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Comparative Performance Evaluation of Spectrum Scheduling Algorithms for Cognitive Radio Network

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Abstract -Scheduling is the most important for the providing the Quality of service in the modern networks. The objective of scheduling is to achieve the best usage of resources, to assure the QoS guarantees, to make best use of throughput and to reduce power consumption. Here in this paper we implemented the four scheduling algorithms that are Round Robin Scheduling Algorithm, Weighted Round Robin Scheduling Algorithm, Shortest Job first Scheduling Algorithm and Earliest Deadline First Scheduling Algorithm with the help modulation and coding schemes for the cognitive radio network. Here in this paper we used three modulation and coding schemes that is BPSK, QPSK, 16QAM. By using these modulations and coding schemes we calculate the throughput and number of HARQ retransmissions required for each frame for different values energy per symbol to the noise ratio.

Keywords- BPSK, QPSK, 16QAM, HARQ, RR, WRR, EDF

I. INTRODUCTION

First in First out (FIFO) scheduling technique can be used to decide which queue to service and how much data to transmit. This technique is very simple but unfair. A little more complicated scheduling technique is Round Robin (RR). This technique provides the fairness among the users but it may not meet the QoS requirements. Also it is not fair if the packet size is variable. [1]
In this project we used four scheduling algorithms that are Round Robin scheduling algorithm, Weighted Robin scheduling algorithm, Shortest Job First scheduling algorithm, Earliest Deadline First Scheduling Algorithm. In this section, we describe the factors that scheduler designers need to consider.
QoS Parameters-The first aspect is whether the scheduler can guarantee the QoS requirements for various service classes. Main parameters are the minimum reserved traffic, the maximum allowable delay and the tolerated jitters. For example, the scheduler may need to reschedule or interleave packets in order to meet the delay and throughput requirements. Earliest First (EDF) is an example of a technique used to guarantee the delay requirement. [1]
Throughput Optimization-In wireless networks resources are limited so it is important how to maximize the total system throughput. The system throughput can be increased by full utilization of link. Also the system throughput can be increased by using the good put which is the actual transmitted data not including the overhead and lost packets. The overheads include MAC overhead, fragmentation and packing overheads and burst overhead. [1]

II. MODULATION AND CODING SCHEMES

A. BPSK

A cyclic redundancy check (CRC) code is added to a data block which can be used to determine whether an error in transmission has occurred or not. The transport block is bit scrambled by using a predetermined code array after the attachment of CRC. Hence the bits output from the HS-DSCH CRC attachment are scrambled in the bit scrambler.

After this through code clock division the bit-scrambled output bit array is divided into a number of code blocks of a same size. All transport blocks in a TTI are serially concatenated. After the concatenation of the transport blocks if the number of bits in a TTI is larger than Z (the maximum size of a code block in question) then code block segmentation is performed. The maximum size of the code blocks depends on whether convolutional coding or turbo coding is used or the transmission channel. Maximum code block sizes in this project used is Z=5114 as turbo coding is used for the implementation.

After the physical channel segmentation the signal processing of device includes the interleaving and constellation rearrangement. The interleaver is of a fixed size for BPSK modulation R2=16 rows and C2=30 columns and it is $U \leq R2 \times C2$. [7]

For calculating the throughput using BPSK modulation we used information bits i.e. K_info=1601, number of physical channel i.e. P=5, number of bits in one TTI for one physical channel i.e. U=480.For constellation of BPSK number of symbols M=2.The channel type used is AWGN and 20 number of frames are transmitted. The Size of virtual IR buffer that is N_IR=9600. The cyclic redundant bits that is K_crc =1625. [7]

B. QPSK

After the physical channel segmentation the signal processing of device includes the interleaving and constellation rearrangement. The interleaver is of a fixed size for BPSK modulation R2=32rows and C2=30 columns and it is $U \leq R2 \times C2$. [7]

For calculating the throughput using QPSK modulation we used information bits i.e. K_info=3202, number of physical channel i.e. P=5, number of bits in one TTI for one physical channel i.e. U=960.For constellation of QPSK number of symbols M=4.The channel type used is AWGN and 20 number of frames are transmitted. The Size of virtual IR buffer that is N_IR=9600. The cyclic redundant bits that is K_crc =3226.[7]

C. 16QAM

After the physical channel segmentation the signal processing of device includes the interleaving and constellation rearrangement. The interleaver is of a fixed size for BPSK modulation R2=32rows and C2=30 columns and it is $U \leq R2 \times C2$. [7]

For calculating the throughput using 16QAM modulation we used information bits i.e. K_info=4664, number of physical channel i.e. P=5, number of bits in one TTI for one physical channel i.e. U=1920.For constellation of 16QAM number of symbols M=16.The channel type used is AWGN and 20 number of frames are transmitted. The Size of virtual IR buffer that is N_IR=9600. The cyclic redundant bits that is K_crc =4688. [7]

III. SCHEDULING ALGORITHM

A. Round Robin Scheduling Algorithm

Round robin allocation can be considered the very first simple scheduling algorithm. RR equally assigns the allocation one by one to all connections. The fairness considerations need to include whether allocation is for a given number of packets or a given number of bytes. Round robin scheduling algorithm can be used as an alternative to FIFO in best-effort packet switching and other statistical multiplexing.

With the help of multiplexer, switch & router Round robin scheduling has a separate queue for every data flow and a data flow may be recognized by its source and destination address. The scheduling is work- conserving that is if one flow is out of packets the next data flow will take its place. Hence the scheduling tries to avoid link resources from going unused. [1]In Round robin scheduling data packets are equally sized and the data flow that has waited for the longest time is given scheduling priority. This scheduling is not useful if the size of the data packets varies widely from one job to another.
In this project we implement the RR scheduling algorithm by using three modulation schemes i.e. BPSK, QPSK, 16QAM. We form the queue of users and each user uses either of the three modulation schemes.

B. Weighted Round Robin Scheduling Algorithm
Round Robin algorithm cannot be used for different service classes so Round Robin with weight i.e. Weighted Round Robin has been applied for CR Network Scheduling. The weights can be used to adjust for the throughput and delay requirements. The weights are in terms of queue lengthand packet delay or the number of slots. The weights are randomly changing over time. To avoid the issue of missed opportunities and variation in packets of RR the Deficit Round Robin (DRR) or Deficit Weighted Round Robin (DWRR) can be used. [1]
In this project we implement the WRR scheduling algorithm by using three modulation schemes i.e. BPSK, QPSK, 16QAM. We form the queue of users with giving the highest priority to higher throughput values and each user uses either of the three modulation schemes.

IV. RESULTS AND SIMULATION

Table 1. Comparison of Time & HARQ retransmission for 3dB to 5dB of BPSK, QPSK & 16 QAM

ESN0dB	Throughput(Kbps)			Time(ms)			HARQ Retransmission		
	BPSK	QPSK	16QAM	BPSK	QPSK	16QAM	BPSK	QPSK	16QAM
3	4269	10673	9328	0.66	1.84	13.56	1	2	2
4	4269	10673	9328	0.66	1.21	12.22	1	1	2
5	4269	10673	9328	0.64	1.00	11.71	1	1	2

Table 2. Comparison of Time & HARQ retransmission for 15dB to 20dB of BPSK, QPSK & 16 QAM

ESN0dB	Throughput(Kbps)			Time(ms)			HARQ Retransmission		
	BPSK	QPSK	16QAM	BPSK	QPSK	16QAM	BPSK	QPSK	16QAM
15	4269	10673	18656	0.58	0.96	1.38	1	1	1
16	4269	10673	18656	0.59	1.01	1.36	1	1	1
17	4269	10673	18656	0.59	0.93	1.30	1	1	1
18	4269	10673	18656	0.59	0.99	1.29	1	1	1
19	4269	10673	18656	0.57	0.91	1.29	1	1	1
20	4269	10673	18656	0.56	0.99	1.27	1	1	1

Table 3. Comparison of Time & HARQ retransmission for -5dB to -2dB of BPSK, QPSK & 16 QAM

ESN0dB	Throughput(Kbps)			Time(ms)			HARQ Retransmission		
	BPSK	QPSK	16QAM	BPSK	QPSK	16QAM	BPSK	QPSK	16QAM
-5	1423	0	0	9.67	19.97	48.61	3	0	0
-4	1447	2668	0	8.57	21.60	42.44	3	4	0
-3	2235	3186	0	5.93	22.02	46.80	2	3	0
-2	2135	3558	0	5.20	17.03	43.22	2	3	0
-1	2135	3558	4664	4.17	16.53	23.52	2	3	4
0	3162	5337	6219	3.74	11.03	25.06	1	2	3
1	4269	5337	6219	1.08	8.80	18.49	1	2	3

C. Shortest Job First Scheduling Algorithm

In this project we implement the SJF scheduling algorithm by using three modulation schemes i.e. BPSK, QPSK, 16QAM. We form the queue of users with giving highest priority to lower throughput values and each user uses either of the three modulation schemes.

D. Earliest Deadline First Scheduling Algorithm

EDF assigns a deadline to each packet at the server and then always serves the packet with the earliest deadline.EDF compares the packets at the head of the flow queues, and schedules the packet the earliest deadline limit. [10]

From above table number 1 it is clear that if Energy per symbol to Noise ratio is in between the 3dB to 5dB then QPSK modulation get the highest throughput values and requires less number of HARQ retransmissions as compared to BPSK & 16QAM modulation. Hence QPSK modulation can be used for Internet Services.

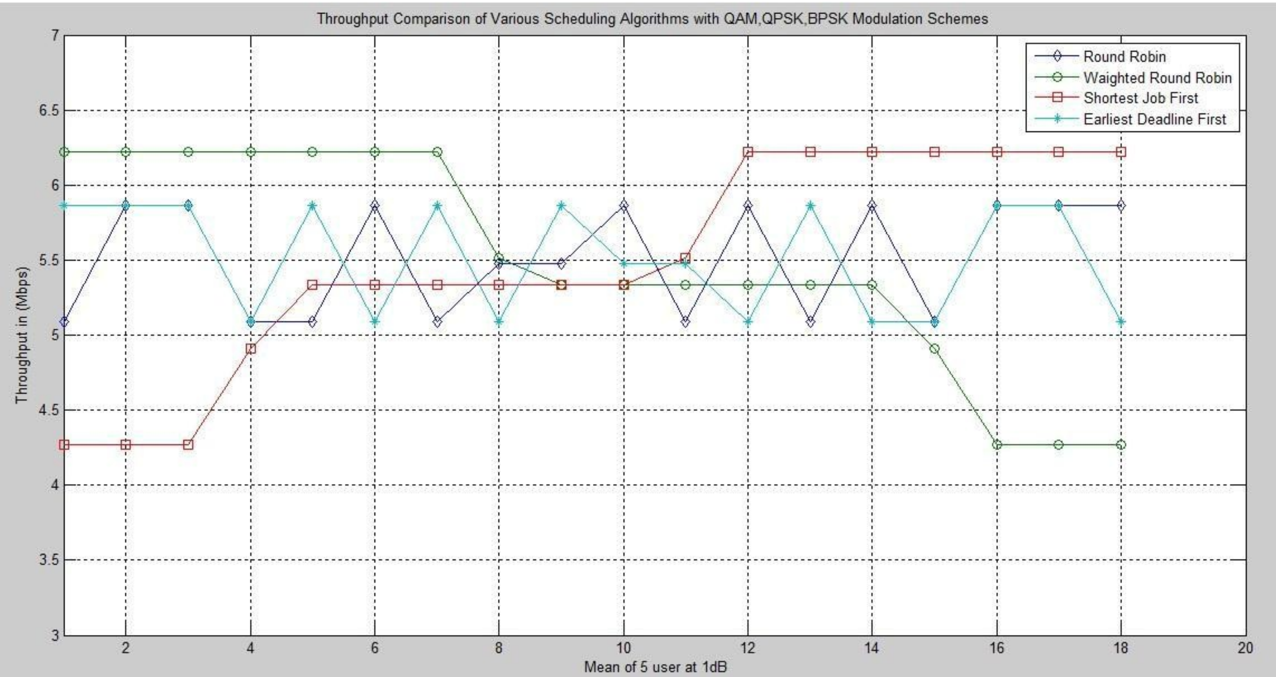

Figure 1. Throughput comparison of RR, WRR, SJF & EDF by using BPSK, QPSK & 16QAM modulation at 4Db

From above table number 2 it is clear that if Energy per symbol to Noise ratio is in between the 15dB to 20dB then 16QAM modulation get the highest throughput values and requires less number of HARQ retransmissions as compared to BPSK & QPSK modulation. Hence 16QAM modulation can be used for video data transmission.

From above table number 3 it is clear that if Energy per symbol to Noise ratio is in between the -5dB to 2dB then BPSK modulation get the highest throughput values and requires less numberof HARQ retransmissions as compared to QPSK & 16QAM modulation. Hence BPSK modulation can be used for voice channels.

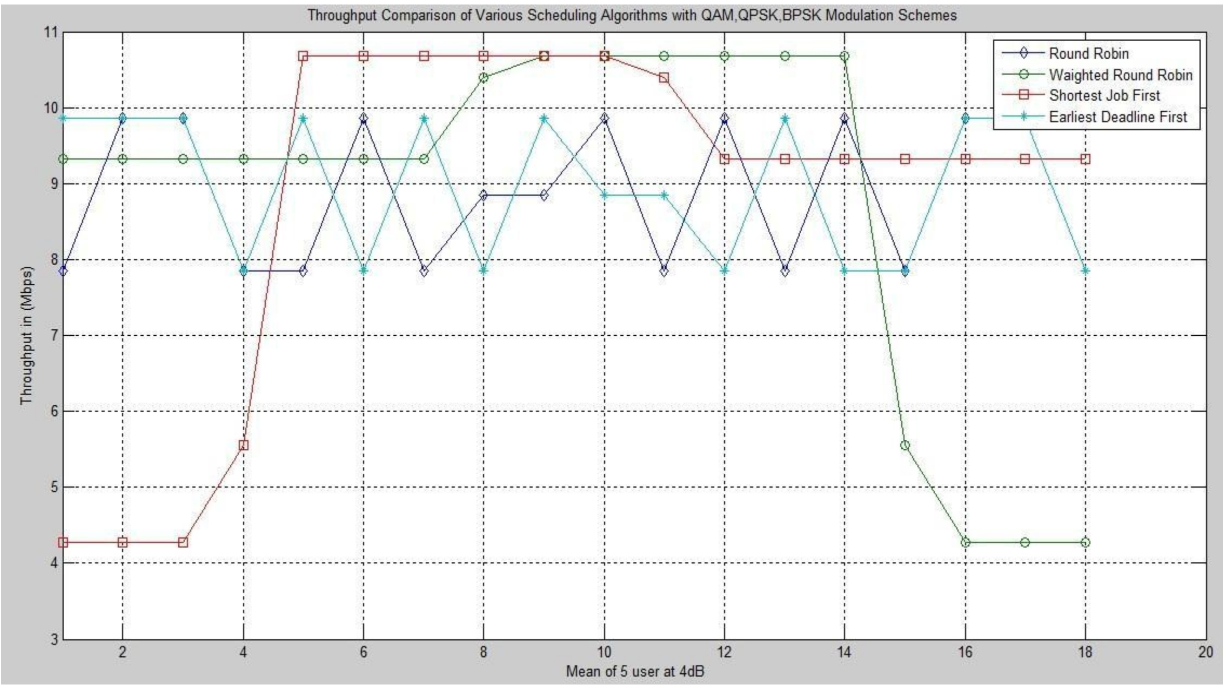

Figure 2. Throughput comparison of RR, WRR, SJF & EDF by using BPSK, QPSK & 16QAM modulation at 4dB

Figure 1 & 2 shows throughput comparison of RR, WRR, SJF and EDF by using BPSK, QPSK and 16QAM modulation at 1dB and 4dB in which WRR gives highest priority to higher throughput values, SJF gives highest priority to lower throughput values and RR takes throughput values according to MCS used by each user in queue and EDF takes throughput values of deadline users in the queue and each user uses these three MCS.

V. CONCLUSION

From figure 1 it is clear that WRR uses the highest throughput value near about 6.2Mbps for the first 35 users in the queue, next 30 users' uses the 5.3Mbps and end users of queue uses the 4.2Mbps.SJF uses the lowest throughput value near about 4.2Mbps for the first 15 users in the queue, next 30 users' uses the 5.3Mbps and end users of queue uses the 6.2Mbps. RR and EDF uses the variable throughput values from start to end of the queue of users.

In this paper we implement the four scheduling algorithms RR, WRR, SJF, EDF by using different MCS(modulation & coding schemes) and it is clear that as the energy per symbol to noise ratio is increased throughput of scheduling algorithm is increased as it takes less HARQ retransmissions of frames.

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