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

Submission Title: [MATLAB Simulation Program for TSV-channel model]

Date Submitted: [September 18, 2006]

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Re: []

Abstract: [Proposing a MATLAB Simulation Program for TSV-channel model]

Purpose: [To be considered in 15.3c transmission performance by computer simulation]

Notice:

MATLAB Simulation Program for TSV-channel model

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Summary of this document

- Finished to prepare MATLAB simulation program for TSV-channel model
- Explain the flowchart of the MATLAB model
- Show comparison of experimental and simulated results
- Summarize available LOS / NLOS channel models by the MATLAB-based TSV channel model

Definition of final 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: 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

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

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

Arrival rate: Poisson process

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

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 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)

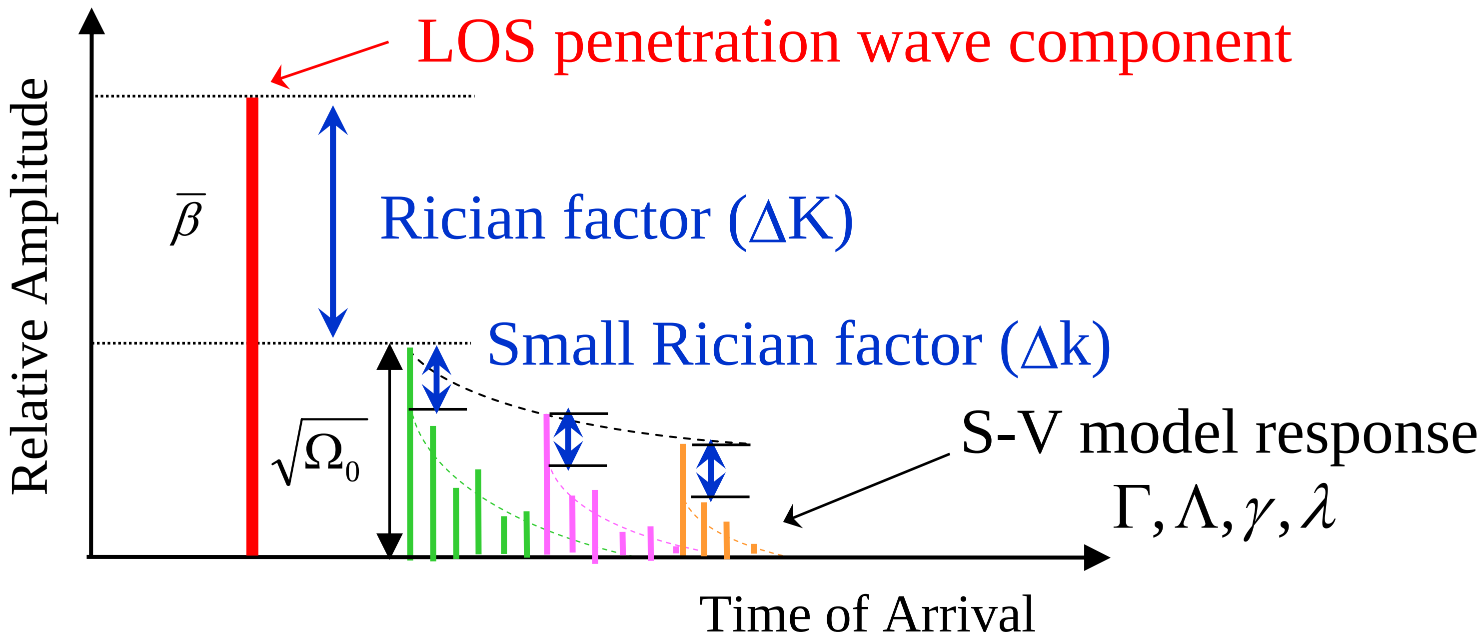
$Gt(\theta,\phi)$: Antenna gain of Tx
$Gr(\theta,\iota)$: Antenna gain of Rx

Rician factor (2)

k : Small Rician effect in each cluster

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

Impulse response

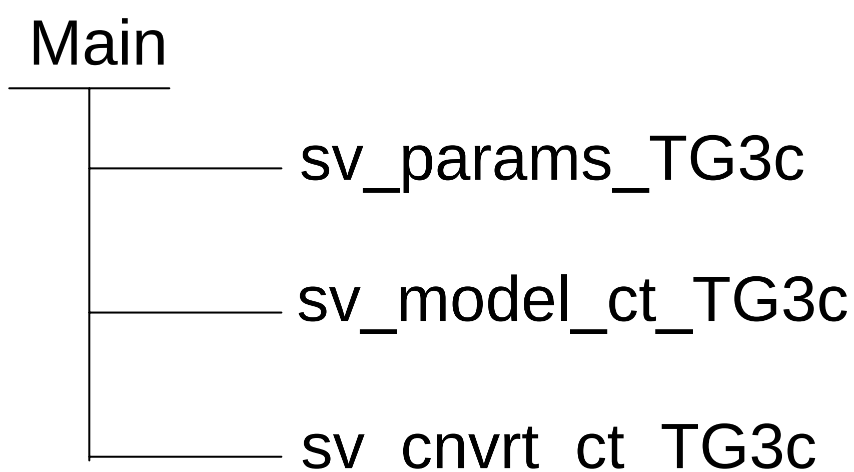


This response can be also obtained in TSV model by setting $\Gamma_0 = 0$

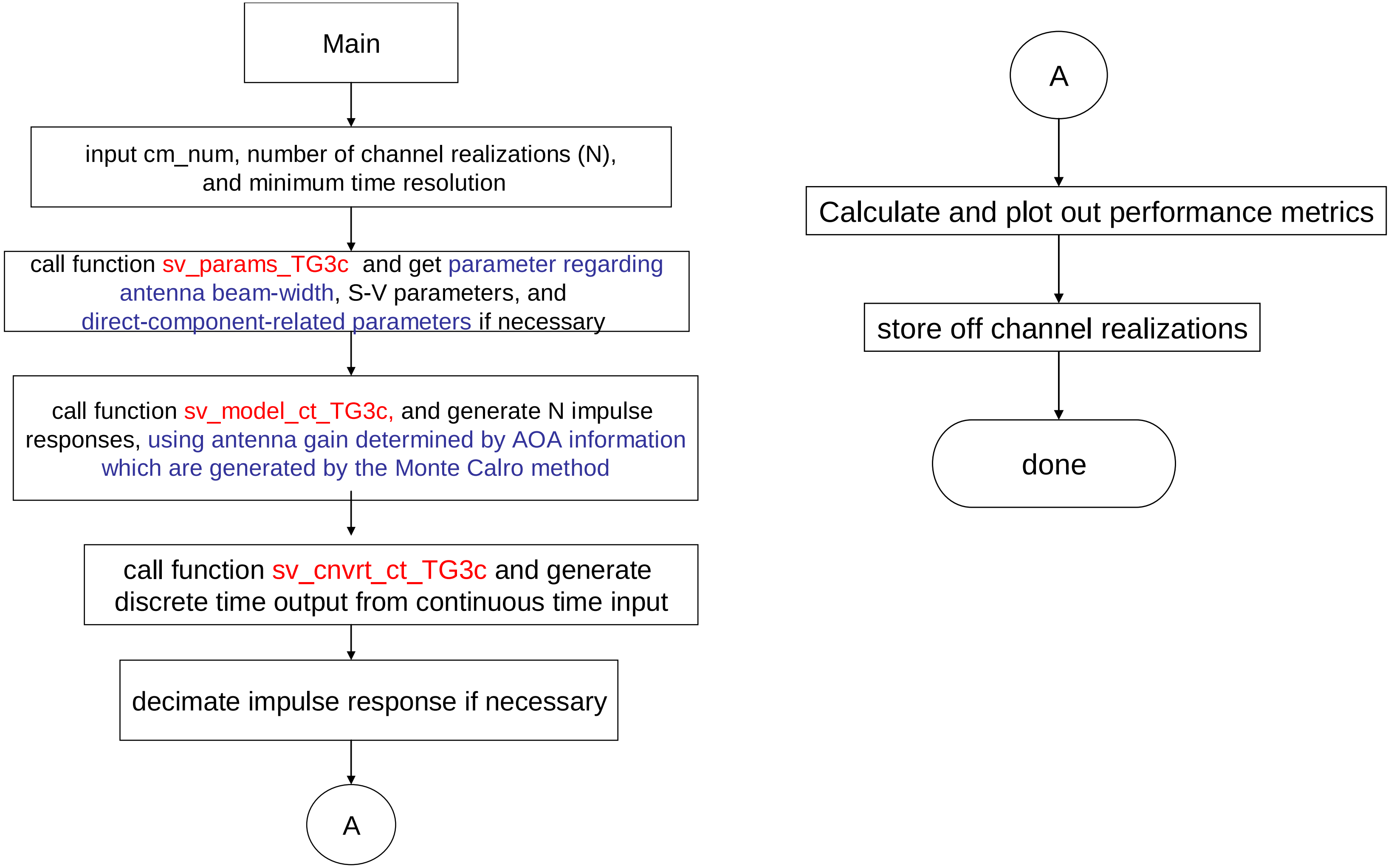
Examples of parameters for TSV model

	TSV Model	Small Rician factor	S-V model oriented parameters							Number of cluster
Parameter	Ω_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:60 Rx:60	3.46 D-98.4	3.97	22.3	21.1	17.2	2.68	7.27	4.42	38.1	3

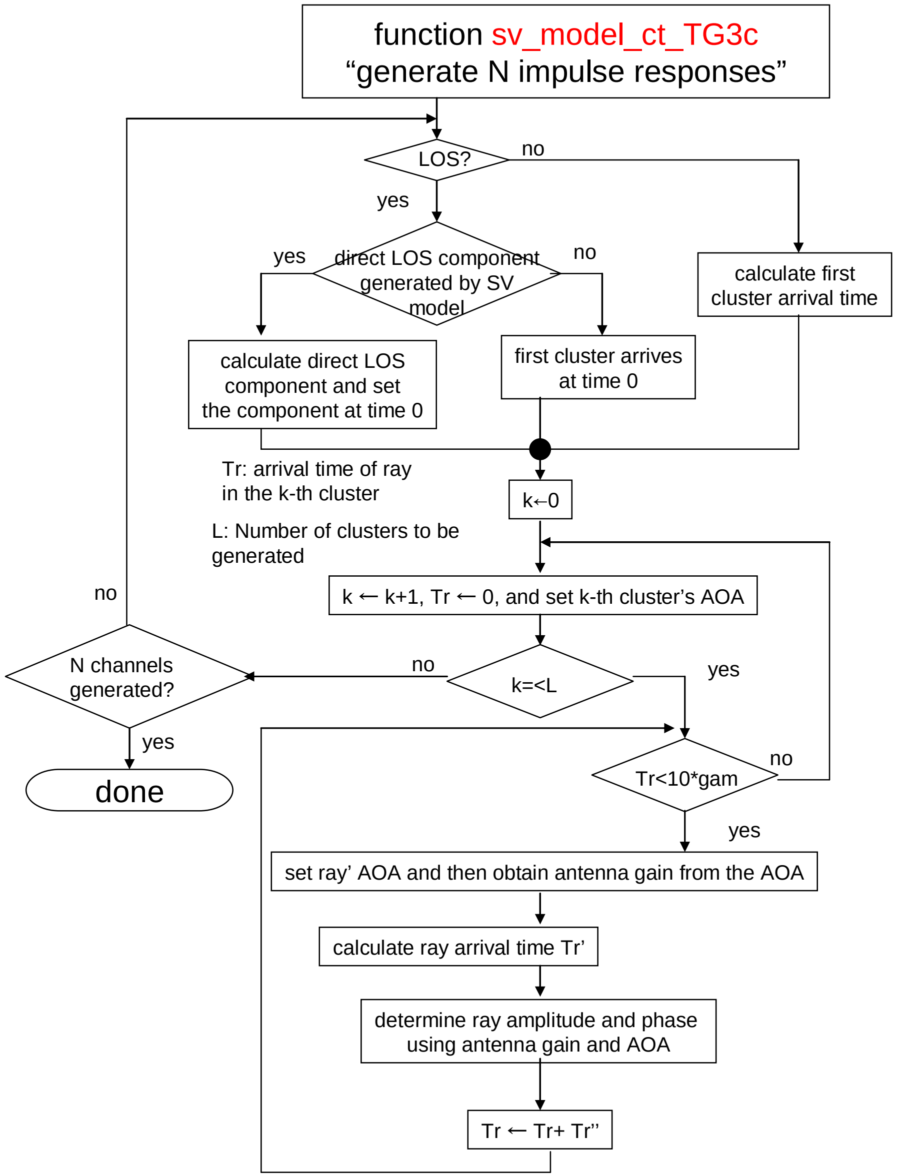
Function calls



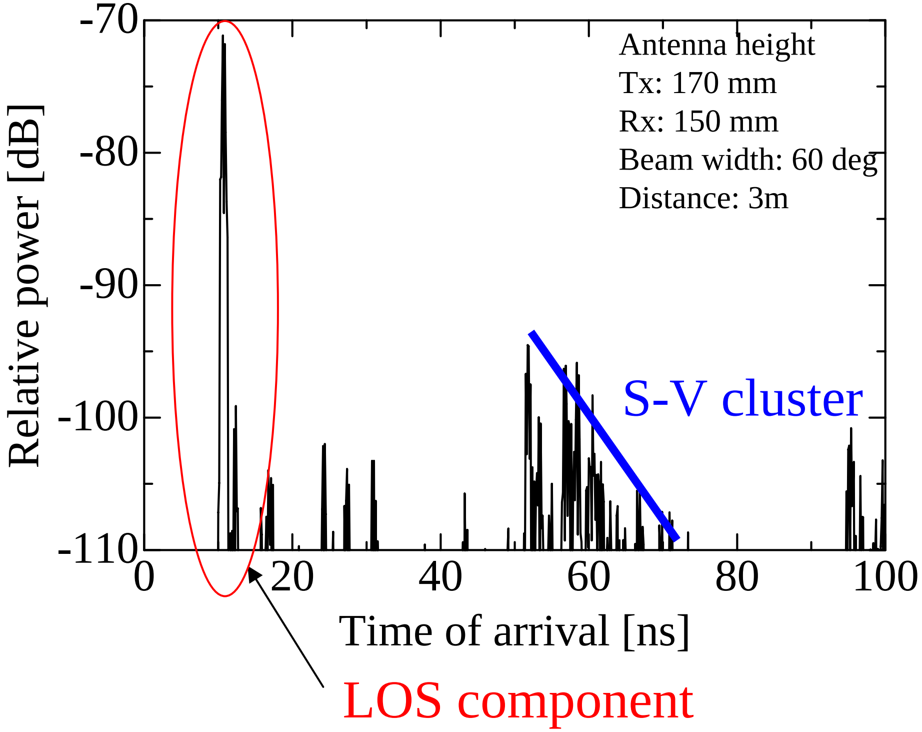
Flowchart (overview)



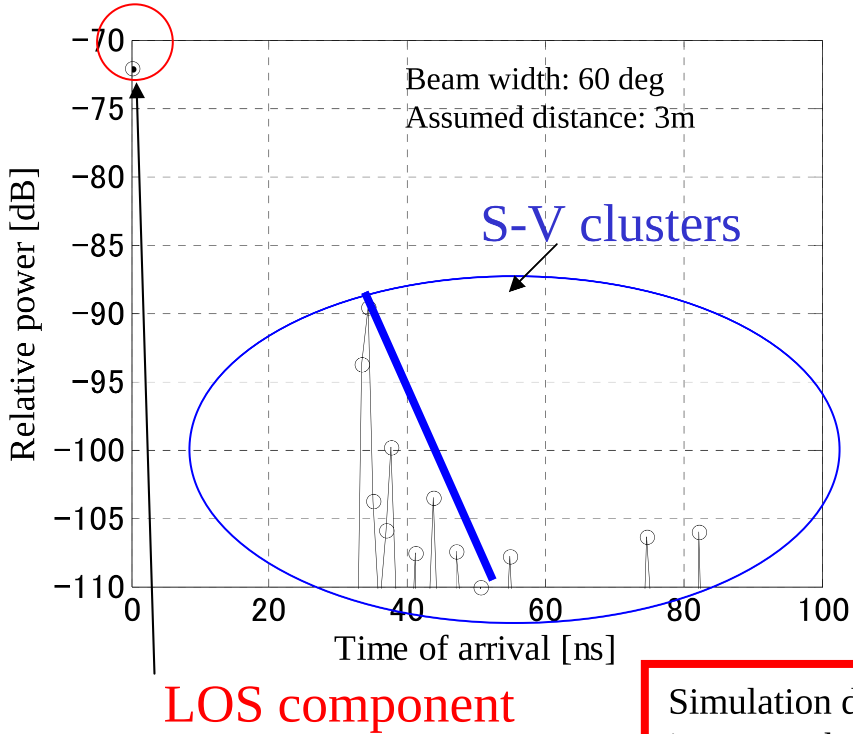
Flowchart of sv_model_ct_TG3c



Comparison of experimental and simulated results



(a) Experimental result



Simulation data is a snap-shot.

(b) Simulation result

	Experimental results	Simulated results
Average RMS delay spread	10.6[ns]	9.2 [ns]

Summary of available LOS / NLOS channel models by MATLAB based TSV-channel model

	LOS	NLOS
Office	Available (NICT)	Available (NICTA)
Residential	Available (NICT)	N/A
Desktop	Available (NICT)	N/A
Library	Available (IMST/Intel)	N/A

Measurement and analysis to get TSV parameters are finished by NICT. MATLAB program is now available by using analyzed parameters.

Measurement is finished by NICT. Analysis to get TSV parameters is also possible within a couple of week. MATLAB program will be prepared by using analyzed parameters.

Summary

- Finished to prepare MATLAB simulation program for TSV-channel model
- Explained the flowchart of the program
- Showed comparison of experimental and simulated results
  - Performance is almost similar to the experimental one
- Summarized available LOS / NLOS channel models by MATLAB based TSV-channel model
  - NLOS as well as LOS can be covered by the proposed MATLAB program.