Minimizing Channel Interference in Wireless Networks during Disaster Response Operations

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Abstract – Wireless networks encounter co-channel interference owing to the resource limitations. The number of available channels is limited during disaster recovery operations. Telecommunication services are essential for both emergency responders and civilians in the aftermath of a disaster. An efficient capacity and interference based channel assignment strategy has to be deployed to provide a better estimation of the throughput for quick recovery.

Keywords – disaster; channel assignment; interference.

I. INTRODUCTION

When disasters such as earthquakes, hurricanes and tsunamis strike, disaster response operations are critical to prevent death and injury. Telecommunication systems are often disrupted in disaster areas. Wired and wireless network cooperation (NeCo) system to quickly recover civilian telecommunication services has been proposed. The NeCo system achieves both rapid recovery and throughput using wireless bypass routes backhauled by wired networks. With the NeCo system, active leaf nodes relay packets to and from dead leaf nodes whose wired communication channels have been disrupted. Optimal bypass routes are computed to maximize the expected wireless throughput by solving a linear programming problem. The number of dead nodes connected to the same active node should be considered for a better estimation of the throughput. Some of the bypass routes share the same channel owing to the limited number of available channels. Thus, a channel assignment strategy based on capacity and interference to minimize the co-channel interference among bypass routes is developed.

II. EXISTING SYSTEM

NeCo system focuses on the fringe areas of disasters [1]. Root nodes are placed in central offices. Leaf nodes are deployed based on the demand distribution, and these are connected to the root nodes with wired networks. Either a single- or double-star topology can be used. A controller is used in order to establish a logical connection to each leaf node. Recovery nodes can be located at candidate points. Recovery nodes are deployed when leaf nodes are distributed in clusters, expanding the application range of the system. They function in the same manner as other leaf nodes. The leaf nodes function with wireless communication and renewable energy, in order to recover communication after disasters. The distribution of leaf nodes is determined by demand distribution. NeCo functions are invalidated under normal operation and initiated only after traffic disruptions occur. When a traffic disruption is detected between a leaf node and a root node, the state of the leaf node changes from active to dead. Optimizing the bypass routes is regarded as a linear programming problem. Optimal bypass routes are then calculated by the controller, based on the distance between dead and active nodes in order to maximize total wireless link throughput. Various channels are appropriately assigned to each bypass route to avoid interference with one another. For the routing metric, the wireless link throughput is determined by the intensity of the reception signal. The IEEE802.11 TGn Channel model as in [12] is used as a propagation model. Dead nodes establish wireless bypass routes to selected active nodes. Consequently, dead nodes can quickly recover communication with the root nodes using these bypass routes. When a disaster occurs, a recovery node acts a relay node to recover communication with other leaf nodes. The recovery node need not be recovered with a bypass route when its wired transmission is determined. The active recovery nodes are added to the set of leaf nodes when the controller calculates the optimal bypass routes for dead leaf nodes. NeCo achieves a higher throughput than wireless multi-hop networks, owing to the cooperation of wired and wireless networks. The bypass routes are limited to single-hop wireless links in order to ensure high throughput and minimize the functions of the leaf nodes. The system improves the throughput of the wireless links by optimizing wireless bypass routes, and it can be employed in standard wired networks irrespective of the topology of the networks. Furthermore, the system can maximize the total expected wireless transmission rate.
for the entire network. The concept of NeCo system is depicted in Fig. 1.

![NeCo system architecture](image)

**Fig. 1 NeCo system architecture**

### III. LITERATURE SURVEY

Network operators must devise a plan for restoring communications in the affected area. Most of the schemes focus on deploying wireless multi-hop networks in disaster-stricken areas. The problem with such schemes is the lacking of promptness when deploying these networks after a disaster. Moreover, the wireless-link throughput decreases in proportion to the number of hops to the destination [13]. A network recovery program has been developed and deployed for emergency network management and business continuity during disasters [7]. Many works focus on facilitating communications among emergency responders using mesh wireless networks [9] [10] [11]. Emergency responders and civilians, a technology that employs a wireless multi-hop backhauling network together with self-organization capabilities powered by renewable energy was proposed [8]. Solar power is one candidate for powering such wireless networks after disasters. The minimum number of non-overlapping channels for interference-free channel assignment to achieve maximum throughput is determined [5]. Contention window extension mechanism integrated with channel switching technique to avoid co-channel interference using distributed cooperative multi-hop scheme was proposed [4]. Interference Aware Channel Segregation based Dynamic Channel Assignment (IACS-DCA) to provide multi-channel access was introduced [6]. IACS-DCA can improve the uplink SIR compared to the conventional quasi-DCA using multi-channel access.

### IV. PROPOSED SYSTEM

The issues such as interference, routing, connectivity affect the network performance in wireless networks. However, by using the appropriate channel allocation algorithm, network quality of service can be optimized. The solution is achieved by selecting the lowest cumulative cost route effectively according to the routing metric and by selecting the channel with minimum interference-capacity ratio. The two key issues in the process of channel allocation are interference and routing. The major factor in reducing network performance is interference. Network throughput has a direct relationship with interference among the links.

Channel allocation in multi-channel not only determines the network topology but also affects the routing directly. The routing determines the distribution of network traffic, and traffic distribution affects the degree of interference among neighbouring links which impacts channel allocation. Therefore, the routing is an important issue in the process of channel allocation. The routing and channel allocation has to be jointly considered because of the mutual dependency in order to make full use of capacity in multi-channel environment. The existing channel assignment schemes use the link based approach. The link based approach suffers from the temporal and spatial spectrum variability cost by spectrum utilization. The network capacity is improved with cognitive route but not related to the channel assignment. Capacity based channel allocation strategy is proposed but did not take into account the route. The proposed channel assignment algorithm only considered interference. Therefore, a new channel assignment strategy, taking into account both channel interference and channel capacity, and a new routing metric is proposed. The limitations of the application of link-based channel assignment are avoided.

#### A. CAPACITY BASED CHANNEL ASSIGNMENT AND ROUTING ALGORITHM

1) **Minimum interference routing algorithm**

The traditional shortest path routing algorithm is used to improve efficiency. In a wireless scenario criteria such as interference and capacity should be considered when routing decisions are made. Routing protocols provide an optimal path facilitating the communication between source node and destination node fast and smooth. An optimal path means that the routing metric cost defined by the path is minimum. A distributed on-demand routing algorithm is used to improve the utilization of network resources. The ideal route in the network is found by the route discovery algorithm in the routing. Each node independently maintains routing table to reach the destination node. The source node broadcasts route request (RREQ) packets when the data sent does not reach the destination node. The destination node on receiving a RREQ unicasts to return route reply (RREP) to the source node. A two-way link between
the source node and the destination node is established when RREP reaches the source node. When the node receives multiple RREQs, selecting the lowest cumulative cost route effectively according to the routing metric. The node broadcasts Hello packets periodically to maintain the neighbours list and further maintain the routing table. An indicator function is defined in order to achieve minimum interference routing.

\[ F_k = \begin{cases} 1, & \text{if } k \in Nu_j, \\ 0, & \text{otherwise}. \end{cases} \]  

(1)

The routing metric is defined as the transmission link costs \( W_{ij} \):

\[ TC_{ij} = \sum_{k \in Nu_j} F_{k,j} \forall i,j \in V \]  

(2)

Where \( TC_{ij} \) denotes transmission link costs from the sending node \( i \) to receiving node \( j \). \( V \) means set of nodes. \( Nu_j \) denotes the number of node \( j \) interfaced by other nodes within two hop interference. The cost depends on the interference level of the link on the receiving node. So, the path is selected with the cost.

\[ TC = \min \left\{ \sum TC_{ij} \mid k,j \text{ is the node on } Q \right\}, \]  

(3)

in which \( Q \) is an optional set of routes.

**Algorithm 1: Minimum interference routing algorithm**

**Input:** \( i \): intermediate node, \( d \): destination node

1) \begin{align*} &2) \quad i_{RouteTable} = \text{Search}_\text{RouteTable} \text{(RREQ)} \\
&3) \quad \text{if } i_{RouteTable} = \text{NULL} \\
&4) \quad \text{Add } RREQ.W \text{ in } routeTable \\
&5) \quad \text{Forward}(RREQ) \\
&6) \quad \text{else if } RREQ.seqno = d_{RouteTable}.seqno \& \& RREQ.W < i_{RouteTable}.W \\
&7) \quad \text{update RouteTable} \\
&8) \quad \text{Forward}(RREQ) \\
&9) \quad \text{else} \\
&10) \quad \text{discard}(RREQ) \\
&11) \quad \text{end} \\
&12) \quad \text{On Receive RREQ}(d) \\
&13) \quad \text{Create}(RREP) \\
&14) \quad \text{Send}(RREP) \text{ and do Channel Assignment} \ \\
&15) \quad \text{end} \end{align*}

According to the algorithm 1 the source node began broadcasting a RREQ for the whole network. The link to reach the destination node is added by the intermediate node \( i \) in the routing table. When the node is forwarding the data, selecting the path of the current minimum link cost from the routing table, and according to the link cost of the next hop forwarding RREQ to the next hop node, so RREQ can spread to the destination node. The destination node \( d \) has been informed of a number of paths from the source node to the destination node, and chooses a path with the smallest cumulative cost to establish routes after receiving all the RREQs. The destination node will send reply (RREP) message to the source node and allocate the channel through the opposite route.

2) **Channel Assignment Algorithm**

A distributed channel allocation algorithm is detailed based on the selected route. The channel allocation along the chosen path should cause less interference in order to increase network capacity. Channel capacity and the interference are to be considered during the channel selection. From all the available channel the best channel is selected according to the ratio of interference and capacity. Each node selects a channel with relatively small interference to neighbours. The performance of network is affected by channel interference. The channel is allocated with minimum interference and maximum capacity for each node to improve network performance in throughput and delay. Channel capacity is defined as the maximum amount of information that the channel can transmit. Each node selects the channel by executing the algorithm 2.

**Algorithm 2: Channel Assignment Algorithm**

**Input:** \( i \): node \( I \), \( A_i \): set of available channels, \( N_i \): set of neighbours for node \( I \), \( A_k \): set of channels for each neighbour node \( k \), \( Inf \): interference for a channel, \( C_i \): the capacity of channel \( i \).

1) \begin{align*} &2) \quad \text{for each } c \in A_i \text{ and } k \in N_i \text{ do} \\
&3) \quad \text{Inf}_i(c, A_k) = \begin{cases} 1, & \text{if } c \in A_k, \\ 0, & \text{otherwise}. \end{cases} \\
&4) \quad \text{Ratio}_i = \sum_{k \in N_i} \frac{\text{Inf}_i(c, A_k)}{C_i} \\
&5) \quad \text{Assigned_channel} = \text{Min} \text{(Ratio}_i) \end{align*}
According to algorithm 2 each node on the selected routes can be assigned a channel with less interference and maximum capacity ratio.

V. CONCLUSION AND FUTURE ENHANCEMENT

A distributed channel allocation and routing algorithm based on capacity and interference to minimize co-channel interference in wireless bypass routes of the NeCo system is proposed. The routing algorithm can effectively choose routing with the lowest cumulative cost, and select the channel taking into account the channel interference and capacity. One future enhancement is to provide leaf nodes with multiple antennas to achieve higher throughput. The co-channel interference can be suppressed using multi-antenna techniques. In adjunct, Multiple-Input Multiple-Output (MIMO) technology should be considered.

REFERENCES


