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

Submission Title: [Merging two-path and S-V models for LOS desktop channel environments]

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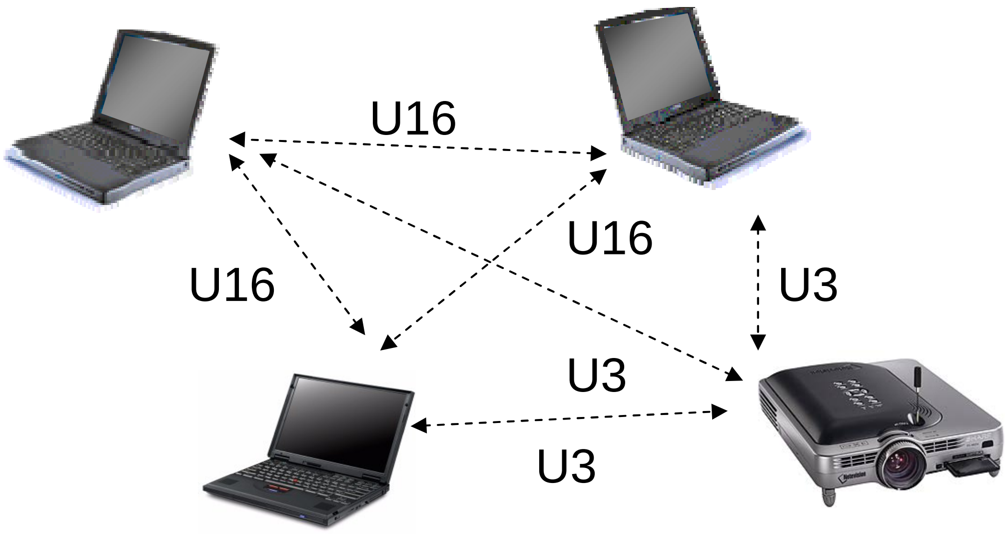
Abstract: [This contribution describes update of the generic channel model merging two-path and S-V models.]

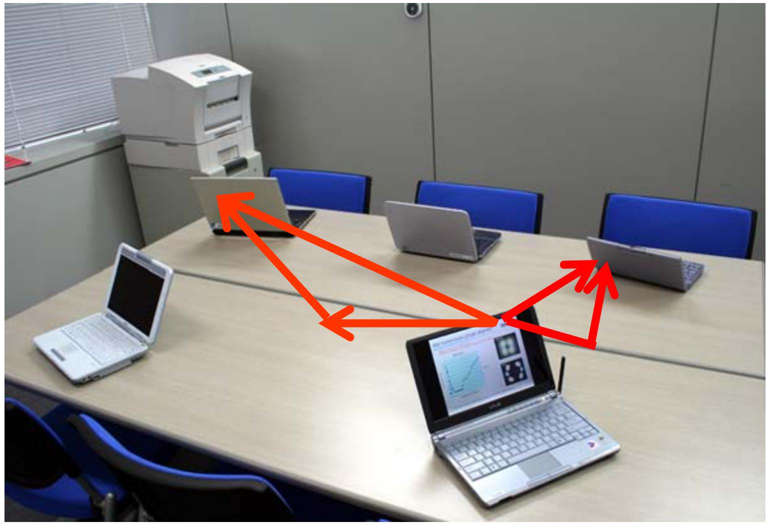
Purpose: [Contribution to mmW TG3c meeting.]

Agenda

- Channel model for LOS desktop environments
- Proposal of TSV model
- Measurement procedure and results
- Extracted TSV model parameters

Importance of channel model for LOS desktop





- LOS desktop is one of useful channel environments for TG3c
- Important to develop channel model for LOS desktop

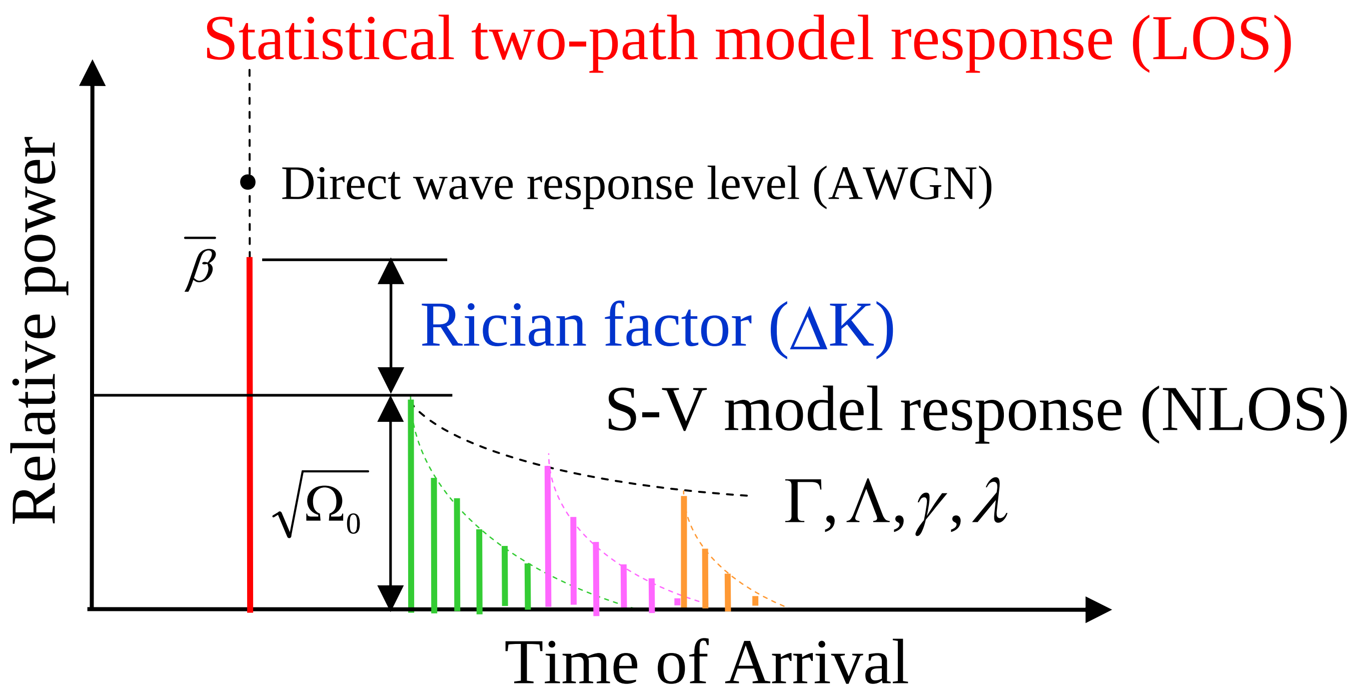
What is suitable channel model for LOS desktop?

- Two-path model is suitable to express LOS desktop environment (06/109)
- Developing statistical two-path model and merging with S-V model was proposed for TG3c generic channel model (06/228)
- This model is named TSV model (Triple SV: Shoji, Sawada, Saleh and Valenzuela model)

Proposed TSV model

TSV model = Statistical two-path model (LOS) + S-V model (NLOS)

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

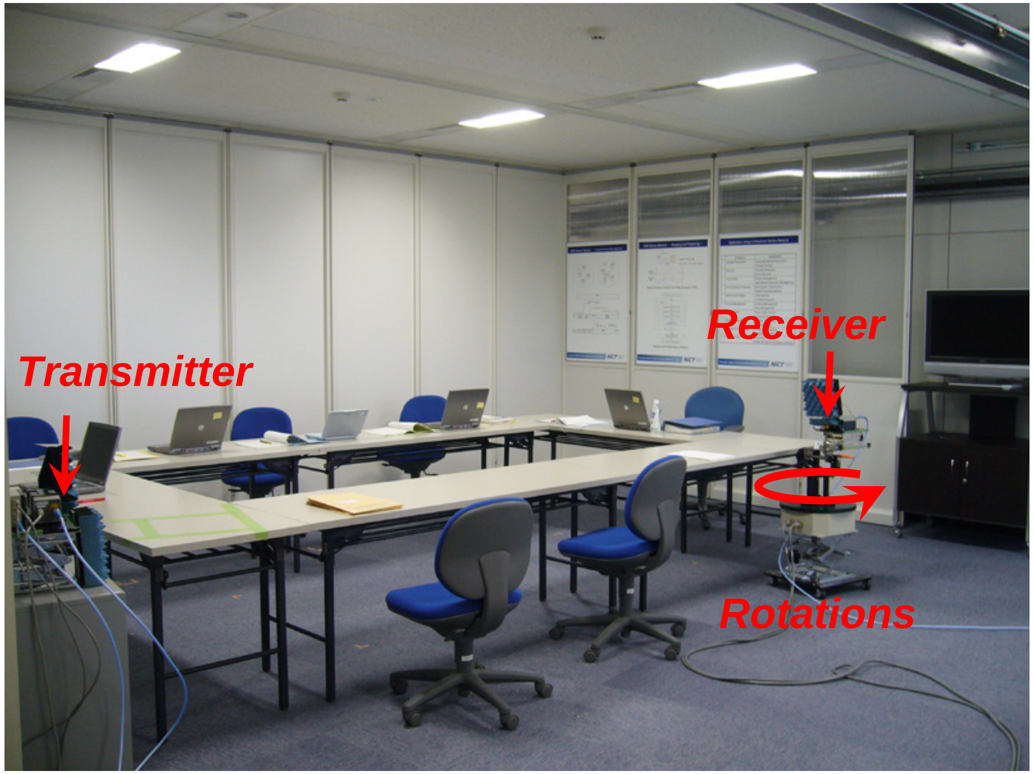


Refer to Appendix B about the definition of each parameter

Purpose of measurement

- To confirm the validity of TSV model in LOS desktop environments
- To extract TSV model parameters

Measurement environment



- Small conference room: 6.4 m × 7.4 m
- Ceiling height: 2.7 m
- Surrounding: metallic wall, Glass window
- Floor: Plaster board covered with carpet
- Furniture: Wooden desk, chair, computer, LCD TV, white board

Measurement conditions

Instrument	HP8510C VNA
Center frequency	62.5 GHz
Bandwidth	3 GHz
Time resolution	0.125 ns
Distance resolution	19.1 cm
# of frequency points	801
Frequency step	3.75MHz
Times of average	128 times

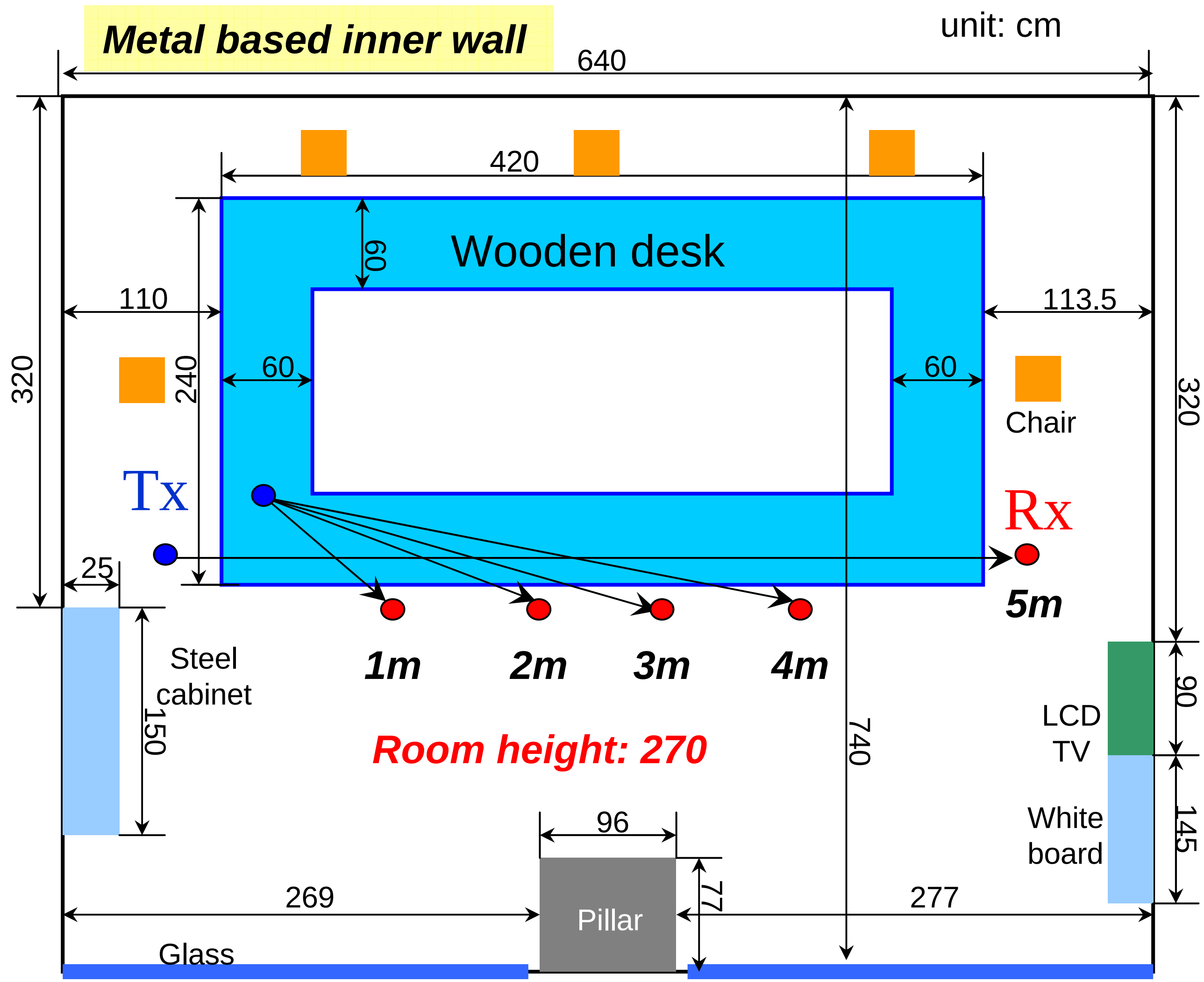
Measurement conditions (cont')

- **Antenna:** Conical horn antenna
- **Polarization:** Vertical
- **Beam-width**: Tx:30 and Rx 30, Tx:60 and Rx60

Conical horn antenna
Beam-width 30 deg

Conical horn antenna
Beam-width 60 deg

Measurement environment (case #1)

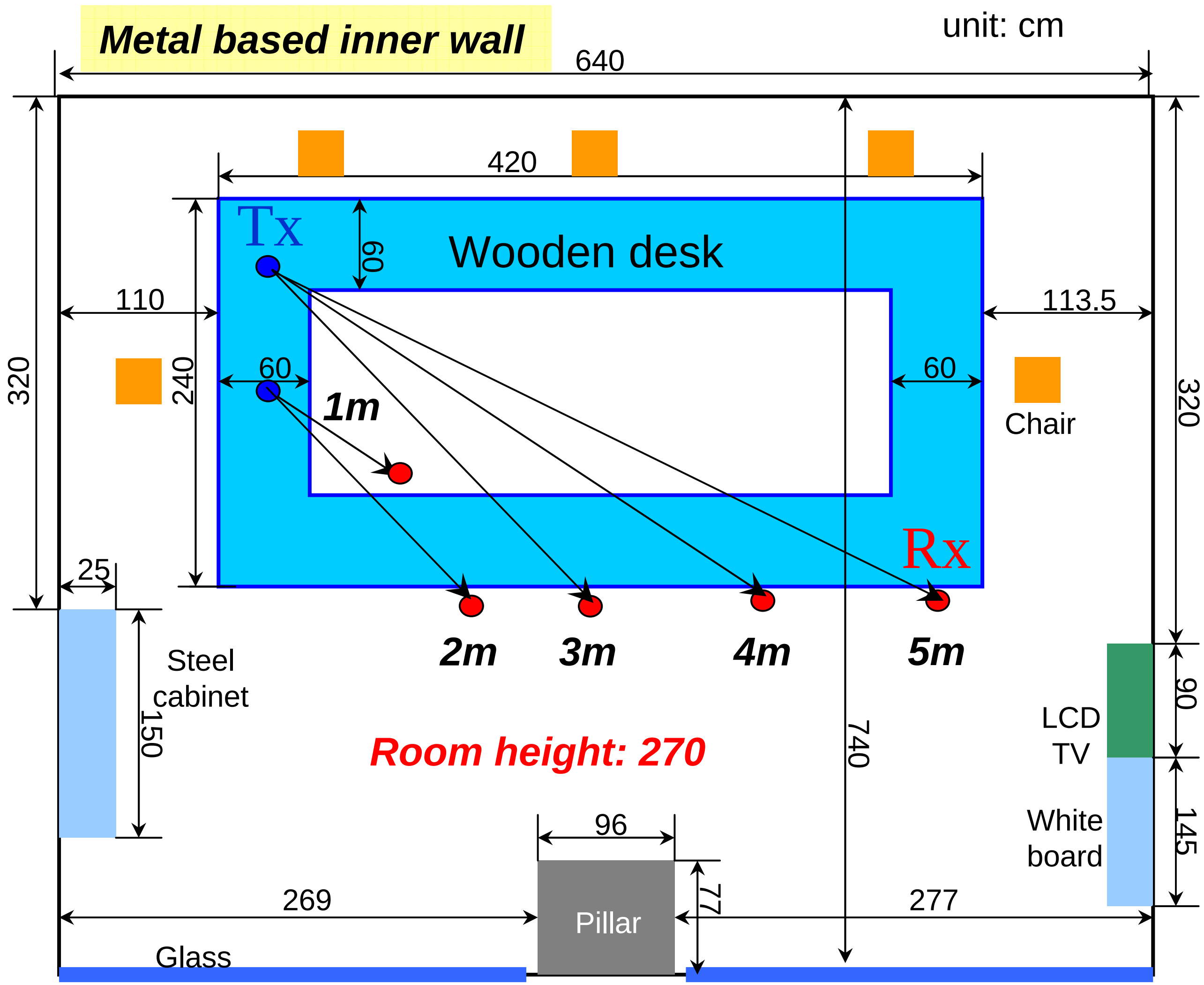


Antenna height from desktop

Tx = 15 cm

Rx = 15 cm

Measurement environment (case #2)

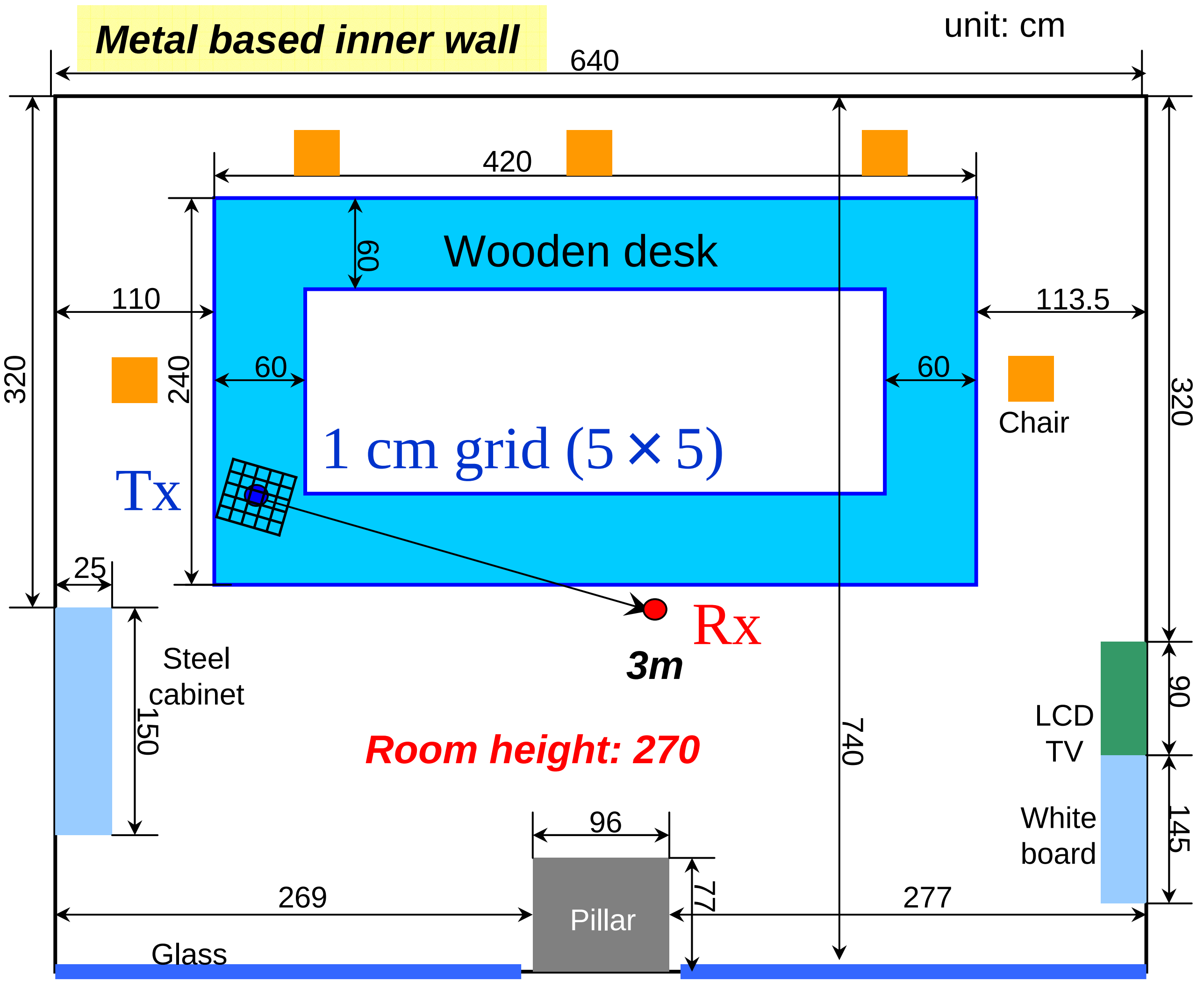


Antenna height from desktop

Tx = 15 cm

Rx = 15 cm

Measurement environment (spatial)

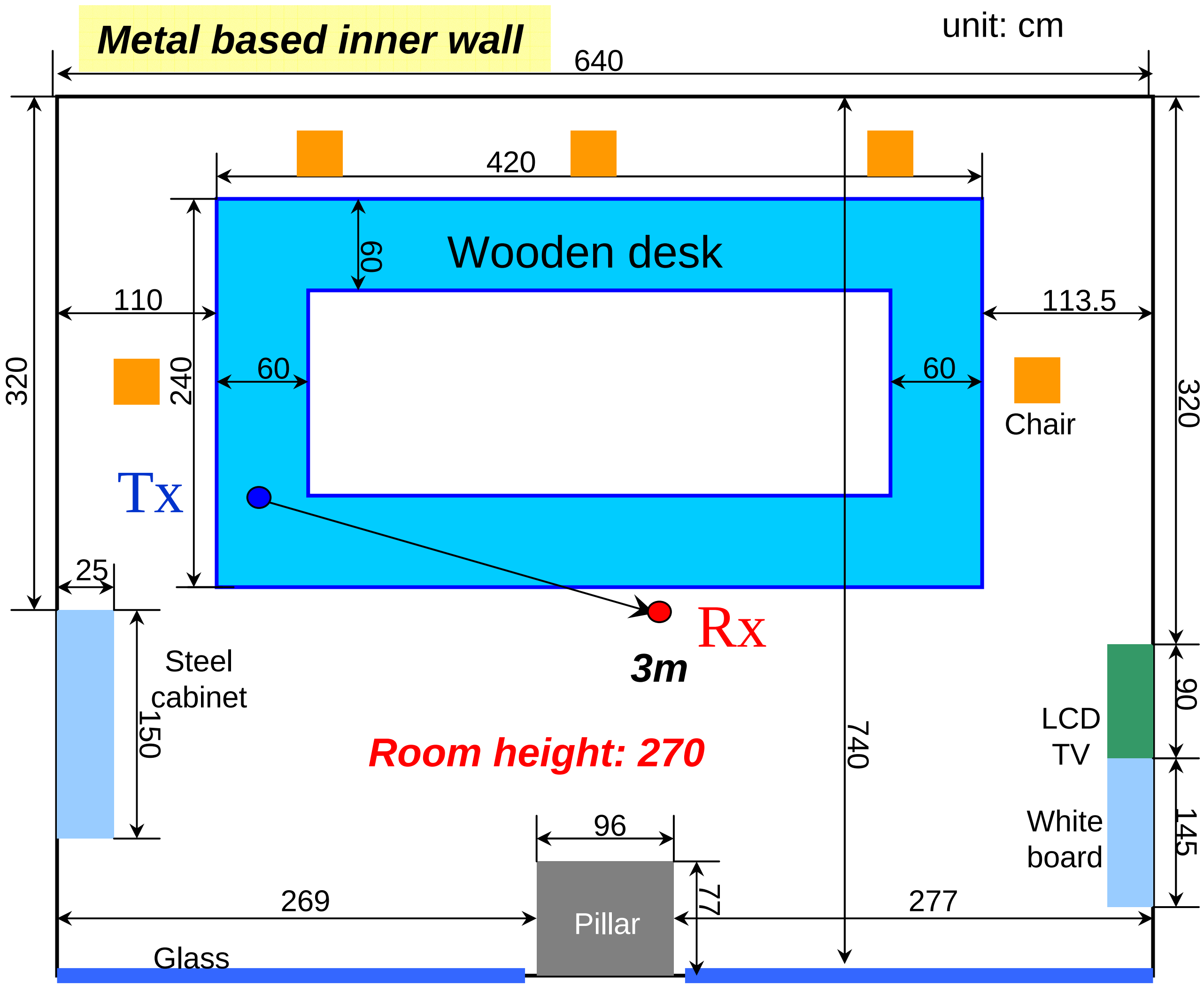


Antenna height from desktop

Tx = 15 cm

Rx = 15 cm

Measurement environment (different heights of Tx)



Antenna height from desktop

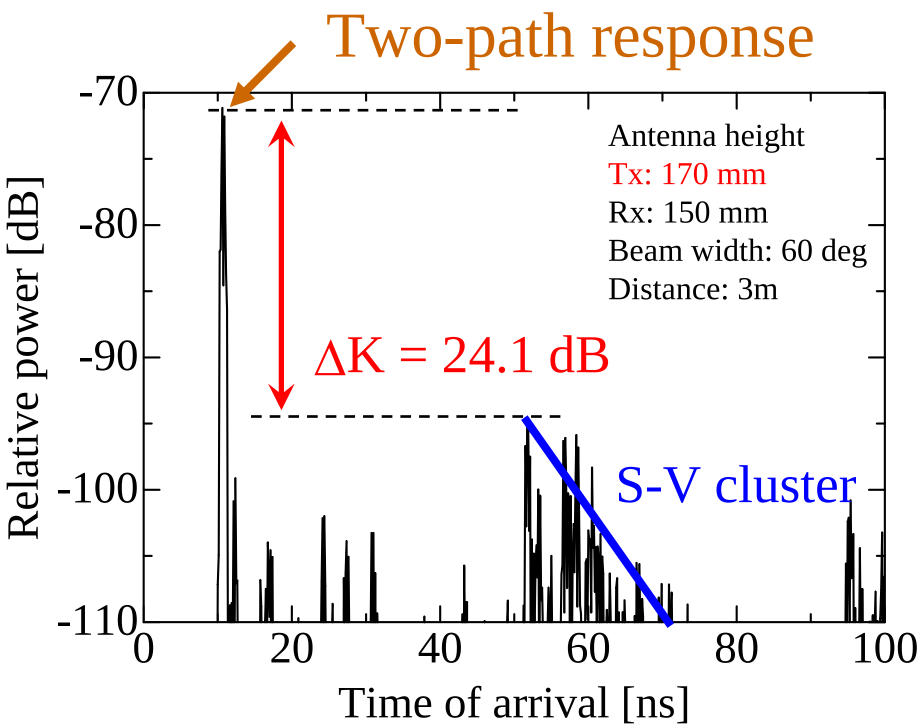
Tx = 17, 14.3 cm

high- and low-Rician cases

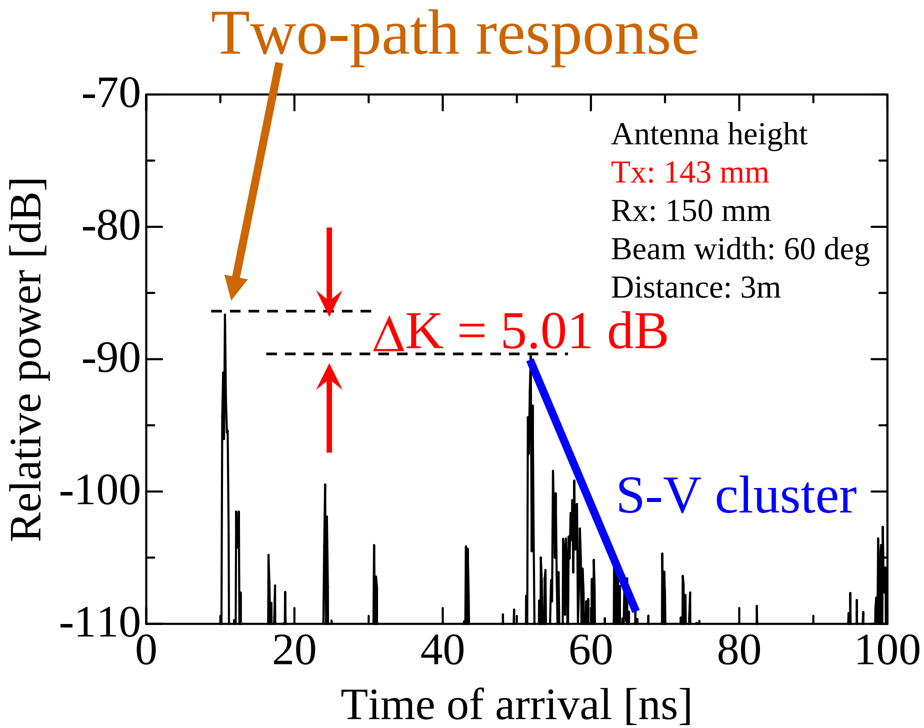
Rx = 15 cm

Measurement results

PDPs for two different antenna heights



(a) High Rician factor



(b) Low Rician factor

- ΔK has 19dB dynamic range
- TSV model is well expressing LOS desktop

TSV model parameters to be extracted

S-V model oriented parameters:

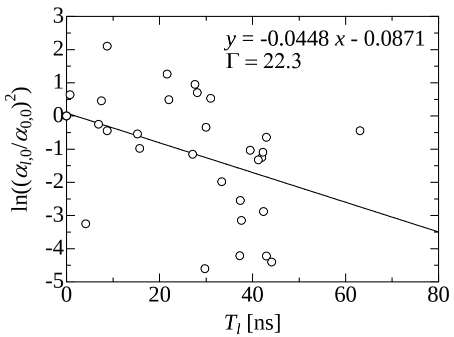
- Γ : *cluster* decay factor
- $1/\Lambda$: *cluster* arrival rate
- γ : *ray* decay factor
- $1/\lambda$: *ray* arrival rate
- σ_1 : *cluster* lognormal standard deviation
- σ_2 : *ray* lognormal standard deviation
- σ_ϕ : Angle spread of ray within cluster (Laplace distribution)

TSV model parameter:

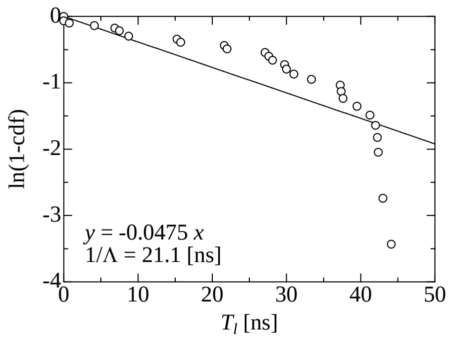
- Ω_0 : Average power of the first ray of the first cluster

Results of data analysis

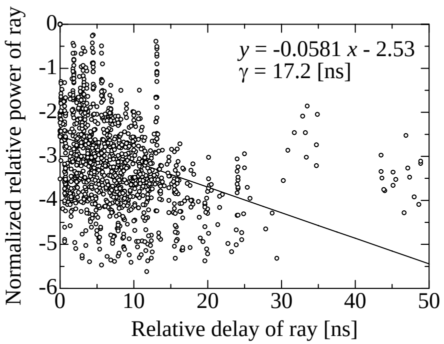
Antenna beamwidth
Tx: 60 deg, Rx: 60 deg



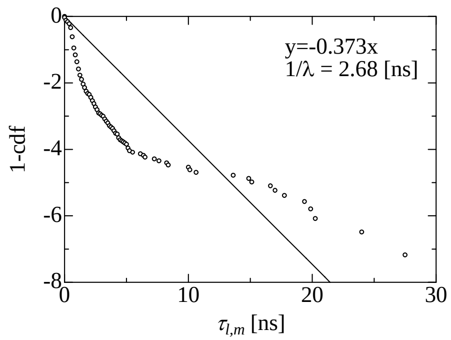
Cluster decay factor (Γ)



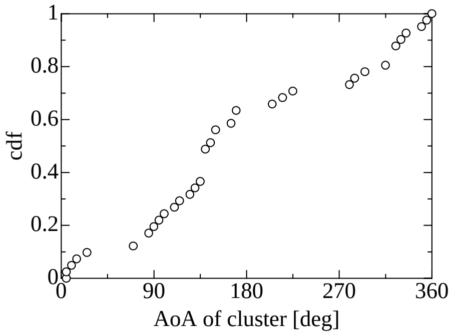
Cluster arrival rate ($1/\Lambda$)



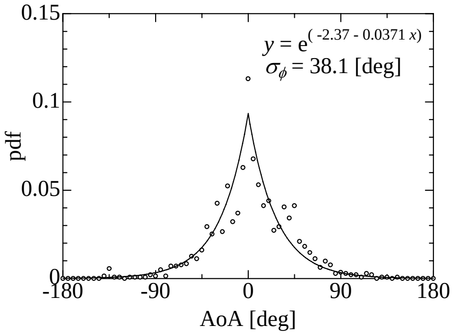
Ray decay factor (γ)



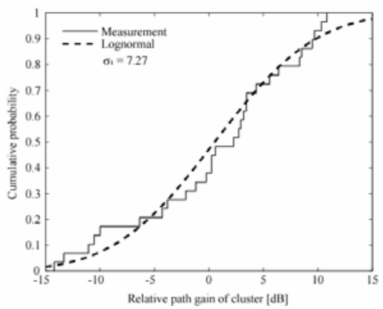
Ray arrival rate ($1/\lambda$)



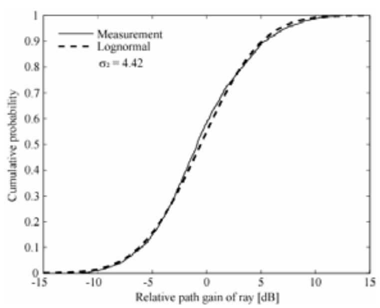
Angle of arrival in cluster ($\propto$ Uniform)



Angle spread of ray (σ_ϕ)



Standard deviation of cluster (σ_1)



Standard deviation of ray (σ_2)

Extracted TSV model parameters

Data	Ω_0(D) [dB]	Γ [ns]	$1/\Lambda$ [ns]	γ [ns]	$1/\lambda$ [ns]	σ_1 cluster	σ_2 ray	σ_ϕ [deg]	Max. ΔK[dB]	Min. ΔK[dB]
Tx:30 Rx:30	4.44 D-105	21.1	27	8.85	1.56	3.01	7.69	34.6	27.0	10.2
Tx:60 Rx:60	3.46 D-98	22.3	21.1	17.2	2.68	7.27	4.42	38.1	24.1	5.01

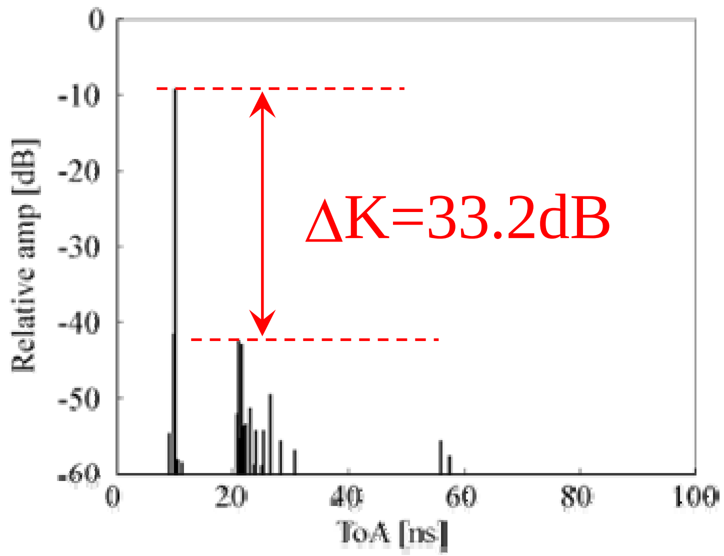
Channel model for LOS desktop environment is available

Conclusion

- Proposed TSV-model is suitable to express LOS desktop environments
- 19dB dynamic range for Δ K was observed
- TSV model with extracted parameters is now available

Appendix A: ΔK in LOS indoor environments

- TSV model can be applied in any LOS environment
- TSV model parameters for LOS residential environments can be obtained since we have measurement data (06/012)
- TSV model parameters for LOS office environments can be obtained if measurement data are provided



LOS Residential (NICT data)
Tx: 15deg
All multi-path components are included

Appendix B: Definition of TSV model

CIR:

(Complex impulse response)

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

$$\overline{|\alpha_{l,m}|^2}=\Omega_0 e^{-T_l/\Gamma}e^{-\tau_{l,m}/\gamma},\ \angle\alpha_{l,m}\propto \text{Uniform}[0,2\pi)$$

t: time[ns]
δ(•): 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

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

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
$|\Gamma_0|\cong 1$: Reflection coefficient (incident angle $\cong\pi/2$)

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)

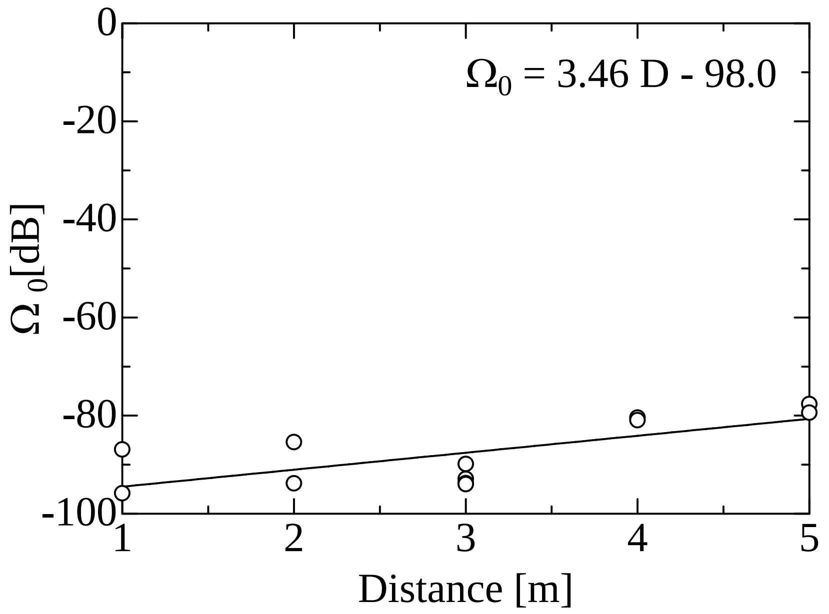
Antenna parameters (2)

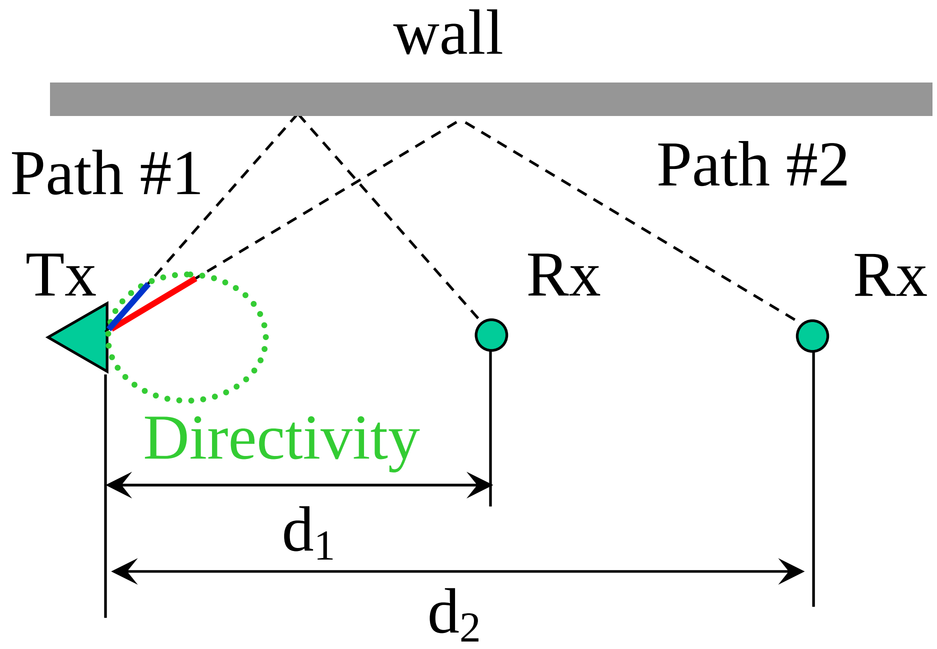
$Gt(\theta,\phi)$: Antenna gain of Tx
$Gr(\theta,\iota)$: Antenna gain of Rx

Rician factor (1)

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

Appendix C: Averaged power of the first ray of S-V response





- Ω_0 increases due to distance, because directional antenna is used in transmitter
- Conventional S-V model does not consider this effect