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

Submission Title: [Revision of TSV model for LOS desktop channel environments]

Date Submitted: [September, 2006]

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Re: []

Abstract: [This contribution describes revision of TSV model for LOS desktop channel environments.]

Purpose: [Contribution to mmW TG3c meeting.]

Revision of TSV model for LOS desktop channel environments

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Agenda

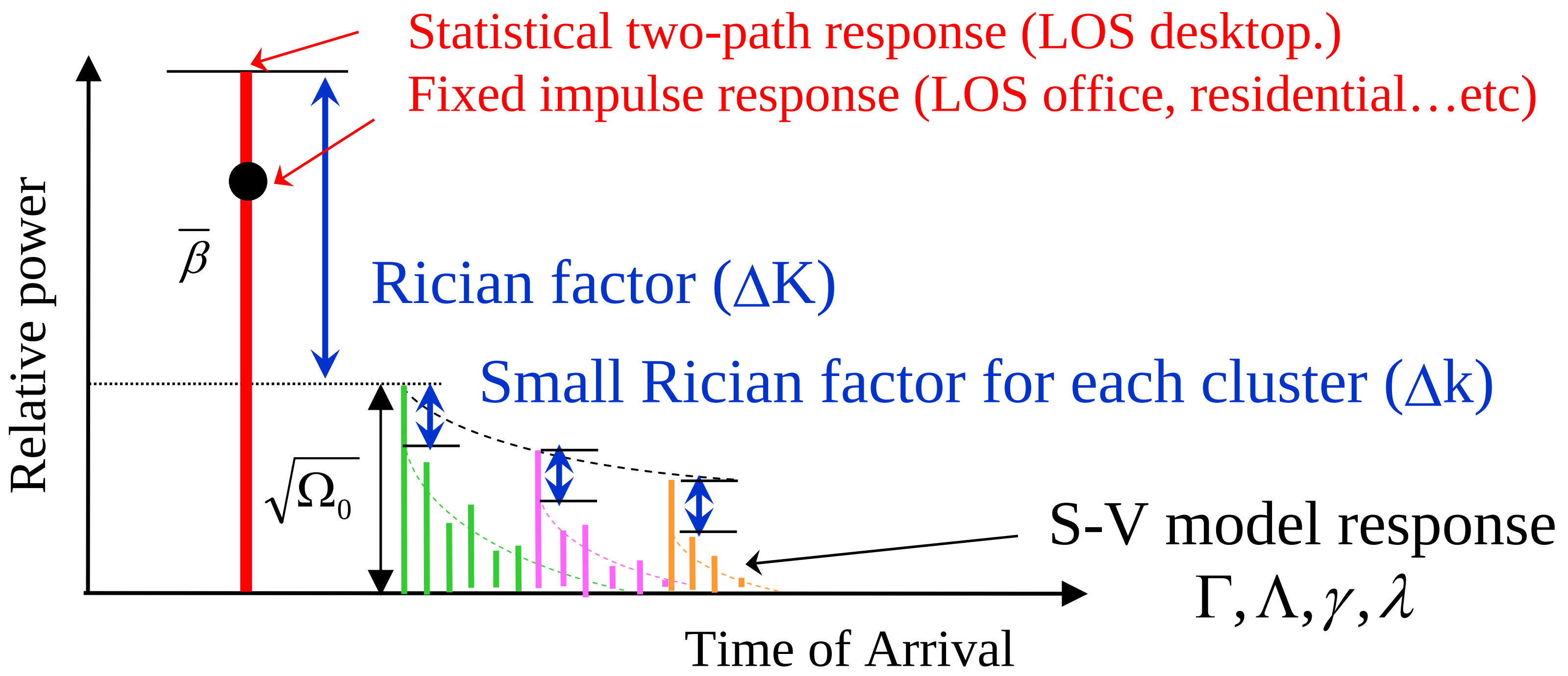
- Revision of TSV model
- Extracted TSV model parameters
- Proposal of default antenna for simulation
- Path-loss results for desktop environment

Modification of TSV model

TSV model = Statistical two-path model + S-V model

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

Refer to appendix A for each parameter



- Each cluster has the Δk of Small Rician factor
- Effects of the receiver antenna pattern are considered in $\alpha_{l,m}$

Small Rician factor (Δk)

$$\log_e |E|^2 = -2.53 \longleftrightarrow 10\log_{10} |E|^2 = -11.0\text{dB}$$

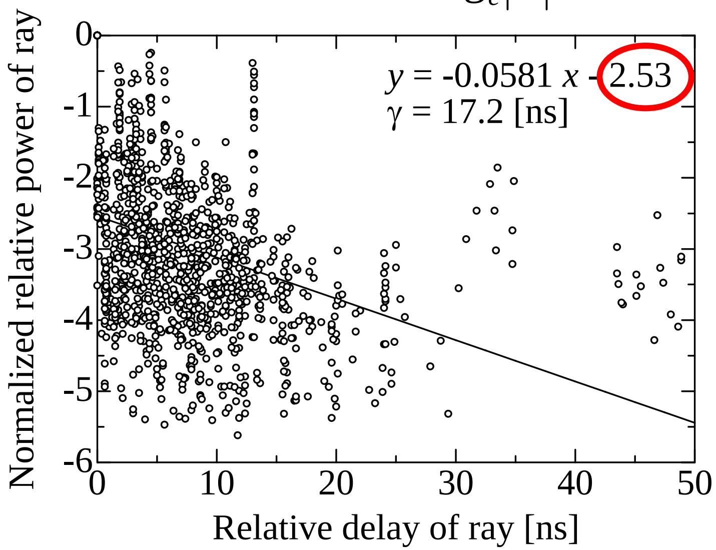


Fig1. Extraction of parameter γ

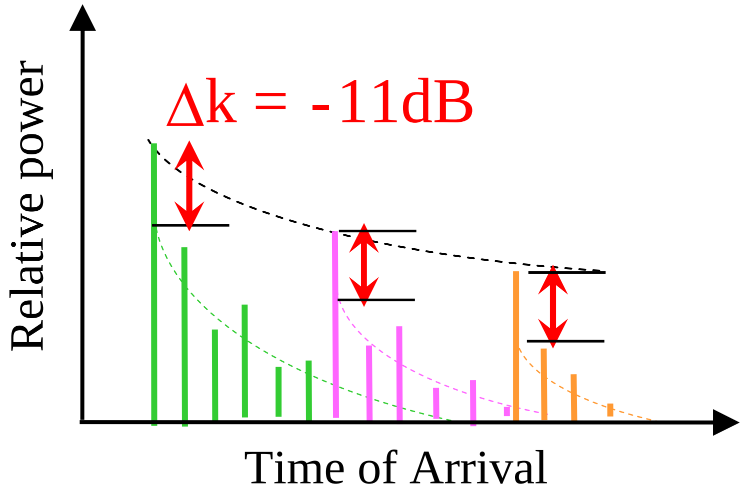


Fig2. Impulse response of each cluster

Giving the Small Rician factor (Δk) is more suitable to express the cluster in the model. (Doc. 06/302)

Extracted TSV model parameters

	TSV Model	Small Rician factor	S-V model oriented parameters							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
Tx:30 Rx:30	4.44 D-105.4	2.53 (11.0 dB)	21.1	27.0	8.85	1.56	3.01	7.69	34.6	3
Tx:60 Rx:60	3.46 D-98.4	3.97 (17.2 dB)	22.3	21.1	17.2	2.68	7.27	4.42	38.1	3

Channel model for LOS desktop environment is available

Refer to appendix B and C for each parameter

Antenna pattern effect

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)

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

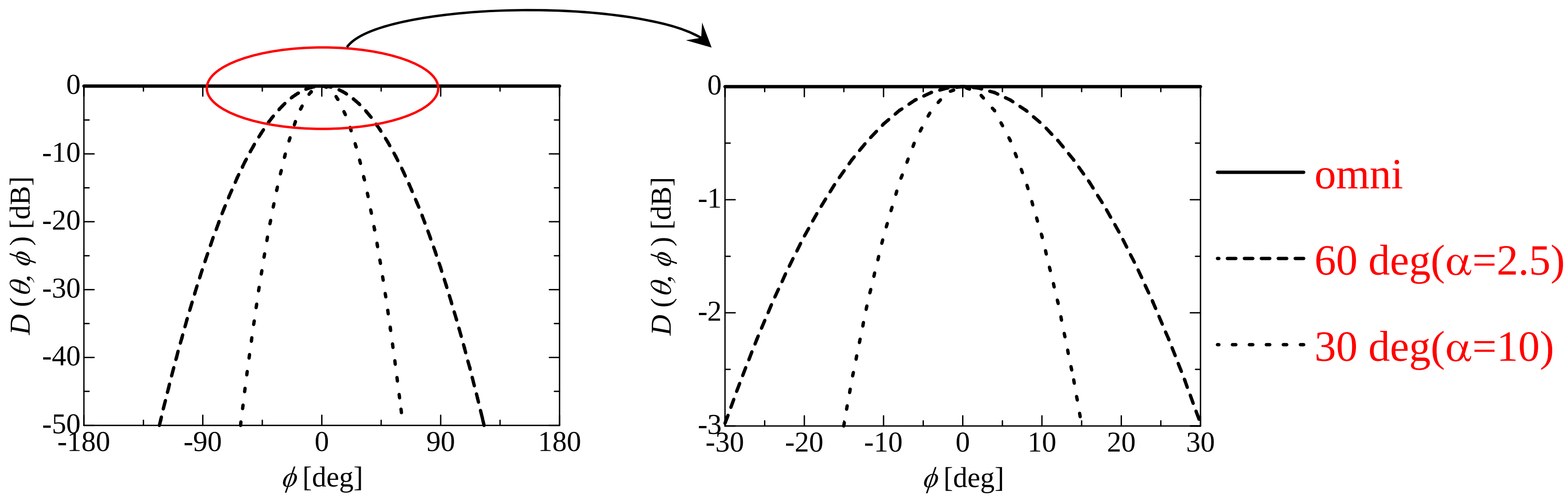
Rx antenna gain in horizontal plane is included

Default antenna patterns

Antenna gain: $G_r(\theta,\phi) = G\,D(\theta,\phi)$

- Omni directional antenna: $D(0,\phi) = 1$
- Directional antenna: $D(0,\phi) = \exp(-\alpha\,\phi^2)$

Simple Gaussian distribution can be used



Path loss model for LOS desktop environment

$$\text{Path loss}\,[\text{dB}] = PL_0 + 10n\log_{10}(\mu_D / D_0)$$

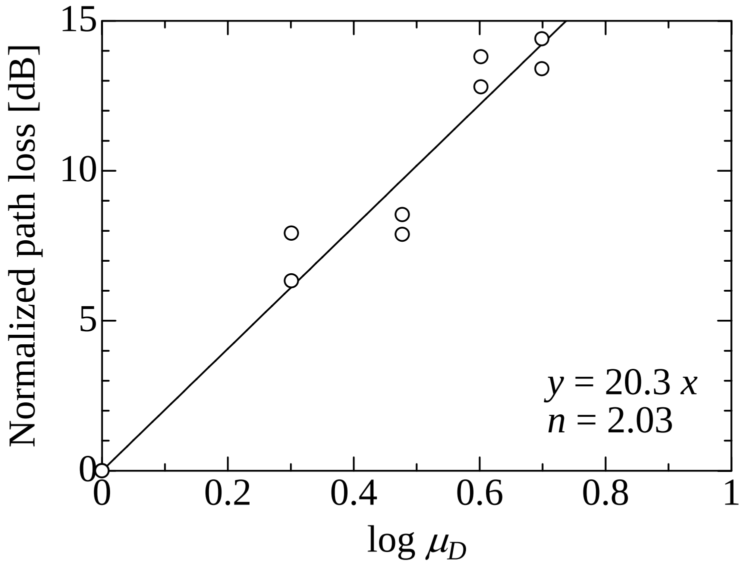


Fig. Path Loss result

- Path loss at D_0=1m distance

$$PL_0[\text{dB}] = 20\log_{10}\left(\frac{4\pi D_0}{\lambda}\right) \approx 68.4$$

$$\lambda \approx 4.8\text{mm}\ (f = 62.5\,\text{GHz})$$

- Path loss exponent

$$n = 2.03$$

- Path loss of LOS component follows free space loss

Summary

- TSV-model was revised
- Parameters for LOS desktop environment were extracted based on the TSV-model
- Path loss for LOS desktop environment was measured
- LOS desktop channel model based on TSV-model is now available
- Default antenna patterns are proposed to simplify the simulation

Appendix A: Definition of TSV model (revised)

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

(Complex impulse response)

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

PL: Path loss of the first impulse response
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

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

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

Arrival rate: Poisson process

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

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 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

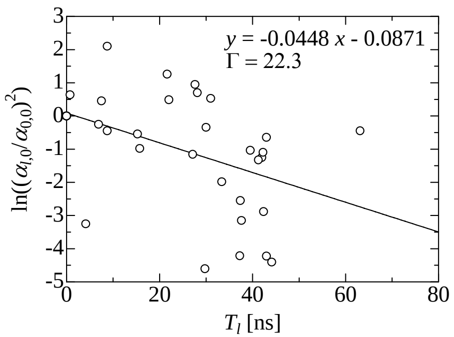
Rician factor (2)

k : Small Rician effect in each cluster

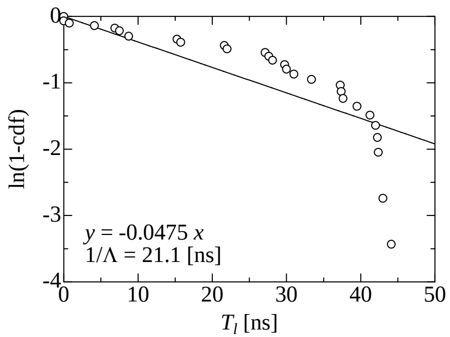
$$K=\frac{\beta^2}{\sum_{l=0}^{L-1}\sum_{m=0}^{M_l-1}\left|\alpha_{l,m}^2\right|\delta\left(t-T_l-\tau_{l,m}\right)\delta\left(\varphi-\Psi_l-\psi_{l,m}\right)G_r\left(0,\Psi_l+\psi_{l,m}\right)}$$

Appendix B: Results of data analysis

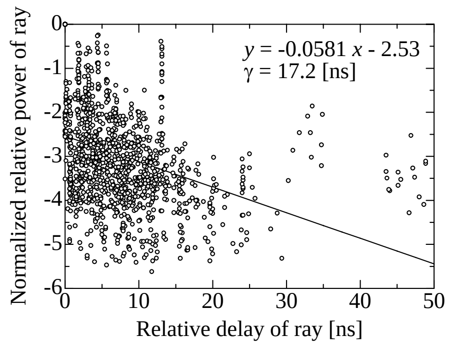
Antenna beamwidth
Tx: 60 deg, Rx: 60 deg



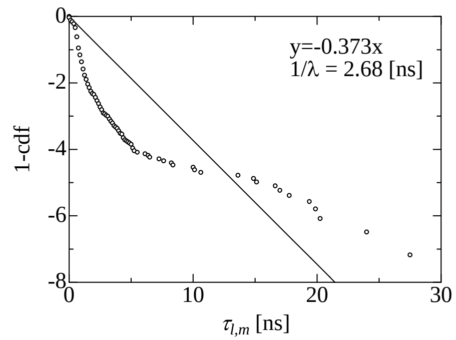
Cluster decay factor (Γ)



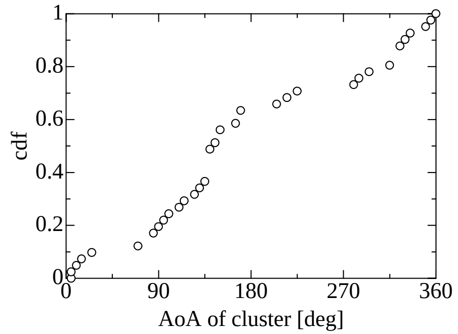
Cluster arrival rate ($1/\Lambda$)



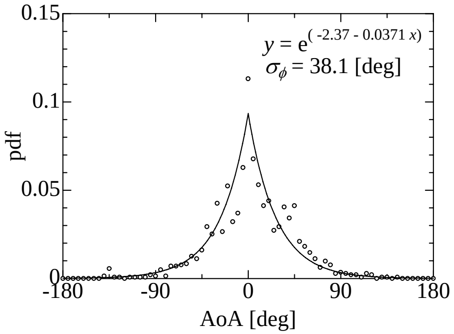
Ray decay factor (γ)



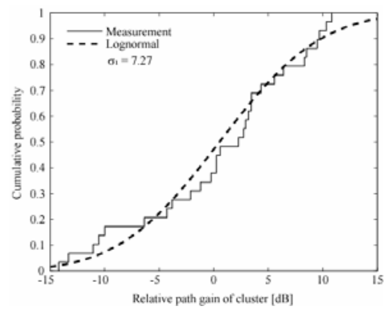
Ray arrival rate ($1/\lambda$)



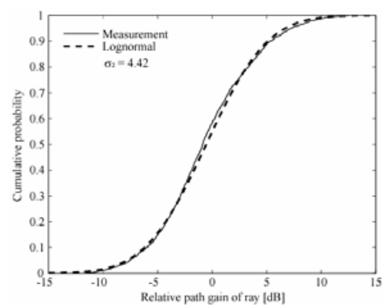
Angle of arrival in cluster ($\propto$Uniform)



Angle spread of ray (σ_ϕ)

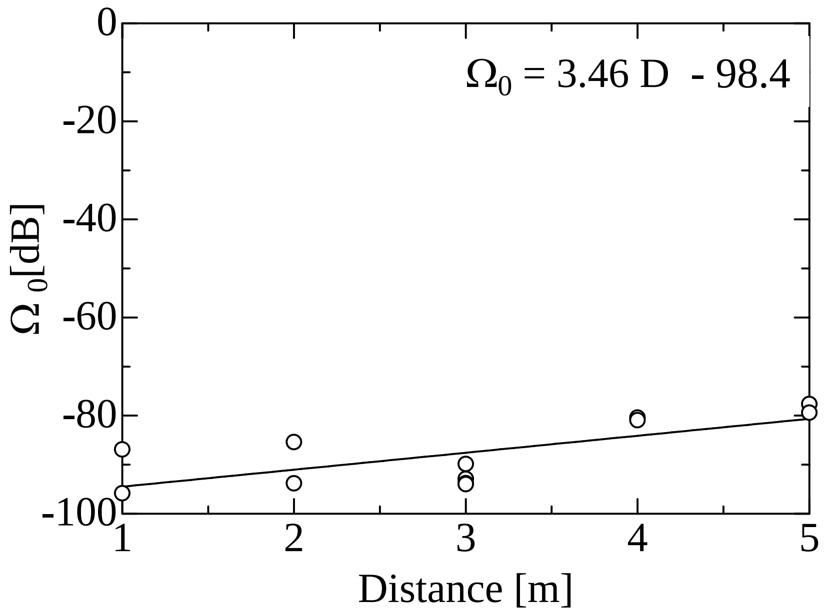


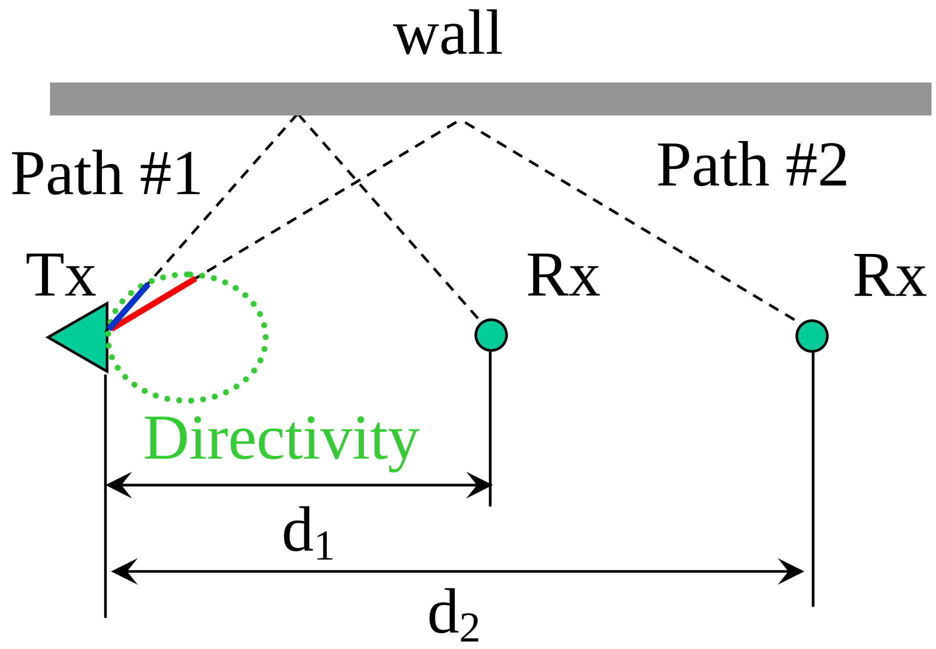
Standard deviation of cluster (σ_1)



Standard deviation of ray (σ_2)

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