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Study on Various Receiver Models in Wireless Communication System

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Abstract: Several wireless communication models have been proposed by researchers till today. All the models proposed so far are having a set of advantages and disadvantages. Hence there is always a scope for further research in this field. Each proposed model used a different set of parameters for regeneration of the data it has received. The response of the atmosphere is unpredictable and most of the properties of the atmosphere will not be considered by all the models. Each model has considered only those properties that are required for it. And hence the generic model for all the applications is not ready yet. A well designed receiver has to counter all the different types of disturbances that have will distort the transmitted signal. In this paper an attempt has been made by the authors to tabulate and compare different properties of several receiver models.
Keywords: Shannon and Weaver Model, David Berlo Model, Schramm Model, Watterson Model, Magesh Valliappan Model

I. INTRODUCTION

Three important segments exist in a wireless communication system (Transmitter, Receiver and the medium). The transmitter block after receiving the data, in the textual format from the user, encodes, modulates and then propagates the modulated signals through the communication channel towards the receiver.

The characteristics of propagating medium vary continuously over the time and it is very difficult to estimate its behavior. The conditions of wireless channel are highly dependent on environment and vary continuously. These variations are either normal or abnormal. The abnormal variations include sudden Ionosphere disturbances (SID), Ionosphere storms, Sporadic reflections, Tides, Winds in ionosphere, Sunspot cycles, Fading [1] [2], whistles etc. Because of these random variations, the received signal strength will fluctuate drastically. Several parameters that will affect the signals, which are propagating through the channel include multi hop reflections, ionosphere height variations with time, Doppler effect, atmospheric absorption, rain effects, Inter Symbol Interference ISI [3], changes in path delay causing multipath spread, phase errors being caused due to motion of either receiver or transmitter side channel layers and random lying amplitude.

The channel model, ought to make up for a portion of the impacts through mechanisms, for example, rehashing vast scope of channel conditions in a controlled way and with utmost precision, plausibility to execute and compare good number of channel models by applying similar type of parameters of the channel that have been modeled and utilizing the services of a channel model that is simulated using a programming language. It should also be possible for re-conducting the experiments for quite a good number of times with reliable channel conditions. One of the system's programming languages has to be used for development of channel simulator model. This method is one approach to acquire quantitative results which also serve as a manual for deciding requirements for hardware and software. It can give a fundamental defense to proceeding with development work without the risk.

Apart from decoding and demodulation, the receiver should take care of several other impairments that affected the data. The multi-hop reflection, Delay distortion and the ISI have to be properly handled to reproduce the data accurately at the receiver side. Otherwise the entire communication system will be a failure.

II. PROBLEM DEFINITION

A well designed receiver has to counter all the different types of disturbances that have distorted the transmitted signal. The signal that has been released by the transmitter will be received at the receiver end of the communication system through multiple reflections. The signal will also be distorted by the path delay and phase delay caused because of the dynamic movement of the transmitter & receiver, inter symbol interference (ISI) are the serious disturbances that have to be well handled by the receiver. The well designed receiver should allow the user to receive the accurate signal/data without any errors and with no retransmissions. All the effects by different types of noise signal interferences, the ISI, Doppler frequency shift have to be well handled by the receiver.

The design of receiver must include and consider all the impairments and secure the data transmission by implementing all the powerful decoding and demodulating techniques.

For looking at the execution of distinctive channel models great number of tests must be led over and again for the same atmospheric conditions. Information should be transmitted more than once for good number of times. Every one of these tests must be conducted over a genuine channel and if required they should all be tried at the same time. Unlike guided or wired communication channel, using cables, whose properties can be precisely characterized and duplicated, wireless or unguided channel properties can't be replicated so effectively. The channel attributes and transmission conditions change wildly. Thus tests can't be repeated at different times under comparable conditions. Also it is very difficult to conduct the tests on the channel using exactly same channel conditions for a number of times. If a channel is modeled, its properties can be repeated controllably and after that these tests can be repeatedly conducted any number of times. The performance of data transmission systems should then be looked at for comparison. Exactly at that point, it is possible to set up standards and milestones for performance evaluation of data transmission system. Thus the modeling of a data transmission channel is very crucial [4].

Thus the main problem is to design receiver part of the communication system that compensates for all the channel disturbances and also facilitate repeated and accurate testing of the channel model.

III. LITERATURE SURVEY

A. *Shannon and Weaver Model (S & W Model)*

A channel model was proposed by Shannon and Weaver [5] [6]. It comprises of 3 very important parts: Transmitter, channel for propagation of data generated by the transmitter, and finally the receiver. The transmitter was the generator of the information into the station, and the recipient was the physical link which can convey the data. S & W perceived that frequently there is stationary tumult that meddles with one receiving the data at the receiver. The reception of noise totally by the receiver gives a meaning that there is no information signal in the received content.

The model proposed by them is often called as the transmission model. The data or information or substance (like the message by human in the native language) is sent in some structure from a transmitter to a receiver. This normal origination of communication, considers the correspondence as a method for transmitting and receiving the information. The qualities of the model thus proposed by S & W are ease, generalization, and quantitative based evaluation.

S & W organized this simulated model in light of a data source, that creates a data packet containing loads of information, a transmitter that converts this message into digital signals, a propagating medium, to which these generated signals are given for propagation towards the receiver, a receiver that demodulated (regenerates) the modulated message, a destination station that receives the message transmitted by the transmitter.

S &W contended that three different levels of issues to be considered are there for communication inside the theory. Out of these three one specialized point is identified with how precisely can the message be transmitted? The semantic issue is identified with how correctly be the signifying 'passed on'? The viability issue identifies with how successfully do the received meaning influence the conduct? Daniel Chandler studied the transmission model by expressing that the communication system is expected to consider the communicators as individuals. No remittance is made for considering different impacts which incorporate unequal power relations, situational settings and so forth, that impacts ordinary communication system.

B. *Schramm's Model*

Different models that are already discussed and presented were all designed, discussed and made by researchers who are keen on communication as a constituent of some other ground of learning. Wilbur Schramm (1954) [7] started studying and examining communication as an important and autonomous discipline. He developed number of models for tending to distinctive inquiries. One assurance Schramm made was to consider the transmitter and receiver's fields of experience. The transmitter encodes the message packet, based upon his field of experience. The user's field of experience guides the process of decoding.

If there is no common feature that is shared in the transmitter and receiver for decoder's experience field, then communication is not possible. The severity to which the signal is effectively decoded at the receiver end (signal decoded with the aim to make the decoded signal same as that of transmitted signal or the original message) relies upon the degree of the overlap of the two fields of experience.

The thought of criticism has been additionally presented by Schramm from the receiver to the transmitter. In this model, communication turns into a constant procedure of loads of messages and information on the quality of the data transmission i.e., feedback. The proposed model takes into consideration 'cooperation'.

C. Watterson Model

he complex Watterson scattering function $G_i(t)$ consists of two independent Gaussian random variables which form a vector having a two-dimensional Gaussian distribution.

$$Gi(t) = G_i a(t) \exp(j\, 2\pi f_{ia} t) + G_i b(t) \exp(j\, 2\pi f_{ib} t). \quad (1)$$

It is known that the absolute value of the complex variable of an independent two-dimensional Gaussian random process has the Rayleigh distribution. Therefore, the Gaussian distribution function forms the well-known Rayleigh fading occurring in the propagation of short radio waves. To generate such a function, white noise with uniform distribution is transmitted through a frequency filter with the Gaussian characteristic, after which the arbitrary process acquires the Gaussian distribution over time and frequency.

To construct a high-rate digital radio communication channel with improved interference immunity, it is necessary to combine narrow-band data transmission sub-channels in a common bandwidth of short-wave transceivers. Each of them in the transmission mode can be protected by its own interference compensator [8]. After that, sub-channel data flows can be multiplexed (combined) in a common high-rate flow. Development of the signal-code design of such a system should be accompanied by interference immunity simulation tests with regard to the modified Watterson model, which is proposed in this work and should include several multi-beam radio signals (the useful signal and the interference having arrived at the receiver along their own ways) and several receiving antennas.

Within this model, two multi-beam radio signals add up at two antennas allowing for different inter-antenna phase shifts in each beam. After that, non-correlated thermal noise in two reception channels is added to the signal-interference mixtures. Two of such mixtures should be fed to the inputs of the algorithm or devices of the spatio-temporal signal processing.

D. Magesh Valliappan Model

The channel model is expected to precisely simulate the impact of transmission of an electrical signal through a medium of transmission, may be wired or wireless. For ideal performance, the receiver and transmitter must adjust to the channel and noise qualities during initialization. The receiver must gauge the channel and noise, perform channel equalization furthermore synchronize the transmitter.

he power of the received signal and noise power estimation can be done simply by computing the mean and variance of the received signal spectrum over the periodically repeating data sequences. From these, the channel and the SNR can be easily computed [9]. The computation can be expressed as synchronous data flow. The channel and SNR estimates are used to compute optimal bit loading [10].

Several techniques for channel equalization have been proposed. The most effective methods attempt to maximize channel capacity or approximations to it [11], [12]. The most successful method in terms of maximizing capacity has been to minimize ISI [13]. A channel estimate is needed to compute the optimal filter. The computation involves Eigen-value decomposition and can be expressed as synchronous data flow [14].

Synchronization can be achieved using a phase locked loop. One of the sub-channels is reserved for a pilot symbol. This pilot smbol is a sinusoid at a fixed frequency in a better part of the channel. The band pass filtering is easily achieved by a using the FFT block. This gives a clean estimate of phase offset that is free from data dependent jitter [9]. This is then used to modulate the frequency of the clock signal. Synchronization of frame boundaries is achieved during the initialization mode. The synchronization frame is used to compute a phase offset in the frequency domain. This is later used to adapt the frame marker. All the individual systems mentioned above are to be modeled as data flow systems having synchronism. A machine with finite states is needed to trigger the operation of these systems at the appropriate instants and to track the state of the receiver during initialization.

IV. DRAWBACK IN THE EXISTING MODELS

A. Shannon and Weaver Model

In this model feedback Mechanism is not implemented thus detection of correct data bit is difficult. Noise has not been handled properly and thus demodulation is difficult. No Special security mechanisms have been considered to safeguard the data. In fact it's a very simple model.

B. David Berlo Model

In this model feedback Mechanism is not implemented properly thus detection of correct data bit is difficult. It is a linear model, No frame boundaries are defined as a result bit overlapping may occur. It's a simple model.

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C. Schramm Model

Though feedback method is used to remove the ISI in this model, the encoding techniques used are very simple. Though frame boundaries are used chances of framed overlap is possible.

D. Watterson Model

High data rates are possible, immune to interference, Equalization is not implemented. Hence data detection is difficult. Multi hop reflection concept has been considered.

V. INVESTIGATIONS AND FINDINGS

Some of the existing models that are proposed by different authors have been studied and the properties of receiver models for evaluating radio performance have been compared. Some of the advantages include repeatability, availability, and a broad range of channel conditions, completeness, accuracy, and lower cost. These general advantages apply for a wide variety of channel models. However, these advantages are debatable when the model on which the receiver design is based is in doubt. Ultimately a reliable model that is based on empirical data rather than on conjectures or mathematical axioms is required.

A. Comparisons of existing models

A survey of various receiver models has been conducted. The purpose of investigating radio receiving technology was to develop general requirements for better radio channel receiver model. It appears desirable to have a channel receiver available to test the performance of prototype systems having these extended characteristics.

Because of the ongoing technical debate about the practicality of frequency selective radio for sky-wave transmitter, it is identified that frequency selective channel transmitter is quite desirable. It would help resolve transmitter and radio design and technical performance issues. Table 1 shows the comparison of different modeling techniques used for designing the receiver part of the communication system. It could be seen from the table that the model presented is comprehensive and addresses all the important issues that must be considered for designing the receiver side of the communication system. The parameters considered for comparison include equalization, security, handling multiple reflections, handling noise, increasing signal to noise ratio, synchronization and frame boundaries.

Table 1 Comparison of Design Models in relation to receiver design

S.No	Property	Shannon and Weaver Model	David Berlo Model	Schramm Model	Watterson Model	Magesh Valliappan Model
1	Feedback Mechanism	Not implemented	No Feedback	Implemented	No	
2	Handling Noise	Not handled properly	No room for noise			Noise power is estimated
3	Synchronization	Not taken care	Linear model	No synchronization used.		Achieved through Phase Locked Loop
4	Data Rate	Simple model	Complex model		High data rates are possible	High data rates are possible
5	Sub channel multiplexing	Not implemented	Not incorporated		Sub channel data is multiplexed	Yes
6	Interference	Not implemented	Not possible		Immune to interference	
7	Equalization	Not implemented	Not done		Not implemented	Channel equalization is proposed.

8	ISI	Not implemented	Not handled			Minimized
9	Synch of frame boundaries	Not implemented	No barriers	Overlap possible		Achieved during initialization phase.
10	Security	No	No	Encoding was done		Encoding method used.
11	Multiple reflections				Are considered	

VI. CONCLUSIONS

The receiver side of the modelling requires consideration of many of the issues/parameters that caters for most of the features that effects the accuracy and correctness of the data received on the receiver side. The models that have been presented in the literature have considered few aspects that effects the communication. In this chapter a design model has been presented that considers for most of the aspects that effects the communication. The issues considered include feedback mechanism, handling noise, synchronization, data rate, sub-channel multiplexing, interference, equalization, ISI, synchronization of frame boundaries, security, and multiple reflections. The model presented is comprehensive. Suitable algorithms have been presented using which the modelling of aspects such as ASCII decoding, DSPK decoding can be undertaken in simulated and automated manner.

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