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Performance Improvement of Intelligent Weather System for Satellite Networks

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Abstract- In high frequency satellite systems prediction of channel characteristics can be of immense value in improving the quality of signals. Signal attenuation impacts QoS in wireless and satellite networks. An intelligent decision support system is therefore necessary for service providers by accurately calculating cloud, fog, rain, gaseous, and scintillation attenuations using predicted signal-weather correlated database in collaboration with ITU-R propagation models combined with gateway, and ground terminal characteristics. The effect becomes a key feature in adjusting and improving satellite signal power, modulation and coding schemes, monitored and controlled altogether by a powerful and efficient intelligent-based attenuation countermeasure system. Weather attenuations can have a distorting effect on signal fidelity at higher frequencies that lead to excessive digital transmission error. This loss of signal is commonly referred to as signal attenuation. Signal attenuation impacts QoS (Quality Of service) in wireless and satellite networks. An intelligent decision support system is therefore necessary for service providers by accurately calculating the attenuations [1]-[5]. In this project we are calculating rain attenuation. The fuzzy logic is added into the system. The fuzzy system will determine the ambiguous signal during the attenuation performed.

Index Terms - Intelligent system, Rain attenuation, fuzzy logic, Ku-Band satellite.

1. INTRODUCTION

Rain attenuation (RA) is major source of impairment to signal propagation at microwave and millimeter wavebands. These impairments become particularly severe at high frequencies, especially above Ku band. As such, it is extremely hard to optimally manage satellite dependent network resources that are impacted by weather attenuations. Thus, the need arises to properly predict significant attenuation factors that affect quality of service (QoS) [1].

To improve receive signal over satellite communications in DVB-S, We propose the fuzzy logic to deploy over the system. Rain attenuation is a dominant source of attenuation over Ku-band satellite communication. Because of the frequency of Ku-band was affected in rhythm of rain attenuation. In case of both of them are synchronized, the signal will loss or attenuated. This is vital problem to occur in Ku-band where high frequency is deployed [3].

We use ITU-R model to accurately compute rain attenuations as a function of both propagation angle and rainfall rate. This data controlled by the intelligent system via a Fuzzy Logic decision mechanism, provide a better estimate satellite networking parameters such as link and queuing characteristics. The derived parameters would enable the IS(intelligent systems) to maintain QoS and SLAs(service level agreements).

In view of these analytical approaches, dealing with weather-impacted QoS and reliable satellite communications are currently non-existent. Other thrusts in satellite service providers are shifting their resolution towards intelligent- based prediction methods. These types of methods accurately predict relevant atmospheric metrics by adaptively applying the prediction methods to regulate transmit power, transmission rate, modulation schemes and channel coding[4]. Consequently, these methods will promptly adjust to new signal changes through the inter-connected network entities, before attenuation problems actually manifest themselves, to maintain end-to-end QoS requirements.

The remaining section of the paper are as follows:
In section 2 we describe fuzzy logic based unit followed by fuzzy variables, membership function and defuzzification process. In section 3 signal to noise ratio modification is presented. Finally, conclusion is outlined in section 4.

1.2. Problem Defination

Rain is a dominant source of attenuation for Satellite networks over higher frequency bands. The signals should be properly received and transmitted with attenuation or not. If SNR is better , we will assume the quality of signal as better. In term of QoS, end user must get quality signal from transmission link weather rain attenuation or clear sky. Service must be strength and quality of signal must be maintained. In order to achieve this, we proposed a good process which can resolve the problem of rain attenuation by applying fuzzy logic inside the exiting Intelligent system.

2. FUZZY-LOGIC-BASED UNIT

Fuzzy logic is a conceptualized as a generalization of classical logic and a mathematical theory, which encompasses the idea of vagueness when defining a meaning. For example, there is uncertainty are ‘fuzziness’ in expressions like ‘tall’ or ‘short’ , since these expressions are imprecise and relative. Variables considered thus are termed ‘fuzzy.’ Fuzziness is simple one means of describing uncertainty. The objective of every receive signal utility is to operate at correct receive bit signal from source. It use fuzzy logic to solve problem.

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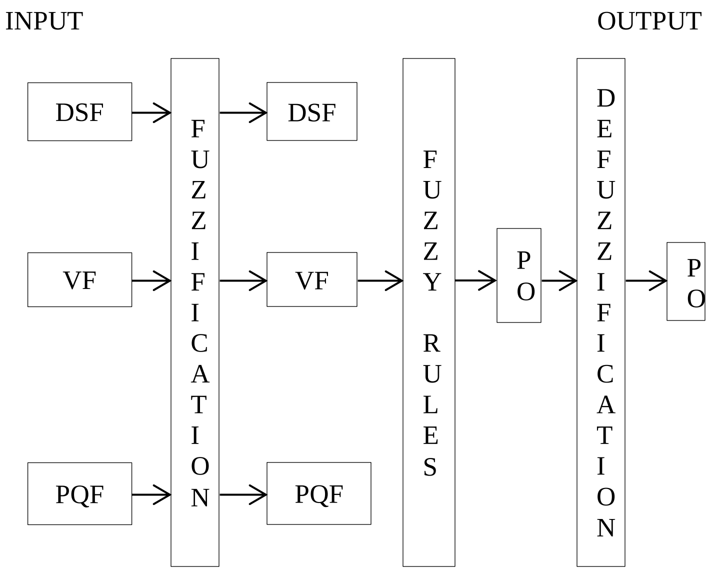

Fig.1. Block diagram of unit commitment using fuzzy logic

DSF: dB State Factor
VF: Voltage Factor
PQF: Phase QPSK Factor
PO: Production Output

2.1 Fuzzy Variables

Signal has characteristic which is sine wave. In mathematically form we can write the equations as below.

$$s(t)=A \sin(\omega t) \quad (1)$$

Fuzzy box has three parameters. This parameter comprise of dB state factor (DSF) is the output of the signal, Second is Amplitude (A), where represent the strength of signal. Phase (ωt) which perform in QPSK factor.

Then we map below parameters to the input parameter for fuzzy.

Fuzzy input variables

- dB State Factor (DSF) as s(t)
- Voltage Factor (VF) as (A)
- Phase QPSK Factor (PQF) as (ω)

Fuzzy output variables

- Production Output (PO)

dB State Factor is first input of the fuzzy, because dB state factor is direct parameter that make effect to retrieve accurate information when signal from satellite admit to the receiver. If it has high power as regular perform (clear sky) good quality of signal will obtain but in contrast when rain attenuation power, the power will drop.

Second is Voltage factor. It is the second input of the fuzzy, because voltage factor is parameter that make effect it retrieve accurate information. If voltage is high at regular perform (clear sky) good quality of signal will obtain but in contrast when rain attenuation voltage, the voltage will drop.

Third is phase QPSK factor. It is taken to be the input of the fuzzy, because QPSK is modulation for ku-band satellite by ωt is phase QPSK factor and sensible to receive signal from satellite when it has rain attenuation. Therefore, if it has phase QPSK factor as regular perform (clear sky) good quality of signal will obtain but in contrast when rain attenuation phase QPSK , the phase QPSK will drop.

2.2 Fuzzy Set Associated with Unit Commitment

After identifying the fuzzy variables associated with the unit commitment, the fuzzy set defining these variables are selected and normalized. This normalized value can be multiplied by a selected scale factor to accommodate any desired variable.

The sets defining the dB state factor (DSF) are as follows:
DSF(dB) ={high, middle, weak}
The Voltage Factor (VF) is stated by the following sets.
VF(v) = {low, strong}
The Phase QPSK Factor (PQF) is defined by the following sets.
PQF = {right, near, outside}
The Production output, is given by,
PO = {rain, somerain, clearsky}

2.3 Membership Function

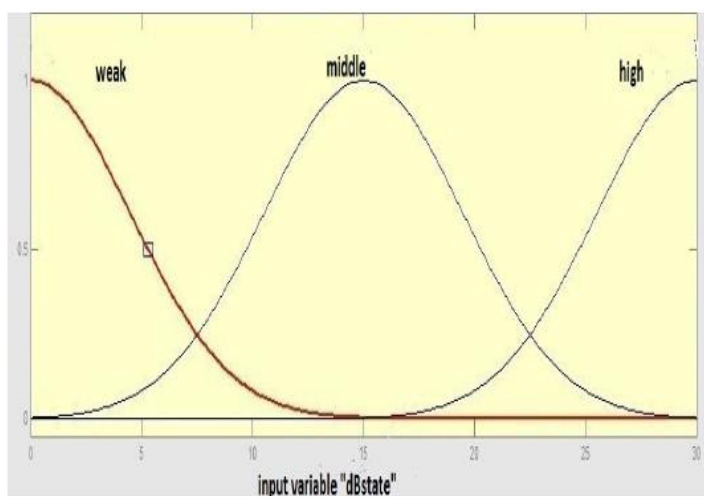

Fig. 2 Membership function of dB state factor

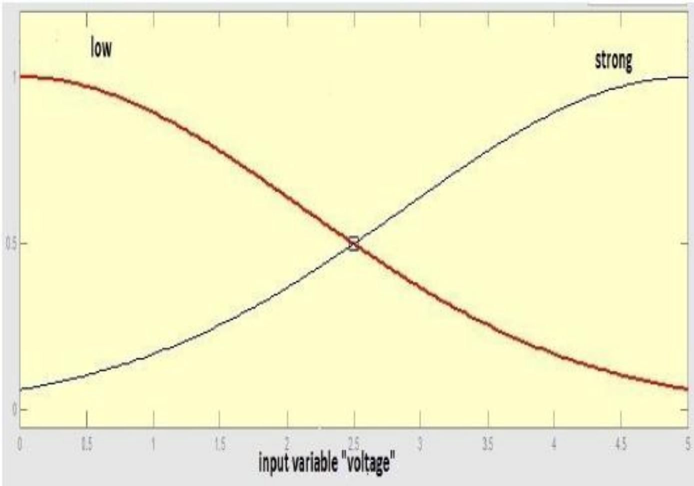

Fig. 3 Membership function of Voltage Factor

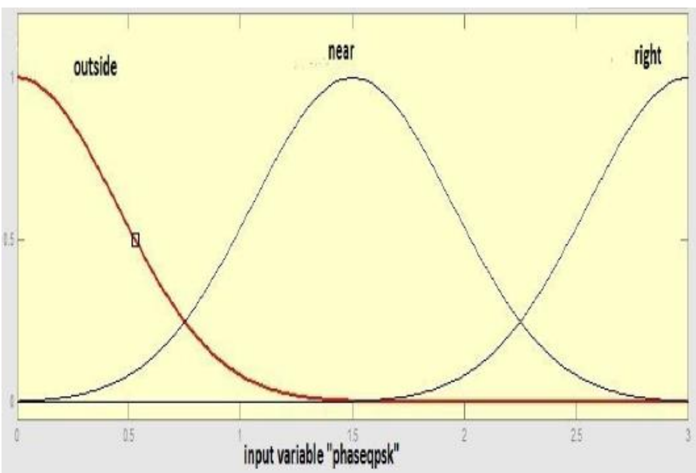

Fig. 4 Membership function of Phase QPSK Factor

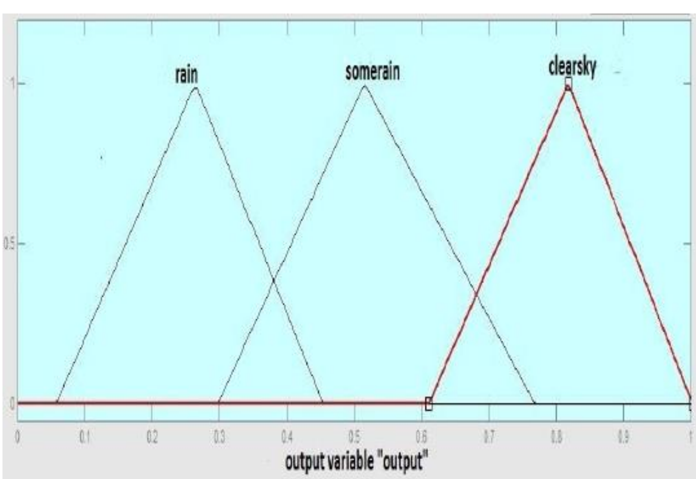

Fig. 5 Membership function of Production output

Based on the aforementioned fuzzy set, the membership functions are chosen for each fuzzy input and output variable . A shape membership function is chosen for all the fuzzy variables.

Fuzzy If – Then Rules

The fuzzy-logic–based approach ,decisions are made by forming a series of rules that relate the input variables to the output variable using If-Then statement. The if (condition) is an antecedent to the Then (consequence) of each rule. Each rule in general can be represented in the following manner:

If (antecedent) Then (consequence)

dB state factor , Voltage Factor and Phase QPSK Factor are considered as input variables and production output is treated as the output variable. This relation between the input variables and the output variable is given as;

Production output = {dB state factor} or {Voltage Factor} or {Phase QPSK Factor}

In fuzzy set notation this is written as

$$PO = DSF \cup VF \cup PQF$$

We use above notation, fuzzy rules are written to associate fuzzy input variables with the fuzzy output variable. Based on these relationships and with reference to Figs., a total of 18 rules can be composed (since there are 3 subsets for dB State Factor, 2 subset for Voltage Factor and 3 subset for Phase QPSK Factor (3*2*3=18)).

For instance, rule 3 can be written as follows:

Rule 1: If (dB State Factor is high) or (Voltage Factor is strong) or (Phase QPSK Factor is right) then (Production Output is clear sky).

Rule 2: If (dB State Factor is middle) or (Phase QPSK Factor is near) then (Production output is some rain).

Rule 3: If (dB State Factor is weak) or (Voltage Factor is low) or (Phase QPSK Factor is outside) then (Product Output is clear rain).

In similar manner total 18 rules can be formed.

After relating the input variables to the output variable, the fuzzy results must be defuzzified through what is called a defuzzification process, to achieve crisp numerical values.

2.4 Defuzzification Process

Defuzzification is final step in process fuzzy logic based. One of the most commonly used methods of defuzzification is the centroid or gravity method. Using this method, the production cost is obtained as follows:

Production output $= \frac{\sum_{i=1}^{n} \mu(PO)i*POi}{\sum_{i=1}^{n} \mu(PO)i}$

where
$\mu(PO)i$ is the membership value of the clipped output
POi is the quantitative value of the clipped output
n is the number of the point corresponding to quantitative value of the output.

3. SIGNAL TO NOISE RATIO MODIFICATION

SNR is a measure of signal strength for satellite signal relative to attenuations and background noise. Signal attenuations caused by rain, gaseous, cloud, fog and scintillation attenuations limit satellite's QoS links and system availability that operate at frequencies above Ku-band. Several factors such as power, modulation, etc., can perform an immense role in improving SNR and in maximizing system throughput and availability of the link. The entire system can be modeled as below.

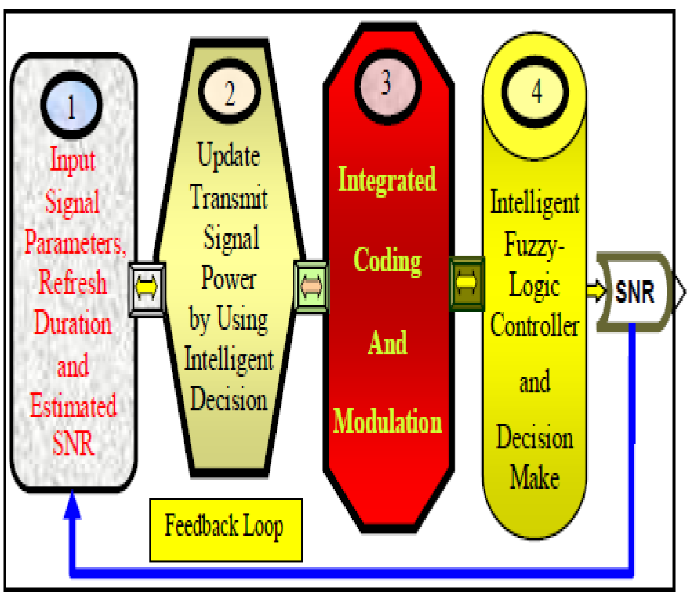

Fig 6. Intelligent Weather aware Scheme for Satellite Network

By controlling rain attenuation factor that supply the fuzzy logic mechanism, to allow better estimates for satellite networking parameters such as link and queuing characteristics. These derived parameters adaptively adjusting signal power, coding, modulation, and would enable the proposed system to maintain SNR by transmission rate under unpredictable forecast. Intelligent systems are employed in the control of satellite systems to improve signal to noise ratio (SNR) by using predicted RAs and SNR factors under extreme signal-weather conditions by adjusting signal power, modulation and coding schemes. Using these scheme, BER(Bit error rate) will be reduced.

By definition,
Es (symbol energy) = C.Ts
= C / Rs,
transmission rate Rs (symbol/sec) is inversely equivalent to Ts (symbol duration) = 1/Rs

Es / N0: Can be used to determine the bit error rate of a digital transmission scheme or visa versa. Fig 6. illustrates a manner for changing parameters of the communication system in order to overcome the deteriorating effect of atmospheric impairments, and to increase reliability of the data transmitted throughout the channel. In the first stage, the system holds input signal parameters such as frame size, propagation angle, etc. and SNR estimated values that were compared against threshold level, in a single database. In the last stage, the system will compromise among different SNR achieved outputs and make decision based on the intelligent fuzzy logic controller according to available parameters and requirements. The given feedback will keep looping until a satisfactory value is reached. Thus, this system can also change data rate, frame size, frequency, etc. in order to adjust SNR in cases such as unpredicted bad weather condition by using refresh duration that is located in the first stage

4. CONCLUSION

This research indicated that the frequency of rain directly affected to QoS on the satellite system. The outcome is key factor in diagnosing, adjusting and improving satellite signal power, modulation and coding schemes, monitored and controlled altogether by a powerful and efficient intelligent-based attenuation countermeasure system. However this research finds method to improve signal can receive the better signal when rain attenuation by use of fuzzy logic in the system. In simulation use of fuzzy logic method can improve receive bit in system more than regular system.

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