Improving Spectrum Sensing in Cognitive Radio Using Routing Technique

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***Abstract*: The delay in transmitting piece of information in our communication network as a result of inefficiency spectrum sensing has become a very big problem in our communication network this present era. The delay in transmitting network as a result of inefficiency in spectrum sensing can be overcome by improving spectrum sensing in cognitive radio using routing technique. It is done in this manner, characterizing the network understudy, determining the interference, congestion, high bit error rate, low signal to noise ratio from the characterized network that prevents spectrum sensing and causes network failure, designing a routing rule base that reduces interference, congestion in the network thereby enhances spectrum sensing and network performance, determining the shortest route that enhances easy flow of data and spectrum sensing, training the rule base to stick strictly in reducing interference, congestion and enhancing spectrum sensing, designing an algorithm for trained rule sensing in the network, designing a Simulink model for improving spectrum sensing in cognitive radio without using routing technique, designing a Simulink model for improving spectrum sensing in cognitive radio using routing technique and justifying and validating the network performance conventionally and using routing technique . The result obtained is conventional congestion of 3.05 and congestion when routing technique is used is 1.1000. The percentage congestion reduction when routing technique is used over conventional approach is 46.98%. With this results obtained, it shows that using routing technique has better spectrum sensing ability and free communication network than when conventional method is applied.**

***Keywords:* Spectrum, Sensing Cognitive radio, Routing**

I. INTRODUCTION

Cognitive radio emerged as a solution to spectrum scarcity problem (Rashad et al, 2014). The radio frequency is a limited natural resource and getting higher day by day due to growing demand in wireless communication application. To operate on a specific frequency band, licenses are needed. The use of radio spectrum in each country is governed by corresponding government agencies. In conventional techniques, every user is assigned a license to operate in a certain frequency band. Most of the time, spectrum remains unused and it is difficult to find it. Spectrum utilization varies with time, frequency and geographical location as a result this; it is not properly used (Goutnam*et al*, 2014). Thus to overcome the spectrum scarcity and unutilized frequency, a new communication phenomenon called cognitive radio (CR) was introduced.

II. REVIEW

Routing metrics in wireless ad hoc networks are important considerations due to the quality of link in a network. Existing wireless ad hoc routing protocols typically select routes using minimum hop count. Moreover, many new link quality metrics have been proposed. Draves (2004) compares the performance of the following three metrics. Draves measures the round trip delay of unicast probes between neighboring nodes and proposes Per-hop Round Trip Time (RTT). Per-hop Packet Pair Delay (PktPair) measures the delay between a pair of back-to-back probes to a neighbor node. Expected Transmission Count (ETX) measures the loss rate of broadcast packets between the pairs of neighboring nodes and calculates the number of retransmissions that are required to send unicast packets. Weighted Cumulative Expected Transmission Time (WCETT) is used for selecting channel-diverse paths and accounts for the loss rate and bandwidth of individual links. Park et al. (2005) presented a new metric, Expected Data Rate (EDR), used for finding high-throughput paths in multi-hop ad hoc wireless networks based on a new model for transmission interference in a network. Moreover, none of these metrics can be directly applied to wireless sensor network that simultaneously take into account delay, throughput and interference.

III. METHODOLOGY

To characterize the base station

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

Days	Packet Transferred Data	Packet Retransmitted	Average Delay(Slot)	Arrival Rate (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	0.714
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

To calculate the network loss in DAY3

Network loss = 100 – 28.6 = 71.4

Network Loss = 0.714

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

Network Loss = 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= 48.1

To calculate the network loss in DAY 7

Network loss = 100 –48.1

Network loss = 51.9 = 0.519

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
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 0.867

$W2 = \sqrt{8 / 3 \times 0.867}$

$W2 = \sqrt{8 / 2.571}$

$W2 = \sqrt{3.11}$

W2 = 1.76

Congestion in day 3 when packet loss is 0.286

$W3 = \sqrt{8 / 3 \times 0.286}$

$W3 = \sqrt{8 / 0.858}$

$W3 = \sqrt{9.324}$

W3 = 3.05

Congestion in day 4 when packet loss is 0.643

$W4 = \sqrt{8 / 3 \times 0.643}$

$W4 = \sqrt{8 / 1.929}$

$W4 = \sqrt{3.4677}$

W4 = 1.86

Congestion in day 5 when packet loss is 0.654

$W5 = \sqrt{8 / 3 \times 0.654}$

$W5 = \sqrt{8 / 2.001}$

$W5 = \sqrt{3.998}$

W5 = 1.99

W5 = 2.0

Congestion in day 6 when packet loss is 0.536

$W6 = \sqrt{8 / 3 \times 0.536}$

$W6 = \sqrt{8 / 1.962}$

$W6 = \sqrt{4.08}$

W6 = 2.02

Congestion in day7 when packet loss is 0.519

$W7 = \sqrt{8 / 3 \times 0.519}$

$W7 = \sqrt{8 / 1.635}$

$W7 = \sqrt{4.89}$

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 = 0.5/99000

BER1 = 0.00000505bits

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

BER2 = 0.867/99000

BER2 = 0.00000876bits

To find the bit error rate in day 3 when the packet loss is 0.286

BER3 = 0.286/99000

BER3 = 0.0000029bits

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

BER4 =0.643 /99000

BER4 = 0.00000649bits

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

BER5 = 0.654/99000

BER5 = 0.0000066 bits

To find the bit error rate in day 6 when the packet loss is 0.536

BER6 = 0.536/99000

BER6 = 0.00000541bits

To find the bit error rate in day 7 when the packet loss is 0.519

BER7 = 0.519/99000

BER7 = 0.0000524bits

Packet Loss Experienced Daily	Congestion Experienced Daily	Bit Error Rate
0.5	2.31	0.00000505
0.867	1.76	**0.0000087**
0.286	3.05	**0.0000029**
0.643	1.86	**0.00000649**
0.654	2.0	**0.0000066**
0.536	2.02	**0.00000541**
0.519	2.21	**0.00000524**

The sources of instability is when the network experiences high bit error rate, congestion and interference from the collected packet loss data used for the evaluation of the mentioned core of network failure.

The signal-to-noise ratio (SNR) compares the level of the Wi-FI signal to the level of background noise. A ratio of 10-15dB is the accepted minimum to establish an unreliable connection; 16-24dB (decibels) is usually considered poor; 25-40dB is good and a ratio of 41dB or higher is considered excellent. (**Ken, 2017**)

'd say 20 dB or greater is good SNR. Greater than 40 dB is even better! Recommended minimum SNR for data is 18 dB and for voice over wifi it is 25 dB. As more interference is introduced, the SNR decreases because it raises the noise floor.

The ratio is usually measured in decibels (dB) using a signal-to-noise ratio formula. If the incoming signal strength in microvolts is V_s, and the noise level, also in microvolts, is V_n, then the signal-to-noise ratio, S/N, in decibels is given by the formula: $S/N = 20 \log_{10}(V_s/V_n)$ If $V_s = V_n$, then S/N = 0.

To compute the signal to noise ratio

$SNR = \mu/\sigma$ (Ken, 2017)--------------------------- -------------5

μ= <u>X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8 + X9 + X10 + X11 + X12/</u> n

Where μ is mean of the given data (Analytical congestion data)

n is the number of occurrence.

σ Standard deviation

μ= <u>2.31 +1.76+ + 3.05 +1.86 + 2.0 +2.02 +2.21</u> /7

μ = 15.21/7

μ = 2.17 =

$$\sigma = \sqrt{(X1-\mu)^2} ----------------------6$$

$$\sigma = \sqrt{(2.31-2.17)^2 + (1.76-2.17)^2 + (3.05-2.17)^2 + (1.86-2.17)^2 + (2.0-2.17)^2 + (2.02-2.17)^2 + (2.21-2.17)^2}$$

$$\sigma = \sqrt{(0.4)^2 + (-0.41)^2 + (0.88)^2 + (-0.31)^2 + (-0.17)^2 + (-0.15)^2 + (0.04)^2}$$

$$\sigma = \sqrt{(0.16) + (0.1681) + (0.7744) + (0.0961) + (0.0289) + (0.0225) + (0.0016)}$$

$$\sigma = \sqrt{1.2516}$$

$$\sigma = 1.12$$

To compute SNR

$SNR = 1.925/1.25$

$SNR = 1.54$

To design a Simulink model for improving spectrum sensing in cognitive radio using routing technique

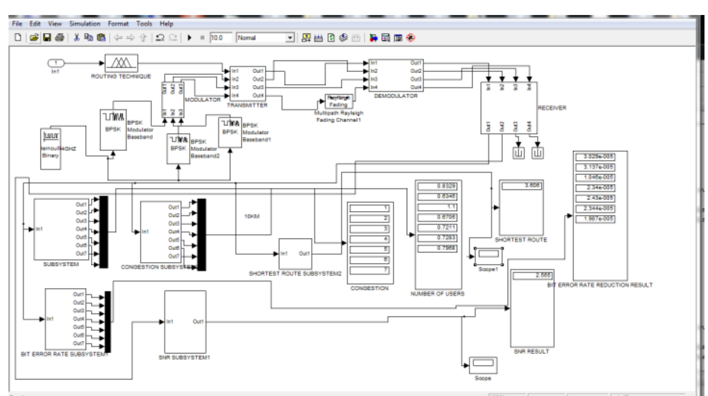

Fig 1 designed Simulink model for improving spectrum sensing in cognitive radio using routing technique. Fig 1 shows designed simulink model for improving spectrum sensing in cognitive radio using routing technique. The results obtained after simulation are shown in figures 2 .

IV. DISCUSSION OF RESULT

Table 1 Comparing Conventional congestion and Routing congestion in improving spectrum sensing in cognitive radio using routing technique

Time (s)	Conventional congestion(m/s)	Routing congestion(m/s)
1	2.31	0.8329
2	1.76	0.6346
3	3.05	1.1
4	1.86	0.6706
5	2	0.7211
6	2.02	0.7283
7	2.21	0.7968

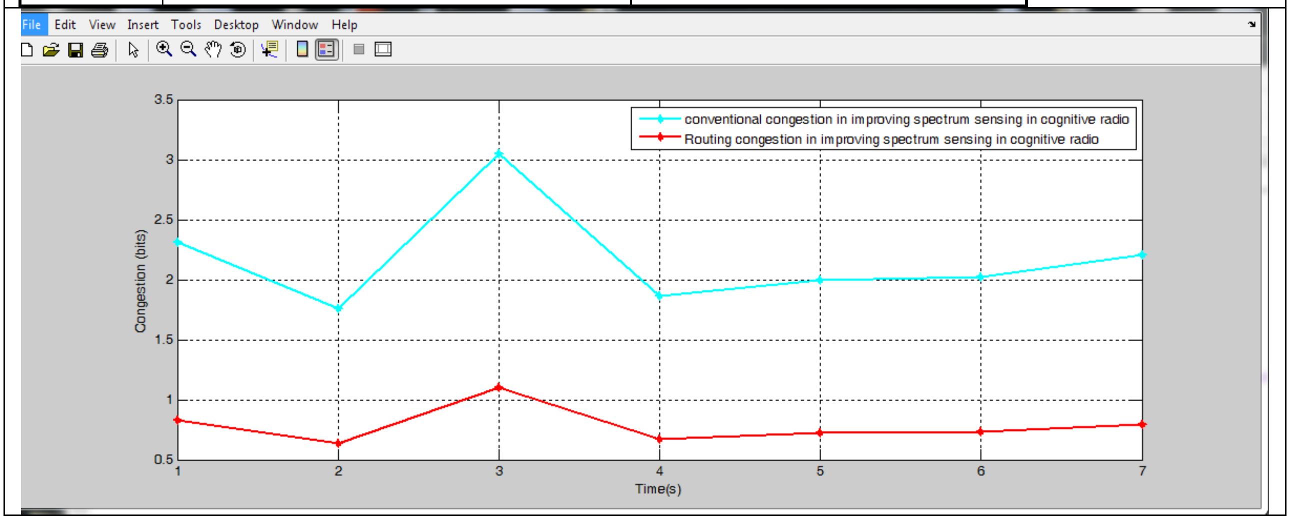

Fig 2 Comparing Conventional congestion and Routing congestion in improving spectrum sensing in cognitive radio using routing technique

Fig 2 shows comparing conventional congestion and routing congestion in improving spectrum sensing in cognitive radio using routing technique. In fig 1 the highest conventional congestion occurred at 3.05 while the highest congestion when routing technique is used is 1.1. With these results, it shows t hat using routing technique gives better sensing ability than the conventional approach.

V. CONCLUSION

The way and manner by which communication network finds it difficult to transmit data from one point to the other calls for improving spectrum sensing in cognitive radio using routing technique for efficient transmission of data from one point to the other through the nearest allocated channel when sensed fast. This is done in this manner, characterizing the network understudy, determining the interference, congestion, high bit error rate, low signal to noise ratio from the characterized network that prevents spectrum sensing and causes network failure, designing a routing rule base that reduces interference, congestion in the network thereby enhances spectrum sensing and network performance, determining the shortest route that enhances easy flow of data and spectrum sensing, training the rule base to stick strictly in reducing interference, congestion and enhancing spectrum sensing, designing a Simulink model for improving spectrum sensing in cognitive radio without using routing technique, designing a Simulink model for improving spectrum sensing in cognitive radio using routing technique and justifying and validating the network performance conventionally and using routing technique.

REFERENCE

[1] RASHAD M. Eletreby, Hany M. Elsayed and Mohammed M. Khairy "Optional Spectrum Assignment for Cognitive Radio Sensor networks under coverage constraint"
[2] Department of Electronics and Electrical Engineering, Faculty of Engineering, Cairo University, Egypt, 2014.
[3] Goutnam Ghosh, Prason Das and SubhajitChalterjee "Cognitive Radio and Dynamic Spectrum Access – A study" International Journal of Next-Generation networks (IJNGN) vol. 6, No. 1, March 2014.
[4] Anita Garhwal and PratimBhattaelarge" A survey on dynamic spectrum access techniques for cognitive radio" international

Journal of next generation network (IJNGN) vol. 3, No.4, December 2011

[5] Hishan Mohammed Almaseid Spectrum Allocation algorithm for cognitive radio mesh networks (2011). Graduate these and dissertations. Paper 10383.

[6] Shahzad A. et al. (2010), " Comparative Analysis of Primary transmitter Detection based spectrum sensing techniques in cognitive radio system; australan journal of basic and applied scenes. 4 (a), pp: 45 22-4531, INSI net publication.

[7] Mansi Subhedar and GajananBirajdar "Spectrum for Sensing techniques in cognitive radio networks: A survey" International Journal of next-generation on networks (IJNGN) vol. 3, No. 2, June 2011

[8] Akyildiz I. F. and Xudong Wang. "A survey on wireless mesh networks" IEEE communication magazine, 43(a): S23-S30, Sept. 2005.

[9] Hincapie R., Li Zhang, Jian Tang, GuoliangXue, R.S. Wolff, and R. Bustamalt. " Efficient recovery algonthms for wireless mesh networks with cognitive radios in IEEE International Conference on Communications (ICC), Rayes 1-5, June, 2009.

[10] Chowdhory K.R. and I. F. Akyildiz "Cognitive wireless mesh networks with dynamic spectrum access" IEEE Journal on selected Areas in communications, 26(i): 168-181, January, 2008.

[11] Tao Chan, Honggary Zhang, G.M. Mossio, and I Chlamtac. Cog-mesh " A Chester-based Cognitive radio network" In second IEEE International symposium on new frontiers in Dynamic Spectrum Access Networks (DSPAN), payes 168-178, April 2007.

[12] Pereira R. C, R.D. Souza, and Pellenz M.E "Using Cognitive Radio for improving the capacity of wireless mesh networks" in IEEE vehicular Technology conference (VTC), payes 1-5, September 2008.

[13] Hishan M. Almsaeid and Ahmed E. Kamel "Receiver-based channel allocation for wireless cognitive radio mesh networks" in Dynamic Spectrum Acces Networks (DSPAN), April 2010.

[14] Tao Chen, Honggangzhang, M.matinimikko and M.Dkatz "cog-mesh" "Cognitive wireless mesh networks" in IEEE GLOBECOM workshops, payes 1-6, December 2008.

[15] Open Spectrum: A path to Ubiquitous connection Queue, 1(3), 60-68, 2003.

[16] Wei Wang and Xin Liu "Graph-colouring based channel allocation for open-spectrum wireless networks, the 62nd IEEE vehicular technology conference (VTC), I.P.P 640-694, 2005.

[17] Yan Xiao, Song Qijun" Dynamic Spectrum allocation based on cognitive radio" Asia – pacific conference on Environmental Electromagnetics. Pp. 254-257, 2009.

[18] Jiao Wang, Yuqing Huang and Hong Jiang "Improved Algorithm of spectrum Allocation Based on Graph-coloring models in cognitive Radio" 2009 International Conference on Communications and mobile computing, pp. 353 – 357, 2009.

[19] Liu Yutao, Jiang MengXiong, Tan Xuezhi and Fan Lu " Maximal Independent set Based Channel Allocation Algonthm in Cognitive Radio", 2009 IEEE Youth Conference on Information, computing and Tele-communication, pp. 78-81, September 2009.

[20] Yao Weng, Zhongzhao Zhang, Fng Li, Jiama Chen "A novel spectrum