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

Submission Title: [IBM Measured Data Analysis Revised]
Date Submitted: [May 2006]
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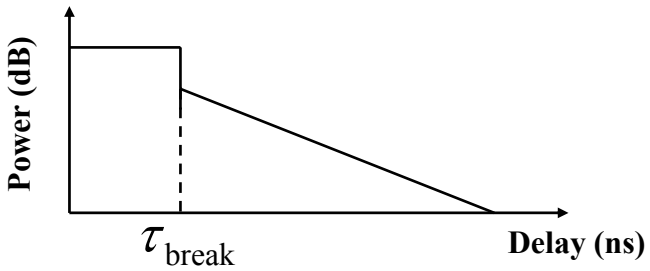
Abstract: []

Purpose: [To update task group on channel modeling simulation work]

Recall: IBM Measured Data

ref: 15-06-0191-00

- Four environments:
  - Office: including cubicles and small conference rooms;
  - Laboratory: highly reflective metallic equipment and walls;
  - Library: large hall;
  - Private home: wood/plasterboard construction.
- Frequency: 59 to 64 GHz
- Time resolution: 0.2 ns
- Vertical polarized omni antennas on both ends
- Over 700 channel measurements
- Proposed CIR model: single-cluster S-V model
- Proposed PDP model: exponential decay preceded by a constant part



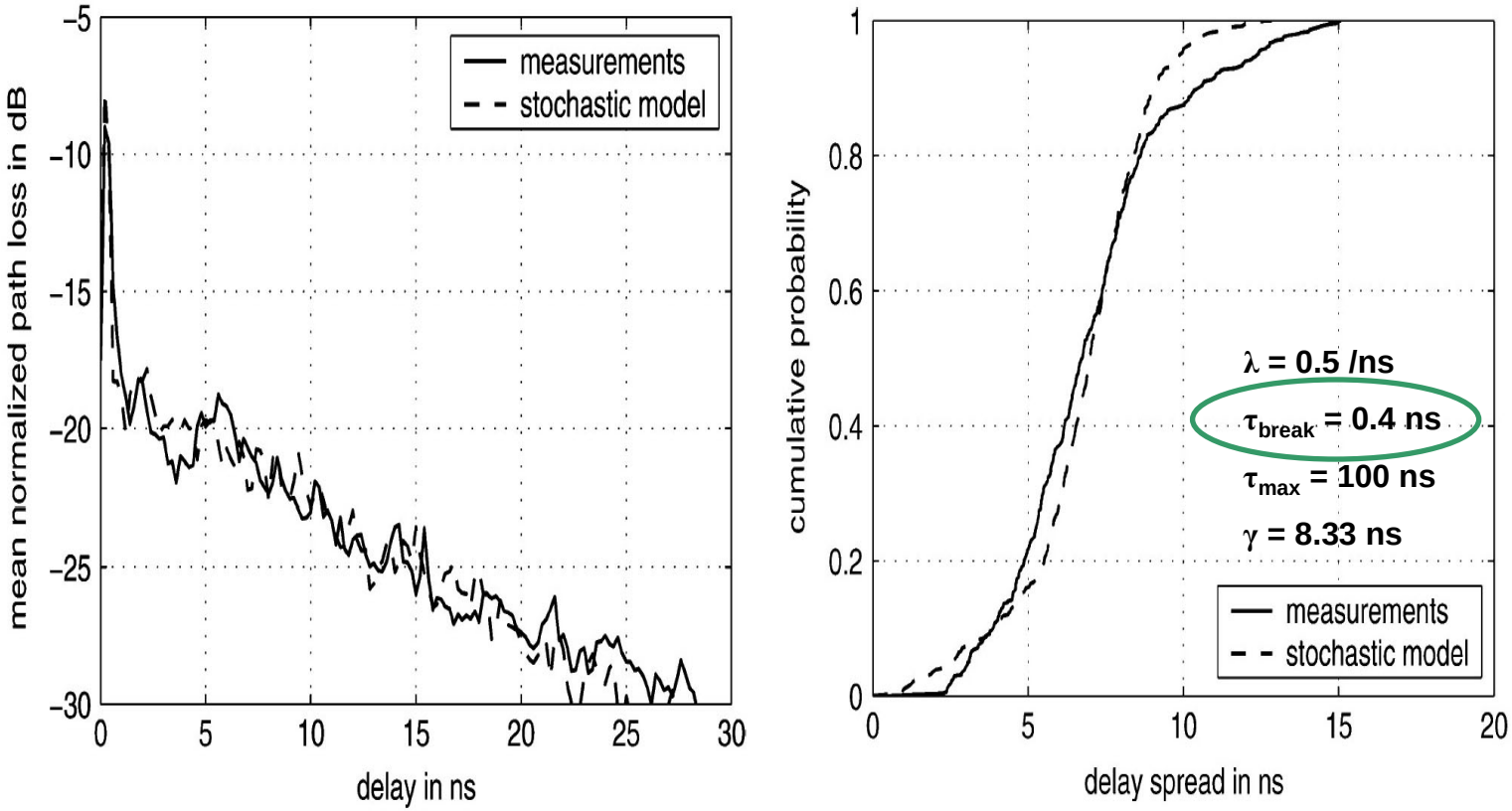
CIR = Channel Impulse Response

PDP = Power Delay Profile

RDS = RMS Delay Spread

Mean Normalized PDP and Cumulative Probability of RDS For Office Environment

Using an Exponential Decay Preceded by a Constant Part*



*Adapted from [Zwick, T., T. J. Beukema, H. Nam, Wideband Channel Sounder with Measurements and Model for the 60 GHz Indoor Radio Channel, *IEEE Transactions on Vehicular Technology*, Volume **54**, Issue **4**, 1266-1277, July 2005].

Revised Model: S-V Model

CIR model: single or multi-cluster S-V model

$$\text{single}: \ h(\tau) = \sum_{k=0}^{\infty} \beta_k e^{i\phi_k} \delta(\tau - \tau_k)$$

$$\text{multi}: \ h(\tau) = \sum_{l=0}^{\infty} \sum_{k=0}^{\infty} \beta_{kl} e^{i\phi_{kl}} \delta(\tau - \tau_l - \tau_{kl})$$

β_k, β_{kl} : Rayleigh distribution

ϕ_k, ϕ_{kl} : uniform distribution over $[0, 2\pi)$

τ_k, τ_{kl} : Poisson distribution with parameter λ

τ_l : Poisson distribution with parameter Λ

PDP model: single or multi-exponential decay

$$\text{single}: \ \overline{\beta_k^2} = \overline{\beta_0^2} \cdot e^{-\tau_k / \gamma}$$

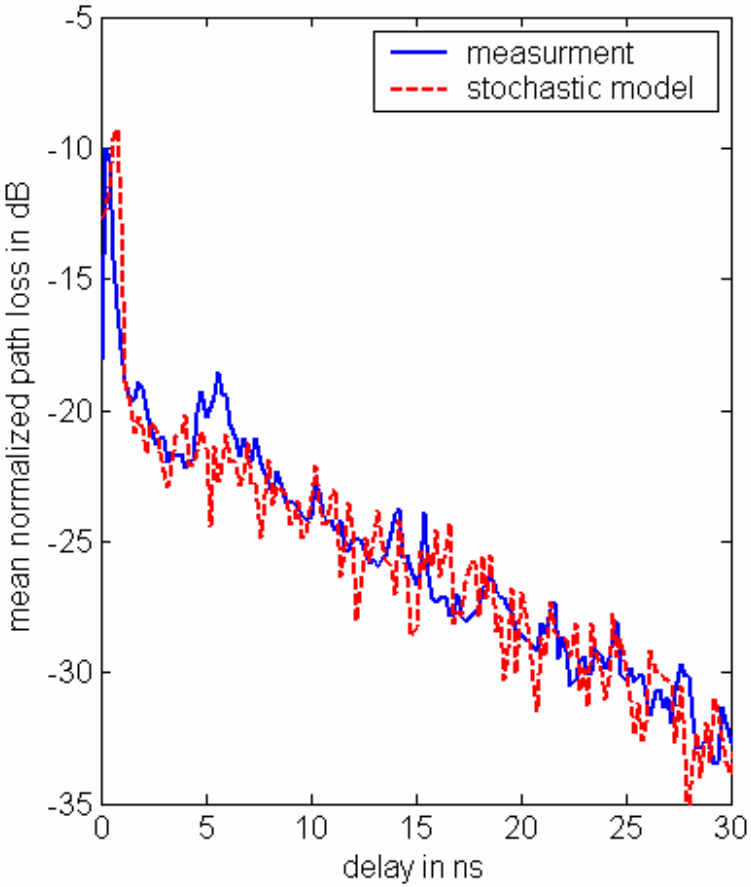
$$\text{multi}: \ \overline{\beta_{kl}^2} = \overline{\beta_{00}^2} \cdot e^{-\tau_l / \Gamma} \cdot e^{-\tau_{kl} / \gamma}$$

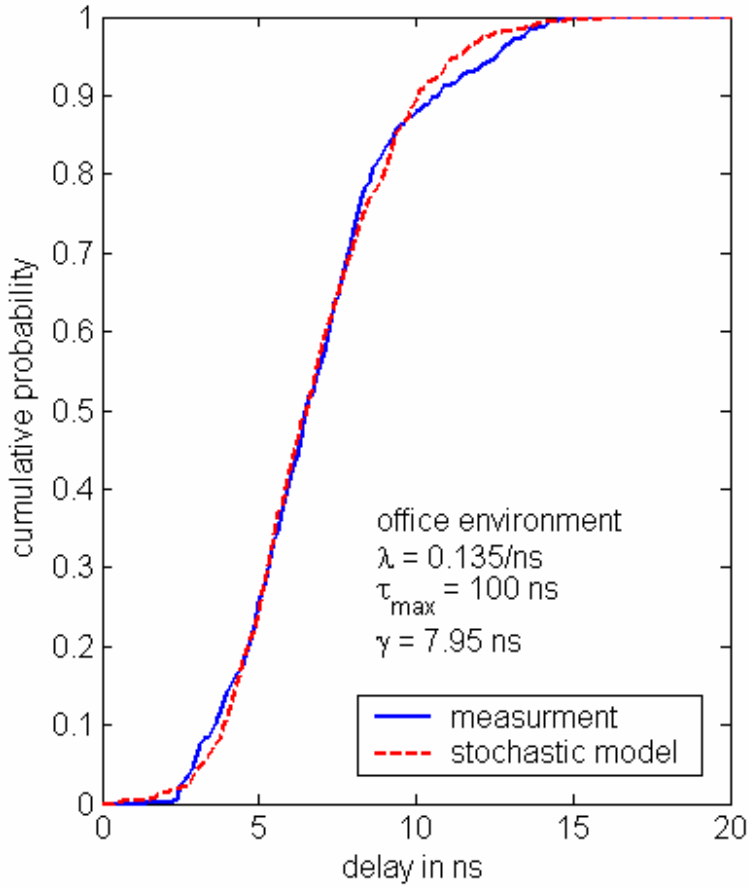
Main Parameters:

- λ = ray arrival rate (1/ns)
- Λ = cluster arrival rate (1/ns)
- γ = ray decay factor (ns)
- Γ = cluster decay factor (ns)

Mean Normalized PDP and Cumulative Probability of RDS For Office Environment

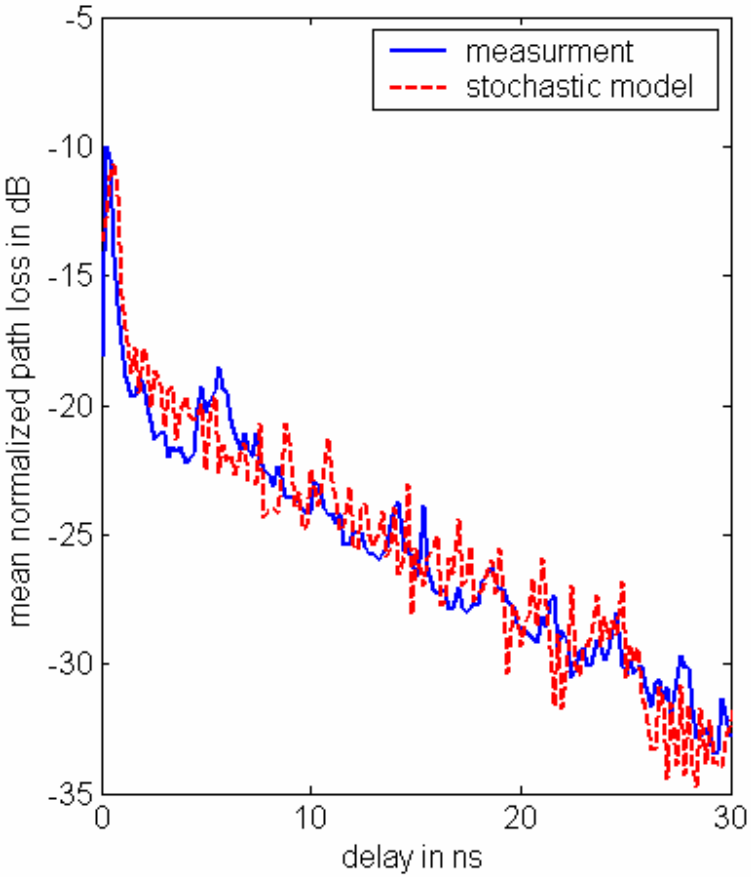
Using Single-Cluster S-V Model

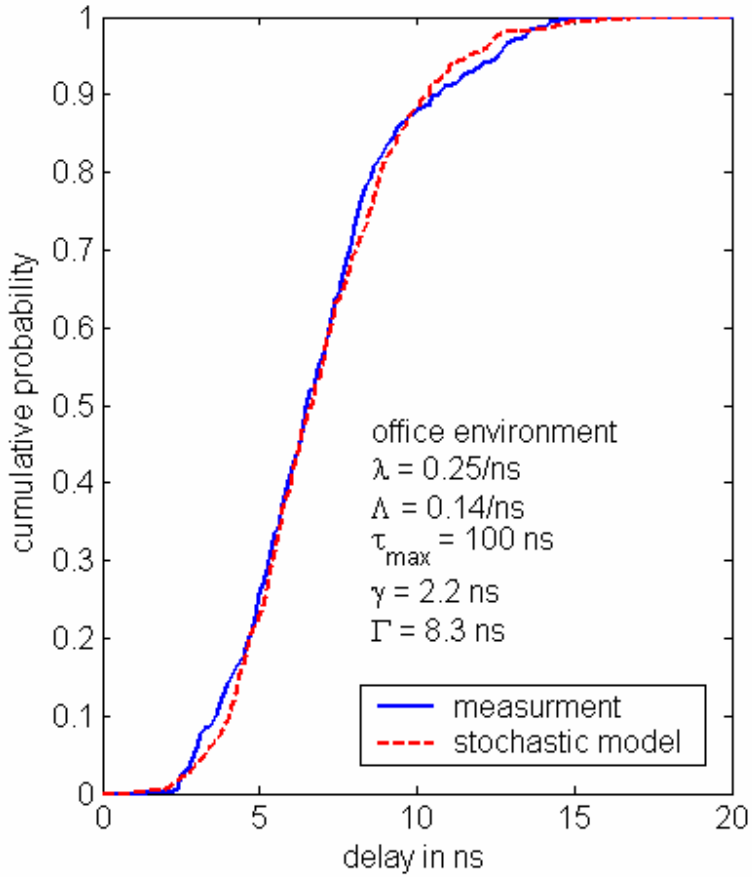


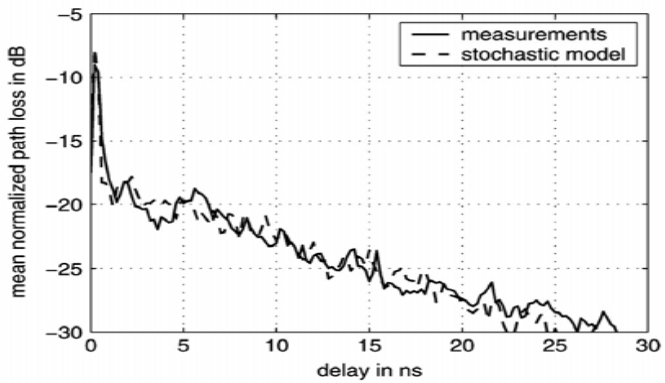


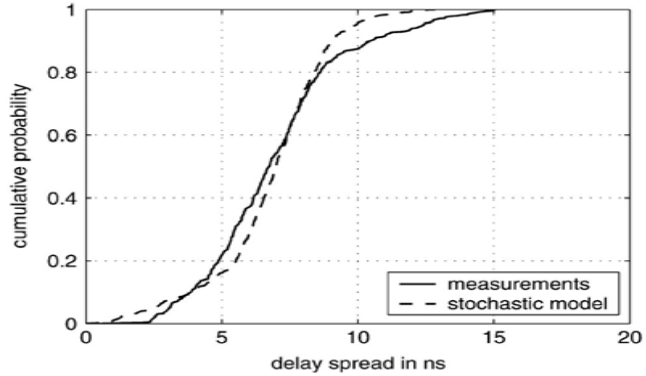
Mean Normalized PDP and Cumulative Probability of RDS For Office Environment

Using the Conventional Multi-Cluster S-V Model





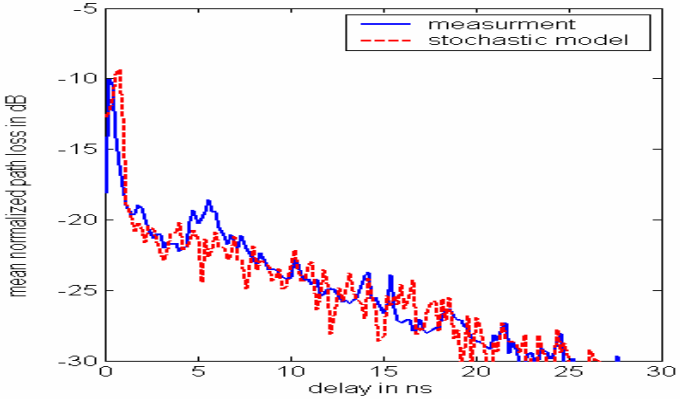


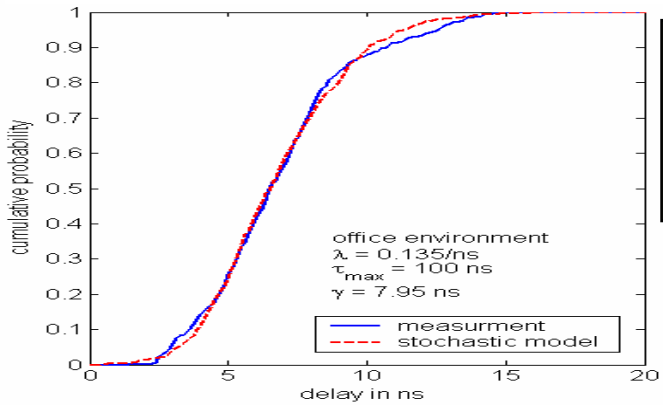


Original fitting

λ = 0.5/ns

γ = 8.33 ns

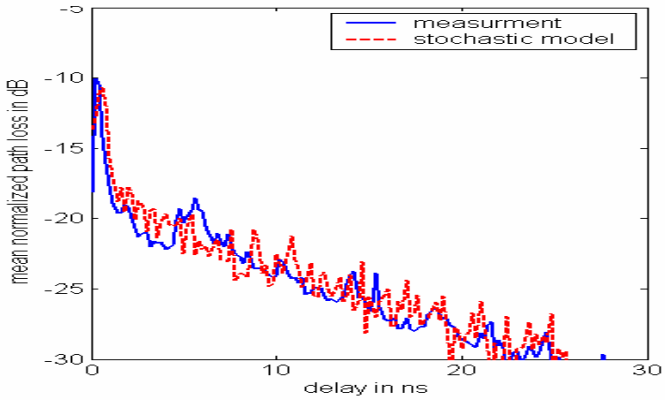


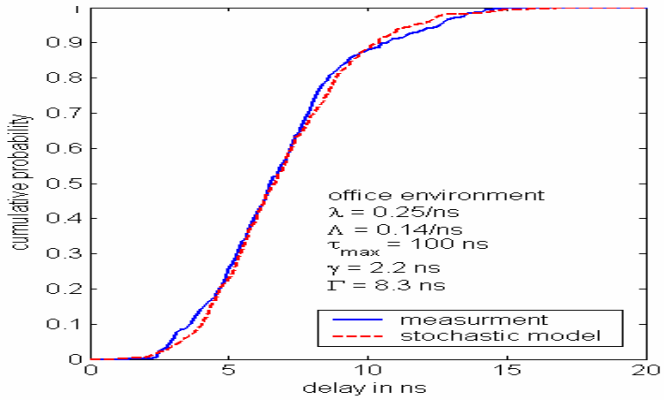


Single-cluster S-V

λ = 0.135/ns

γ = 7.95 ns





Multi-cluster S-V

λ = 0.25/ns

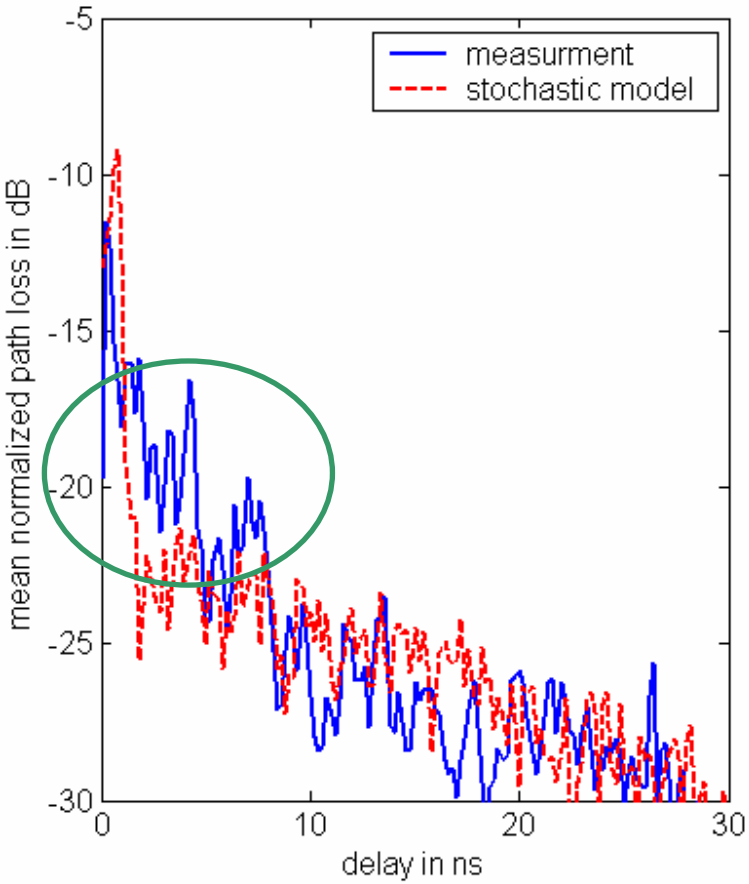
Λ = 0.14/ns

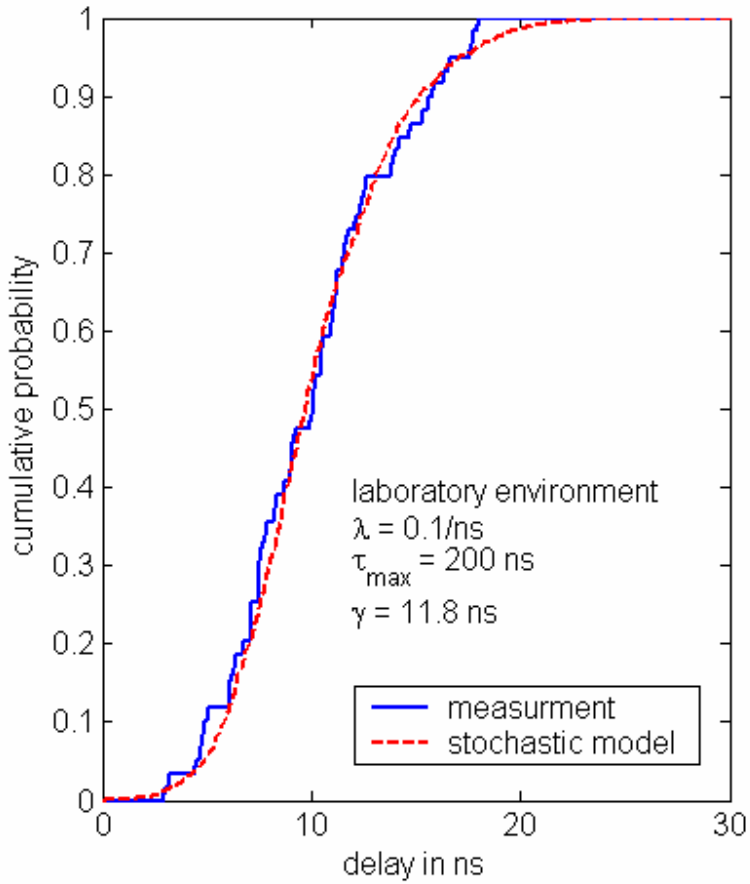
γ = 2.2 ns

Γ = 8.3 ns

Mean Normalized PDP and Cumulative Probability of RDS For Laboratory Environment

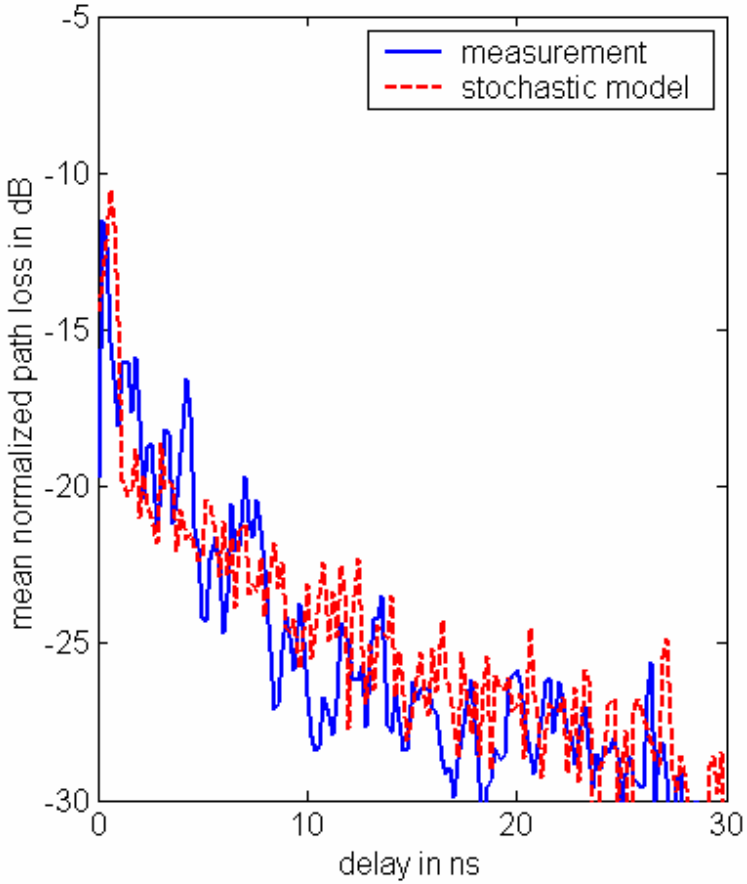
Using Single-Cluster S-V Model

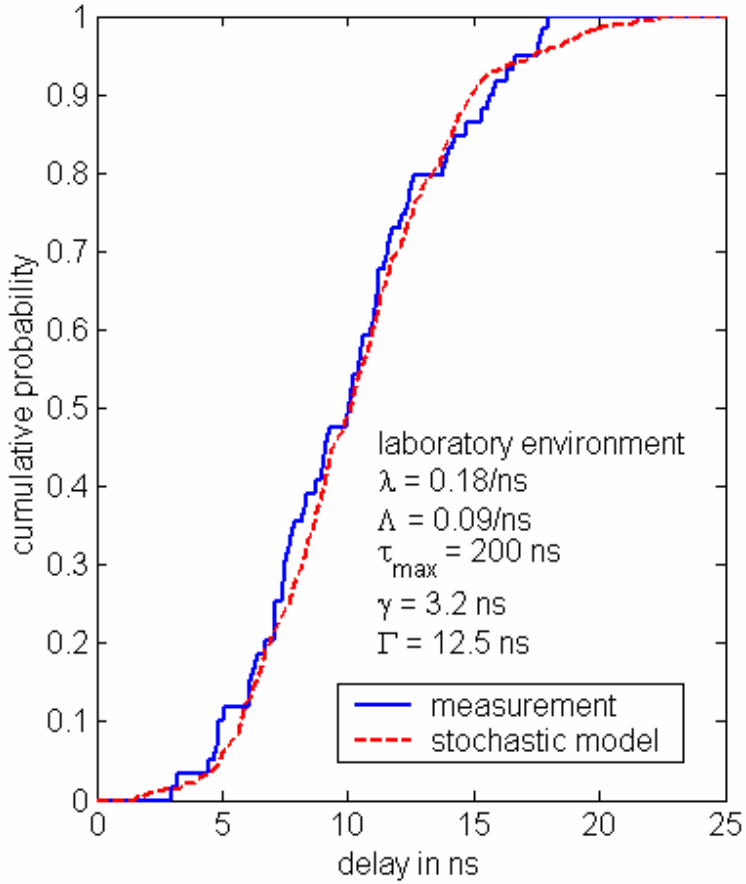




Mean Normalized PDP and Cumulative Probability of RDS For Laboratory Environment

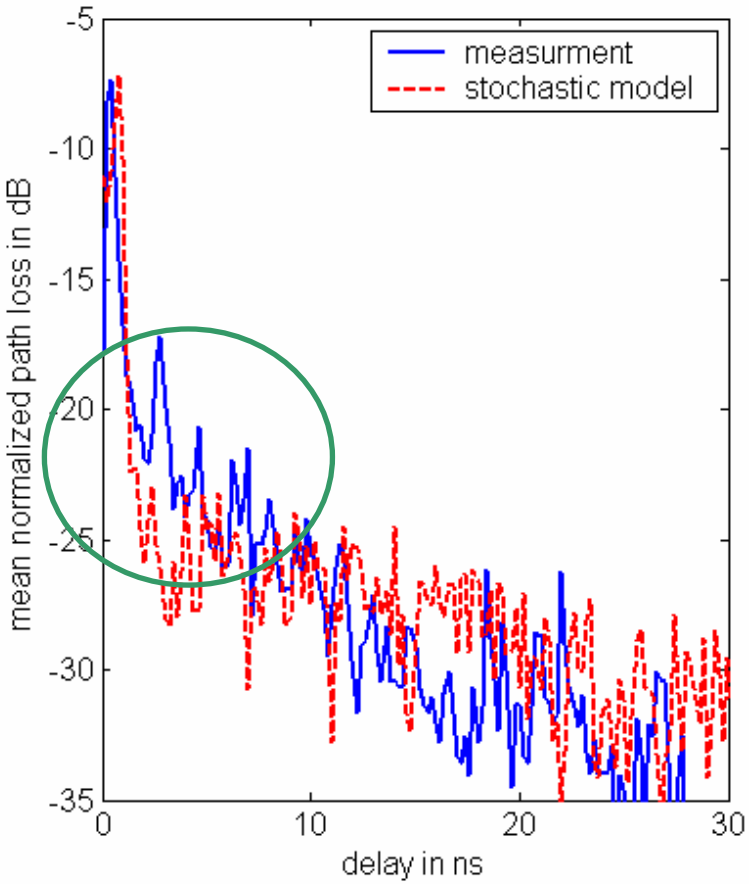
Using the Conventional Multi-Cluster S-V Model

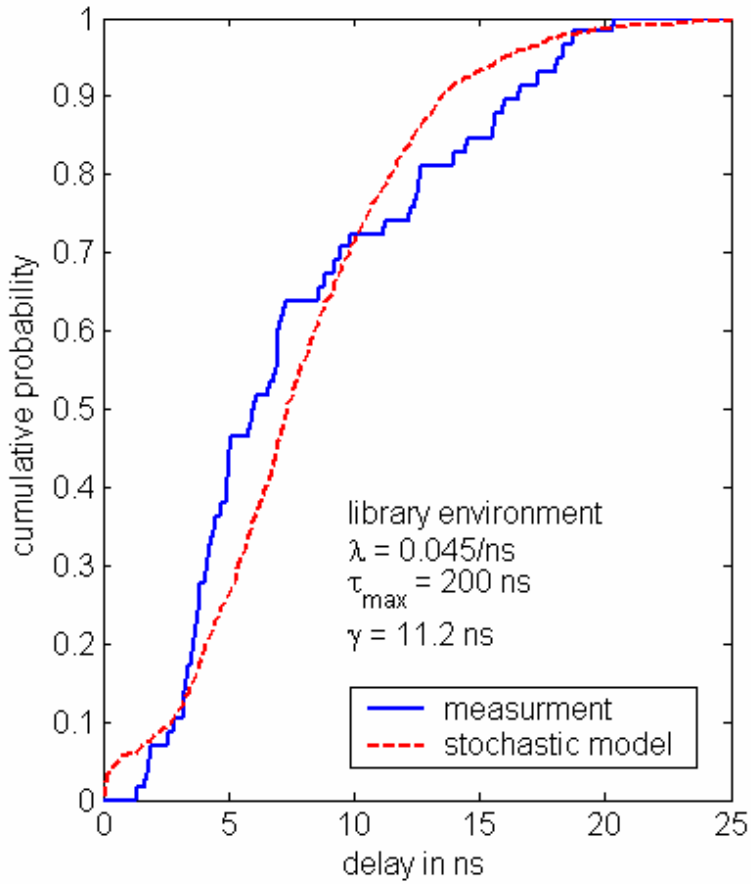




Mean Normalized PDP and Cumulative Probability of RDS For Library Environment

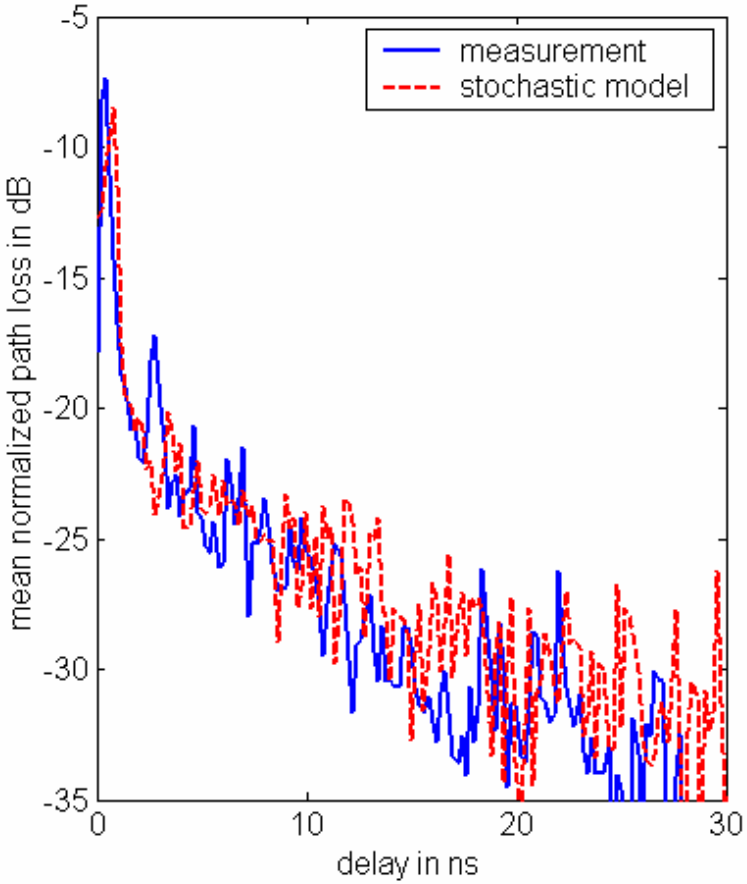
Using Single-Cluster S-V Model

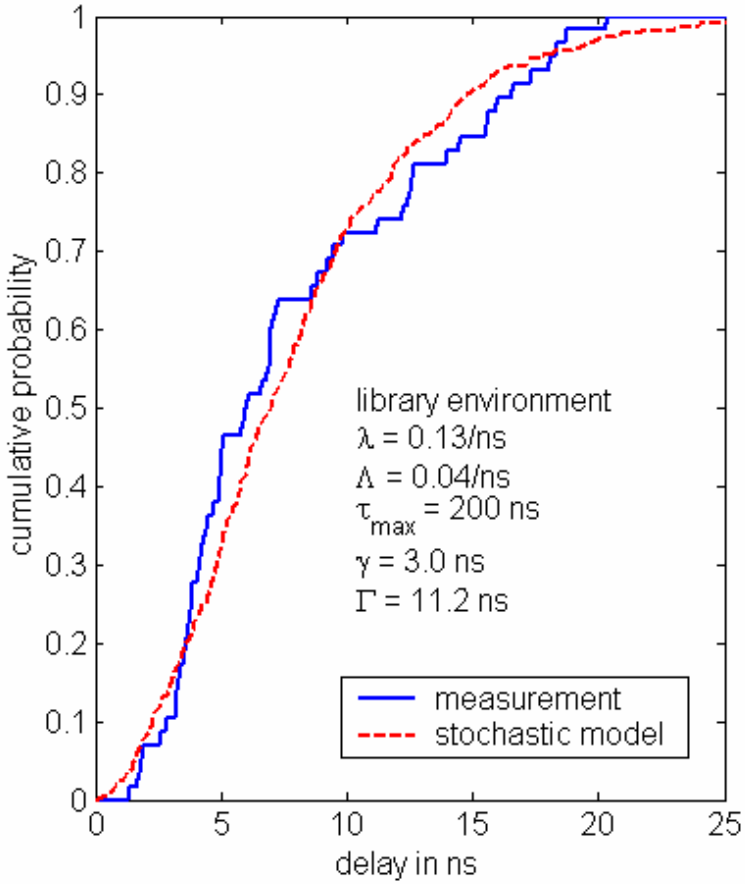




Mean Normalized PDP and Cumulative Probability of RDS For Library Environment

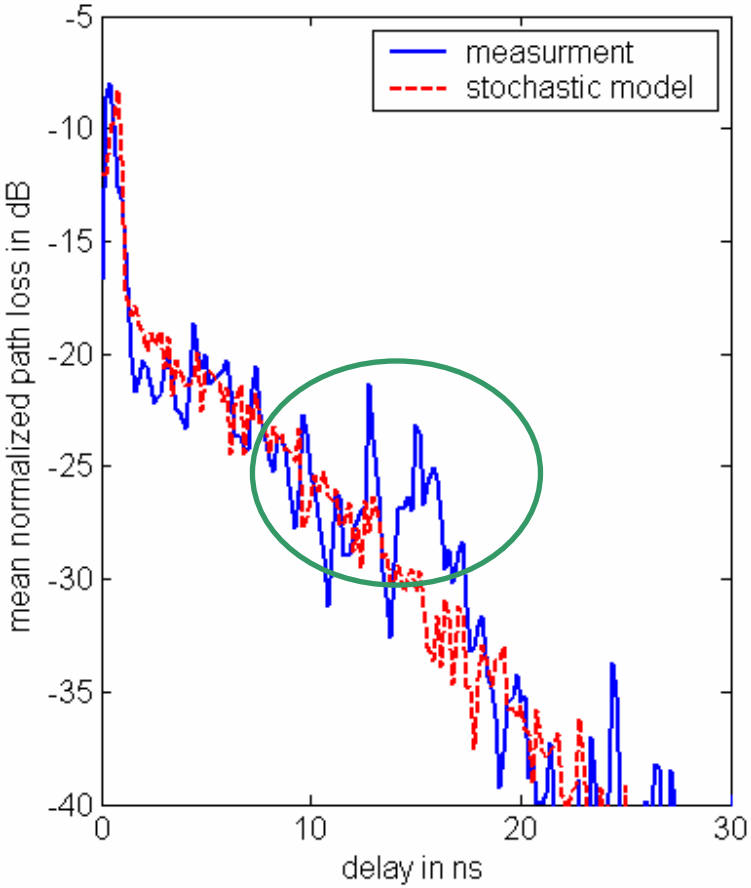
Using the Conventional Multi-Cluster S-V Model

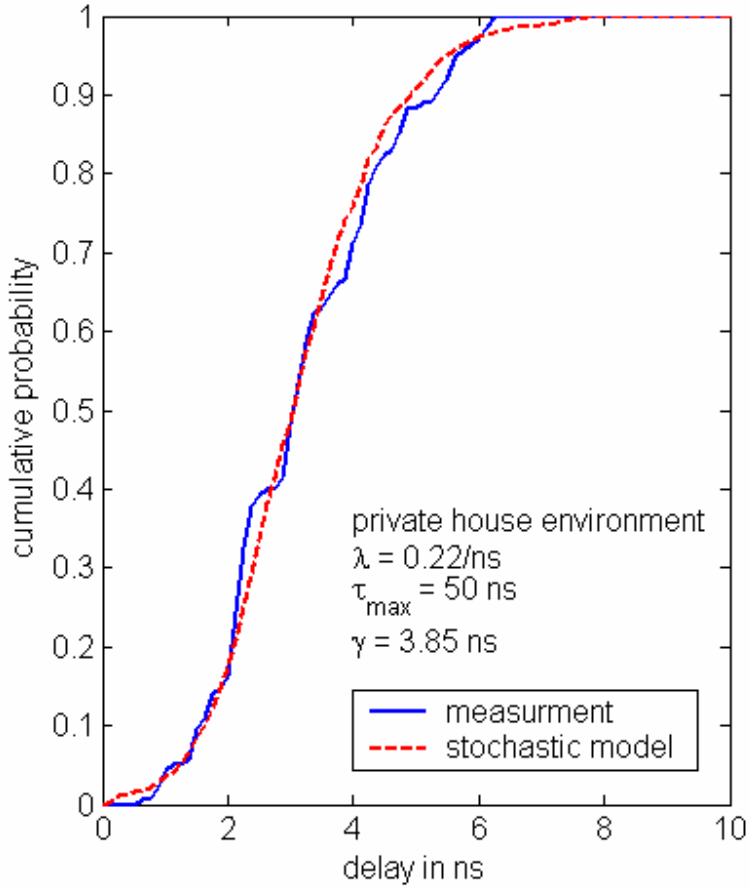




Mean Normalized PDP and Cumulative Probability of RDS For Private House Environment

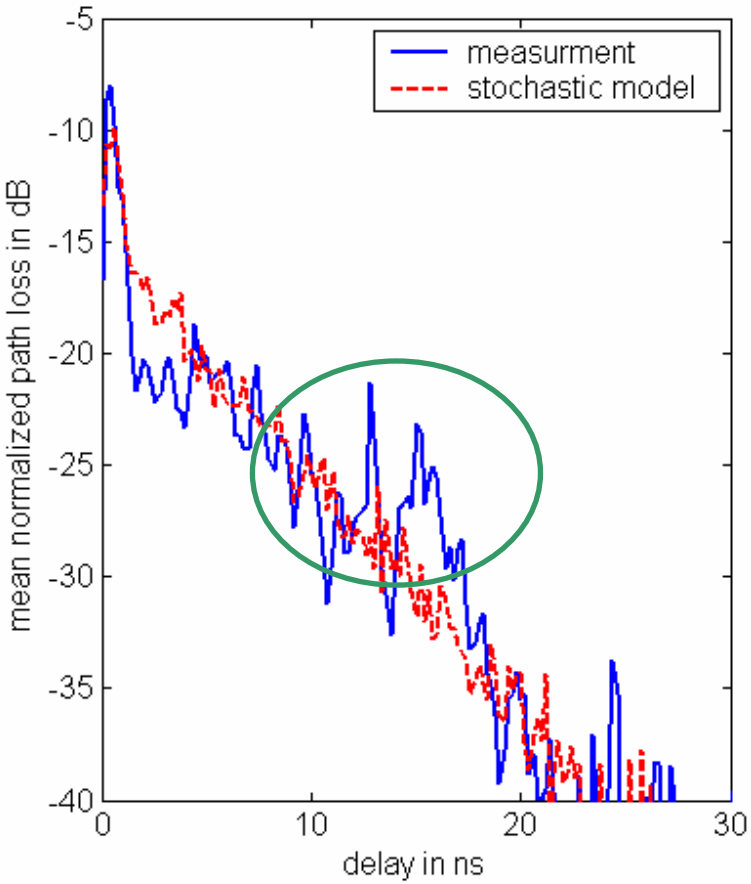
Using Single-Cluster S-V Model

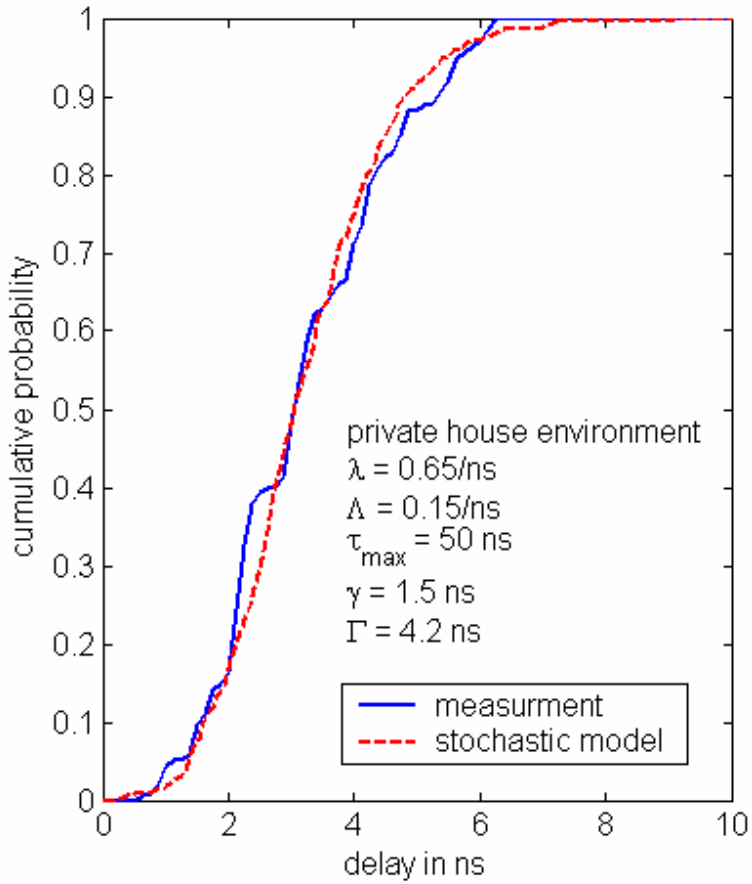




Mean Normalized PDP and Cumulative Probability of RDS For Private House Environment

Using the Conventional Multi-Cluster S-V Model





Multipath Model Parameters

parameters \ environments	Office		Laboratory		Library		Private home	
	Single	Multi	Single	Multi	Single	Multi	Single	Multi
ray arrival rate λ (1/ns)	0.135	0.25	0.1	0.18	0.045	0.13	0.22	0.65
cluster arrival rate Λ (1/ns)	-	0.14	-	0.09	-	0.04	-	0.15
ray decay factor γ (ns)	7.95	2.2	11.8	3.2	11.2	3.2	3.85	1.5
cluster decay factor Γ (ns)	-	8.3	-	12.5	-	11.2	-	4.2
mean excess delay (ns)	7.01		9.99		7.85		3.39	
rms delay (ns)	6.83		9.44		6.03		3.19	
maximum delay (ns)*	100		200		200		50	

* The maximum delay used in the simulation to ensure the capture of all possible rays.

Summary and Conclusions

- Four sets of measured data (office, laboratory, libratory, private house) provided by IBM were fitted to S-V model.
- Parameters (ray/cluster arrival rates, ray/cluster decay factors, mean excess delay, and rms delay) were extracted.
- For the office environment, the new fitting (S-V model) is better than the original one (exponential decay preceded by a constant part).
- S-V model is well supported by IBM measured data. For office and private house environments, the measured data were equally well fitted to the single-cluster model and the multi-cluster model. For laboratory and library environments, the multi-cluster model has a better fitting.