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# REVIEW ON CLASSIFICATION OF CHANNEL MODELS AND DETERMINATION OF THE PARAMETERS FOR CHANNEL MODELING

**S. Venkateswarlu*, JKR. Sastry** & Ch. Radhika Rani*****
* Sreyas Institute of Engineering and Technology, Hyderabad, Telangana
** K. L. University, Vaddeswaram, Guntur, Andhra Pradesh
*** Department of CSE, K. L. University, Vaddeswaram, Guntur, Andhra Pradesh

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**Abstract:**

Communicating knowledge from one location to different locations needs some type of medium. These communication media, uses 2 varieties of media: Wired and Wireless. The medium is employed to convey the knowledge in analog or digital format from one or many senders or transmitters, to one or many receivers. When the information is propagating from source to destination, it under goes different changes because of diverse sorts of disorders, errors brought in as a result of the clamor into the information, delay spread, numerous reflections and so forth. The received information won't be same as the information that has been transmitted by the source. Many of the channel parameters will affect the data that is being communicated to the receiver. This paper presents parametric analysis of a communication system and presents the method of selection of parameters that together present a composite communication system.

**Key Words**: Communication & Parametric Identification.

## 1. Channel Model Classification and Determination of Model Parameters:

An assortment of channel models, a considerable lot of them taking into account estimations, has been accounted for in the previous years. These models that speak to a channel can be characterized into distinctive classifications taking into account the band, time difference, physical, scientific, institutionalized and so forth. Every kind of model is further ordered. Diverse parameters are utilized to show a model in view of the sort utilized for the order.

## 2. Taxonomy / Classification Based on Band Used:

Models can be classified as narrowband and Broadband. Narrowband refers to communications that use frequency content within the coherence band of a frequency channel. For applications requiring long-range, low-power, and reliable communications, narrowband tends to be the dominant choice. Whereas Broadband channels are used by the communication systems that have the highest data rate, the frequency spectrum used must be wide. This invariably lowers the power, range, and resistance to interference.

## 3. Taxonomy / Classification based on Time Variance:

A model is required for the evolution based on the Doppler effects on a channel whose parameters might vary as the time changes. On the other hand double-directional impulse response by the channel can be designed and described by using time-invariant channels.

## 4. Taxonomy / Classification Based on the Modelling Approach:

Two types of approaches can be used to classify the channel models which primarily can be classified as Physical and Analytical. Fig. 1 shows the classification of models with full decomposition of each of the approaches.

## 5. Physical Channel Models:

A deterministic measurement, stochastics geometric, stochastic non-geometric based classifications falls under the category of physical models. The deterministic models are classified based on the concepts of ray tracing, stored measurement and stochastics oriented geometry. Zwick and Saleh-Valenzuela models are the models which are stochastic and geometry based. Electromagnetic waves that effect multipath spread in two directions between the transmitter and receiver cluster defines the domain for physical models. Late arrival of MPC (Multipath Components), DoA (Direction of Arrival), DoD (Direction of Departure), Complex Amplitude are the parameters that effects the wave and such waves can be modelled through physical models. Some more models exists that fuse time variance and polarization. Precise radio propagation and reproduction and bandwidth system also are taken into consideration by the physical models. Various parameters that are used to configure antennas are received by the physical models in autonomous manner (Reception antenna, pattern antenna, polarization, antenna coupling). Physical models can be characterized into two classes which include deterministic and geometric-based models. The parameters that relate to propagation are characterized in deterministic manner whereas the channel parameters are characterized by impulse response in respect of geometric stochastic-based models (GSM). The impulse response is determined by using the laws of propagation that include Diffraction, Refraction, Scattering, Reflection etc. The impulse responses are either directed to a transmitter or receiver or to the geometrics which are scattered in a random-stochastic manner. The physical parameters such DoA, DoD and Delay which are Non-Geometric stochastic models are described using probability distributions Saleh-Valenzuela model. No geometry as such is used for describing the physical parameters.

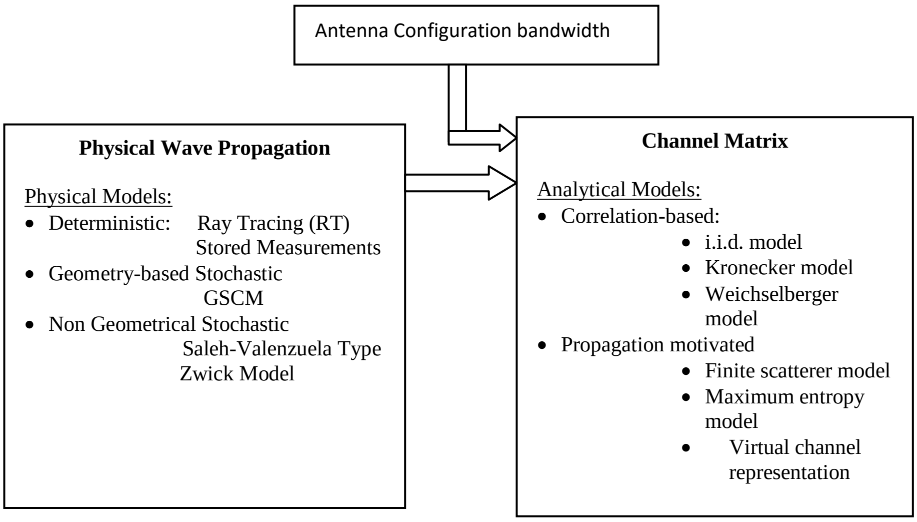


Figure 1: Taxonomy/Classification of the models based on the approach

The models that use radio propagation in a repeating manner especially based on the environment used fall under the category of Deterministic models. The electromagnetic propagation in such domains can be simulated using software in which case the working of the radio link can be replaced by the simulation program which obviously would be software.

The models which are deterministic are very important as they behave precisely. The models can be used to estimate channel parameters especially when sufficient time is non-existent to setup a real environment or when one encounters a situation which is very hard to setup a hardware environment. The models that use methods of moments (MoM) of electromagnetics or the methods that use the Finite difference in time (FDTD) are quite useful to study various issues in the region of either the transmitter or receiver. Ray Tracing (RT) models are most suitable models fir effecting the radio propagation. The models are deterministic and fall in the category of physical models.

RT Models uses optics for dealing with reelection to transmit either on plane surfaces or use diffraction to transmit on edges which are of type rectilinear. Ray approximation assumes a wavelength which is quite less when compared to the obstacles that are caused in the surroundings. Ray approximation is the main theme on which geometric optics is quite dependent.

Scatter areas dictates the Stochastic based and geometric based physical models. Scatter areas can be coded and stored in a database. The scatter areas are picked in a random manner in the case of stochastic and geometric based channel models (GSCM) by using probability distribution models. Using the probability distribution models, acceptable impulse response can be found by making the improvements to the RT models. GSCM were initially invented for medium simulations in systems with different reception antennae at the base station. The forerunner of the GSCM set scatterers deterministically on a circle around the moving dynamic station, and accepted that just one scattering happens.

About a quarter century down the line, a few gatherings at the same time proposed to augment this single scattering method that is using scramble model randomly put scatterers. This irregular arrangement has reflected physical reality as much improved. The single-scrambling assumption makes RT greatly basic through employments of diverse parts which incorporate a way of the LoS, two sub-ways uniting the scatterer to the Tx and Rx, individually. The scatter distributions are mainly the distributions of GSCM. When the scatterers are assumed to be simply distributed spatially and analogously, the GSCMs can be acquired. When scatters are used, less power can be used due to the reason that they lose power as they travel long distances. This kind of a model thus can be called geometric model which is a single bounce model.

Another methodology proposes putting the scatterers randomly around the mobile station, and investigate different other scatterer dispersions around the mobile station. The disseminations that have been utilized incorporate an uneven Gaussian appropriation w.r.t. separation from the mobile station which brought about an exponential power delay profile. The distance estimations are in great concurrence with numerous measurement results. For making the density or quality of the scatterers rely on upon distance, two types of executions are conceivable.

- ✓ Scatterers do not happen at long distances from mobile stations which are quite implied when the balanced scatterers can be represented through the probability density functions. The procedure that represents the balanced scatters using the probability density functions is called the classical procedure

- ✓ The loss of power of the scatterers as they travel long distances gets down-weighted when the scatterers are represented using the uniform density function. This kind of a strategy is called as technique of cross section of non-uniform dispersing.

Many effects arise due the existence of cluster of scaterrers like mountains, houses, buildings etc. Angular and temporal dispersion arises due to the cluster of scatterers. The performance of the communication channels considerably effects the performance of the system. In GSCM, the cells are located with the cluster of scatterers which are dispersed.

Various parameters that can be measured in relation to the transmitter without the need for knowing the physical location are considered by the Non-geometrical models. Two types of stochastic non-geometrical are in use in the past. Bunch of MPCs are used to generalize the cluster model created by *A. Saleh et. al., 1987*. The extended cluster model is called as Saleh-Valenzuela model. The MPCs which are grouped and clustered are considered to be in the delay domain through an exponential process. The power of Multi-path is controlled by the profiles which are exponentially decaying.

The mean cluster angle Ɵ can be found to be distributed inside [0, 2π) and φ related tp MPCs can be recognized as distribution which is a Laplacian which means that the probability density function equals to as sown in the equation below:

$$p(\varphi) = \left(\frac{1}{\sqrt{2\sigma)}}\right)\exp(-\sqrt{2}\,/\sigma\,|\varphi-\theta|) \qquad (1)$$

Where φ is same as cluster's angular spread. A Poisson process can be used to represent the mean delay for every individual cluster and the delays which are individual are represented through yet another additional process which is Poisson.

Zwick has presented an architecture that treats MPCs individually. It has been stated and verified that channels which are multipath, indoor will not happen if the speed of the channel is very high [T. Zwickr et. al., 2002]. Multi-path fading will not occur when the speed of the channel is found to be very high. MPCs get generated individually and therefore will not be effected by amplitude fading. MPCs leads to congenital phase changes using various aspects of geometrics which are used to describe transmitter, scatter motion and the receiver.

The actual location of MPC can be determined through a geometric scenario. The location directly relates to the impulse response that evolves over a time. The MPCs which are non-line-of-sight can be modelled through Poisson process. The line-of-sight if required can be included as an additional abstract step.

**6. Analytical Models:**

Impulse response of the channel identified between transmit and receive antennae in a route which is scientific and investigative can be described through Analytical channel models which do not depended on wave propagation expressively. Analytical models are quite suitable for matrix synthetization which is generally undertaken for the development of algorithms, system development and verification of all kinds of developments. The analytical models are either propagation oriented or could be based on inspired correlations of wave propagations.

The propagation driven methodology models the channel matrix by means of properties of propagation. A percentage of the models introduced in the literature that uses propagation motivation incorporate limited scatterer model, the maximum entropy model, and the virtual channel representation exhibited in the literature. Correlation based models portray the channel matrix statistically in terms of the correlations between the matrix entries.

The channel coefficients are represented as Gaussian distribution which is multivariate and complex when it comes to analytic models which support various kinds of narrowband. The channel coefficients are suitable for Rician fading or Rayleigh modelling. According to P. Soma et. al., 2002 the channel matrix will include Hd which is a deterministic part and Hs which is a zero mean stochastic part.

$$H = \sqrt{\frac{1}{1+K}}Hs + \frac{\sqrt{K}}{\sqrt{(1+K)}}Hd \qquad (2)$$

Where the Rician factor is implied when $K \geq 0$. The submatrix of the channel matrix Hd represents the component that relates to the line of sight and other contributions which are non-fading. A focus has been presented further relating to NLoS components which are characterized by the Hs Matrix which is Gaussian. H = Hs when K =0. The matrix is thus is represented as a zero-mean Gaussian distribution which is multivariate and complex and can be represented as h = vec{H} the equation of which is shown below:

$$f(h) = 1/(\pi^{nm}\det\{R_H\})\exp(-h^H R_H^{-1} h) \qquad (3)$$

The {nm X nm} matrix $RH = E\{hh^H\}$ is known as full correlation grid and portrays the spatial channel values. It contains the relationships of all channel matrix components. Implementation of channels with appropriation can be gotten by H=unvec{h}, with $h = RH^{1/2}$ g. Here, $RH^{1/2}$ signifies a self-assertive matrix square root, and g is a nm × 1 vector with i.i.d (independent identically distributed). Gaussian distribution is displayed through zero mean and unit variance. It ought to be noticed that full determination of RH includes $(nm)^2$ genuine and real valued parameters. To decrease these substantial numbers of parameters, distinctive models have been suggested that force a specific structure on the correlation matrix. The models introduced incorporate i.i.d model, Kronecker Model, Weichselberger model, and Maximum Entropy Model.

The analytical model which is less complex and at times looks like a canonical model is the i.i.d model. In the cases of i.i.d model RH = ρI which indicates that the components of the channel matrix are not correlated and the matrix is autonomous in a way and has $\rho^2$ as the variance. This kind of a matric is equivalent to channel which is white. The i.i.d. model is used regularly for contemplating the hypothesis like theoretic data analysis of the systems.

The coupling of DoA with DoD can be achieved through single bounce scattering. This kind of a simple coupling cannot be reproduced using the Kronecker method and the method as such is weak. In spite of such a limitation the model is used for the theoretical analysis through simulation of the channel. More over the model allows for the improvement of freelance array at the receiver and transmitter side. The Kronecker model as such is quite simple that many application which are spread out can be implemented using the model. This approach is based on the dependence on the decay of Eigen value that are related to Tx and Rx correlation matrices as shown below:

$$R_{Tx} = U_{Tx}\wedge_{Tx}U^{H}{}_{Tx} \quad (4)$$

$$R_{Rx} = U_{Rx}\wedge_{Rx}U^{H}{}_{Rx}. \quad (5)$$

The URx and UTx are the matrices of type unary. The sections of the matrices are Eigen vectors of RRx and RTx and the diagonal lattices are ^Rx and ^Tx relates to the Eigen values. The model can be represented in terms of a mathematical equation as shown below:

$$H = U^{Rx}(\Omega \,\Theta\, G)\,U^{T}{}_{Tx}, \quad (6)$$

Where gain is G and the i.i.d. matrix being n × m, Schur-Hadamard product is signified as Θ, and n×m coupling matrix is represented as Ω whose real valued and nonnegative components decide the coupling of the power between the receiver and the transmitter Eigen values.

The problem of channel modelling has also been handled by [M. Debbah et. al., 2005] using different statistical inferences. The entropy has been proposed based on the prori data to actuate the distribution of channel matrix .The advance data may include parameters of the propagation environment and system properties which include DoAs, bandwidth, DoDs, multiple reflections, path delay, time variation, propagation, noise, Doppler drift etc. The assumption of entropy based model has been justified considering the objective to ignore any of the assumptions of the model which cannot be supported accurately.

**7. Reference Models:**

Reference channel models have been defined which can be used as a basis for comparing different modelling systems. Using reference models channel models can be reproduced. The reference channel models can be specified by selecting any of the existing models, the environment in which the model is expected to work and also fix the parameter values for the environment that is selected. Target scenarios must also be defined when analytical models are selected as reference models.

Improvement of radio systems requires that a standardized model be selected and implemented. Standardized models will help implementing diverse procedures such as wide access, signal processing etc. and also help in upgrading the capacity and enhancing the execution performance. The standardized models must bind various advantages so that the model can serve several end users. For example the wideband power profile model which is COST207 is being used to improve GSM. Many models are being utilized which include directional models, 3GPP SCM model, calibration model, COST 259/273 model.

The spatial channel model (SCM) was developed by incorporating 3GPP/3GPP2 to be a standard reference for evaluating totally different ideas in out of doors environments at a middle frequency of 2 GHz and a system bandwidth of 5MHz. The SCM consists of 2 parts; a standardization model, and system-simulation model.

The standard model (Calibration model) that is developed using the 3GPP/3GPP2 standard can be implemented either as diagnostic model, physical model or as a analytical model. The wideband qualities of the channel represented as tapped delay time in terms of spatial expansion of ITU-R models. Taps are of type freely fading and every tap is represented by its power range expressed in terms of Angular Spread (AS), Laplacian or uniform and the course is mean either at base station or mobile station.

The SCM proposed for execution assessment is known as the simulation model. [A.F. Molisch et. al., 2006] proposed a physical model which recognizes three distinct situations: urban macrocell, rural macrocell, and urban microcell. The model structure and simulation methodology are indistinguishable for every one of these situations, however the parameters, as angular spread, delay spread and so forth, are distinctive. The model that has been simulated utilizes both geometrical and stochastic components. The model can be utilized to represent a solitary link or numerous links in the middle of MS and BS. The parameters of the channel can be drawn according to a distribution for each drop of the cell. In the beginning of each drop the MS positions are assorted. The channels can still be challenged even in the presence of BS and MS sectors. The BS locations are fixed in the cell blueprint for certain number of drops which are alternating. However the MS locations are randomly positioned at the entry of each of the drop.

A model can be made to be antenna independent by making the antenna geometries, antenna orientation and antenna radiation patterns arbitrary. Analytic formulations can be extended form the chosen model when all the parameters including that of antennas are defined. The alternation matrix that represents a drop can be altered to suit to an analytic model. Few elements are included into the simulation model to include polarization, line of sight, scattered bunches to the address the issues of Micro Cells.

**8. Identification of Effective Model Parameters:**

It has been seen while comparing the conventional and advanced models that many parameters are involved and the way a parameter is used in the model has been differing. An elaborate study of each parameter has to be undertaken to find the importance of the same and also to find the way the parameters must be introduced into the model. Every parameter can be introduced in different style and manner. It is necessary to find the most effective way of implementing a parameter within a design model. The detailed description of each of the parameter, the methods that can be used for introducing the parameters and the most effective way of implementing the parameters are shown in Table 1.

Table 1: Parameters that are used in the channel models

| **Parameter** | **Parameter Description** | **Methods of implementing the parameter** | **Effective way of implementing the parameter** |
|---|---|---|---|
| DoD (Direction of Departure) | It is the direction from which usually propagating wave will leave the transmitting antenna | Omni directional antenna will release the signals in all the directions equally well. | Omni directional antenna will release the signals in all the directions. |
| DoA (Direction of Arrival) | It is the direction from which usually propagating wave arrives at a receiver | The receiving antenna will receive the signals from the direction in which they arrive. | The receiving antenna will receive the signals from the direction in which they arrive. |
| Polarization | It is a property of waves that can sway with more than one introduction. Electromagnetic waves and gravitational waves do display the polarization. | Single polarization. | Multiple orientation is used. |
| | | Dual Polarization | |
| | | Depolarization is just displayed in a measurable manner and the cross polarization proportion is dealt with as an arbitrary variable. | |
| Time variation | Channel time variation is the difference between the time of arrival of multiple reflected signals that arrive at eh receiving antenna. This can be characterized statistically. | Factually prescribing so as to describe channel time varieties TX, Rx movement. | Statistically characterizing channel time variations by prescribing transmitter and receiver motion. |
| | | Channel time variety is because of development of terminals or scatterers. | |
| | | Considering actual physical and capture time variations via statistical characterization. | |
| Radio propagation | The application of wave propagation to radio communications is known as radio wave propagation. | Waves propagate equally likely between any pair of stations. | Motivation reaction of the channel is portrayed between the individual Tx and Rx receiving wire mathematically without unequivocally representing wave proliferation. |
| | | Motivation reaction of the channel is portrayed between the individual Tx and Rx receiving wire mathematically without unequivocally representing wave proliferation. | |
| Antenna pattern | Antenna pattern is typical polar radiation plot. Most antennas show a pattern of "lobes" or maxima of radiation. | Antenna pattern is typical polar radiation plot. | Antenna pattern is typical polar radiation plot. |
| Impulse | In sign preparing, the drive | Impulse response consists of | Motivation reaction of |

| | | | |
|---|---|---|---|
| response | reaction, or motivation reaction capacity (IRF), of a dynamic framework is its yield when given a brief info sign, called a drive. | several strong paths. | the channel is portrayed between the individual Tx and Rx wire without expressly representing wave spread. |
| Laws of wave propagation | Study of Reflection, Refraction, Diffraction, Scattering etc. Which are the properties exhibited by waves are known as laws of wave propagation. | All the laws of wave propagation have been considered with all the models. | All the laws of propagation have been considered while designing the new model. |
| Propagation delay | Propagation delay is the amount of time a data packet takes for the head of the signal to travel from the sender to the receiver. | The receiver has to consider the propagation delay of signals received through various paths for calculating net received signal. | The receiver has to consider the propagation delay of signals received through various paths for calculating net received signal. |
| Transmit antenna | Antenna that is used for transmitting the signal from the transmit end is called as transmit antenna. | It is assumed that the transmitting antenna is omni directional. | It is assumed that the sender antenna is omni directional. |
| Receive Antenna | Antenna that is used for receiving the transmitted signal from the receive end is called as receive antenna. | It is assumed that the receiving antenna will receive the signals from al the directions. | It is assumed that the Rx antenna will receive the signals from all the directions. |
| Ray approximation | The beam estimation gives a satisfactory portrayal of light transmission gave diffraction impacts can be disregarded. | Not considered. | Not considered. |
| Scatterer locations | The identified locations used for the computation of the position of scatterers in absolute coordinates directly from the raw data received from the radar. | Single bounce scattering.<br>Rich scattering environments noted by MPCs | Multiple bounced scattering is used. |
| Propagation time | Time the propagated signal takes before it is received by the receiver, once it has been released by the transmitter station is known as propagation time. | Propagation time calculated based on arrived signal phase and time of arrival. | Propagation time calculated based on arrived signal phase and time of arrival. |
| Overall attenuation | Amount of power loss by the signal that was released by the transmitter station after being received by the receiver station is known as overall attenuation. | It is measured after calculating the received signal strength. | The transmitted signal strength is informed to the Rx. The Rx will calculate the signal strength and will find the attenuation |
| delay drifts | A delay drift is a type of drift where the data packet hops and waits until just before being received by the other station. | As all the models have used multiple reflection of the signals, delay drift is also considered. | The signal will reach the received after getting multiple hops during propagation. Hence delay drift is considered. |
| Power delay profile | The PDP gives the power of a sign got through a multipath channel as an element of time postponement. The time deferral is the distinction in | Delay power profile is determined by the impulse response of system.<br>Postponement force profile is examined and every proliferation pat is discretized. | Postponement force profile is examined and every proliferation pat is discretized. |

| | | | |
|---|---|---|---|
| | travel time between multipath entries. The abscissa is in units of time and the ordinate is generally in decibels. | | |
| Shadow | The region which will not receive any of the propagated signals is known is shadow region. | Not Applicable | Not considered |
| Propagation paths | In wi/l communications the path followed by the radio signals before they reach the rx. is known as path of propagation. Generally the radio signals do follow two or paths for reaching the receiver antenna. | Multiple propagation paths are considered. | Multiple propagation paths are considered. |
| Scatterer distributions | A scatterer conveyance is utilized to name the general scientific capacity which portrays the path in which the light is scattered by a surface. | Waves engender just as likely between any pair if BS and MS scatterers | Drive reaction of the channel is described between the individual Tx and Rx wire mathematically without unequivocally representing wave spread. |
| Angular dispersion | A measure of the angular separation of rays of different wavelength or color traversing through a medium is known angular dispersion. | Not considered | Not considered. |
| Multipath Components | Various components that are present in the signal that is received at the receiving antenna after travelling through multiple paths are MPCs. | Diffuse MPC is included to describe non-specular components | Diffuse MPC is included. |
| | | It implements a detachable DoD-DoA range. | |

It can be seen that as many as 22 parameters can be used in modelling a channel. If all the parameters are used, the process of modelling becomes complex. Thus the problem is to select fewer numbers of parameters and the method that should be used to introduce each of the parameter in such a way that the combined effect of the fewer parameters will be more are less compensated for the combined effect taking together all the 22 parameters.

**9. Conclusions:**

Many conventional models and advanced models exist in literature for modelling the channels. Different types of parameters are used for undertaking the modelling of a channel. Each parameter is introduced into the model by using different methods of implementation. Using all the parameters and considering the effective method of each of the parameter leads to a complex method of undertaking the modelling of a channel. Fewer set of parameters and a specific method of implementation of the same have to be chosen and introduced into the model so that the model becomes simple. A justification however is needed to show the way the chosen parameters more or less represents all the 22 parameters that can be used for undertaking modelling. In this paper fewer numbers of parameters have been chosen that best represents all the 22 parameters used considering both the conventional and advanced models.

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