A New Channel Allocation Scheme for Vehicle Communication Networks

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Abstract. In roadway networks, the timely, reliable, and high-throughput transmission is particularly important to vehicles, e.g., for roadway safety warning applications. However, it is difficult to achieve these goals at the same time in vehicle-to-vehicle communications due to mobility, interference, etc. In this paper, we tackle this issue and propose a new channel allocation scheme based on OFDM(Orthogonal frequency-division multiplexing). Our design can achieve highly reliable transmission through dynamically allocated interference free channels demanding on timeliness, and high throughput through secondary channels for information transmission insensitive to timeliness. In our evaluation study, the results show that our scheme can provide a guarantee for reliable and high-throughput transmission.

Keywords: vehicle networks, channel allocation, reliability.

1 Introduction

With the increasing demand on high-data-rate wireless communication services, the bandwidth allocation design is expected to accommodate more users and support higher data rate on the guarantee of the quality of service. OFDMA is one of such communication systems. However, most existing OFDMA schemes are centralized and meet difficulties to satisfy users' requirements in vehicle networks. In a typical vehicle network, the topology of the network is changing rapidly all the time. Therefore, it is imperative to provide a dynamic and distributed channel allocation scheme rather than the centralized ones.

In this paper, the proposed channel allocation scheme allows each node to share parts of the channels with others never appearing in their link interference sets. Through this way, we can increase the number of available channels implicitly with little coordination among vehicles. In our design, different channel is allowed to choose better sub-channel for information transmission and to access to different sub-channel to avoid interference. Note that after a node selects one sub-channel for exclusive usage in its neighbor set, there still remains a large amount of channels unused. Based on this observation, we further propose a greedy design to utilize the remaining channel resources using OFDMA.

The rest of this paper is organized as follows: In Section 2, we briefly survey the related work about OFDM. The channel allocation algorithm is proposed

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in Section 3. Section 4 try to list some of the theorem to be clear about the performance of our scheme.Section 5 provides the simulation results and Section 6 concludes the paper.

2 Related Work

OFDMA system has been studied for a long time. [1] proposed a simple greedy algorithm and proved that its much better than ribbon OFDMA. [2] raised a theoretical optimal allocation scheme and achieved a sub-optimal result on simulation. However, this algorithm doesn't take the fairness among users into consideration. There is another channel allocation algorithm considering fairness with low complexity—-BABA+ACG[3]. It calculates an estimation of essential sub-carriers and allocates them to each user after adjustment.

Both the algorithms mentioned above are based on MA (margin adaptive). [4] proposes a sub-carrier allocation scheme based on RA guidelines. This scheme can maximize the throughput of the system and guarantee a fixed ratio of the speed of each user. Nonetheless, it needs a large amount of computing resource in bit allocation. Someone has improved this algorithm by combining sub-carriers and power and proposed a sub-optimal algorithm which can simplify the bit allocation process[5].

Under normal assumption, [6] proposes a progressive greedy algorithm which can be divided into two parts. The first part is BABS to get the number of sub-carriers by average channel gain and the ratio that users need[7]. The second part is ACG algorithm. It chooses a pair of sub-carrier and the corresponding user which can maximize its channel gain. If the user doesn't get enough sub-carrier, he will be allocated the sub-optimal carriers until there is none left. MAO algorithm proposed by Wong mentioned above gives out theoretical optimal result. However, its complexity is difficult to adopt and it neglects the fairness. BABS+ACG simplifies the process, but it needs cycling iteration to calculate the number of sub-carriers users need and the problem of fairness isn't improved[8,9].All these schemes mentioned above work in a centralized manner. They lack the ability to support distributed vehicle communication networks.

3 Channel Allocation Algorithm

3.1 Vehicle Network Model

In this section, we briefly introduce the basic network model and some underlying assumptions.

We model the vehicle communication network as a MR-MC(multi-radio multi-channel) network consists of $|V|$ nodes, where there are N orthogonal frequency wireless channels, denoted as $k_1, k_2, \cdots, k_N$. Each node has Q multi-input and multi-output antennas. And we suppose $Q \leq N$.

For the channels available to each node, the N channels can be divided into *primary channels* and *secondary channels*. We can use a N-dimension vector

$\overrightarrow{c_u}$ to denote the label and division of a channel for a node u, where value 1 represents *primary channel* and value 0 represents *secondary channel*[10]. For example, $\overrightarrow{c_u} = (1, 0, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0)'$ represents that channel k_1, k_4, k_8, k_{10} are *primary channel* for node u, and the rest are *secondary channel* for node u.

Generally,a node tends to use the channel close to it rather than the *secondary channel*.And we suppose that the number of *primary channel* of a node is less than the number of *secondary channel*. For simplicity, suppose the channel code for each node is unique.

In our work, the vehicle network is modeled as an undirected graph $G(V, E, C)$, where V represents the vertex set and E represents the edge set. Each node has a channel coding, and all the channel coding of the vehicle network can be described as a matrix C with the size $N * |V|$.Each column of matrix C represents the code word of a node. For example, the $u - th$ column represents the code word $\overrightarrow{c_u}$ of node u.

We assume that a data packet from node u to v needs to be acknowledged that it has been received by sending ACK from node v to u. $N_1(u)$ denotes nodes which are one hop away from node u, and $N_2(u)$ denotes nodes which are two hops from node u, it is obvious that $u \notin N_1(u), u \notin N_2(u)$. In this paper we adopt the protocol interference model. For a node $u \in V$, we represents the interference set of node u as $\mathcal{N}(u)$. If the transmission of node $v \in V$ interfere u with the signal receiving, then v is an interference node of u, we have $v \in \mathcal{N}(u)$. In protocol interference model, $\mathcal{N}(u)$ represents the nodes within two hops away from u, then $\mathcal{N}(u) = N_2(u)$. So it will generate conflicts and interferences if nodes within two hops use the same channel. This is the basic rule of our algorithm and allocation plan. Our objective is to ensure the channel used by a node is disjoint with its interference set.

3.2 Superimposed Code

In this part, we will simply introduce *superimposed code*, then combine *superimposed code* (s,1,N) (also *s-diajunctcode*) with the channel allocation of MR-MC network[11].

Suppose $N, t, s, L \in Z$ satisfies $1 < s < t, 1 \le L \le t - s, N - 1$, for a given binary matrix $\mathcal{X}$ with size $N \times t$, the $i - th$ column of $\mathcal{X}$ $X(i) = (x_1(i), x_2(i), \cdots, x_N(t))'$ represents a binary code word numbered i. This kind of code word corresponds to a channel coding vector of a node in our later channel assignment. The boolean sum of $X(1), X(2), \cdots X(s)$ is

$$Y = \bigvee_{i=1}^{s} X(i) = X(1) \bigvee X(2) \bigvee \cdots \bigvee X(s)$$

It is also a binary code word $Y = (y_1, y_2, \cdots, y_N)'$, where for $j = 1, 2, \cdots, N$:

$$y_i = \begin{cases} 0, if \quad x_j(1) = x_j(2) = \cdots x_j(s) = 0, \\ 1, otherwise, \end{cases}$$

And for code word Y and Z, we call Y covers Z if $Y \bigvee Z = Y$.

A (s, L, N) SC word code (also called *superimposed − code*), where N represents the length of a word code, s represents strength, its characteristics is that the boolean sum of any s word code set in $\mathcal{X}$ will not cover over $L-1$ code word of its complementary set. The SC code where $L = 2$ also called $s - disjunct$ code. We can get $G(V, E, C)$ if we append matrix C with $s - disjunct$ code to a corresponding graph $G(V, E)$, where each code word of matrix C corresponds to the availability channel condition of this node[10].

3.3 Algorithm Design

The timeliness of information transmission is vary essential in the vehicle network especially, which also means that the reliability of signal transmission must be ensured first. In our protocol interference model, to ensure a node without interference we must try our best to make its two-hop neighbors to use different channels to deliver messages. The core of our channel allocation scheme is to choose the channel that is not used by its interference set for each node. To meet the requirement of both the reliability and high throughput, our scheme can be divided into two parts:

- **I**: Each node chooses its primary channel (a channel without interference to send some essential and necessary information).
- **II**: Each node chooses available channels by priority with distributed system for OFDMA.

The specific channel allocation scheme is presented in Algorithm 1: $\mathcal{X}$ represents the superimposed code set of all nodes, $AvailableCH(u)$ means node u's available channel set, $R(u)$ represents the forecast throughput of node u, $Rate(u)$ is on behalf of node u's the average speed of sending message, $Priority(u)$ shows u's priority to choose channel, $NumCh(u)$ represents the channel number u needs according to its situation, $ChEstimate(u)$ is the channel-estimation vector node u make for all its available channels, $N_1(u)$ means u's one-hop neighbor and $\mathcal{N}(u)$ represents u's neighbors within two hops.

This allocation scheme is a reasonable solution based on a vehicle network in which all the nodes are distributed. The main idea is dividing all the available channels into two parts: One is a primary channels $CH_1(u)$, which can not be selected by nodes adjacent within two hops. This channel is the first level to ensure sending important information and some control signals in our algorithm. The other part is a set of available channels $CH_2(u)$ for each node according to the rule, which can be used directly to make the OFDMA or further to divide the sub-channels and realize the multi-carrier OFDMA. After the partition, each node can choose a proper channel according to the packet's character or application can select the better channel to meet its requirement themselves. In brief,packets with high real-time requirements can be sent in $CH_1(u)$,and much quantity in the $CH_2(u)$.

Now, we focus on the acquirement of $CH_1(u)$ and $CH_2(u)$. The algorithm consists of two parts:

I: Each node transmits its network ID to its neighbor node, and then forward the ID it received to its neighbor, thus each one has all the ID number about the neighbor in two-hop distance. (To avoid the broadcast storm, too much noise and just try to send message within two-hop distance, each node can decide whether the ID message is from the source node or transmitted by others by judge if the ID number is among its neighbor after receiving IDs. Here we send information directly to $\mathcal{N}(u)$ instead of the broadcasting process details.)

After getting the $\mathcal{N}(u)$, each node u can calculate its $CH_1(u)$ set by the boolean operation with $\mathcal{N}(u)$ and u's s-disjunct code. The $CH_1(u)$ is primary channel to u,but secondary to the $\mathcal{N}(u)$. It could be proved that when $s \geq |\mathcal{N}(u)|$, $BoolSum(\mathcal{X}(\mathcal{N}(u)))$ will not be covered by $\mathcal{X}(u)$,which means there exists at least one row in $\mathcal{X}$ that $\mathcal{X}(u) = 1$ but all $\mathcal{X}(\mathcal{N}(u)) = 0$, so $CH_1(u)$ exists surely.

Algorithm 1. A distributed wireless channel allocation scheme for vehicle networks

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Input: The initial information of each node u: C, $ChEstimate(u)$, $N_1(u)$, $NumCh(u)$, $R(u)$, $Rate(u)$.
Output: Each node u chooses its primary channel $CH_1(u)$ to send important information and the channel set $CH_2(u)$ to deliver large amounts of packets.
step 1: Each node broadcasts its ID and forward the received neighbor ID once, thus everyone will get the $\mathcal{N}(u)$.
step 2: $\forall u \in V, CH_1(u) =$
$Channels(BoolSum(\mathcal{X}(\mathcal{N}(u) \bigcup \{u\}))) \bigoplus BoolSum(\mathcal{X}(\mathcal{N}(u)))$
$\triangleright$ find the primary channels for u, and secondary channels for $\mathcal{N}(u)$, then choose one to be the $CH_1(u)$.
step 3: $\forall u \in V, AvaliableCH(u) = C -$
$\sum_{v \in (\{u\} \bigcup \mathcal{N}(u))} CH_1(v)$. ($C$ represents the whole channel set)
step 4: $\forall u \in V, Priority(u) = \frac{R(u)}{Rate(u)}$, and send it to their $\mathcal{N}(u)$.
step 5: $\forall u \in V, Sort(Priority(v)), v \in (u \bigcup \mathcal{N}(u))$, thus we can get each node u's priority order $Seq(u)$ among the nodes in $\mathcal{N}(u)$.
step 6: $Token = 1$;
step 7: $\forall u \in V$, **if** $Seq(u) == Token : CH_2(u) =$ the highest $NumCh(u)$ channels on the value of $Estimate(u)$ among the $Available(u)$.

if $|CH_2(u)| < NumCh(u)$

then $Pritority(u)$ Add **endif**

$Token = Token + 1$ **endif**.
step 8: **if** there exists any node u which has not been involved in the allocation scheme, **turn to step 7**;
else **break**;

II: Now each node need to calculate some information which will be used later. First, they have to confirm their own available set to make OFDMA: just cut the primary channels of their own as well as their interference neighbour set

$\mathcal{N}(u)$'s form the whole giant channel set (neighbor's primary channels can be gotten by computing themselves or form neighbor's broadcast). After that, each node compute its own priority among $\{u+\mathcal{N}(u)\}(Priority(u))$ and the channel number u perhaps need($NumCH(u)$). the $Priority(u)$ can be computed by the ratio of $R(u)$ and $Rate(u)$, which suggests that the user with more quantity messages to send and lower send speed should get the higher priority (Make every node can transmit its information evenly to guarantee the fairness). Each node send its own $Priority(u)$ to $\mathcal{N}(u)$, and $NumCH(u)$ can be gotten from the $BABS$ algorithm or just by fuzzy processing with the $R(u)$.

The node u needs to sort the $Priority$ of u and $\mathcal{N}(u)$ and take notes each sequence as $Seq(u)$ after receiving the priority from $\mathcal{N}(u)$. $Seq(u)$ shows the sequence for node u to choose the channel among $\mathcal{N}(u)$. It's strictly related with the $Priority(u)$, which guarantees the fairness of the principle of channel allocation.

For each node, we set a global variable $Token = 1$, then all the nodes which satisfy the condition $Seq(u) = Token$ start to make a decision to select the highest $NumCh(u)$ channels on the value of $Estimate(u)$ among the $Available(u)$, and make this as $CH_2(u)$. Each node broadcast the $\mathcal{N}(u)$ and the receiver v begin to adjust the $Available(v)$. The adjustment operation is just cut the $CH_2(u)$ from $Available(v)$ and then make the $Token$ add one. So until every node has been allocated the required channels.

We must notice that there may exist one node whose available channel set is empty (It means the quantity of message this node need to send is small, and with high transmission speed, thus it's reasonable for the node to send packets through the $CH_1(u)$). We make a compensation that add a appropriate constant on its priority, which leads to that node can get better channels with high opportunity in the next allocation process after the network topology changes.

4 Performance Analysis

To be clear about the performance of our assignment,We try to give some conclusion theoretically as follows.

Lemma 1. *If $s \geq |\mathcal{N}(u)|$ and $\mathcal{N}(u)$ is the complete set of interferers of u for any node,the $CH_1(u)$ exists surely.*

Proof. Since $\mathcal{X}$ is an s-disjunct code,$BoolSum$ $(\mathcal{X}(\mathcal{N}(u)))$ dose not cover $\mathcal{X}(u)$,which means that there exists at least one row in $\mathcal{X}$ at which $\mathcal{X}(u)$ has the value 1 and all $\mathcal{X}(\mathcal{N}(u))$ have the value 0.Therefore the conclusion $CH_1(u) \neq \varnothing$ holds.

Lemma 2. *If the channel set u's first choice $CH_1(u) \neq \varnothing$,then u has no interference with its two-hop neighbor $\mathcal{N}(u)$.*

Proof. Given that $CH_1(u) \neq \varnothing$,node u picks a channel $\alpha \in CH_1(u)$.And we know that form lemma 1 in the $\mathcal{X}$,on the αth row,

$$\mathcal{X}(\alpha, u) = 1, but \quad \mathcal{X}(\alpha, \mathcal{N}(u)) = 0 \qquad (\forall v \in \mathcal{N}(u))$$

In other word,the channel α is primary to u, and secondary to $\mathcal{N}(u)$. So node u can pick up a channel α from $CH_1(u)$,which will not be in interference with $\mathcal{N}(u)$.

Theorem 1. *If $CH_1(u) \neq \varnothing$ holds for $\forall u \in V$ and $\mathcal{N}(u)$ is the complete set of interferers of u in the network $G(V;E)$,the communications with $CH_1(u)$ can be guaranteed interference. free in the network.*

Proof. The theorem holds from Lemma 1 and Lemma 2.

Theorem 2. *The proposal assignment based on the above algorithm can guarantee the instantaneity of each node to send real-time information.*

Proof. For each node u,it can always pick the $CH_1(u)$ as the one to send significant information.We only need to proof that any node in the its interference set won't use same one as follows.We pick the channel $\alpha \in CH_1(u)$ as the selected one for simplicity:

$\forall$ node $v \in \mathcal{N}(u)$,the channel it might use must be in either $CH_1(v)$ or $AvailableCH(v)$.On the one hand,it could be proved that $CH_1(u) \bigcap CH_1(v) = \varnothing$ by the definition of CH_1 on our allocation scheme.Therefore $\alpha \notin CH_1(v)$.On the other hand,as our algorithm, $AvaliableCH(v) = C - \sum_{w \in (\{v\} \bigcup \mathcal{N}(v))} CH_1(v)$. And $v \in \mathcal{N}(u)$,so $u \in \mathcal{N}(v)$,which means $u \in W$,then $CH_1(u) \bigcap AvaliableCH(v) = \varnothing$.Therefore no one node in $\mathcal{N}(u)$ will use the channel α.In other word,node u can pick the $CH_1(u)$ without any interference at any time,which means can the instantaneity is guaranteed.

Generally,On our scheme,To choose one better primary channel on the first step,for a node,which is influence most crucial for the nodes' performance.We then briefly try to make an analysis on the network's performance which choose the primary channel at the Super-imposed Code we provided.There is no doubt that if each node could choose the channel with highest estimated value as the primary one,then all the nodes do the best.Before discussion,we need two premise:$K \geq |\mathcal{N}(u)|$,and $s \geq |\mathcal{N}(u)|$;thus the first step to choose channel could work successfully,and it's a reasonable assumption and can be easy to satisfy.

Theorem 3. *If the condition each node u has its exclusive best channel $B(u)$ and mutually disjoint.Then there must be one assignment solution to make sure that all node can get its best.*

Proof. It could be proved that there exists one simple but effective scheme which could achieve the goal:just make each node select the channel with highest estimated value among its available channel set.In fact,given a node u,it selects the $B(u)$,and $B(u)$ has the maximum value when node u make the channel estimation on the whole channel set.u can always get the $B(u)$ unless the channel $B(u)$ has been chosen by another node $v (v \in \mathcal{N}(u))$ at the same time.Hence there is $B(u) = B(v)$ as the scheme.which contradicts with the premise.In other word,every node can get its exclusive best channel. which proved our proposition is tenable.

This conclusion reflects in our algorithm:Under the given premise on the 3,node u just need to choose the channel with maximum estimated value after computing the candidate channel set $Channels(BoolSum(\mathcal{X}(\mathcal{N}(u) \bigcup \{u\}))) \bigoplus BoolSum(\mathcal{X}(\mathcal{N}(u)))$,then it could get its best primary channel.

Of course the premise of3 can be always satisfied.Hence we need to make another analysis and estimation of network performance on an universal condition.

Theorem 4. *Each node u chose the channel according to its own like,and there are K channels totaly.The maximum number of nodes' neighbor is $\mathcal{N}(u)$.When $K \geq \mathcal{N}(u)$ holds,the probability of each node get its own best is $\frac{K(K-1)\cdots(K-\mathcal{N}(u))}{K^{\mathcal{N}(u)+1}}$.*

Proof. Because each node u only is related to its $\{\mathcal{N}(u)\}$ on the first choose step.We might as well to simplify the model,and just to focus on the selection process among one local independent set $u \bigcup \mathcal{N}(u)$.The node u is random and arbitrary,Hence the original problem can be converted into a reasonable,simple problem of combination and can be described as follows:

There are N people who would select items from a set of size K,and it conflicts when the same item gets to be multiple selected.we need to compute the probability of system without conflict.

Answer:N people try to choose in-order:When computes the chose option number without conflict,first person have K options,and the next only have $(K-1)$ options,Hence it totally counts to $K(K-1)\cdots(K-N+1)$;As for the whole choose way including the conflict:Each person can chose K.The goal probability is $\frac{K(K-1)\cdots(K-N+1)}{K^N}$.

Corresponding to the original problem,N people represents the set $\{u \bigcup \mathcal{N}(u)\}$ of size $\mathcal{N}(u)+1$.The item set represents the channel set of size K.Hence the probability that each node chose its best channel is $\frac{K(K-1)\cdots(K-\mathcal{N}(u))}{K^{\mathcal{N}(u)+1}}$.

Actually,we make a statistics about the real probability on the Section 5.In our experiment,$K = 13, \mathcal{N}(u) = 4$,so the probability $\frac{K(K-1)\cdots(K-\mathcal{N}(u))}{K^{\mathcal{N}(u)+1}} = 41.59\%$. The practical result is 40%,which proves our conclusion is correct and realistic.

Sometimes,we don't have to be restricted to the only best channel,when the condition relieves:each node could chose another channel $B_2(u)$ if the best channel $B_1(u)$ has been chosen.It can be formalize as a complete matching on a special bipartite graph as 1:Each node among the set N has two sides,while the Node of set K doesn't need to. It's a complicated problem to compute the probability that the bipartite graph have the complete matching.But we can get some perfect result if we add some little restriction on the K set.

- **I**:If we can make sure that for each node in set K,the degree d of node holds for $d \leq 2$,then it could be proved that the complete matching exists.

  Proof. Given that $d \leq 2$holds,we can just make a complete matching with some little steps as follows:

①: First to find out all the nodes in set K and only have one side connected to nodes in N to compose a subset $\hat{K}$ and the corresponding subset$\hat{N}$(it's the nodes which are linked by red line in our example .Fig.1).Make these nodes in $\hat{N}$ match the nodes in $\hat{N}$.Each node in $\hat{K}$ links to one node in $\hat{N}$,and each node in $\hat{N}$ has at least one link or even more with $\hat{K}$.Hence the match is easy to be made.
②:After the matching in first step,then we could remove all the nodes in set $\hat{K}$ or $\hat{N}$ from the whole node set.and then cut off all the lines which are linked with any node in set $\hat{K}$ or $\hat{N}$.Also,if the node in K has no side,it's nothing important with our matching,it should be removed at the same time.
③:There may be some new node with one side because of the lines' cut.And we need to repeat the work in ①,② until there are no node in K which has one side.In other word.All the nodes in K and N have two links with the node in the other set.It's easily to be proved that they form a series of circle,and obviously easy to make a matching in a circle(in our example .Fig.1,it's only need to select any two line which are not adjacent from the circle with blue lines).Hence the goal has achieved.

– **II**: In fact, we can make alternative relax on the restriction:If the degree d_i of each node i in the K,satisfy the equation:$d_i > 0$.The matching always exists too.(The proof is like above)

We make some useful work like above to provide some theoretical proof on the realistic performance on our algorithm. To sum up,the selection scheme could make our user to get pretty good channel on the whole to send important information and also offer enough channels for them to improve services on demand.which could make a better optimization of resource allocation to a extent.

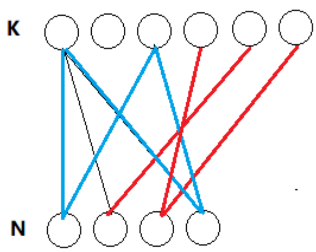

Fig. 1. A particular bipartite graph

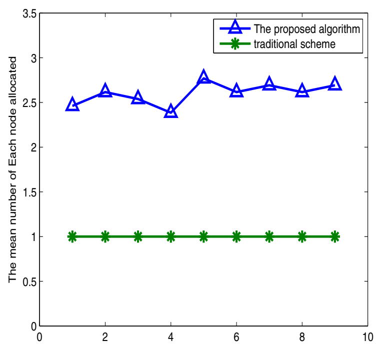

Fig. 2. The average number of wireless channel reused

5 Simulation Results

We simulate the channel allocation scheme mentioned above on MatLab platform. We compare this scheme with the original solution mainly on the number of repeated used channel and the system's ability to prove the advantages and improvements.

In the process of simulation, We ignore details of transmission process and the status of channels to focus on the effect of our scheme (In fact, we still have made the implementation of a typical OFDM system to guarantee the completeness). Because the fairness of each user must be ensure, the status (channel estimation, forecast throughput) of each node and the topology (the distribution and the contact between the various nodes) of the whole network are all randomly generated with the given requirements, which ensures the universality of our results.

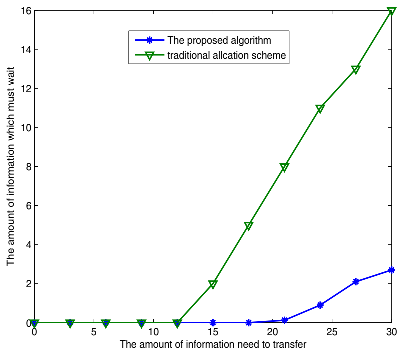

Fig. 3. The change about the queue length of the network node under load gradually to increase

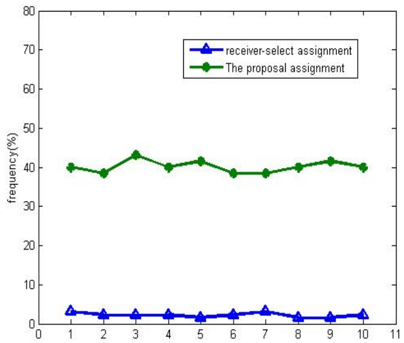

Fig. 4. The probability of each node chose its best channel

In the protocol interference model, a node will not be interfered when transmitting messages if and only if there is no neighbor within two-hop distance using the same channel as that it's using. If we apply the multiplexing on those nodes without interference, the number of channels can be used on the whole network will be greatly increased. In the traditional OFDMA solution, each node monopolizes its own channels. We compare the number of channel multiplexing in our simulation (as shown in Fig.2) and it is obviously that the traditional scheme of a single node monopolize a single channel is of great disadvantage. The new scheme takes 13 channels as example and it shows that each channel is reused about 2.5 times generally, which means that we can increase the throughput capacity of network greatly without any increase in bandwidth and cost of the whole system.

While measuring a network system, it is indispensable to check the performance of system with a heavy load to make sure the reliability and stability of our results. Fig.3 has embodied the performance of traditional algorithm well and the proposed scheme in the state of network load gradually to increase. We use the sum of the length of each node's waiting queue when this node can't send all its packets with all the allocated channels to measure the ability of robustness under heavy load .It apparently shows that the waiting queue will begin to appear when the number of load is bigger than 13 (We take the packet number that a channel can quickly send out alone as the unit "1") by the traditional scheme. And the length of queue increases quickly, when the number of the load is up to 30 or so, the length of waiting queue has reached 16, exceeded the node number, which means each node now is waiting to send packets but all the wireless channels are occupied. In other words, the network has almost supersaturated and even paralyzed. In contrast to the original solution, the network that take proposed allocation scheme will not have any waiting queue until the load is heavy and still be of strong capacity of load, while the network with traditional scheme has already been paralyzed.

In addition to the obvious advantages mentioned above, the fairness of our new algorithm also cannot be ignored: A node with a large amount of information to send and slow sending speed can be allocated more channel resources, thus it could reduce the waste of channel resources by the optimization of the matching of the whole channel resources. In addition, the cost of base station brought by the centralized allocation and the disadvantages such as waiting delay of the process of gathering whole information and analysis can be avoided by the distributed allocation solution better.

Our assignment is based on the "Sender-select",and some others have proposed the "Receiver-select"[12].They allocate each node one channel for receiving,and then any other who want to communicate with it must send the packets on the channel the receiver selected.Thus every node only need to listen its own channel.It greatly reduced the receiver's workload.But on the contrary,the delivery process is getting more complicated.There are exists several disadvantages which is not with our algorithm such as switch delay,channel collision and the cost to send control information in all channel.

To evaluate the rationality of our allocation,we make a comparison between our scheme and the "Receiver-Select" on the probability of each node chose its best one(see the Fig 4).In the "Receiver-Select" scheme,the value is less than 10%.But in our scheme, the average probability of each node chose the best channel(the channel which has the max channel estimate value with the node)is about 40%(the theoretical probability could be calculated with the theorem4 and the value 41.59% is very close to 40%),which means half the node can use the best channel to send information.In other word,we can improve the load capacity and Qos through our scheme to optimize the channel allocation.

6 Conclusion

This paper proposes a distributed fair channel allocation scheme to realize reliable and high throughput transmission. In the proposed channel allocation design, we can ensure realtime message transmission in a reliable way with little interference, on the other hand, we achieve high throughput through dynamic priority based channel allocation with OFDMA. and we have proved some theorem to explain why our scheme could performance better. In our future work, we will combine MIMO technology with OFDMA.

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