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# Video Transmission using Priority Scheduling for Improvement of QoS in Cognitive Radio Networks

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***Abstract:*** ***Need of spectrum resources have increased due to rapid growth of wireless multimedia applications, but as this spectrum is inefficiently used it has become scarce. Cognitive Radio network (CNR) solves current spectrum in efficiency problems and offer users a best wireless accessing environment depending on dynamic spectrum allocation.Due to involvement of more number of user's spectrum allocation and scheduling should be wisely done. If proper spectrum allocation is not done, the probability of collision increases in the network which in turn degrades the network performance. A new technique known as Improved Quality of Service Scheduling (IQS) is proposed in order to avoid collisions and to improve the Quality of Service (QoS). IQS enhances the QoS parameters. In this proposed technique network bipartition is done and each region is provided with a Cognitive radio (CR)base station, it allocates appropriate scheduling to each node which lies in its region. Here, spectrum allocation is based on priority, real-time and non-real-time video transmission applications are considered for priority considerations. This leads to increase in network performance. The simulation results convey that, IQS decreases the overhead ratio, collision probability, delay and also increases throughput and network efficiency.***

***Index Terms: Scheduling, IQS, Cognitive Radio Networks, Distributed architecture, QoS, Network efficiency***

## I. INTRODUCTION

Multimedia applications are bandwidth-greedy and much sensitive to delay; they have gained immense attention in today's world. Transmission of multimedia applications needs to be more cautious in terms of QoS, bandwidth, timeliness and reliability. Multimedia applications like Netflix, You Tube, Skype and others are in huge demand today. As these multimedia applications require huge spectrum for transmission, hence CRN is most suitable to use the accessible spectrum intelligently and also efficiently.

In CRN, allocation of spectrum to primary as well as to secondary users becomes a key task. Only certain portion of spectrum is used when primary user is active. Due to this unused and unallocated spectrum, delay, latency increases in CRNs; basically, allocation of these channels to secondary users is a tedious task and it may increase collision. In cognitive radio network, two types of transmissions are used, multicast transmission and broadcast transmission. The multicast transmissions follow multi-path and multi-hop concept; here multiple paths are used by all nodes of the network to reach destination. In broadcast network, the data is transmitted by server node to the co-operative nodes, and these cooperative nodes forward it to the destination. As there is a high collision probability due in this type of transmission, scheduling becomes an important exercise in CRN.

Proper Scheduling reduces collision probability, decrease the delay and to increase the efficiency of the CRN. CRN has the ability to cater for real-time, non real-time traffic. Transmitting multimedia content over CNR is a challenging job because of its dynamic nature [1]. To overcome time and delay related issues during transmissions, various advances in architecture, and interference mitigation approaches have been made in CNRs. Parameters like collision probability, throughput, drop rate, delivery rate, overhead ratio and end-to-end delay are used to analyze QoS of CRNs.

CNRs follow two types of architectures, i) Centralized Architecture and ii) Distributed Architecture. [2]

***Centralized Architecture*:** In this architecture, the server node amplifies and forwards the data to all the other nodes within the network. Here for data transmission, scheduling of each node is allocated by central node.

***Distributed Architecture:*** In this architecture, nodes are distributed and are in a decentralized manner. Here due to its decentralized model many scheduling issues occur. Qos needs to be improved to avoid these issues in the distributed network. A new scheme IQS, is proposed for this CNRs.

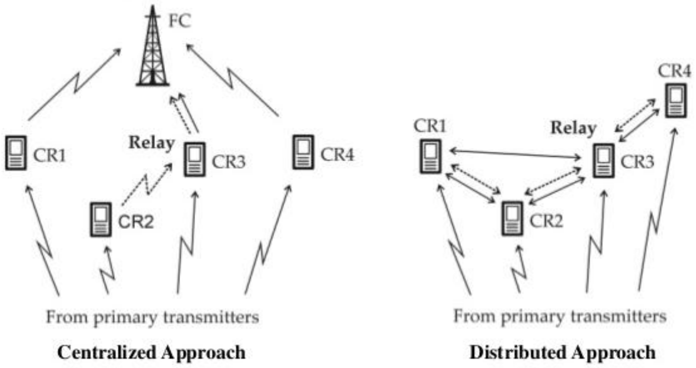

**Fig. 1 CRN Architectural Approaches**

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## II. MOTIVATION

It is estimated that, out of overall internet consumer's traffic, 69% is used only by multimedia applications, especially video streaming [3] and it is presumed to be increased still in future. Multimedia applications have become the major applications of the users. Hence, it becomes very important to focus and to measure their performance. QoS is the much widely used network based standard of measurement to check the performance of a networks and its ability to support delay sensitive traffic.

## III. RELATED WORK

Qadir et al. [4] proposes a cognitive radio which is an artificial-intelligence-based and it uses the CR protocol. It improves the performance of CRN. Tham et al. [5] suggested a scheduling which is of two-level, level one deals with uplink and the second manages downlink for CRNs by using OFDM. Sun et al. [6] explains a scheme to increase the efficiency of spectrum in CRNs, by accessing and routing method. Performance of the network is boosted by decreasing the end-to-end delay and latency using this scheme. Premarathne et al. [7] suggested an energy management system for CRN. This provides good spectrum sensing and reliable priority scheduling to the network. Maity et al. [8] explains sensing method in CNR by using the fuzzy C. Siya et al. [9] proposes scheme for management of the network and monitoring it for enhancing spectrum efficiency within the CRN. Sharifi et al. [10] suggest a cooperative sensing scheme in which malicious threads in CRNs are detected. It focuses on the primary user imitation attack, which can be detected and avoided within the CRN. Ye et al. [11] proposes heterogeneous CRNs and he suggested a frame work of cross-layer optimization which can maintain consistent transmissions between both types of users, and achieves best spectrum utilization in CRNs. Kumuthini et al. [12] suggests an optimized scheme for priority scheduling which is beneficial for secondary users and its improvement. Lei Xu et al. [13] discuss video packet scheduling problem for the sustainable internetwork video transmission over the call duration for cognitive heterogeneous networks. Its aim is to enhance the lower limit of video quality under QoS constraints. The QoS-based prioritization model (QBPM) [14] is used to manage and monitor the CRN. A Markov chain [15] concept is to enhance the throughput and to reduce the interference between primary and secondary users in CRNs. For better performance Femtocell [16] architecture is used in CRNs. To avoid collisions the BRACER [17] broadcast protocol is used in CRNs. This scheme uses a method to detect collision and avoid them by using global network topology. A RPCB forming technique [18] is used for sharing of spectrum between both the users. A cross-layer scheduling (CLS) scheme [19] is used for increasing the spectrum sensing between both the users in CRNs for OFDM.

## IV. PROPOSED WORK

The proposed model is used for distributive cognitive networks and it is known as Improved QoS Scheduling (IQS). This scheme enables adequate communication between the users in the network. Here decentralized architecture of distributed type of network is considered where all nodes of the network are randomly distributed. In the proposed scheme distributed network architecture is created and it is split into different regions. One node from each of these regions is fixed as a base station for that region in the network. These base stations are used to allocate better scheduling between both the users of its region.

Scheduling is an important task for transmission of multimedia content based on its application over CNR. Proper and resourceful scheduling is depending on the type of the multimedia being transmitted. Depending on real-time and non-real-time video transmission applications, first priority is set to real-time video streaming applications and second priority to non-real-time Video on Demand (VoD) applications. The proposed method is analyzed by using two non identical data traffic conditions: Hypertext Transfer Protocol (HTTP) and File Transfer Protocol(FTP). HTTP uses a variable bit rate while constant bit rate is used by FTP for packet transmission.

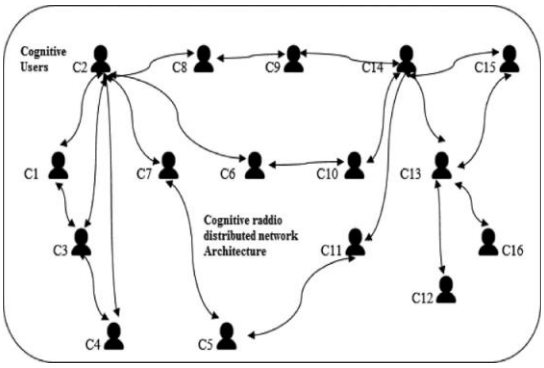

**Fig.2 Distributed Network Model**

Let distributed network be denoted by N (*n*, *l*) which includes decentralized nodes and links which are randomly connected. Here N- denotes distributed network

*n* -denotes the nodes
*l* -denotes the links

The network subset is denoted as S(A). If N is a bipartite network having two partitions of (*i*, *j*) then it requires matching. Distributive network with is random nodes, decentralized and distributed is depicted in Fig. 2. Suppose distributed network N contains a bipartition of (*i*, *j*) such that every node in '*i*' gets saturated.

Then network N has matching, which saturates all nodes in *i*. Considering A as the subset of *i* and if all vertices in A are matched to M with the value of S(A), then bi-partitioning of the network is done using the condition mentioned below.

$$|S(A)| \leq |A| \qquad (1)$$

Distributed network N will be partitioned into two parts and the partitions are with reference to the number of network subsets.

$$N(n, l) = A * B \qquad (2)$$

The above equation indicates that the network N is divided into two types i.e: A and B which includes saturated and unsaturated vertices respectively. Saturated vertex extracts saturated nodes forming region 1 and unsaturated vertex extracts unsaturated nodes forming region 2.

$$A = N \cap i \qquad (3)$$

$$B = N \cap j \qquad (4)$$

If there are even numbers of vertices then the network N will split using matching condition, if odd then unmatched condition is used, as mentioned in Eq. (5).

$$|B| = |A| - 1 \qquad (5)$$

In matched vertex, condition for unmatched vertex will be selected for other region and network subset uses vertex of ‘j’ for it, as indicated in Eq. (6).

$$S(A) = B \qquad (6)$$

Comparing equations (1) (5) & (6) we get the value of N(A) as :

$$S(A) = |A| - 1 \leq |A| \qquad (7)$$

Finally the Eq. (7) conveys that the nodes of the network N should be larger than the network subset.

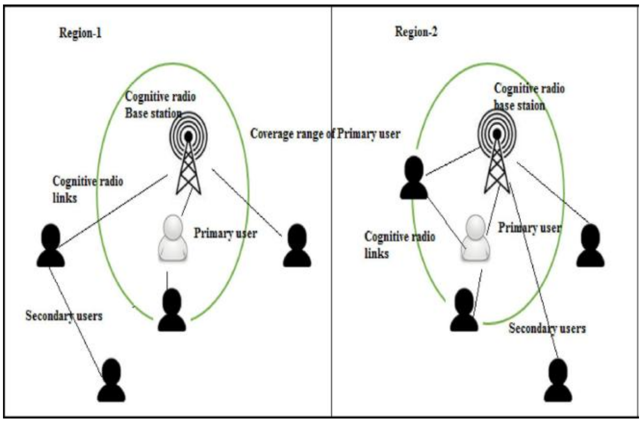

Fig. 3 Bipartite Network Architecture

Based on the subsets dividing the distributive network into bipartite network, sequence of jobs are to be followed in order to achieve the required quality of output:

1) Selection of suitable base station- Depending on number of links
2) Selection of primary user - Based on the bandwidth parameter.
3) Scheduling - Considering real time or non real time user.
4) Spectrum allocation - Based on status of channels
5) Implementation of IQS Algorithm - To improve QoS.

### 1) *Selection of Suitable Base Station:*

Base stations are selected for each partition to provide better communication. Based on the connectivity of nodes, the node with more links is picked as a suitable base station for that partition. Control messages are sent by each node to all its neighboring nodes and these nodes after receiving the control message; they have to send an acknowledgement back to the sender node. The node with more number of acknowledgements is selected as a base station. Here, received control messages helps to compute the number of links connected to it. In fig. 1 the node C2 has more number of links in region 1 and node C14 has more number of links falling into region 2.

Let ‘C’ be a node and’ Nn’ be its neighboring nodes then ‘Cn’ sends the control message RTS to ‘Nn’.
Where n=1, 2, 3….. is the nodes count ,
Nn acknowledges CTS to Cn

Each node receives acknowledgements as per the links and nodes connected to it; these acknowledgements are counted in the routing table. Using this, the number of links connected to each node is compared. The node with more links is selected as a suitable base station.

From Figs. 2&3, Region 1 has 8 nodes, denoted by 1, 2, 3….8; C1, C2, C3, C4, C5, C6, C7 & C8 has 2,7,2,2,2,2,3 & 2 number of links respectively. By counting the received acknowledgements from the neighboring nodes it can be calculated.

```
-----------------------------------------------------------------------
 If Cn > > C(n + 1)
Cn  is the base station
else
n ++;
end
------------------------------------------------------------------------------------
```

Appropriate base station with more number of links is selected and to maintain stable condition its mobility is changed to 0m/s. This stability is used to achieve flexibility to avoid link failures. Base stations make communication possible between region 1&2 and upon the need vertices which are unsaturated can be shifted to saturate. Conversation is made through the base stations and information about the availability of free spectrum is sent to the base stations using control messages. Fig. 3 shows the bipartite network architecture with region 1 & 2 which includes saturated and unsaturated vertex of *i* & *j* respectively.

### 2) *Selection of Primary User:*

The base station plays a prominent role in selecting the primary user depending on the bandwidth, area of coverage of the node. Base station calculates area of coverage and bandwidth of each node in its region. Bandwidth is the ratio of rate of transmission to the network interface.

$$Bw = Tr/Ni \qquad (8)$$

Here Bw - bandwidth,
Tr -rate of transmission and
Ni - network interface.

Coverage range is, area covered by all nodes.

$$Cr = A\,(Nni)\ \forall\, n \qquad (9)$$

Where Cr - coverage range,
A (Nni) - area covered by neighboring nodes and
*n* - represents all nodes.

```
-------------------------------------------------------------------------
Algorithm -1
-------------------------------------------------------------------------
Input: Distributed network N (n, l)
Output: Transmission using primary & secondary users in bipartite network
Creating of N (n,l) with n as nodes, l as links
Bipartition  N (n,l) = A * B
Set A→ Represents region- 1
Set B→ Represents region- 2
Compute Ni, \\Ni→ node degree here, i=1, 2, 3… l
Select and create  Bsi→ n has high Ni; for each region Rp, p=1, 2 … n
Connect Bsi to Nn, \\  Nn - neighbor nodes
Bsi traces Pu; Pu- primary users
If Bw (Nn)k>> Bw(Nn)k+1; Bw-bandwidth; k=1, 2 … n; denotes the neighboring nodes connected to base station.
 If Cr(Nn)k >>Cr(Nn)k+1; Cr -coverage range
(Nn)k is assigned as Pu \\ Pu with high BW and range of coverage.
Else
(Nn)k+1 is assigned as Su \\  Su - secondary users
Remaining nodes with lesser band width are assigned to Su.
 end
If Pu is busy then
Dt{(Pu)i, Bsi}; \\ Pu Transmits the data to base in $i_{th}$ region
Else if Pu is idle
Dt{(Su)i, Bsi}; \\ Su Transmits the data to base in $i_{th}$ region.
Utilization of free channels by Su
End
-------------------------------------------------------------------------
```

Selection of primary user is based on Eqs. (8) & (9). The base station calculates bandwidth & coverage range of all nodes with the assistance of control messages. After comparing all the values, the node with larger bandwidth and high coverage range is designated as a primary user and all other remaining nodes connected to base station are designated as secondary user. If primary user is transmitting data to its base station by accessing a channel then it is shown as busy state. When primary user is idle, then secondary user can use that free channel for transmission of data.

### *3) Spectrum Scheduling:*

In the scheme which is proposed for improved scheduling, base stations help in scheduling for each user. Here the scheduling is altogether based on whether the data to be transmitted belongs to real time or non real time video application. Real time video transmission is given the first priority in this scheduling.

The real time user is denoted by 'u', its traffic rate is denoted by 'r'. Allocation of channels to real & non real time users is depending on the service coefficient condition 'Sj'. It is defined as the ratio of number of free channels F to the number of users Nu.

$$Sj \;=1+e^{-F/Nu}; \quad Sa \rightarrow \text{Real time user}$$
$$=1 \;; \quad Sa \rightarrow \text{Non real time user} \qquad (10)$$

Scheduling access priority (Sa) is depends upon the Eq. (10). Scheduling access is set to real time user if the first condition of the above expression is satisfied. It is given to non real time user if its coefficient is 1.

### *4) Spectrum Allocation:*

In general, channel can be either busy or free based on it status of utilization. Hence channels are split into two categories during allocation, ie: busy or free channels. The status of these channels can be known using the control messages; control channels are used for identifying their status. Here free channels are denoted by F and B denotes busy channels.

*If Channel is busy:* The source node waits for a predefined threshold time and then repeats the request again to know the status of that channel.

$$Ch\ (B) = Wt \ll \tau,\ Sn\ U\ Cm \qquad (11)$$

Where Ch (B) denotes busy channel, Wt - waiting time,
τ- Threshold time, Sn - source node, Cm - control messages.

*If Channel is free:* Source node transmits real time video to the destination node by using the free channel.

$$Ch\ (F) = Sc\ (Dt) \rightarrow De\ (Dt)\ \forall\ F \qquad (12)$$

Where Sc (Dt)- source to carry data ; → represents that occurrence of transmission by Sc (Dt) to De (Dt) ; here De (Dt) is the data receiving destination, and F denotes free channel.

### *5) Algorithm for Improved QoS Scheduling:*

Quality of service can be improved in distributive cognitive networks by fulfilling certain procedural conditions:

i) Proper scheduling by following priority in scheduling for real time users.
ii) During high level of traffic collision should be avoided.
iii) Even high queuing conditions should reduce the delay.
iv) Improvement in throughput should be done.

All the above conditions needs to be satisfied to have a best QoS, for every satisfied condition QoS factor will be added by one. Since all four conditions will be satisfied for ideal considerations, the QoS factor will be equating to 4.
The proposed algorithm for Improved QoS Scheduling is as mentioned below. Here, input is a distributed CRN, and the output expected is the IQS network with genuine scheduling and bi-partitioning.

```
-------------------------------------------------------------------------
Algorithm -2
-------------------------------------------------------------------------
Input: N(n,l)
Output: {Ps * Qs}* {N(n,l)}
Create N (n,l) \\ distributed network with n nodes and l links
Bipartition N (n,l) = A *  B
Set A→ Represent region -1
Set B→ Represent region -2
Create Bsi ¥ Rp, p=1, 2, .. n \  No. of regions & base station
Connect Bsi to Rp(n), p=1, 2, … n \\  No. of regions & base station
Allocation of Ps  \\ Genuine
Scheduling from Eq. (10)
Check Sj \\  Service
Coefficient
```

```
If Sj=1
NRTV      \\ Non real time video
Send to Queue
Repeat if
Else
RTV       \\ Real-time Video
Allocation of  Sa \\ Scheduling channel access
Data transmission
End
Ps ∗  N (n,l) \\ Successfully genuine scheduling is done
Check Qs    \\ QoS
If Qs≥4       \\ Four conditions needs to be satisfied
{Ps ∗ Qs}∗ { N (n,l))}  \\ QoS improvement and genuine scheduling is completed
Else repeat Ps  \\ genuine scheduling
End
----------------------------------------------------------------------------------
```

The algorithm and the proposed model is as follows.

- Initially, distributed network with random number of nodes are created, which are further partitioned into bipartite networks Region 1 & 2 for subsets A&B. Each portion has its base station, a primary & secondary users.

- Genuine scheduling for real time and non real time users will be allocated by base station of each region within its partition.

- Real time users are identified depending on service coefficient values and channels are allocated to them by the base station.

- Based on service coefficient value, non-real-time users are detected and sent to queue. Free channels are allocated to these users only after fulfillment of data transmission by the primary users.

- QoS is checked after proper scheduling is attained. If all the 4 conditions are satisfied by the QoS then it will be considered as IQS for distributed CRNs.

- QoS is different from prioritization of traffic. Depending on the data rate, traffic gets categorized as low, medium and high. If it is low then prioritization is not required, if its data rate is high, prioritization is required in order to avoid packets loss and to minimize delay

## V. SIMULATION AND RESULTS

Using network simulator random 100 to 400 cognitive nodes were randomly generated and simulation results were obtained. Two data traffic rates have been analyzed in this proposed scheme: Hypertext Transfer Protocol and File Transfer Protocol. Here HTTP uses variable bit rate where as constant bit rate is used by FTP for data transmissions. The Broadcast Protocol for CRNs (BRACER) and the QoS-Based Prioritization Model (QBPM) are the two existing approaches which are compared with the proposed scheme. The QoS parameters of overhead rate, delivery ratio, throughput, end-to-end delay, network efficiency and probability of collision are analyzed to determine the performance of CRN. Table1 shows the parameters of routing and their range.

| **Parameters** | **Range** |
|---|---|
| Routing protocol | Ad hoc on -Demand Distance Vector |
| Number of nodes | 100 to 400 nodes |
| Mobility | 20 m/s |
| Simulation time | 200 sec |
| Queuing time | 50 sec |
| Queuing type | Priority queuing |

**Table- 1 Details of Routing Parameters**

Fig. 4 depicts overhead analysis. Overhead is the ratio of the data messages received to the number of control messages. If control messages increases overhead also increases. As BRACER Protocol and QBPM uses more control messages for data transmission within the nodes their overhead ratio is relatively high. By properly assigning separate base stations to each region the distributed behavior of the network is converted into a partly-controlled network. Base stations controls the channel assignment for primary and secondary users due to which less control messages are used in the proposed IQS technique, it makes the overhead to reduce.

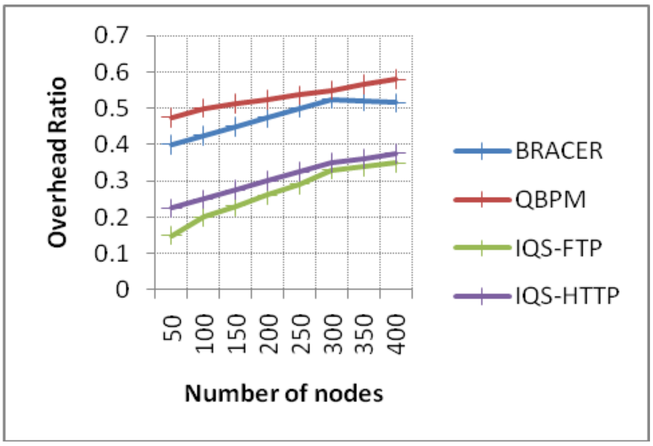

**Fig. 4. Overhead Ratio**

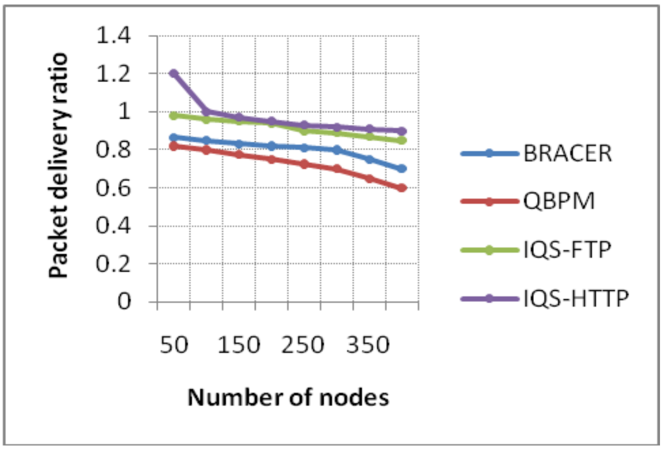

**Fig. 5 Packet Delivery Ratio Analysis**

Fig.5 depicts the analysis of packet delivery, Packet delivery is the ratio of packets received to the packets transmitted. Over head and delivery ratio are inversely proportional, if over head increases then packet delivery decreases. As BRACER Protocol and QBPM have high overhead ratio their delivery rates between source and destination reduces. Due to Less overhead, decrease in collision and prioritizing of real time videos makes the packet transmission faster in the proposed IQS scheme, this in turn achieves a higher delivery rate.

Fig. 6 depicts end-to-end delay. The time needed to transmit the data from source to destination, including the queuing time is known as end to end delay. Due to broadcasting the BRACER protocol & QBPM have huge end-to-end delay. The delay is reduced in the proposed scheme IQS, as the service coefficient condition are used by the base station. Here the real-time video applications are discharged faster, and the queue is cleared swiftly, giving spectrum space for the non-real-time video transmission due to this delay reduces.

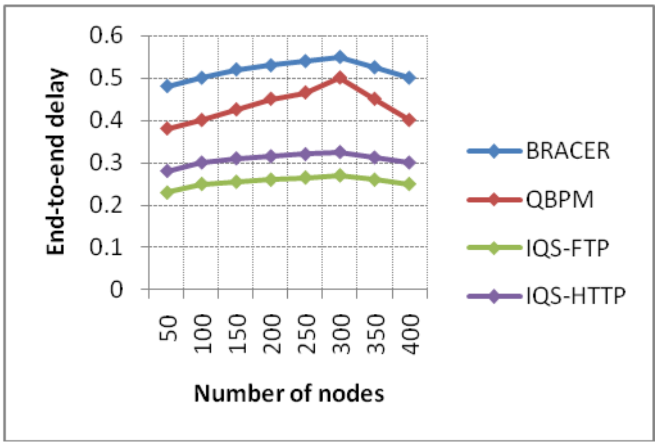

**Fig.6. End-to-End delay**

Fig.7 depicts network efficiency analysis. Network Efficiency is the ratio of number of successfully received data packets by the destination to the number of successfully transmitted data packets by the source.

As BRACER Protocol and QBPM have huge delays and drop rates they cater lower efficiencies. However, by decreasing drop rate and delay the proposed IQS model increases network performance. By using Service coefficient, the base station immediately allocates the unused channels to the secondary users, which improves spectrum & network efficiency.

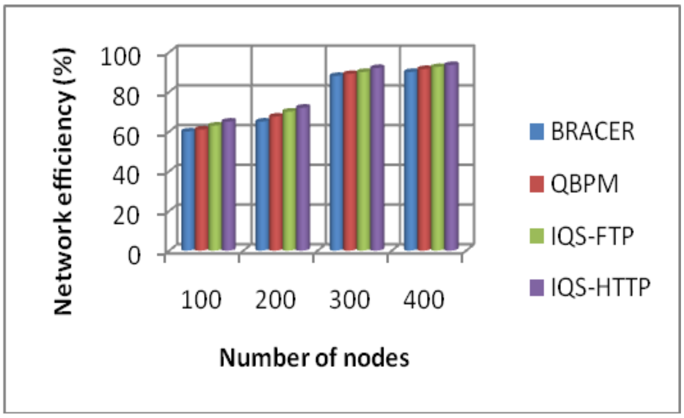

**Fig.7 Network Efficiency**

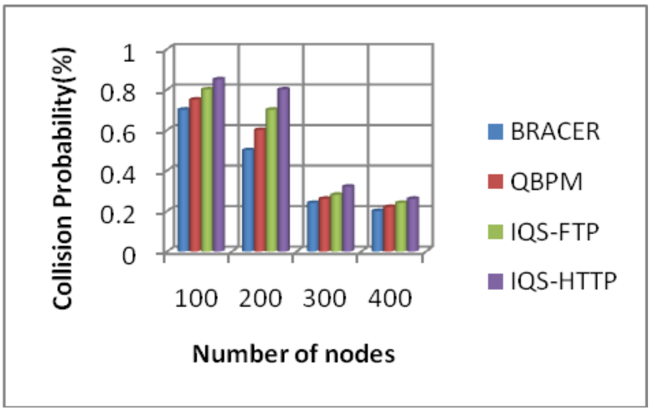

**Fig.8 Collision Probability**

Fig. 8 depicts collision probability. Collision probability is the ratio of the number of dropped packets to the transmitted packets. Collision probability is directly proportional to dropped packets rate. i.e: Larger the drop rate larger will be the collision probability. BRACER has high collision since it uses message broadcasting, and QBPM has large drop rate because of QoS- scheduling. Hence these both have high collision probability. However, in the proposed IQS model, service coefficient based scheduling reduces both collision and the drop rate.

Fig. 9 depicts throughput analysis. It is the ratio of the number of control and number of data packets successfully received within the simulation time. Its analysis is based on the considered parameters during simulation, i.e: after the simulation is completed at 200 s, channel bandwidth 2 Mbps, the present method used 1.7 Mbps of the available spectrum. BRACER protocol & QBPM have poor throughput.

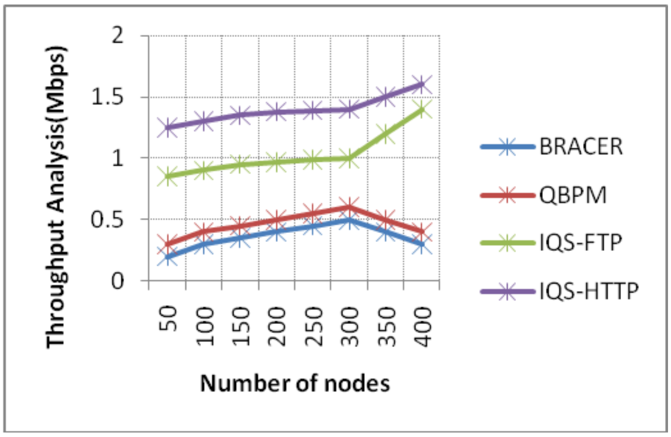

**Fig.9 Throughput Analysis**

Using proper spectrum allocation with the help of base stations in each region the proposed IQS scheme increases the throughput. Here, due to a reduction in overhead, drop rate, and collision and due to high network efficiency, delivery ratio the throughput is increased.

## VI. CONCLUSION

In the proposed IQS model it has been observed that there is an increase in QoS in FTP and HTTP traffic conditions. Due to use of data broadcast for the multi-hop CRNs, BRACER broadcast protocol has a poor network performance. The QBPM has a poor network performance since it uses QoS-based prioritization in scheduling procedure. In the proposed IQS scheme the network is split into regions and allocates base station to each region. These base stations provide proper scheduling by considering real time or non real time video transmission for each node in the network which in turn increases QoS of the network and improves network performance. Results of simulation show that the proposed IQS scheme increases the network efficiency and throughput. This method has prioritized scheduling and allocation will be useful for live video streaming and video on demand application. Real time live streaming application would be best served by following the proposed scheme. In future, this scheme can be analyzed in concern to the availability of spectrum, its quality and the application it can serve using priority scheduling in order to increase QoS.

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