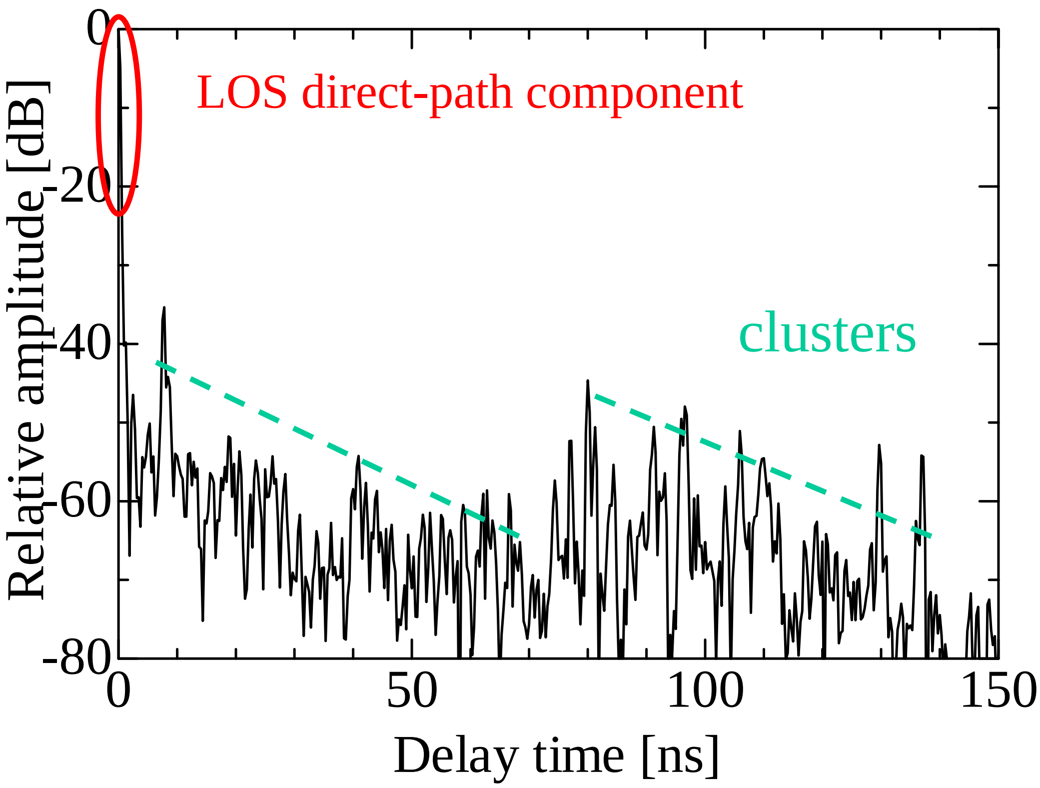
- Calibration performed with 1m reference separation
- Time resolution and distance resolution were determined by bandwidth

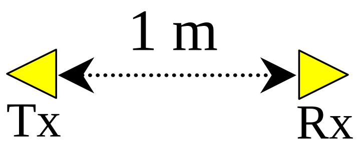
Measurement conditions (cont')

- **Antenna:** Conical horn antenna
- **Polarization:** Vertical
- **Beam-width:** Tx:30 and Rx 30

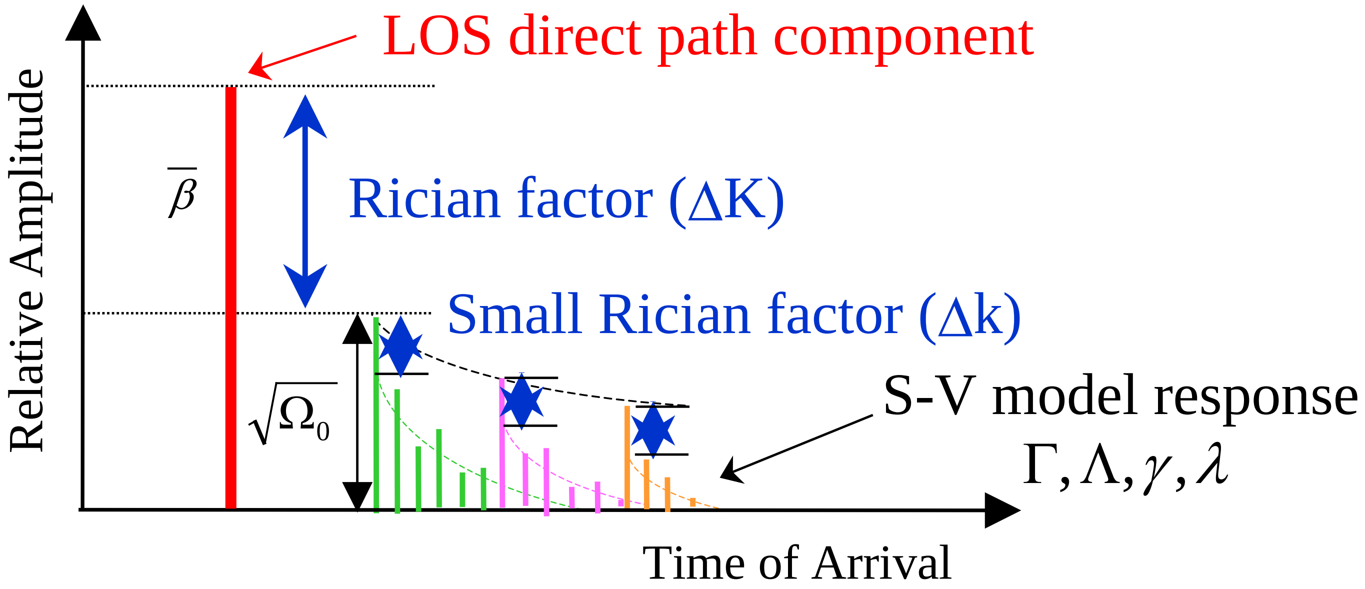
Conical horn antenna
Beam-width 30 deg

Example PDPs (Power delay profile) in measurement environment 1 (Beam width: Tx=30, Rx=30)





Impulse response



By setting $\Gamma_0 = 0$, TSV model can generate impulse response for LOS kiosk channel without any modification

TSV model for LOS kiosk environment

- For LOS desk top environment (06/297)

TSV model = Two-path component + S-V component

$$h(t)=\beta\,\delta(t)+\sum_{l=0}^{L-1}\sum_{m=0}^{M_l-1}\alpha_{l,m}\,\delta\left(t-T_l-\tau_{l,m}\right)\delta\left(\varphi-\Psi_l-\psi_{l,m}\right)$$

$$\beta=\left(\frac{\mu_D}{D}\right)^2\left|\sqrt{G_{t1}G_{r1}}+\sqrt{G_{t2}G_{r2}}\Gamma_0\exp\left[j\frac{2\pi}{\lambda_f}\frac{2h_1h_2}{D}\right]\right|$$

Statistical factors in both two-path and S-V

- For LOS kiosk environment

Reflection coefficient: Γ_0 0

Modified TSV model = Direct-path component + S-V component

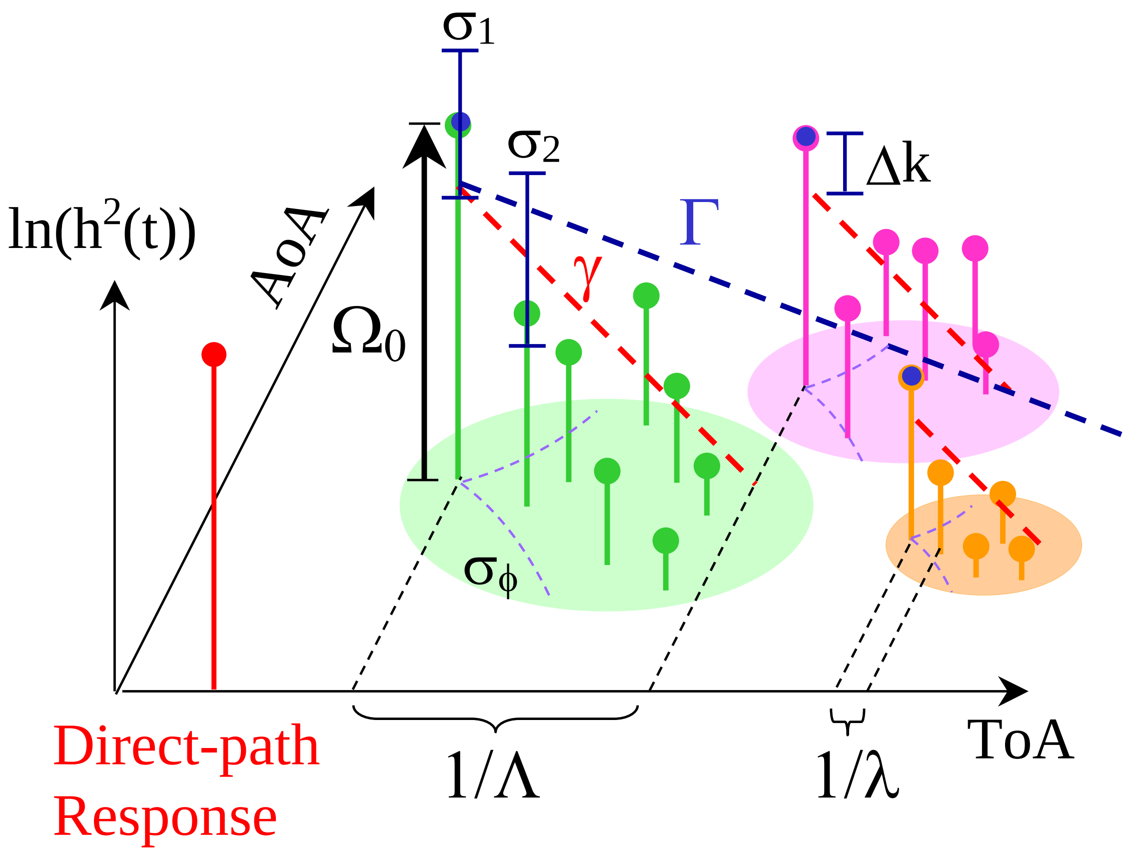
$$h(t)=\beta\,\delta(t)+\sum_{l=0}^{L-1}\sum_{m=0}^{M_l-1}\alpha_{l,m}\,\delta\left(t-T_l-\tau_{l,m}\right)\delta\left(\varphi-\Psi_l-\psi_{l,m}\right)$$

$$\beta\Big|_{\mu_D<<D}=\sqrt{G_{t1}G_{r1}}$$

Statistical factors in only S-V

Refer to Appendix A for each parameter

TSV model parameters to be extracted



Γ : *cluster* decay factor

$1/\Lambda$: *cluster* arrival rate

γ : *ray* decay factor

$1/\lambda$: *ray* arrival rate

σ_1 : *cluster* lognormal standard deviation

σ_2 : *ray* lognormal standard deviation

σ_ϕ : Angle spread of ray within cluster (Laplace distribution)

Ω_0 : Average power of the first ray of the first cluster

Small Rican factor Δk and Ω_0 are necessary for TSV model

Extracted TSV model parameters

Channel model		TSV Model	Small Rician effect	S-V model oriented parameter							Number of cluster
	Parameter	$\Omega_0(d)$ [dB]	k (Δk)	Γ [ns]	$1/\Lambda$ [ns]	γ [ns]	$1/\lambda$ [ns]	σ_1 cluster	σ_2 ray	σ_ϕ [deg]	N
LOS Kiosk measurement environment 1	Tx:30 Rx:30	-98.0 @1m	11.0 dB	30.2	18.3	36.5	1.09	2.23	6.88	34.2	5
LOS Kiosk measurement environment 2	Tx:30 Rx:30	-107.8 @1m	9.1dB	64.2	22.6	61.1	0.99	2.66	4.39	45.8	7
LOS office	Tx:30 Rx:30	-3.27D-85.4	21.9dB	49.8	24.6	45.2	1.03	6.60	12.8	102	6

Sigma 1 and 2 of kiosk environment are smaller than those of LOS office environment, respectively

Refer to Appendix B for each parameter

Conclusions

- Propagation characteristics of Kiosk environments were re-measured and TSV model parameters have been extracted
- A new channel model for LOS kiosk environment has been created
- The New LOS Kiosk channel model should replace the current UM5 channel model

Vote

- New LOS Kiosk channel model is replaced to UM5 channel model.

Yes:

No:

Abstain:

Move: Second:

Appendix A: Definition of TSV model

CIR: $$h(t) = \beta\,\delta(t) + \sum_{l=0}^{L-1}\sum_{m=0}^{M_l-1} \alpha_{l,m}\,\delta(t - T_l - \tau_{l,m})\,\delta(\varphi - \Psi_l - \psi_{l,m})$$

(Complex impulse response)

$$|\alpha_{l,m}|^2 = \Omega_0 e^{-T_l/\Gamma} e^{-\tau_{l,m}/\gamma - k[1-\delta(m)]} \sqrt{G_r(0, \Psi_l + \psi_{l,m})},\ \angle\alpha_{l,m} \propto \text{Uniform}[0, 2\pi)$$

PL_d: Path loss of the first impulse response
t: time[ns]
$\delta(\cdot)$: Delta function
l = cluster number,
m = ray number in l-th cluster,
L = total number of clusters;
M_l = total number of rays in the l-th cluster;
T_l = arrival time of the first ray of the l-th cluster;
$\tau_{l,m}$ = delay of the m-th ray within the l-th cluster relative to the firs path arrival time, T_l;
Ω_0 = Average power of the first ray of the first cluster
$\Psi_l \propto$ Uniform[0,2π); arrival angle of the first ray within the l-th cluster
$\psi_{l,m}$ = arrival angle of the m-th ray within the l-th cluster relative to the first path arrival angle, Ψ_l

Two-path response

$$\beta\,[\text{dB}] = 20 \cdot \log_{10}\left[\left(\frac{\mu_d}{d}\right)\left|\sqrt{G_{t1}G_{r1}} + \sqrt{G_{t2}G_{r2}}\,\Gamma_0 \exp\left[j\frac{2\pi}{\lambda_f}\frac{2h_1h_2}{d}\right]\right|\right] - PL_d(\mu_d)$$

$$PL_d(\mu_d)[\text{dB}] = PL_d(d_0) + 10 \cdot n_d \cdot \log_{10}\left(\frac{d}{d_0}\right) \qquad PL_d(d_0)[\text{dB}] = 20\log_{10}\left(\frac{4\pi d_0}{\lambda_f}\right) + A_{NLOS}$$

A_{NLOS}: Constant attenuation for NLOS

Path number of G_{ti} and G_{ri} (1 : direct, 2 : refrect)

Arrival rate: Poisson process

$$p(T_l \mid T_{l-1}) = \Lambda \exp[-\Lambda(T_l - T_{l-1})], \quad l > 0$$
$$p(\tau_l \mid \tau_{l,(m-1)}) = \lambda \exp[-\lambda(\tau_l - \tau_{l,(m-1)})], \quad m > 0$$

Two-path parameters (4)

$d \propto$ Uniform : Distance between Tx and Rx

$h_1 \propto$ Uniform : Height of Tx

$h_2 \propto$ Uniform : Height of Rx

$\mu_d \propto$ Average of distance between Tx and Rx

$|\Gamma_0|$: Reflection coefficient

$|\Gamma_0| \cong 1$: LOS Desktop environment (incident angle $\cong \pi/2$)

$|\Gamma_0| \cong 0$: Other LOS/NLOS environment

S-V parameters (7)

Γ : *cluster* decay factor

$1/\Lambda$: *cluster* arrival rate

γ : *ray* decay factor

$1/\lambda$: *ray* arrival rate

σ_1 : *cluster* lognormal standard deviation

σ_2 : *ray* lognormal standard deviation

σ_ϕ : Angle spread of ray within cluster (Laplace distribution)

Antenna parameters (2)

$Gt(\theta, \phi)$: Antenna gain of Tx

$Gr(\theta, \iota)$: Antenna gain of Rx

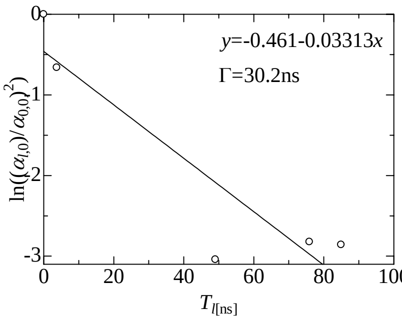
Rician factor (2)

k : ray Rician effect in each cluster

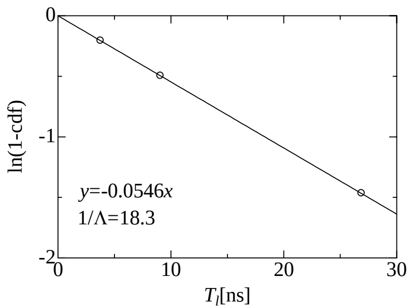
$$K = \frac{\beta^2}{\sum_{l=0}^{L-1}\sum_{m=0}^{M_l-1} |\alpha_{l,m}^2|\,\delta(t - T_l - \tau_{l,m})\,\delta(\varphi - \Psi_l - \psi_{l,m})\,G_r(0, \Psi_l + \psi_{l,m})}$$

Appendix B: Results of data analysis

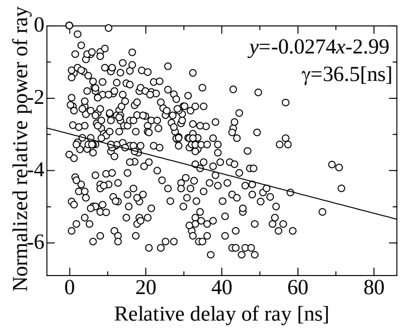
Antenna beamwidth
Tx: 30 deg, Rx: 30 deg



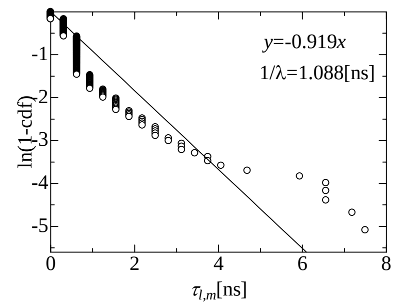
Cluster decay factor (Γ)



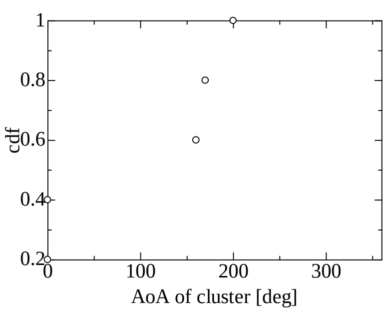
Cluster arrival rate (1/Λ)



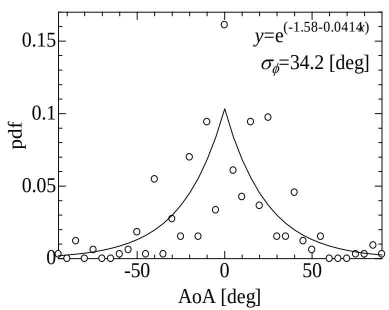
Ray decay factor (γ)



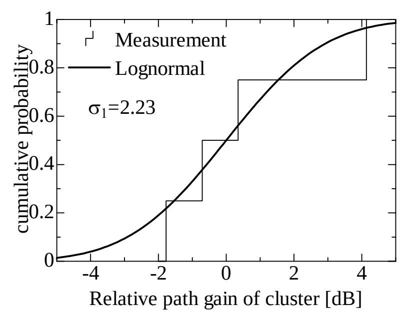
Ray arrival rate (1/λ)



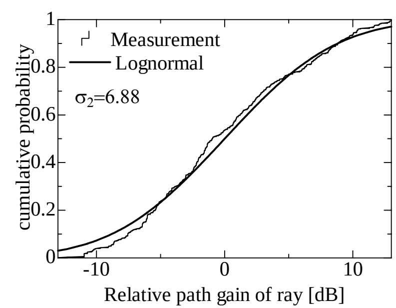
Angle of arrival in cluster (∝Uniform)



Angle spread of ray (σ_ϕ)



Standard deviation of cluster (σ_1)



Standard deviation of ray (σ_2)