Competent Broadcasting in MANET

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Abstract - **In Mobile Ad Hoc Network, flooding is the vital operation. Flooding suffers from signal collision, excessive redundant of messages and resource contention. This causes high protocol overhead and interference with the existing traffic in the networks. In the existing system flooding algorithms require every node has to maintain 2-hop (or more) neighbors information. In our proposed system we introduced two efficient broadcasting algorithms based on 100 percent deliverability and every node maintaining 1-hop neighbor information. First, sender based broadcasting algorithm that reduces the Time complexity of computing forwarding nodes to O (n). Here, the number of forwarding nodes in worst case is 11. Second, a simple and highly efficient receiver based broadcasting algorithm, where nodes are uniformly distributed, we prove that the probability of 2 neighbor nodes broadcasting the same message exponentially decreases when the distance between them decreases or when the node density increases. Using simulation results, we confirm that the number of broadcasts in our proposed receiver based broadcasting algorithm can be even less than one of the best known approximations for the minimum number of required broadcasts.**

Index Terms — Flooding, broadcasting, mobile ad -hoc networks, wireless networks.

I. INTRODUCTION

A mobile ad-hoc network (MANET) is a collection of nodes, which have the possibility to connect on a wireless medium and form an arbitrary and dynamic network with wireless links. That means the links between the nodes can change during time, new nodes can join the network, and other nodes can leave it. A MANET is expected to be of larger size than the radio range of the wireless antennas, because of this fact it could be necessary to route the traffic through a multi-hop path to give two nodes the ability to communicate. There are neither fixed routers nor fixed locations for the routers as in cellular networks. A MANET has no permanent infrastructure at all. All mobile nodes act as mobile routers.

Flooding is one of the most fundamental operations in mobile ad hoc networks. Most of the major routing protocols, such as DSR [11], AODV [10], ZRP [9], etc., rely on flooding for disseminating route discovery, route maintenance, or topology update packets. The simplest broadcasting algorithm is flooding, in which every node broadcasts the message when it receives it for the first time. Using flooding, each node receives the message from all its neighbors in a collision-free network. Therefore, the broadcast redundancy significantly increases as the average number of neighbor's increases. High broadcast redundancy can result in high power and bandwidth consumption in the network. Moreover, it increases packet collisions, which can lead to additional transmissions. This can cause severe network congestion or significant performance degradation, a phenomenon called the broadcast storm problem. The main objective of efficient broadcasting algorithms is to reduce the number of broadcasts while keeping the bandwidth and computational overhead as low as possible. Some broadcasting algorithms such as flooding and probabilistic broadcasting algorithms [6], [4] do not rely on neighborhood knowledge. These algorithms cannot typically guarantee full delivery and/or effectively reduce the number of broadcasts. However, these algorithms either perform poorly in reducing redundant transmissions or require each node to maintain 2-hop neighbor information. Maintaining 2-hop neighbor information for each node incurs extra overhead of the system and the information can hardly be accurate when the mobility of the system is high.

A dominating set is a subset of nodes such that every node in the graph is either in the set or is adjacent to a node in the set.. Any routing in MANETs can be done efficiently via CDS [7]. Although finding minimal CDS is NP-hard even in unit disk graph [11], however, maintaining a CDS in the network is costly, which is not suitable for flooding operations in highly mobile situations.

In the proposed model, the broadcasting algorithms reduce the number of broadcasts and achieve local optimality by selecting the nodes with a higher battery life time to forward the message. Forwarding-node selection algorithm results in fewer broadcasts in the network. For efficient broadcasting, if sender-based broadcast algorithm based on N nodes are used, the number of forwarding nodes can be reduced from O(n) to O(11) nodes in the worst case by using battery life time and in receiver-based broadcast the size of the message is not increased by adding a list of forwarding nodes

We prove that our proposed sender-based algorithm can achieve full delivery with time complexity O (n). We also propose a receiver-based broadcasting algorithm. In this, the receiver decides whether or not to broadcast the message. The proposed receiver-based algorithm can significantly reduce the number of broadcasts in the network. We show that using our proposed receiver-based algorithm, two close neighbors are not likely to broadcast the same message. The number of broadcasts using our

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receiver-based algorithm is less than one of the best known approximations for the minimum number of required broadcasts. We propose a simple and highly efficient receiver-based broadcasting algorithm.

II. SYSTEM MODEL

In Broadcasting one node sends message to all other nodes. Efficient Broadcasting algorithm are used to keep the efficiency and computational overhead as low as possible. Flooding is a broadcasting algorithm which results in broadcast redundancy. For efficient broadcasting sender-based and receiver-based broadcasting algorithms are used. The flooding approach for the broadcast storm is proposed to avoid the problems of redundant rebroadcasts, contention and collision. Adaptive approaches provides better performance than flooding and also do not rely on neighborhood knowledge and results in number of broadcasts. The medium access control (MAC) protocol for IEEE 802.11 is a CSMA/CA protocol. CSMA/CA sender tries to avoid collision.

We assume that all nodes are located in a 2D plane and have a transmission range of R. We assume that the network is connected. Two nodes are considered neighbors if they are in the transmission range of each other. We suppose that each node knows its location via a localization technique such as Global Positioning System. Each node periodically broadcasts a very short Hello message, which includes its ID and position. Thus, each node gets the position of its neighbors as well. In the medium access control layer, we assume that scheduling is done according to the p-persistent CSMA/CA protocol, which is based on IEEE 802.11 in the broadcast mode. In the p-persistent CSMA/CA protocol, when a node has a message to transmit, it initiates a defer timer by a random number and starts listening to the channel. If the channel is busy, it continues to listen until the channel becomes idle. When the channel is idle, it starts decrementing the defer timer at the end of each time unit. The message is broadcast when the timer expires. Several flooding schemes that use 1-hop information and guarantee 100 percent deliverability were discussed in [6].

AODV allows mobile nodes to obtain routes quickly for new destinations, and does not require nodes to maintain routes to destinations that are not in active communication. AODV allows mobile nodes to respond to link breakages and changes in network topology in a timely manner. The operation of AODV is loop-free, and by avoiding the "counting to infinity" problem offers quick convergence when the ad hoc network topology changes (typically, when a node moves in the network). One distinguishing feature of AODV is its use of a destination sequence number for each route entry. The destination sequence number is created by the destination to be included along with any route information it sends to requesting nodes. Using destination sequence numbers ensures loop freedom and is simple to program.

Efficient broadcasting algorithms are used to reduce the number of broadcasts while keeping the bandwidth and computational overhead as low as possible. In efficient broadcasting algorithm forwarding-node set selection results in fewer broadcasts in the network. The algorithm use MAC layer to schedule a broadcast and to reduce network traffic by using standard IEEE 802.11. Two efficient broadcasting algorithms are implemented. They are, Efficient Sender-Based Broadcasting Algorithm and Efficient Receiver-Based Broadcasting Algorithm

III. PROPOSED SYSTEM

A. An Efficient Sender-Based Broadcasting Algorithm

Our first proposed broadcasting algorithm is a sender-based algorithm, i.e., each sender selects a subset of nodes to forward the message. Each message can be identified by its source ID and a sequence number incremented for each message at the source node. Algorithm 1 is a general sender-based broadcasting algorithm and indicates the structure of our proposed sender-based broadcasting algorithm. After receiving a message from the sender each node schedule a broadcast. If the node is selected by the sender, and if it has not scheduled the same message before, then the message has been broadcasted. Otherwise node will drop the message. Each node may only schedule a broadcast when it receives a message for the first time.

Broadcast schedule can be set by using timer in MAC layer. Broadcasting algorithm can reduce both the computational complexity of selecting the forwarding nodes and the minimize number of selected nodes even in the worst case. Upon expiration of the timer, the algorithm requests the MAC layer to schedule a broadcast. The message scheduled in the MAC layer is buffered and then broadcast with a probability p. This adds another delay in broadcasting the message. The MAC-layer delay in IEEE 802.11 is a function of several factors including the network traffic. Note that there is a chance that a node changes its decision (regarding the selected nodes or regarding whether to broadcast) during the MAC-layer delay due to receiving other copies of the message. The network can be represented as a unit disk graph G (V, E).

We assume the network is connected. Each node v in V has a unique ID, denoted by id (v). Let N (v) denote the set of neighbor nodes of v. That is, nodes in N (v) are within the transmission range of v and can receive signals transmitted by v. Node v needs to know the information of its direct neighbors, including their IDs and their geographic locations. The 1hop neighbor information can be easily obtained from the HELLO messages periodically broadcasted by each node.

The basic idea scheme is as follows. When a node (source) has a message to be flooded out, it computes a subset of its neighbors as forwarding nodes and attaches the list of the forwarding nodes to the message. Then, it transmits (broadcasts) the message out. After that, every node in the network does the same as follows. Upon receiving a flooding message, if the message has been received before, it is discarded; otherwise the message is delivered to the application layer and the receiver checks if itself is in the forwarding list. If yes, it computes the next hop forwarding nodes among its neighbors and transmits the message out in the same way as the source. The message will eventually reach all the nodes.

B. Forwarding-Node Selection Algorithm

A forwarding node is a downstream node designated by the current node that will forward the broadcast packet. Forwarding node can be selected based on following constraints. Let LB_A (P) and RB_A (P) denote the left bulged slice, right bulged slice of P around A respectively. The B-coverage set of node can be represented as a subset of neighbors of N_A is called a B-coverage set of N_A if any nonempty bulged slice around A contains at least one node from the set. A bulged slice is empty if there is no node inside it.

Suppose that node N_A uses the forward node selection algorithm to select the forwarding nodes from its neighbors. Let us assume that N_A stores all of its neighbors IDs and locations in an array of length n, where n is the number of neighbors. The algorithm selects the first node N_{S1} randomly from the array. The first node can also be selected deterministically by, for example, selecting the node that is the farthest away from N_A. It represent in Fig.1.

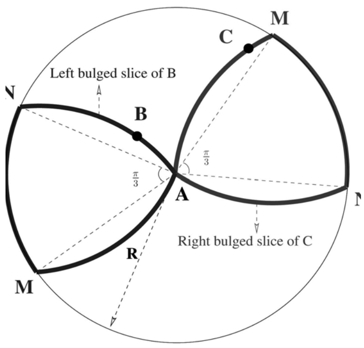

Fig.1. Left bulged and Right bulged slice around 'A'

A forwarding node selection algorithm is called a slice-based selection algorithm if for any node NA, it selects a B-coverage set of it. We first show that Algorithm 1 can achieve full delivery if it uses any slice-based algorithm to select the forwarding nodes. We then present an efficient slice-based algorithm that selects 11 nodes in the worst case and has computational complexity O (n), where n is the number of neighbors.

Algorithm 1: A general sender-based algorithm

Algorithm 1 shows the basic structure of our proposed sender-based broadcasting algorithm. Each node schedules a broadcast for a received message if the node is selected by the sender and if it has not scheduled the same message before. Clearly, each message is broadcast once at most by a node. A broadcast schedule can be set at any time. For example, a message can be dropped after the first reception but scheduled for broadcast the second time.

```
Extract information from the received message M.
 if M has been scheduled for broadcast or does not
        contain node's ID then
        drop the message
else
        set a defer timer
end if
When defer timer expires.
Select a subset of neighbors to forward the message.
Attach the list of forwarding node to the message.
Schedule a broadcast
```

Theorem 1: In a collision-free network, Algorithm 1 can achieve full delivery if it uses a slice-based selection algorithm to select the forwarding nodes.

Theorem 2: The proposed slice-based selection algorithm will select at most 11 nodes.

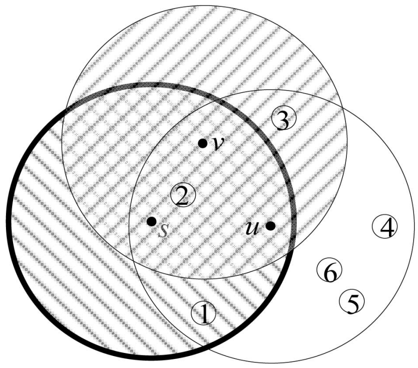

Fig.2. An example of optimizing F (u)

C. Forwarding node optimization

In sender-based broadcasting algorithms each broadcasting node attaches a list of its selected forwarding nodes to the message before broadcasting it. This procedure will increase the bandwidth and power required to broadcast the message. Forward node can get reduce by sorting the neighbor's weight. Node weight can represent the neighbour's battery life time or its distance to N_A or the average delay of the node, the level of trust, or a combination of them. Forward node selection algorithm reduces the number of selected forwarding nodes to 11 in the worst case.

In this scenario assume that the weight of each node represents its battery lifetime in a wireless network. It may be desirable to select the nodes with a higher battery lifetime to forward the message in order to keep the nodes with a lower battery life time alive. By selecting node with higher battery lifetime to forward message an optimal solution can be obtain.

Theorem 3: The OptFwdNodes algorithm guarantees that all nodes can receive a flooding message. Time complexity of the proposed slice-based selection algorithm is O (n), where n is the number of neighbors.

Theorem 4: In a collision-free network, Algorithm 2 can achieve full delivery if it uses the proposed RBS to determine whether or not to broadcast.

Algorithm2:A general receiver-based algorithm

```
Extract information from the received message M
      if M has been received before then
           drop the message
      else
           set a defer timer
      end if
 When defer timer expires
decide whether or not to schedule a broadcast
```

D. Highly Efficient Receiver-Based Broadcasting Algorithm

Receiver-based broadcasting algorithm can significantly reduce redundant broadcasts in the network. The main design challenge of receiver-based broadcasting is to determine whether or not to broadcast a received message. In receiver-based broadcasting algorithms, the receiver of the message decides whether or not to broadcast the message. Therefore, a potential advantage of receiver-based broadcasting algorithms over sender-based ones is that they do not increase the size of the message by adding a list of forwarding nodes.

A trivial algorithm is to refrain broadcasting if and only if all the neighbors have received the message during defer period. Although this algorithm is simple to implement, it has limited effect in reducing the number of redundant broadcasts.

Suppose N_A's defer time expires at t_0. Using the above strategy, node N_A will broadcast if some of its neighbours (at least one) have not received the message by t_0. However, this broadcast is redundant if all such neighbours receive the message from other nodes after time t_0. This scenario typically occurs when t_0 is small compared to the maximum defer time. To avoid this responsibility-based scheme it reduces the redundant broadcasts without any changes in the MAC-layer defer-time design.

E. Responsibility-Based Scheme

Algorithm 3 shows the proposed RBS. The main idea of Algorithm 3 is that a node avoids broadcasting if it is not responsible for any of its neighbors. As shown in the figure 3 node N_A is neighbor to node N_B, N_C such that node N_A is not responsible for a neighbor N_B if N_B has received the message otherwise N_C will responsible for the received message. The output of RBS determines whether or not the broadcast is redundant.

In RBS the initial step first uses this information to determine which neighbors have not received the message. It then returns false if and only if it finds a neighbor has not received the message otherwise it return true.

In modified RBS**,** the position and transmission range of the broadcasting nodes are used to determine which neighbors have not received the message. It then returns false if and only if it finds a neighbor that has not received the message.

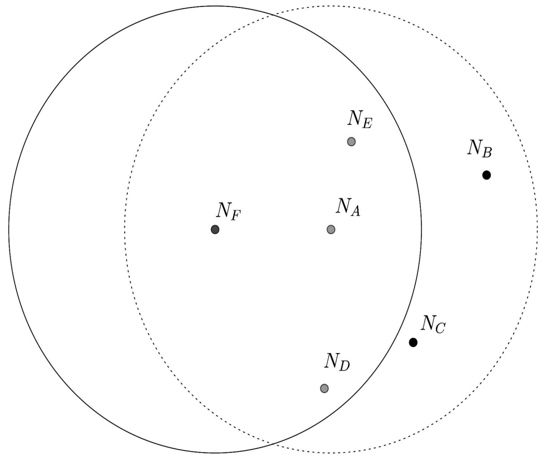

Fig .3.An Example of RBS Decision

Algorithm 3: Responsibility Based Scheme

```
Input: ListA: List of all neighbors of NA, and
ListB: List of broadcasting neighbors
Output: true or false
ListC ←ListA
for i =1; i ≤ length(ListC);  i++ do
for j = 1; j ≤length(ListB);  j++ do
if dist(ListC[i]; ListB[j]≤ R then
removeElement(ListC[i]; ListC)
break
end if
end for
end for
ListD ← ListA - ListC
for i =1; i ≤ length(ListC); i++ do
check← true
for j = 1; j ≤length(ListD); j++ do
if dist(ListC[i]; ListD[j]) < dist(ListC[i];NA)
then
check ←false
break
end if
end for
if check then
return (false)
end if
end for
return (true)
```

As shown in Fig. 3, NA has five neighbors. Suppose that NA has received a message from NF. Note that NA has the position of all its neighbors. Therefore, it can find that NE and ND have received the message but NB and NC have not. As shown in Fig. 3, NA is not required to broadcast. Using Algorithm 3, each node broadcasts a message at most once. Therefore, broadcasting will eventually terminate. The proposed RBS can significantly reduce the number of broadcasts in the network.

In particular, our simulation shows that using RBS, the average number of broadcasts is less than one of the best known approximations for the minimum number of required broadcasts.

It is also possible that node NB receives the message from more than one neighbor in it's defer period. In this case, the number of NB's neighbors that have received the message increases, and the number of that have not received the message decreases. Consequently, the probability that NB is required to broadcast the message further decreases compared to the case where NB receives the message from only one neighbor. It is worth mentioning that RBS can guarantee that the number of forwarding nodes is within a constant factor of the optimal solution (minimum CDS) if it is provided with 2-hop neighbor information [1].

IV SIMULATION

A pure MANET scenario similar to the simulations was set up in order to gain some experience and to verify the structure of the experiment. The simulation settings were as follows:

- 125 wireless nodes. Simulation area of 1500m×300m. A rectangle area is chosen to have longer distances between the nodes than in a quadratic area, i.e. packets are sent over more hops.
- IEEE 802.11 MAC.
- Two ray ground propagation model.
- Node mobility defined by random waypoint movement model.
- Constant bit rate traffic.

Input value: Transmission Range, Network Size, propagation bandwidth, no of node, routing protocol, channel usage. Loss monitor tool usage in the agent through that we calculate the no of packet received and data loss and throughput.

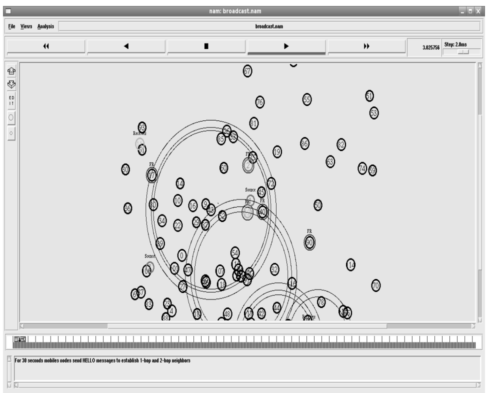

Fig.4. Broadcasting signals

Fig 4 shows broadcasting signals within range of bulged slice model transmitting packets between nodes and selecting the forwarding nodes based on the criteria of selecting the node that is the farthest away from broadcasting range the left bulged slice and right bulged slice around coverage, respectively. Fig 5 shows the graph of the number of packets received in the existing vs proposed system.

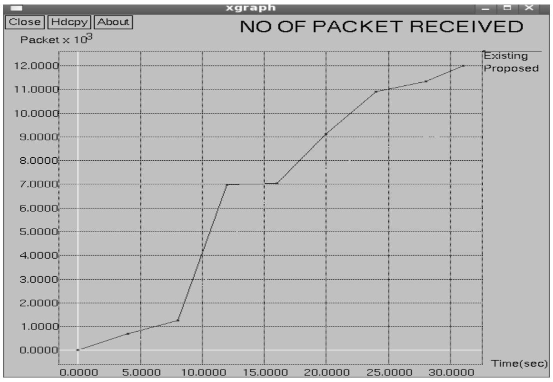

Fig.5. Existing vs proposed system

Fig 6 shows average generated packets versus throughput of receiving bits.

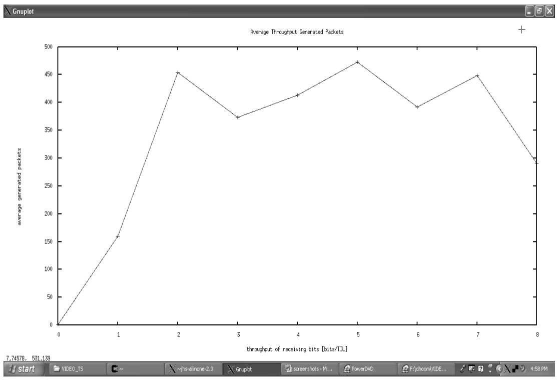

Fig.6.Gnuplot throughput.plot

Fig 7 shows Intermediate nodes received packets versus packet sending time.

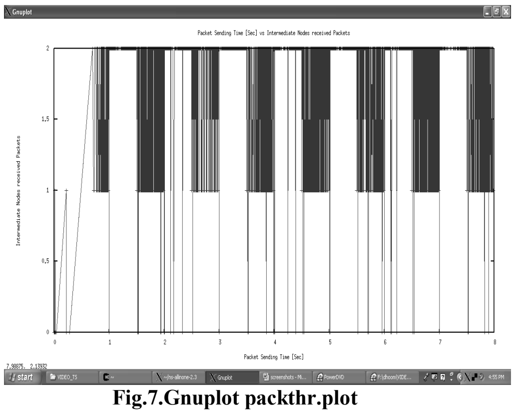

Fig.7.Gnuplot packthr.plot

Performance of our scheme is the best among all schemes. When the number of nodes reaches 600, the number of collisions of our scheme is only 211 while that of Edge Forwarding and CDS-based schemes are 335 and 469, respectively. After that, their collisions are more than 100 percent higher than our scheme.

Fig 8 showsEnd2End delay Versus Packet send time at Source node.

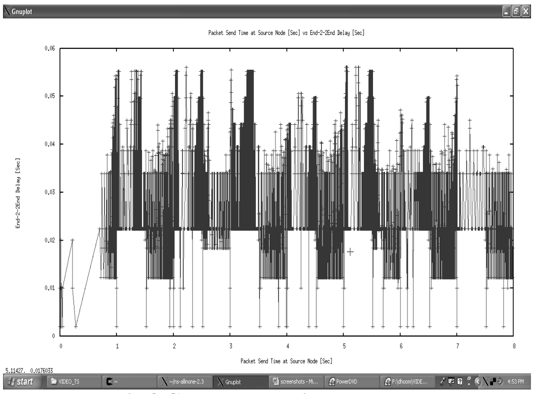

Fig.8.Gnuplot eventtime.plot

Our scheme guarantees 100 percent deliverability when the number of nodes varies from 200 to 400, while deliverability ratios of other schemes are only 75 percent-92 percent around. Although collisions occur in our scheme even the number of nodes is small, a node that misses flooding messages from a forwarding node still has chance to receive messages from another forwarding node. So the value of our scheme can almost reach 100 percent if the number of nodes are in between 200 to 600 (the number of collisions is low). Fig 9 shows End2End delay Versus Throughput

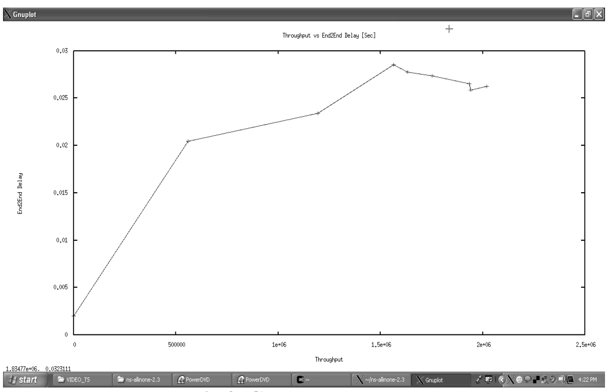

Fig.9. Gnuplot delay.plot

We proved that the proposed forwarding-node selection algorithm selects 11 nodes in the worst case. In practice, the number of selected nodes is typically less than 11. To avoid the complexity of mathematical analysis, we used a simulation to find the average number of selected nodes.

V. CONCLUSION

We have presented an efficient flooding scheme that uses only 1-hop neighbor information. We showed that our proposed forwarding-node selection algorithm results in fewer broadcasts in the network. In the first part, we proposed a forwarding node selection algorithm that selects at most 11 nodes in O (n), this limited number of nodes is an improvement. In the second part, we proposed an efficient receiver-based algorithm and showed why it significantly reduces the number of forwarding nodes in the network. The 2-hop-based version of our existing receiver-based algorithm can guarantee constant approximation to the optimal solution (minimum CDS). This is the first broadcasting algorithm that constructs a CDS "on the fly" and can guarantee both full delivery and a constant approximation ratio to the optimal solution. As part of our future work, we will investigate the necessary conditions to guarantee both full delivery and constant approximation ratio to the minimum CDS.

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