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

Submission Title: [A new LOS kiosk channel model based on TSV model]
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Abstract: [This contribution describes a 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 contains excessively strong reflections
- We re-measured the propagation characteristics of the kiosk environment and created a new channel model
- We suggest that the new channel model be added on the current model (UM5)

Problem of kiosk (UM5) channel model

- Kiosk and office environments are quite different
- The metal walls of offices cause strong reflections, however, this is not true for kiosks
- In kiosk environments, distance between server and PDA is 1m and human body blocks large delay reflection waves, so the delay spread will be smaller than that in LOS office environments
- More suitable channel model for kiosk environments is required

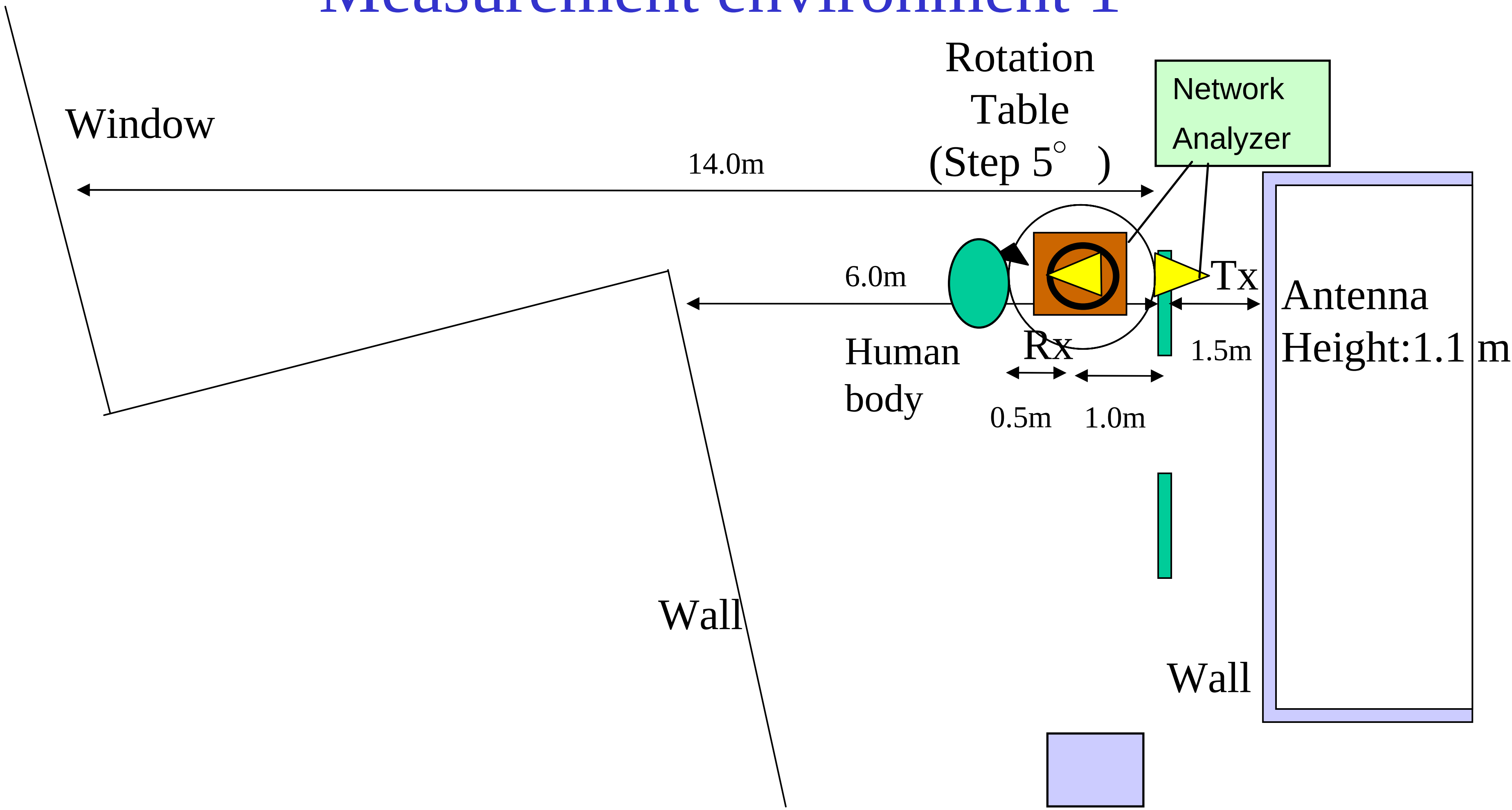
Measurement environment 1

Entrance hall of building

•With Objects that look like kiosk servers

•With Human body

Measurement environment 1



Floor plan of LOS kiosk environment

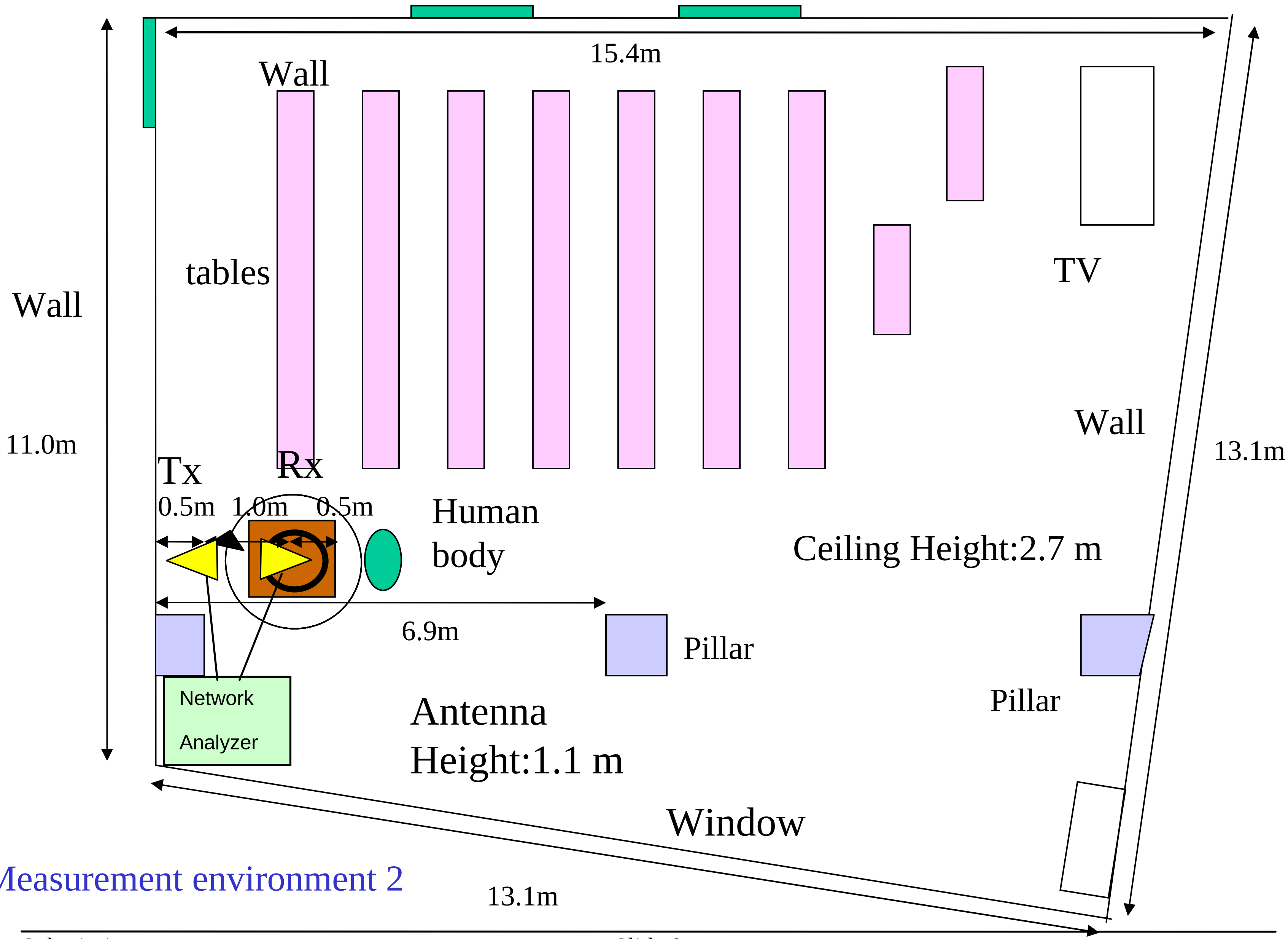
Measurement environment 2

Large room in building:11.0mx15.4m

(situation: such as convenience store)

•Surrounded by plaster boards and glass windows

•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
Averaging interval	128 steps

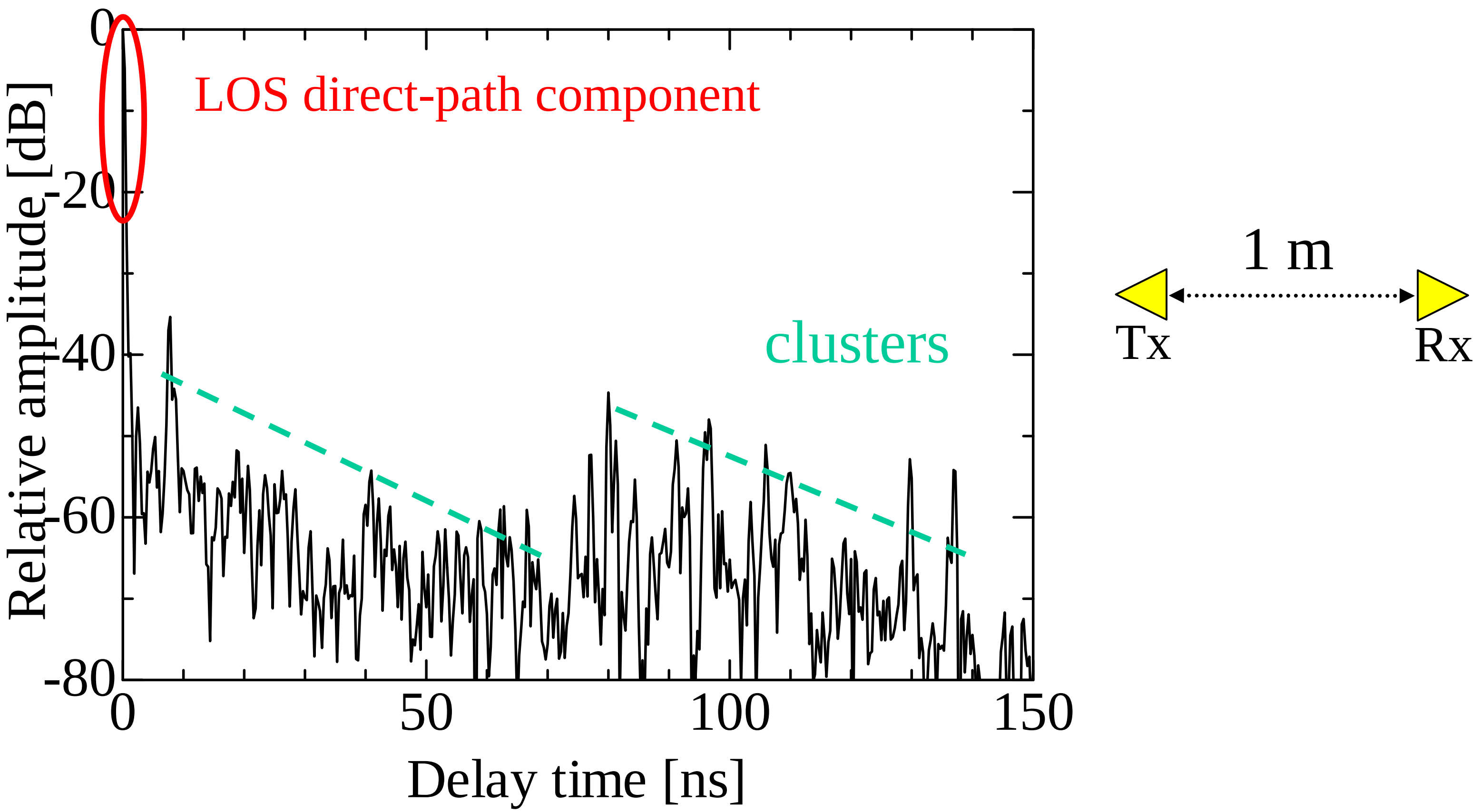
- Calibration performed with 1m reference separation
- Time resolution and distance resolution were determined by bandwidth

Measurement conditions (cont')

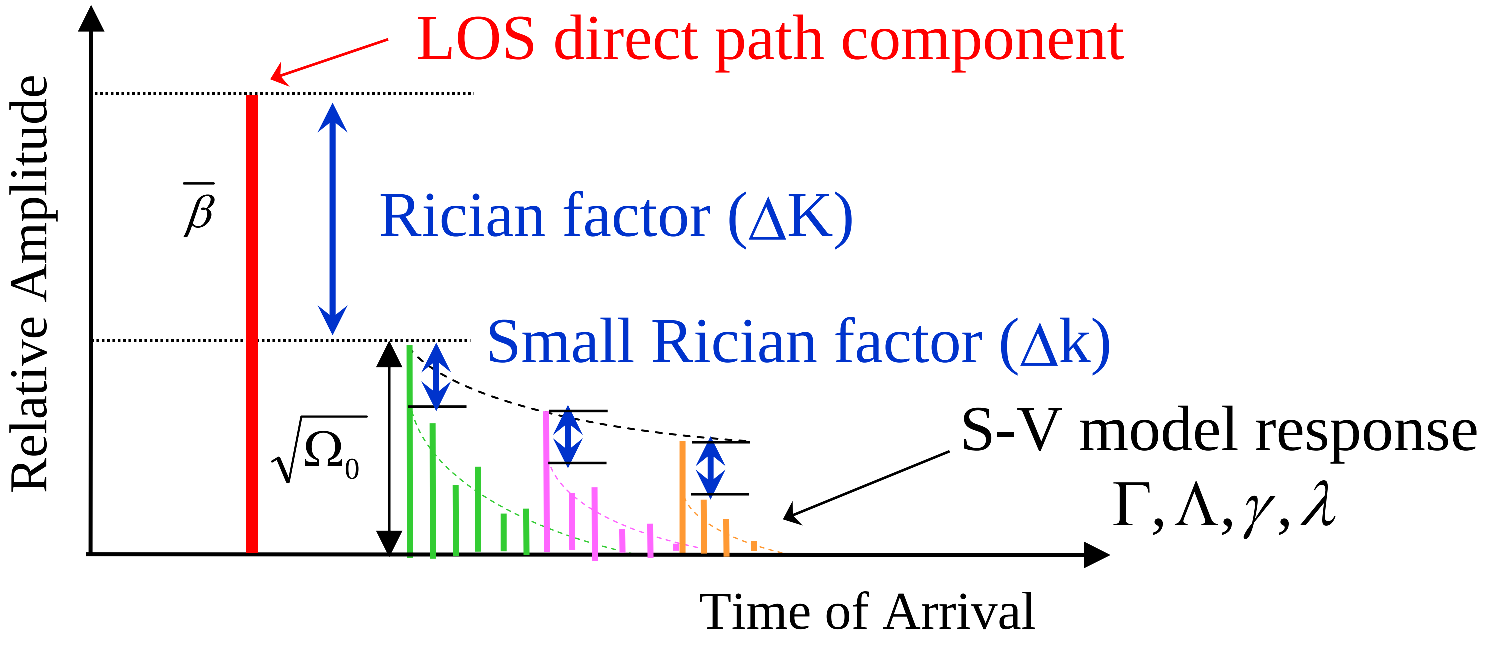
- **Antenna:** Conical horn antenna
- **Polarization:** Vertical
- **Beam-width:** Tx:30 and Rx 30

Conical horn antenna
Beam-width 30 deg.

Example: PDP (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

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

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

Statistical factors in both two-path and S-V

- For LOS kiosk environment

Reflection coefficient: $\Gamma_0 \cong 0$

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

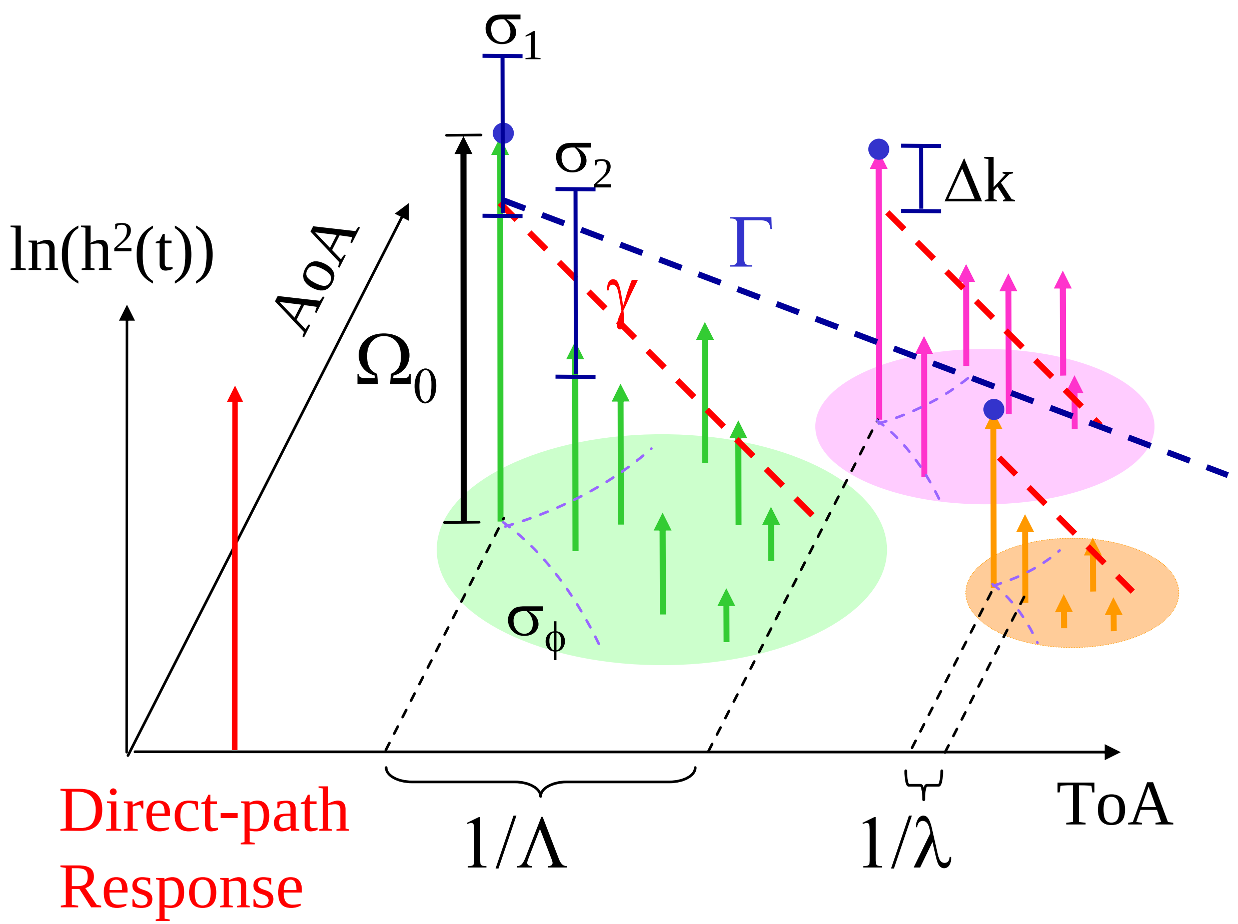
$$h(t) = \beta\,\delta(t) + \sum_{l=0}^{L-1}\sum_{m=0}^{M_l-1}\alpha_{l,m}\,\delta(t - T_l - \tau_{l,m})\,\delta(\varphi - \Psi_l - \psi_{l,m})$$

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

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 parameters							Number of clusters
	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

Refer to Appendix B and C 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 be added on to the current UM5 channel model

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)

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

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

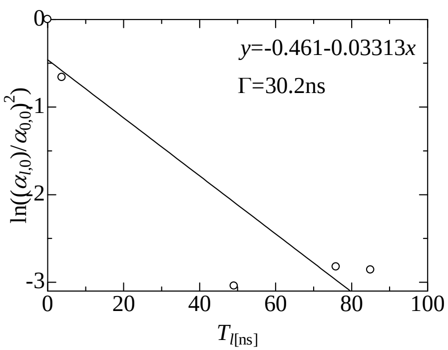
Rician factor (2)

k : ray Rician effect in each cluster

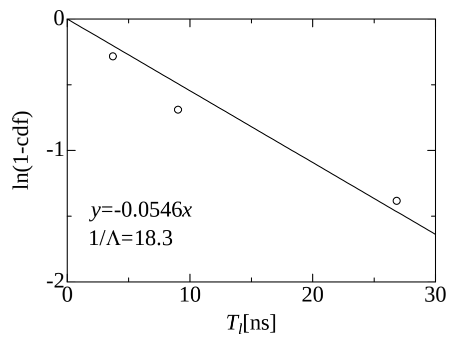
$$K=\frac{\beta^2}{\sum_{l=0}^{L-1}\sum_{m=0}^{M_l-1}|\alpha_{l,m}^2|\,\delta(t-T_l-\tau_{l,m})\,\delta(\varphi-\Psi_l-\psi_{l,m})\,G_r(0,\Psi_l+\psi_{l,m})}$$

Appendix B: Results of data analysis

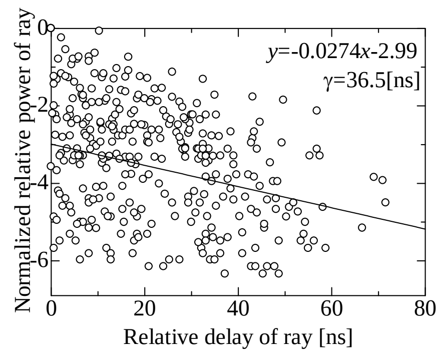
Antenna beamwidth
Tx: 30 deg, Rx: 30 deg



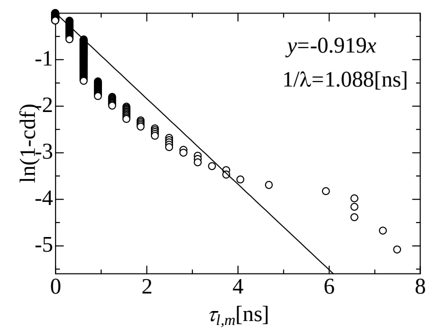
Cluster decay factor (Γ)



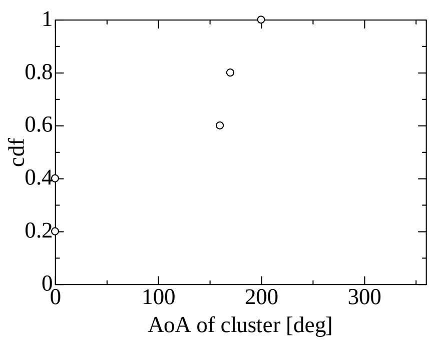
Cluster arrival rate (1/Λ)



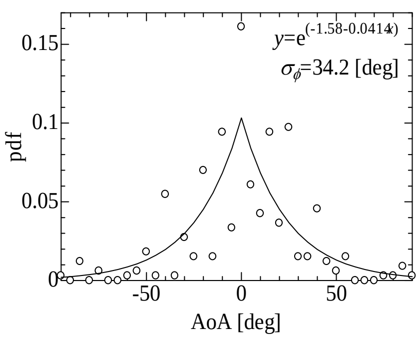
Ray decay factor (γ)



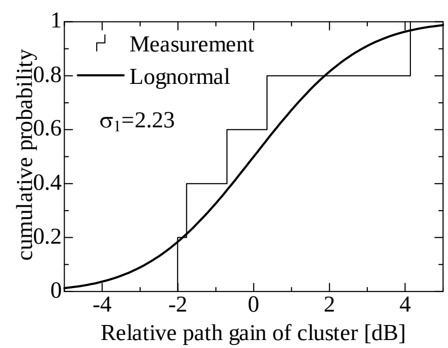
Ray arrival rate (1/λ)



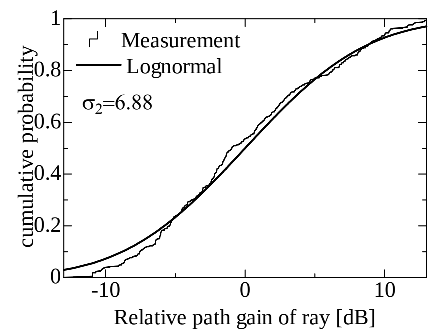
Angle of arrival in cluster (∝Uniform)



Angle spread of ray (σ_ϕ)



Standard deviation of cluster (σ_1)

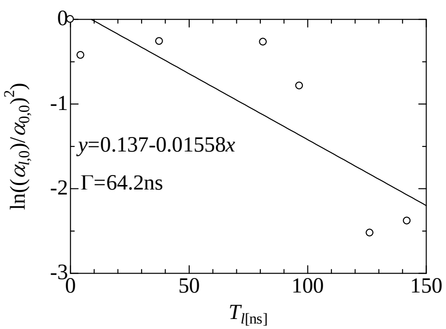


Standard deviation of ray (σ_2)

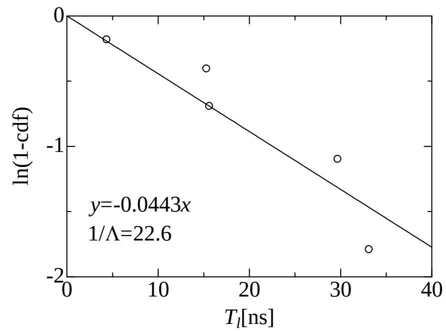
Appendix C: Results of data analysis

Antenna beamwidth

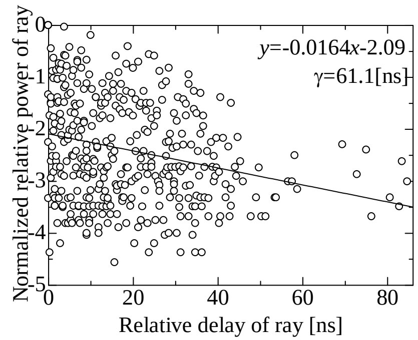
Tx: 30 deg, Rx: 30 deg



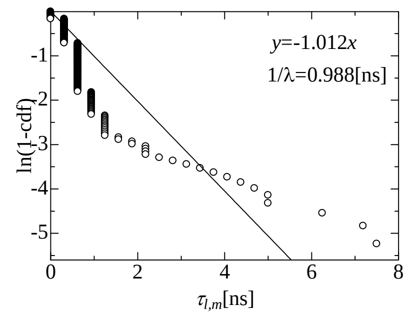
Cluster decay factor (Γ)



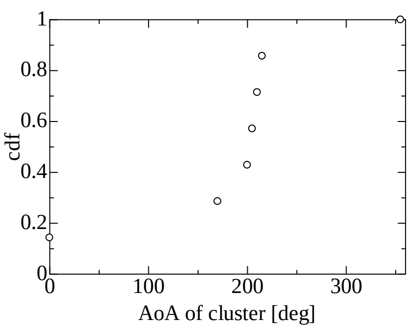
Cluster arrival rate (1/Λ)



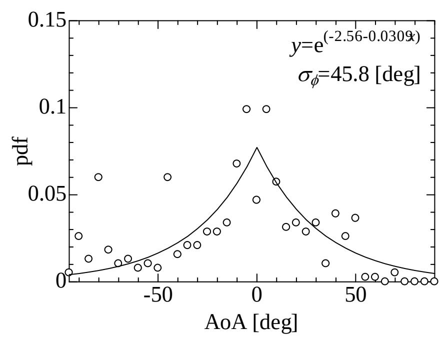
Ray decay factor (γ)



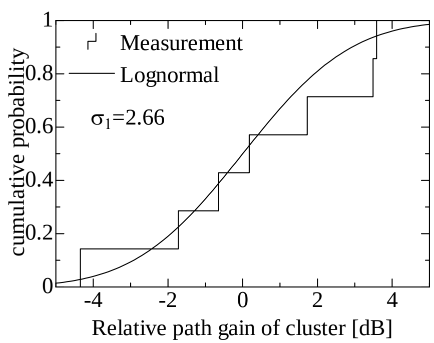
Ray arrival rate (1/λ)



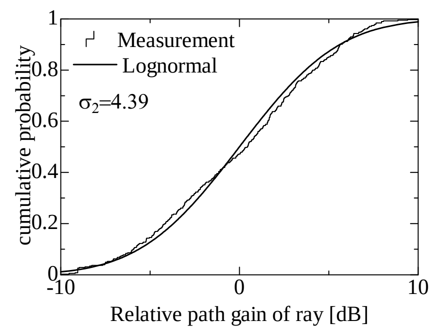
Angle of arrival in cluster (∝Uniform)



Angle spread of ray (σ_ϕ)



Standard deviation of cluster (σ_1)



Standard deviation of ray (σ_2)