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Optimized Real Time Monitoring and Evaluation of GSM Quality of Service Using Fuzzy Logic Controller

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ABSTRACT
The consistence low quality of service in GSM network that is caused by congestion, high bit error rate to mention a few is overcome by introducing optimized real time monitoring and evaluation of GSM quality of service using fuzzy logic controller. To achieve this, it is done in this manner, characterizing real time monitoring and evaluation of GSM quality of service, establishing the causes of poor quality of service in GSM network from the characterized data, optimizing the causes of poor quality of service in GSM network to attain quality service performance, designing a rule base that monitors and enhances the optimized quality services in GSM network and designing a SIMULINK model for optimized real time monitoring and evaluation of GSM quality of service using fuzzy logic controller. The results obtained, the highest conventional congestion experienced in GSM network is 0.21116 and that occurred in day 6 while when fuzzy controller is incorporatedin the system it reduced it to 0.1931thereby increasing the quality of service in GSM network. the highest conventional bit error rate that decreases the quality of service in GSM network occurred in day 4 and it is 0.0741bits, In the same day when fuzzy controller is imbibed in the operational mechanism of the system it reduced the bit error rate to 0.06776 bits thereby boosting the quality of service of GSM network and the highest conventional quality of service of GSM network is 452.3 and it occurred in days 4 and 10. On the other hand, when fuzzy controller is introduced in the system it enhanced the quality of service to 540.8. The percentage improvement in quality of service of GSM network over its conventional aspect is 19.6%.

Keyword: Optimized, Real time, monitoring, evaluation, GSM, quality of service, fuzzy logic controller

I. INTRODUCTION

Real time monitoring and Evaluation of GSM quality of service using intelligent agent is the pivot of this project. With this it is a well-known fact that Wireless mobile communication system has grown from the first generation (1G) of analogue system, through the second generation (2G) of digital system to the ever maturing third generation (3G) high speed multiple service system and has transformed the ease of communication the world over. However, the widespread use of mobile communications has heightened consumer demand for better quality service. Thus, network operators the world over, face the challenges of improving the quality of service while increasing capacity and rolling out new services as they provide wider coverage at the same time had led to 4G (fourth generation) as the fourth generation of mobile telecommunications technology, succeeding 3G and preceding 5G (fifth generation)and 6G (sixth generation). A 4G system support applications like amended mobile web access, IP telephony, gaming services, high-definition mobile TV, video conferencing, 3D television, and cloud computing in addition to the usual voice and other services of 3G. Two 4G candidate systems are Performance and quality of service (QoS) evaluation are the most important to the mobile operators as the revenue generation and customer satisfaction are directly related to network performance and quality. The Network needs to be under continuous monitoring and control to maintain and improve the performance of the system (Peter, 2017). Usually, statistics generated from drive tests or

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network management systems are used to unravel network problems and provide useful recommendations to resolve them. This process called radio frequency (RF) optimization is continuously required as the network evolves.

II. METHODOLOGY

To characterize real time monitoring and evaluation of GSM quality of service

DATA COLLECTION ON PACKET LOSS DUE TO CONGESTION

An hourly measured data-of packet-loss was collected from GLO network in Enugu metropolis for eight days likeshown in table:1.

Table 1 DATE OF DATA COLLECTION: 10th to 18th of March, 2021

TIME	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5	DAY 6	DAY 7	Day 8	TOTAL
12.00 AM	5	8	4	8	7	6	5	8	
1.00 AM	4	7	6	3	5	7	5	7	
2.00 AM	6	5	8	7	5	4	6	5	
3.00 AM	8	5	7	8	7	9	10	9	
4.00 AM	6	10	8	11	9	12	11	8	
5.00 AM	12	11	12	10	14	9	10	13	
6.00 AM	18	15	17	19	15	17	18	16	
7.00 AM	22	19	20	25	23	22	24	21	
8.00 AM	30	35	33	30	40	42	39	37	
9.00 AM	49	52	55	50	53	51	54	53	
10.00 AM	33	38	40	37	35	40	43	39	
11.00 AM	29	31	27	33	30	29	28	33	
12.00 PM	22	26	21	23	25	22	23	25	
1.00 PM	30	34	32	31	33	35	38	36	
2.00 PM	45	40	50	55	49	53	48	52	
3.00 PM	19	24	22	26	20	24	21	23	
4.00 PM	28	27	30	29	33	28	31	32	
5.00PM	55	50	53	57	51	49	52	56	
6.00 PM	48	52	47	50	49	44	48	51	
7.00 PM	30	28	33	29	31	35	32	31	
8.00 PM	18	22	19	21	20	25	23	22	

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9.00 PM	14	12	15	18	16	13	15	14	
10.00PM	12	9	11	13	11	9	10	11	
11.00PM	8	7	6	5	7	9	8	6	
TOTAL	452	595	576	734	548	594	602	578	

Total	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
Packet transmitted	900	830	920	980	820	930	815	922
Packet received	448	235	344	246	272	336	213	345

The mathematical model for congestion control in improving optimized real-time monitoring and-evaluation of GSM service quality using intelligent agent is as shown in equation 2
L = 8/ 3W2……….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 3.1
The mathematical model for congestion in the network is as shown in equation 2
W = Square root of 8/3L……………2
To find the network congestion in day one W1 = square root 8/ 3 x 452
W1 = square root 8 / 1356 = 0.07681 Congestion in day two
W2 = square root 8/3 x 595 = 8 / 1785 = 0.0044818W2 = square root of 0.0044818
W2 = 0.06695
Congestion in day three
W3 = Square root of 8/ 3 x 576
W3 = square root of 8/ 1728 = 0.04456 W3 = Square root of 0.04456 = 0.2111 Congestion in day four
W4 = Square root of 8/ 3 x 734
W4 = square root of 8/ 2202 W4 = Square root of 0.003633W4 = 0.06027
Congestion in day five
W5 = square root of 8/3 x 548 W5 = Square root of 8/ 1644
W5 = Square root of 0.004866 W5 = 0.06976 Congestion in day six
W6 = Square root 8 / 3 x 594W6 = Square root 8 / 1782 W6 = Square root 0.04489 W6 = 0.21116
Congestion in seventh day W7 = Square root 8/ 3 x 602 W7 = Square root 8/ 1806 W7 = Square root 0 0044296
W7 = 0.066555
Congestion in day eightW8 = 8/ 3x 578
W8 =8/1734
W8 = square root of 0.004614W8 = 0.06793 3.2

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

The bit error rate that caused the collected packet loss in the communication network understudy is calculated withequation 3.3
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 Where the MTU is the maximum transmission unit, and using the Ethernet standards it is set to 1500 bytes for the simulations and thenthe 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 one when the packet loss is 452.

Make BER the subject formula in equation 3
BER1 = PER/8 ×MTU × 1.03125 4
BER1 = 452/8 x 12000 x1.03125
BER1 = 452/9900 BER1 = 0.0457 bits
To find the bit error rate in day two
BER2 = 595/9900
BER2 = 0.0601
Bit error rate in day three
BER3 = 576/9900
BER3 = 0.0582
Bit error rate in day four
BER4 = 734/9900
BER4 = 0.0741bits
Bit error rate in day five
BER5 = 548/9900
BER5 = 0.0554 bits
Bit error rate in day six
BER6 = 594/9900
BER6 = 0.06 bits
Bit error rate in day seven
BER7 = 602/9900
BER7 = 0.0608
Bit error rate in day eight
BER8 = 578/9900
BER8 = 0.0584bits

Table 2 Evaluated results obtained from the characterized data

Total packet loss for eight days	**Congestion experienced for theeight days**	**Bit error rate**
452	0.07681	0.0457bits
595	0.06695	0.0601
576	0.2111	0.0582
734	0.06027	0.0741bits
548	0.06976	0.0554 bits
594	0.21116	0.06 bits
602	0.066555	0.0608
578	0.06793	0.0584bits

These bit error rate were-used to form-the rule in the fuzzy to increase the reduction of bit error rate that caused congestion-in the communication network.

To optimize the causes of poor quality of service in GSM network to attain quality service performance.

MAXIMIZE
Q = 0.07681C + 0.0457B …………….5
SUBJECT TO
0.06695 C + 0.0601B ≤ **595 ……….6**
0.2111 C + 0.0582 B ≤ **576 ………. 7**
Where
Q is quality of service
C is congestion that decreases quality of service.
B is high bit error rate that decreases quality of service

```
>> % OPTIMIZED REAL TIME MONITORING AND EVALUATION OF GSM QUALITY OF SERVICE USING FUZZY LOGIC CONTROLLER
%
% Maximize Q = 0.07681C + 0.0457B…………5
%ST     SUBJECT TO

% 0.06695 C + 0.0601B ≤ 595…………..6
% 0.2111 C + 0.0582 B ≤ 576…………7
% Where
% Q is quality of service
% C is congestion that decreases quality of service
% B is high bit error rate that decreases quality of service.

f=[-0.07681;-0.0457];
A=[0.06695 0.0601;0.2111 0.0582];
b=[595;576];
Aeq=[0 0];
beq=[0];
LB=[0 0];
UB=[inf inf]; [X,FVAL, EXITFLAG]= linprog (f,A,b,Aeq,beq,LB,UB)

Optimization terminated.

X = 1.0e+003 *

0.0000
9.8969

FVAL = -452.2887

EXITFLAG =1
>>
```

From the results obtained, the high bit error

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rate reduced to 0.0098969 while the quality of service observed is452.2887.

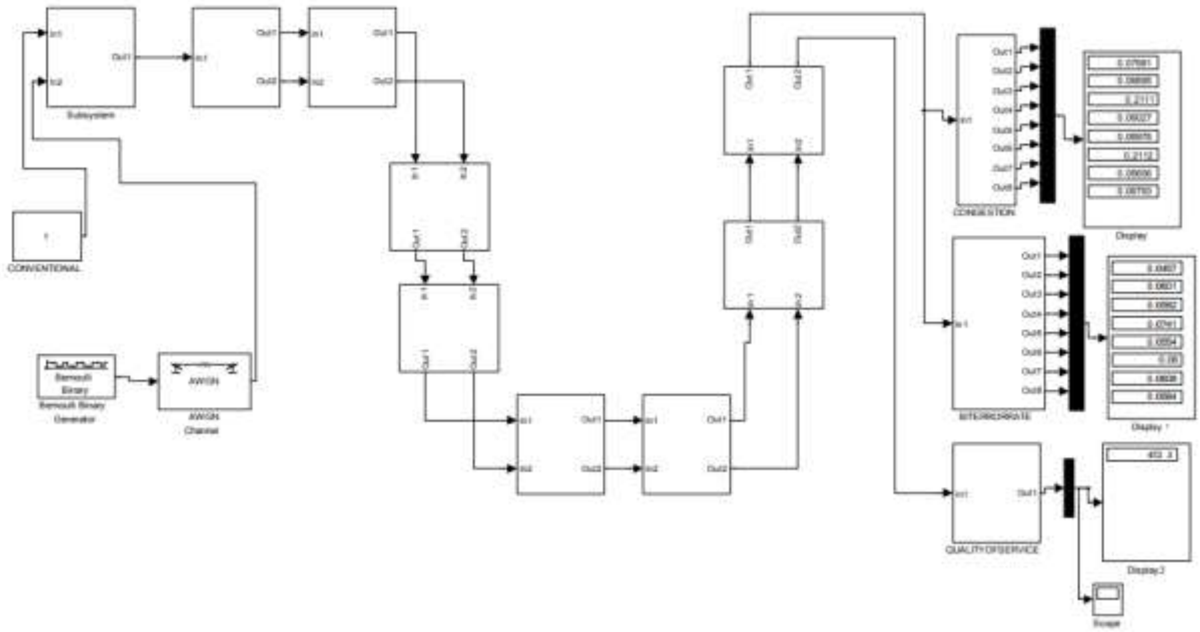

Fig 1 Conventional real time monitoring and evaluation of GSM quality of service

Fig 1 shows Conventional real time monitoring and evaluation of GSM quality of service. The results obtained areas shows in figures 6, 7 and 8.

To design a rule base that monitors and enhances the optimized quality services in GSM network.

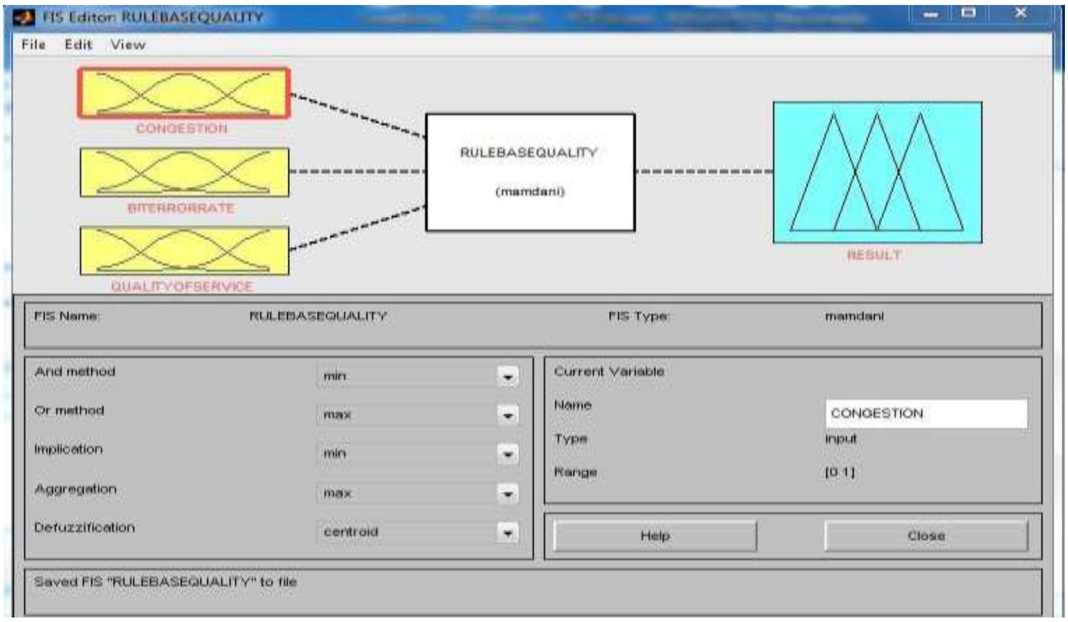

Fig 2 designed fuzzy inference system that monitors and enhances the optimized

Fig 2 shows designed fuzzy inference system that monitors and enhances the optimized quality of services in GSMnetwork that enhances the efficacy of monitoring and boosting quality of services in GSM network.

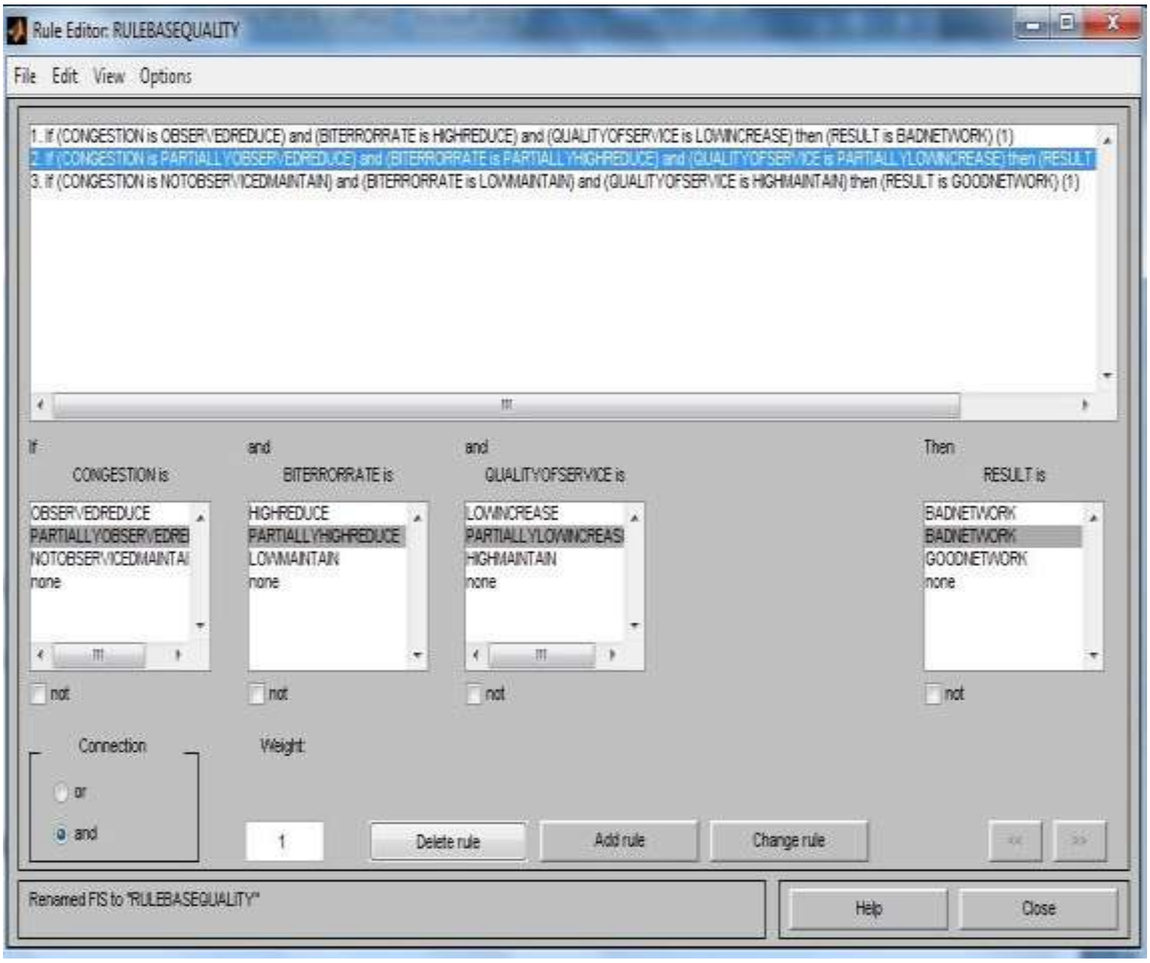

Fig 3 designed rule base that monitors and enhances the optimized quality services in GSM network. The comprehensive details of the rule base that monitors the quality of services in GSM network is shown in table 3.

Table 3 designed rule base that monitors and enhances the optimized quality services in GSM network.

1	IF CONGESTION IS OBSERVED REDUCE	AND BIT ERROR RATE IS HIGH REDUCE	AND QUALITY OF SERVICE IS LOW INCREASE	THEN RESULT IS BAD NETWORK
2	IF CONGESTION IS PARTIALLY OBSERVED REDUCE	AND BIT ERROR RATE IS PARTIALLY HIGH REDUCE	AND QUALITY OF SERVICE IS PARTIALLY LOW INCREASE	THEN RESULT IS BAD NETWORK
3	IF CONGESTION IS NOT OBSERVED MAINTAIN	AND BIT ERROR RATE IS LOW MAINTAIN	AND QUALITY OF SERVICE IS HIGH MAINTAIN	THEN RESULT IS GOOD NETWORK

To design a SIMULINK model for optimized real time monitoring and evaluation of GSM quality of service using fuzzy logic controller.

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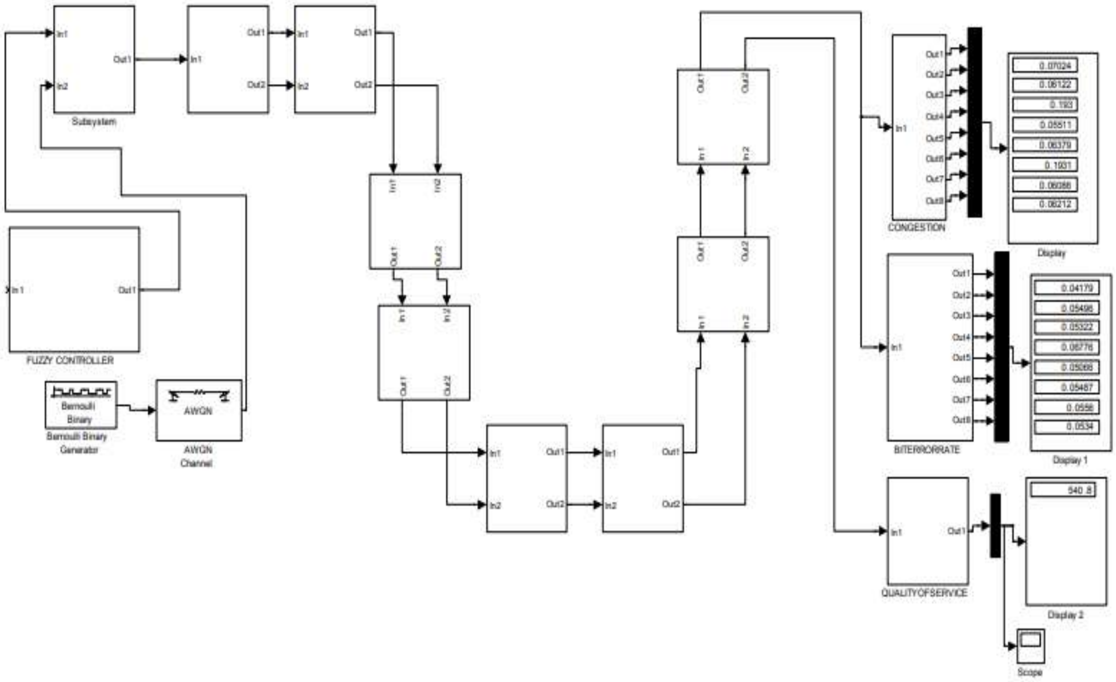

Fig 4 designed SIMULINK model for optimized real time monitoring and evaluation of GSM quality of service using fuzzy logic controller.

The results obtained after simulating fig 4 are as shown in figures, 6, 7 and 8.

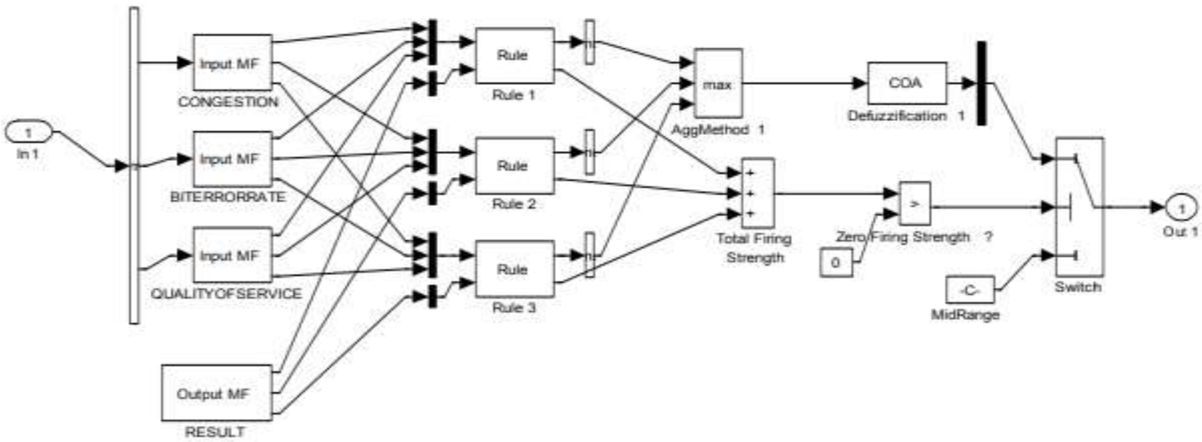

Fig 5 model obtained after the application of the rule base that monitors quality of service in GSM network.

III. DISCUSSION OF RESULT

Table 4 Comparing conventional and fuzzy controller congestion in optimized real time monitoring andevaluation of GSM quality of service

TIME(DAYS)	Conventional congestion in optimized real timemonitoring and evaluation of GSM quality of service(bits/s)	fuzzy controller congestion in optimized real time monitoring and evaluation of GSM quality of service(bits/s)
1	0.07681	0.07024

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2	0.06695	0.06122
3	0.2111	0.193
4	0.06027	0.0551
5	0.06976	0.06379
6	0.21116	0.1931
7	0.066555	0.06086
8	0.06793	0.06212

Conventional congestion in optimized real time monitoring and evaluation of GSM quality of service(bits/s) fuzzy controller congestion in optimized real time monitoring and evaluation of GSM quality of service(bits/s)

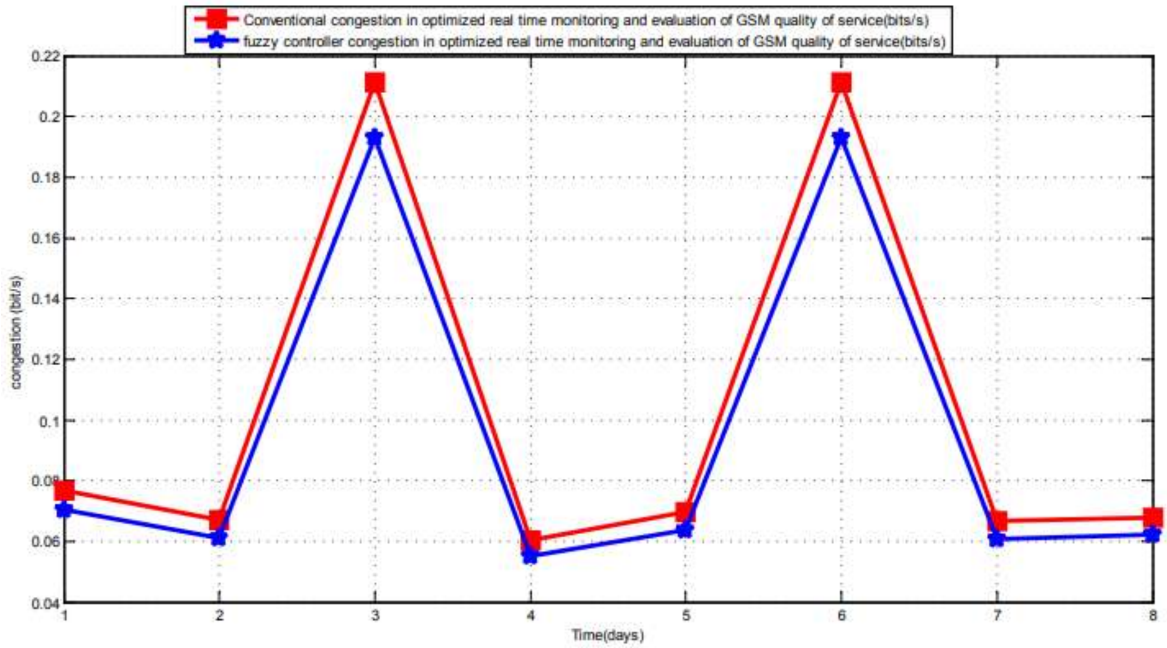

Fig 6 Comparing conventional and fuzzy controller congestion in optimized real time monitoring and evaluationof GSM quality of service

Fig 6 shows that the highest conventional congestion experienced in GSM network is 0.21116 and that occurred in day 6 while when fuzzy controller is incorporated in the system it reduced it to 0.1931thereby increasing the qualityof service in GSM network.

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Table 5 Comparing conventional and fuzzy controller bit error rate in optimized real time monitoring and evaluation of GSM quality of service

TIME(DAYS)	Conventional bit error rate in optimized real timemonitoring and evaluation of GSM quality of service(bits)	fuzzy controller bit error rate in optimized real time monitoring and evaluation of GSM quality of service(bits)
1	0.0457	0.04179
2	0.0601	0.05496
3	0.0582	0.05322
4	0.0741	0.06776
5	0.0554	0.05066
6	0.06	0.05487
7	0.0608	0.0556
8	0.0584	0.0534

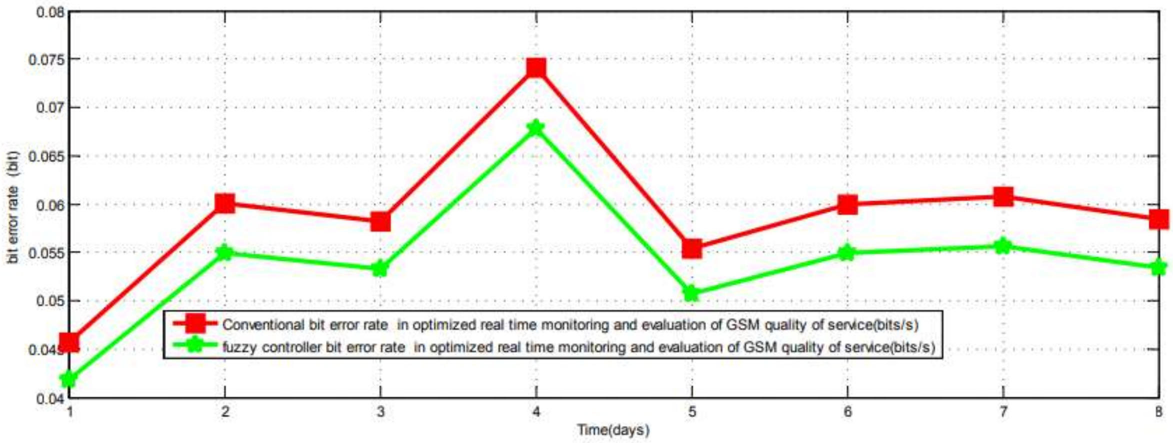

Fig 7 Comparing conventional and fuzzy controller bit error rate in optimized real time monitoring and evaluation ofGSM quality of service. In fig 7 the highest conventional bit error rate that decreases the quality of service in GSMnetwork occurred in day 4 and it is 0.0741bits, In the same day when fuzzy controller is imbibed in the operationalmechanism of the system it reduced the bit error rate to 0.06776 bits thereby boosting the quality of service of GSMnetwork.

Table 6 Comparing conventional and fuzzy controller quality of service in optimized real time monitoring andevaluation of GSM quality of service

TIME(DAYS)	Conventional quality of service in optimized real time monitoring and evaluation of GSM quality of service	fuzzy controller quality of service in optimized real time monitoring and evaluation of GSM quality of service
0	0	0
1	280	320
2	390	480
3	430	510
4	452.3	540.8
10	452.3	540.8

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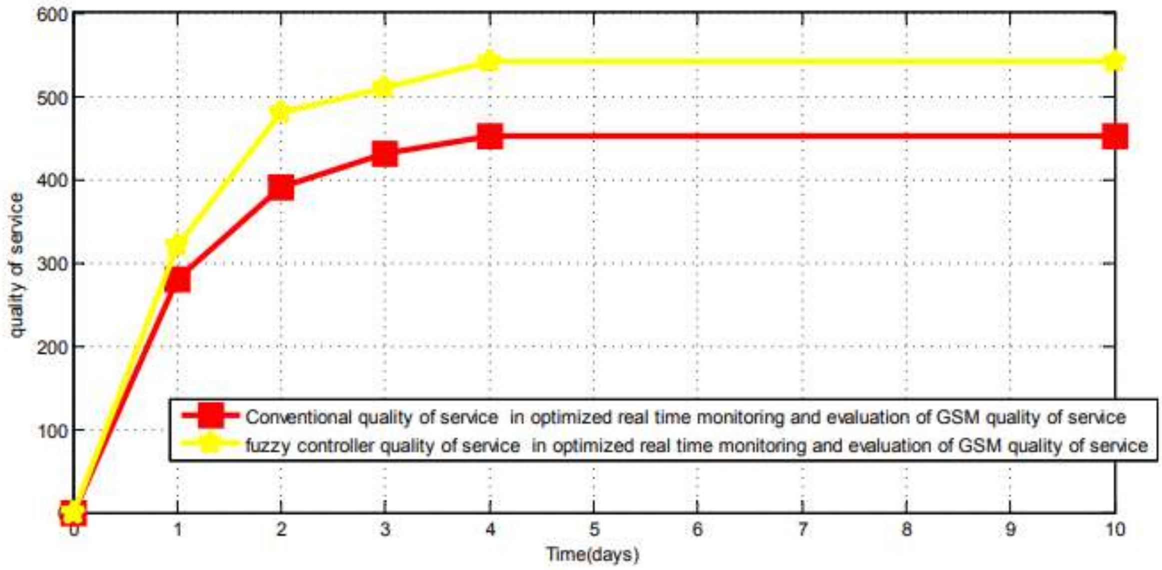

Fig 8 Comparing conventional and fuzzy controller quality of service in optimized real time monitoring and evaluation of GSM quality of service. In fig 8 the highest conventional quality of service of GSM network is 452.3 and it occurred in days 4 and 10. On the other hand, when fuzzy controller is introduced in the system itenhanced the quality of service to 540.8. The percentage improvement in quality of service of GSM network over its conventional aspect is 19.6%.

IV. CONCLUSION

The low quality of service observed in GSM network has liquidated some establishments that mainly depend on communication for their routine business. This is surmounted by introducing optimized real time monitoring and evaluation of GSM quality of service using fuzzy logic controller. To achieve this, it is done in this manner, characterizing real time monitoring and evaluation of GSM quality of service, establishing the causes of poor quality of service in GSM network from the characterized data, optimizing the causes of poor quality of servicein GSM network to attain quality service performance, designing a rule base that monitors and enhances the optimized quality services in GSM network and designing a SIMULINK model for optimized real time monitoring and evaluation of GSM quality of service using fuzzy logic controller. The results obtained, the highest conventional congestion experienced in GSM network is 0.21116 and that occurred in day 6 while when fuzzy controller is incorporated in the system it reduced it to 0.1931thereby increasing the quality of service in GSM network. the highest conventional bit error rate that decreases the quality of service in GSM network occurred in day 4 and it is 0.0741bits, In the same day when fuzzy controller is imbibed in the operational mechanism of the system it reduced the bit error rate to 0.06776 bits thereby boosting the quality of service of GSM network and the highest conventional quality of service of GSM network is 452.3 and it occurred in days4 and 10. On the other hand, when fuzzy controller is introduced in the system it enhanced the quality of serviceto 540.8. The percentage improvement in quality of service of GSM network over its conventional aspect is 19.6%.

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