Enhancing Cognitive Radio Spectrum Sensing Using Intelligent Routing Technique

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Abstract: **The delay in transmitting data from one point to the other has necessitated to introducing enhancing cognitive radio spectrum sensing using intelligent routing technique. This can be achieved in this manner; characterizing the base station, determining the interference, congestion, high bit error rate, from the characterized network that prevents spectrum sensing and causes network failure, designing a fuzzy based rule for cognitive radio spectrum sensing that would reduce high bit error rate and congestion in the system and designing a SIMULINK model for enhancing cognitive radio spectrum sensing using intelligent routing technique. The results obtained for highest conventional congestion is 2.21 while that when intelligent routing is incorporated is 1.946 at day seven. Similarly highest conventional bit error rate occurred at day one is 0.000084bits while the highest bit error rate when an intelligent routing occurred at the same day one is 0.00007394bits. With these results obtained, it shows that using intelligent routing gives better network performance in terms of transmitting data fast than when conventional method is applied in the system.**

***Keywords*: Enhancing, Cognitive radio, Spectrum sensing, Intelligent, Routing.**

I. INTRODUCTION

The passage of data from the sending point to the receiving point can be delayed by high bit error rate in cognitive radio. This issue of delay in data movement from one point to the other is addressed by intelligent routing technique. In Cognitive radio paradigm, wireless users are classified into two categories based on whether they are licensed to use a particular band or not, the primary users are the licensed band and secondary users are the unlicensed users. Cognitive radio recognize radio spectrum that are unused by Primary User (PUs) and intelligently allocate these spectrum to Secondary User (SUs). So unused radios spectrum is called spectrum opportunity and also known as white space (Shahzad et al, 2010) or spectrum hole (Mansi and Gajanan, 2011).Secondary Users are allowed to opportunistically use the spectrum as long as they do not cause harmful interference to active Primary Users

II. REVIEW

Cognitive radio is a system that senses its operational electromagnetic environment and autonomously adjusts its radio operating parameters to modify system operations, such as maximize throughput, mitigate interference, facilitate interoperability and access secondary markets (Federal Communication Commission, 2005). In other words, cognitive radio is a generic term used to describe a radio that is aware of the environment around it and can adapt its transmissions according to the interference it sees.

III. METHODOLOGY

To characterize the base station

This empirical data shown in table 1 is obtained from GLO in Enugu metropolis.

Table 1 collected empirical data from GLO network

DAYS	PACKET TRANSFERRED DATA	PACKET RETRANSMITTED	AVERAGE DELAY (SLOT)	ARRIVALRATE (PACKET/SLOT)	ATTENUATION RAINFALL	Packet loss
1	40	20	2.45	0.1	62.8	0.5
2	30	26	4.7	0.15	62.8	0.867
3	28	20	6.2	0.2	47.8	0.286
4	28	18	7.05	0.25	100.5	0.643
5	26	17	6.25	0.3	416.2	0.654
6	28	15	13.7	0.36	236	0.536
7	27	14	34	0.4	306.3	0.519

To calculate the efficiency in DAY1

Recall

Efficiency = 100% x (transferred – retransmitted)/Transferred

Efficiency = 100 x (40 – 20)/ 40

Efficiency = 100 x 20/40

Efficiency = 50%

Then, **to calculate the network loss in DAY 1**

Network loss or packet loss = 100 – efficiency

Network loss = 100 -50 = 50 =0.5

To calculate the efficiency in DAY2

Efficiency = 100% x (transmitted – retransmitted)/transmitted

Efficiency = 100 x (30 – 26)/30

Efficiency = 100 x 4 /30

Efficiency =13.3

To calculate the network loss in DAY2

Network loss = 100 – 13.3

Network loss = 86.7

Network loss = 86.7 =0.867

To calculate the efficiency in DAY3

Efficiency = 100% x (28 – 20)/28

Efficiency = 100 x 8/28 = 28.6 = 0.286

To calculate the network loss in DAY3

Network loss = 100 – 28.6 = 71.4

To calculate the efficiency in DAY4

Efficiency = 100% X (28 -18)/ 28

Efficiency = 100 x 10 /28

Efficiency = 35.7

To calculate the network loss in DAY 4

Network loss = 100 – 35.7

Network loss = 64.3 = 0.643

To find the Efficiency at DAY 5

Efficiency = 100% X (26 - 17)/ 26

Efficiency = 900/26= 34.6

To calculate the network loss in DAY5

Network loss = 100 – 34.6 = 65.4 = 0.654

To find the Efficiency at DAY6

Efficiency = 100 x (28 -15)/28

Efficiency = 1300/28 = 46.4

To calculate the network loss in DAY6

Network loss = 100 – 46.4

Network loss = 53.6 = 0.536

To calculate the efficiency at DAY 7

Efficiency = 100 x (27 –14)/27

Efficiency = 1300/27

Efficiency = 48.1

To calculate the network loss in DAY 7

Network loss = 100 –48.1

Network loss = 51.9 = 0.519

Table 2 Analytical conventional congestion

Packet loss experienced daily	Congestion experienced daily
0.5	2.31
0.867	1.76
0.286	3.05
0.643	1.86
0.654	2
0.536	2.02
0.519	2.21

To determine the interference, congestion, high bit error rate, low signal to noise ratio from the characterized network that prevents spectrum sensing and causes network failure.

The mathematical model for improving spectrum sensing in cognitive radio without using routing technique is as shown in equation 2

$L = 8/ 3W^2$ --1

Source (Chen,2003) transport layer III congestion control strikes back

Where L is packet loss

W is the network congestion

Then, make W the subject formula in equation 1

The mathematical model for congestion in the network is as shown in equation .2

$L = 8/ 3W^2$

$3W^2L = 8$

$W^2 = 8/3L$

$W = \sqrt{8}/3L$---2

To find the network congestion in Day 1 when the packet loss is 0.5

$W1 = \sqrt{}\ 8 / 3 \times 0.5$

$W1 = \sqrt{}\ 8 / 1.5$

$W1 = \sqrt{}\ 5.33$

W1 = 2.31

Congestion in day 2 when packet loss is 0.86

W2 = √ 8 / 3 x 0.867

W2 = √ 8 / 2.571

W2 =√ 3.11

W2 = 1.76

Congestion in day 3 when packet loss is 0.286

W3 = √ 8 / 3 x 0.286

W3 = √ 8 / 0.858

W3 = √9.324

W3 = 3.05

Congestion in day 4 when packet loss is 0.643

W4 = √ 8 / 3 x 0.643

W4 = √ 8 / 1.929

W4 = √3.4677

W4 = 1.86

Congestion in day 5 when packet loss is

W5 = √ 8 / 3 x 0.667

W5 = √ 8 / 2.001

W5 = √ 3.998

W5 = 1.99

W5 = 2.0

Congestion in day 6 when packet loss is 0.654

W6 = √ 8 / 3 x 0.654

W6 = √ 8 / 1.962

W6 = √4.08

W6 = 2.02

Congestion in day7 when packet loss is

W7 = √ 8 / 3 x 0.545

W7 = √ 8 / 1.635

W7 = √4.89

W7 = 2.21

To determine an ideal bit error rate convenient for the characterized network.

Meanwhile taking into consideration the worst case scenario, the linear relationship between BER and packet error rate (PER) is expressed as:

PER= 8 × BER ×MTU ×66/64-----------------------------------3

Source (Enrique, 2013) A bit error rate analysis for TCP traffic over

Parallel free space photonics.

However, from the stipulated mathematical model for bit error rate calculation, in improving spectrum sensing in cognitive radio using routing technique

MTU is the maximum transmission unit, and using the Ethernet standards it is set to 1500 bytes for the simulations and then the MTU is increased to improve performance. A conversion from 8 bits to 1 byte is shown,

Recall 1 byte = 8bits

1500bytes = 8 x 1500 = 12000bits

MTU = 12000bits

PER is packet loss and BER is bit error rate

To evaluate the bit error rate in day 1 when the packet loss is 0.5

Make BER the subject formula in equation 3

BER1 = PER/8 × MTU × 1.03125 ------------------------4

BER1 = 0.5/8 x 12000 x1.03125

BER1 = 0.833/9900

BER1 = 0.000084bits

To find the bit error rate in day 2 when the packet loss is 0.867

BER2 = 0.867/9900

BER2 = 0.000087bits

To find the bit error rate in day 3 when the packet loss is 0.769

BER3 = 0.286/**9900**

BER3 = 0.000029bits

To find the bit error rate in day 4 when the packet loss is 0.643

BER4 =0.643 /**9900**

BER4 = 0.0000649bits

To find the bit error rate in day 5 when the packet loss is 0.654

BER5 = /9900

BER5 = 0.0000674 bits

To find the bit error rate in day 6 when the packet loss is 0.2858

BER6 = 0.643/**9900**

BER6 = 0.000065bits

To find the bit error rate in day 7 when the packet loss is 0.545

BER7 = 0.545/**9900**

BER7 = 0.0000551bits

Table 3 Analytical conventional congestion and high bit error rate

Packet loss experienced daily	Congestion experienced daily	Bit error rate
0.5	2.31	0.000084
0.867	1.76	**0.000087**
0.286	3.05	**0.000029**
0.643	1.86	**0.0000649**
0.654	2.0	**0.0000674**
0.536	2.02	**0.000065**
0.519	2.21	**0.0000551**

To design a fuzzy based rule for cognitive radio spectrum sensing that would reduce high bit error rate and congestion in the system

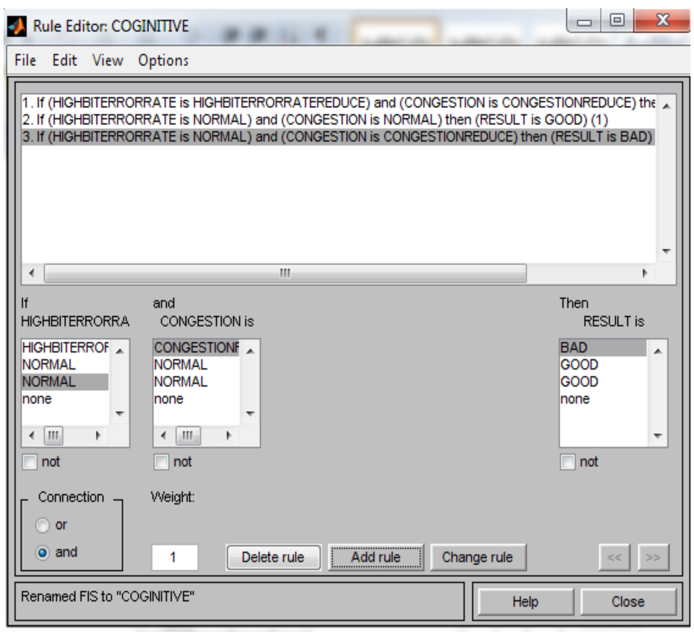

Fig 1 designed fuzzy based rule for cognitive radio spectrum sensing that would reduce high bit error rate and congestion in the system.

Fig 1 shows designed fuzzy based rule for cognitive radio spectrum sensing that would reduce high bit error rate and congestion in the system. Fig 1 shows three rules that identifies if there is congestion or high bit error rate in enhancing cognitive radio spectrum sensing using intelligent routing technique and rectifies it before it causes any harm.

To design a SIMULINK model for enhancing cognitive radio spectrum sensing using intelligent routing technique

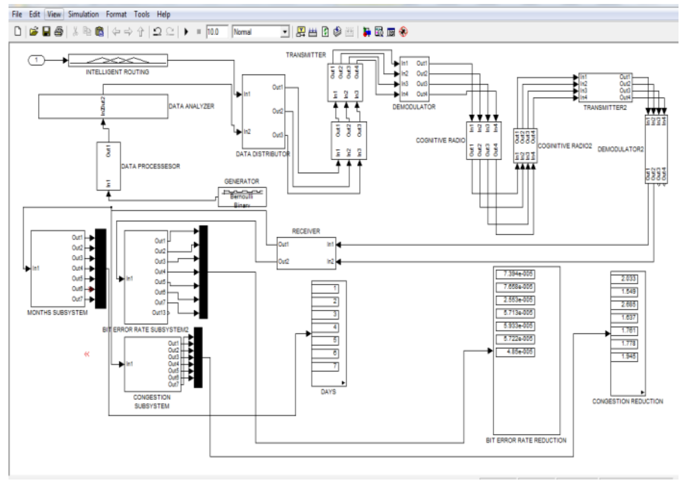

Fig 2 Designed SIMULINK model for enhancing cognitive radio spectrum sensing using intelligent routing technique.

Fig 2 shows SIMULINK model for enhancing cognitive radio spectrum sensing using intelligent routing technique..The simulated results are detailed in figures 3 and 4.

IV. DISCUSSION OF RESULT

Table 4 Comparing congestion of enhancing cognitive radio spectrum sensing without and with intelligent routing.

No of days	Conventional Congestion experienced daily	Intelligent routing congestion
1	2.31	2.033
2	1.76	1.549
3	3.05	2.685
4	1.86	1.637
5	2	1.761
6	2.02	1.778
7	2.21	1.945

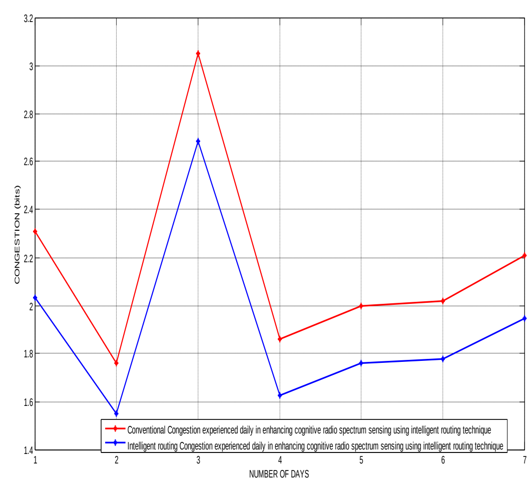

Fig3 Comparing congestion of enhancing cognitive radio spectrum sensing without and with intelligent routing

Fig 3 shows Comparing congestion of enhancing cognitive radio spectrum sensing without and with intelligent routing. Fig 3 shows that the highest conventional congestion is 2.21 while that when intelligent routing is incorporated is 1.946 at day seven. With these results, it shows that using intelligent routing transfer's data fast than when conventional technique is applied in the system.

Table 4 Comparing bit error rate of enhancing cognitive radio spectrum sensing without and with intelligent routing

No of days	Conventional Bit error rate	Intelligent routing bit error rate
1	0.000084	0.00007394
2	**0.000087**	**0.00007658**
3	**0.000029**	**0.00002563**
4	**0.0000649**	**0.00005713**
5	**0.0000674**	**0.00005933**
6	**0.000065**	**0.00005722**
7	**0.0000551**	**0.0000485**

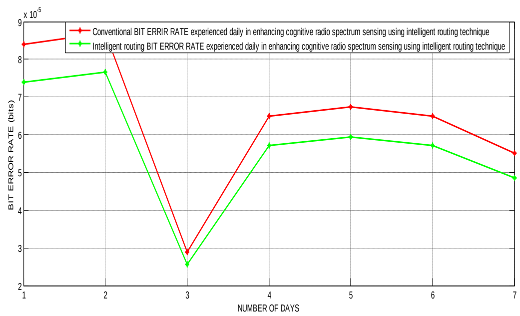

Fig 4 Comparing bit error rate of enhancing cognitive radio spectrum sensing without and with intelligent routing.

Fig 4 shows Comparing bit error rate of enhancing cognitive radio spectrum sensing without and with intelligent routing. Fig 4 shows that the highest conventional bit error rate occurred at day one and is 0.000084bits while the highest bit error rate when an intelligent routing occurred at the same day one but it is 0.00007394bits.

V. CONCLUSION

The delay in the transmitting of data has led to some people to miss their appointments. This has necessitated to introducing enhancing cognitive radio spectrum sensing using intelligent routing technique. This is done in this procedure, characterizing the base station, determining the interference, congestion, high bit error rate, from the characterized network that prevents spectrum sensing and causes network failure, , designing a fuzzy based rule for cognitive radio spectrum sensing that would reduce high bit error rate and congestion in the system and designing a SIMULINK model for enhancing cognitive radio spectrum sensing using intelligent routing technique.

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