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A Review of Different Approaches towards Multipath Routing Techniques

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Abstract- Mobile ad hoc networks (MANETs) consist of a collection of wireless mobile nodes which dynamically exchange data among themselves without the reliance on a fixed base station or a wired backbone network. Thus routing is a crucial issue to the design of a MANET. So, we introduce Multipath routing allows building and use of multiple paths for routing between a source-destination pair. Multipath routing (MPR) is an effective strategy to achieve robustness, load balancing, congestion reduction, and increased throughput in computer networks. At present, multipath routing approach is widely used in Mobile ad hoc networks to improve network performance through efficient utilization of available network resources .In this seminar , goal of the comparative surveys is to present the concept of the existing multipath routing approaches and summarizing the state-of-the-art multipath routing techniques from the network application point of view. In order to achieve multipath routing during path discovery, we introduce the concept of independent directed acyclic graphs (IDAGs) in this seminar, which has several advantages over another approaches 1) used to provide multipath routing; 2) utilizes all possible edges; 3) guarantees recovery from single link failure 4) recovery from dual link failure and 5) reduce the number of overhead bit required in the packet header.

Index Terms: - Mobile ad hoc networks (MANETs), robustness, load balancing, Multipath routing (MPR), independent directed acyclic graphs (IDAGs), and failure recovery.

1. INTRODUCTION

Mobile ad hoc networks (MANETs) consist of a collection of wireless mobile nodes which dynamically exchange data among themselves without the reliance on a fixed base station or a wired backbone on network. MANET nodes are typically distinguished by their limited power, processing, and memory resources as well as high degree of mobility. In such networks, the wireless mobile nodes may dynamically enter the network as well as leave the network. Due to the limited transmission range of wireless network nodes, multiple hops are usually needed for a node to exchange information with any other node in the network. Thus routing is a crucial issue to the design of a MANET. Routing in MANETs must take into consideration their important characteristics such as node mobility.

The increasing use of streaming multimedia necessitates increased bandwidth and fast recovery from network failures. Thus, present-day IP networks employ several different strategies for improved end-to-end bandwidth and load balancing (using multipath routing) and fast recovery from link and node failures (using fast rerouting strategies). Multipath routing is a promising routing scheme to accommodate these requirements by using multiple pairs of routes between a source and a destination. With the scheme, we can achieve robustness [2], load balancing [3], bandwidth aggregation [4], congestion reduction [5], and security [6] compared to the single shortest-path routing that is usually used in most networks. Multipath routing in today's IP networks is merely limited to equal-cost multipath [24], [25].

Techniques developed for multipath routing are often based on employing multiple spanning trees or directed acyclic graphs (DAGs).In the case of DAGs, computed by adding edges to the shortest-path tree, one cannot guarantee that a single-link failure will not disconnect one or more nodes from the destination.

IP Fast Rerouting is essential techniques developed for fast recovery from single-link failures provide more than one forwarding edge to route a packet to a destination. The techniques may be classified depending on the nature in which the backup edges are employed. In [8], the authors develop a method to augment any given tree rooted at a destination with "backup forwarding ports." Whenever the default forwarding edge fails or a packet is received from the node attached to the default forwarding edge for the destination, the packets are rerouted on the backup ports. In [9], the authors present a framework for IP fast reroute detailing three candidate solutions for IP fast reroute that have all gained considerable attention. These are multiple routing configurations (MRCs) [10], failure insensitive routing (FIR) [11], [12], and tunneling using Not-via addresses (Not-via) [13]. The common feature of all these approaches is that they employ multiple routing tables during transmission. However, they differ in the mechanisms employed to identify which routing table to use for an incoming packet .As author in [14] for a detailed description of the above techniques. It is certainly possible to use fast recovery techniques (irrespective of whether they guarantee recovery from single link failure or not) for multipath routing. However, all the above techniques require a significantly large number of routing tables, hence a large number of additional bits in the packet header.

One approach that offers resiliency to single-link failure and provides multipath routing to some degree is “colored trees” [15], [16]. In this approach, two trees are constructed per destination node such that the paths from any node to the root on the two trees are disjoint. The trees may be constructed to obtain link-disjoint or node-disjoint paths if the network is two-edge or two-vertex connected, respectively. Only two multiple routing tables are required. The colored tree approach allows every node to split its traffic between the two trees, thus offering disjoint multipath routing. In addition, when a forwarding link on a tree fails, the packet may be switched to the other tree. A packet may be transferred from one tree to another at most once as the colored tree approach is guaranteed to recover from only a single-link failure. The colored trees are also referred to as “independent trees” in the literature [17]. In [1] author introduces the concept of *independent directed acyclic graphs* (IDAGs), an extension of independent trees. Link-independent (node-independent) DAGs satisfy the property that any path from a source to the root on one DAG is link-disjoint (node-disjoint) with any path from the source to the root on the other DAG.

2. LITERATURE SURVEY

In MANETs communication between nodes is done through the wireless medium. Because nodes are mobile and may join or leave the network, MANETs have a dynamic topology. Nodes that are in transmission range of each other are called neighbors. Neighbors can send directly to each other. However, when a node needs to send data to another non-neighboring node, the data is routed through a sequence of multiple hops, with intermediate nodes acting as routers.

2.1. Issues of MANETs:-

There are numerous issues to consider when deploying MANETs. The following are some of the main issues.

(1) *Unpredictability of environment*: Ad hoc networks may be deployed in unknown terrains, hazardous conditions, and even hostile environments where tampering or the actual destruction of a node may be imminent. Depending on the environment, node failures may occur frequently.

(2) *Unreliability of wireless medium*: Communication through the wireless medium is unreliable and subject to errors. Also, due to varying environmental conditions such as high levels of electro-magnetic interference (EMI) or inclement weather, the quality of the wireless link may be unpredictable .Thus link quality may fluctuate in a MANET.

(3)*Resource-constrained nodes*: Nodes in a MANET are typically battery powered as well as limited in storage and processing capabilities. Moreover, they may be situated in areas where it is not possible to re-charge and thus have limited lifetimes. Because of these limitations, they must have algorithms which are energy-efficient as well as operating with limited processing and memory resources. The available bandwidth of the wireless medium may also be limited because nodes may not be able to sacrifice the energy consumed by operating at full link speed.

(4)*Dynamic topology*: The topology in an ad hoc network may change constantly due to the mobility of nodes. As nodes move in and out of range of each other, some links break while new links between nodes are created.

2.2Types of Faults in MANETs:-

As a result of above issues, MANETs are prone to numerous types of faults including as follow:-

(1)*Transmission errors*: The unreliability of the wireless medium and the unpredictability of the environment may lead to transmitted packets being garbled and thus received in error.

(2)*Node failures:* Nodes may fail at any time due to different types of hazardous conditions in the environment. They may also drop out of the network either voluntarily or when their energy supply is depleted.

(3)*Link failures:* Node failures as well as changing environmental conditions (e.g., increased levels of EMI) may cause links between nodes to break.

(4)*Route breakages:* When the network topology changes due to node/link failures and/or node/link additions to the network, routes become out-of-date and thus incorrect. Depending upon the network transport protocol, packets forwarded may either eventually be dropped or be delayed.

(5) *Congested nodes or links:* Due to the topology of the network and the nature of the routing protocol, certain nodes or links may become over utilized and load will increase, i.e., congested. This will lead to either larger delays or packet loss.

Two main classes of ad hoc routing protocols are table-based and on-demand protocols. In table-based protocols, each node maintains a routing table containing routes to all nodes in the network. Therefore, routes between nodes are computed and stored, even when they are not needed. In on-demand protocols, nodes only compute routes when they are needed. Therefore, on-demand protocols are more scalable to dynamic, large networks. Two of the most widely used protocols are the Dynamic Source Routing (DSR) and the Ad hoc On-demand Distance Vector (AODV) protocols. AODV and DSR are both on-demand protocols.

2.3Multipath Routing:-

Multiple paths can provide load balancing, fault-tolerance, and higher aggregate bandwidth. Load balancing can be achieved by spreading the traffic along multiple routes. This can alleviate congestion and bottlenecks. Multiple paths in ad hoc networks to achieve higher bandwidth may not be as straightforward as in wired networks. Standard routing protocols in ad hoc wireless networks, such as AODV and DSR, are mainly intended to discover a single route between a source and destination node. Multipath routing consists of finding multiple routes between a source and destination node. These multiple paths between source and destination node pairs can be used to compensate for the dynamic and unpredictable nature of ad hoc networks.

2.4. Benefits of Multipath Routing:-

There are so many different benefits of multipath routing which are as follows:-

(1)Fault tolerance **–** Multipath routing protocols can provide fault tolerance by having redundant information routed to the destination via alternative paths. This reduces the probability that communication is disrupted in case of link failure. More sophisticated algorithms employ source coding to reduce the traffic overhead caused by too much redundancy, while maintaining the same degree of reliability.

(2)Load balancing **–** When a link becomes over-utilized and causes congestion, multipath routing protocols can choose to divert traffic through alternate paths to ease the burden of the congested link.

(3)Bandwidth aggregation – By splitting data to the same destination into multiple streams, each routed through a different path, the effective bandwidth can be aggregated. This strategy is particular beneficial when a node has multiple low bandwidth. links but requires a bandwidth greater than an individual link can provide. End-to-end delay may also be reduced as a direct result of larger bandwidth.

(4)Reduced delay **–** For wireless networks employing single path on-demand routing protocols, a route failure means that a new path discovery process needs to be initiated to find a new route.

This results in a route discovery delay. The delay is minimized in multipath routing because backup routes are identified during route discovery.

2.5. Elements of a multipath routing:-

There are three elements of multipath routing: path discovery, traffic distribution, and path maintenance.

2.5.1. PATH DISCOVERY:-

Path discovery is the process of determining the available paths for a source-destination pair. There are various criteria a protocol can use when deciding which subset, if not all, of possible paths it wants to find out in the discovery process.

(1)Disjoint paths **-** The most commonly used criterion is the disjointness of paths, which classifies the independence of paths in terms of shared resources. There are three main types of path disjointness, namely non-disjoint, link-disjoint, and node-disjoint. A set of node-disjoint paths have no common nodes except the source and the destination. Similarly, link-disjoint paths have no common links, but may share some common intermediate nodes. And Non-disjoint paths can have links (and therefore nodes) in common.

(2)Route coupling – In wireless networks, route coupling caused by radio interference or contention between paths can have serious impacts on the performance of multipath routing protocols, even if the paths are topologically disjoint.

2.5.2. TRAFFIC DISTRIBUTION:-

There are various strategies of allocating traffic over available paths. A multipath protocol may decide to forward traffic using only the path with the best metric and keep other discovered paths as backups. *Hop-count* has traditionally been a popular metric to use. Some other choices are: path reliability, disjointness, available bandwidth, degree of route coupling, or a combination of metrics.

(1) Number of paths **–** A protocol can choose to use a single path and keep the rest as backups, or it can utilize multiple paths in a round-robin fashion, with only one path sending at a time. If multiple paths are used concurrently to carry traffic, the protocol needs to decide how traffic is split over the paths and how to handle out-of-order packets at the destination.

(2) Allocation granularity **–** Some possible choices of traffic granularity include, in order of increased control overhead, per source-destination pair, per flow, per packet, per segment. With a fine granularity, load balancing can be more efficient.

2.5.3. PATH MAINTENANCE:-

Over time, paths may fail due to link/node failures or, in ad hoc networks, node mobility. Path maintenance is the process of regenerating paths after the initial path discovery. It can be initiated after each path failure, or when all the paths have failed. Some multipath protocols use dynamic maintenance algorithms to constantly monitor and maintain the quality or combined QoS(Quality of Service) metric of available paths.

3. MULTIPATH ROUTING TECHNIQUES

The ongoing research on multipath routing tries to cope up with fault tolerance and resource limitations of the low power nodes through concurrent data forwarding over multiple paths. As we see earlier that many different elements of Multipath Routing, we focus on the different path discovery methods and providing strategies to maintain it. There are so many different techniques for implementing Multipath Routing by modification in protocol used or in algorithm used with different approaches which are as follow:-

3.1. Equal Cost Multipath (ECMP) Routing in IP Networks:-

In this Equal Cost Multipath (ECMP) that enables the usage of multiple equal cost paths from the source node to the destination node in the network. The advantage is that the traffic can be split more evenly to the whole network avoiding congestion and increasing bandwidth. ECMP is also a protection method, because during link failure, traffic can be transferred quickly to another equal cost path. Link-state protocols such as OSPF (Open Shortest Path First) and IS-IS (Intermediate System-to-Intermediate System) are based on the Shortest Path First (SPF) algorithm that calculates the single shortest path from a source node to a destination node. Equal Cost Multipath is a technique that enables using several equal cost paths in IP routing. This feature helps to distribute traffic more evenly.

ECMP does not require any special configuration, because SPF computes automatically equal cost paths and these paths are then advertised to the forwarding layer. The only variable factor is the number of ECMP paths. The limiting factor is the maximum number of ECMP paths the load balancing algorithm can support. Normally number of ECMP paths can be configured between 1 and the maximum value of supported paths. Common values of maximum paths are 8 and 16. in the network but it is also a protection method.

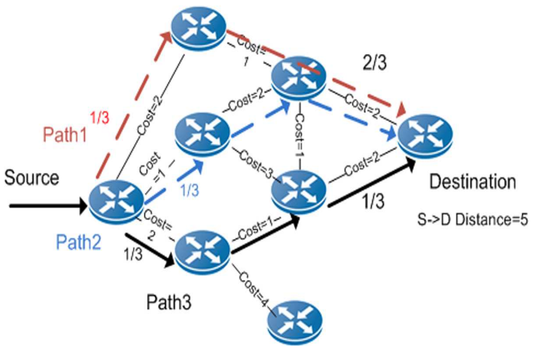


Fig.1.ECMP load balancing

ECMP is a technique which is useful in load balancing, an example of ECMP load balancing is shown in Figure 1. Traffic is spread quite evenly to the whole network. Additionally, these three ECMP paths are backups for each other. If one of the paths fails, traffic is split between the other two paths after failure detection. There is only one node and one link that shares more than one path. In this case, only the source router needs to support ECMP. During this ECMP, we tried to use path only at once to increase the performance. Changes to parts of the software and hardware that are affected by the ECMP feature and are currently supporting single-path routing only.

Techniques developed for multipath routing are often based on employing multiple spanning trees or directed acyclic graphs (DAGs) . When multiple routing tables are employed, a packet has to carry in its header the routing table to be used for forwarding. When the corresponding forwarding edge is not available, the packet needs to be dropped. This dropping is forced due to the potential looping of packets when transferred from one routing table to another. In the case of DAGs, computed by adding edges to the shortest-path tree, one cannot guarantee that a single-link failure will not disconnect one or more nodes from the destination.

Disadvantages-

1. ECMP provides general, simple protection for IP networks. Nevertheless, ECMP does not cover all the single link and node recovery cases.

2.100 % failure recovery is not possible with ECMP.

3. ECMP outperforms single path solutions and it is competitive with even more complex Multiprotocol Label Switching solution.

4. ECMP feature cannot utilize all edges and also need extra bit in transfer of packets.

3.2. IP Fast ReRouting (IPFRR) on Multipath Routing:-

IP Fast ReRouting Techniques developed on Multipath Routing for fast recovery from single-link failures provide more than one forwarding edge to route a packet to a destination. The techniques may be classified depending on the nature in which the backup edges are employed. In order for IP to become a full-fledged carrier grade transport technology, a native IP failure-recovery scheme is necessary that can correct failures in the order of milliseconds. IP Fast ReRoute (IPFRR) intends to fill this gap, providing fast, local and proactive handling of failures right in the IP layer. In [8], the authors develop a method to augment any given tree rooted at a destination with "backup forwarding ports." Whenever the default forwarding edge fails or a packet is received from the node attached to the default forwarding edge for the destination, the packets are rerouted on the backup ports. In [9], the authors present a framework for IP fast reroute detailing three candidate solutions for IP fast reroute that have all gained considerable attention. These are multiple routing configurations (MRCs) [10], failure insensitive routing (FIR) [11], [12], and tunneling using Not-via addresses (Not-via) [13].

In [10] multiple routing configurations (MRCs) approach divides the network into multiple auxiliary graphs, such that each link is removed in at least one of the auxiliary graphs and each auxiliary graph is connected. Every node maintains one routing table entry corresponding to each auxiliary graph for every destination. If the primary forwarding link fails, a packet is routed over the auxiliary graph where the primary link was removed. The routing table to use (or equivalently the auxiliary graph over which the packet is forwarded) is carried in the header of every packet. The limitation of this approach is that it does not bound the number of auxiliary graphs employed.

In [11] Failure insensitive routing (FIR) when a link fails, adjacent nodes suppress global updating and instead initiate local rerouting of packets that were to be forwarded through the failed link. Though other nodes are not explicitly notified of the failure, they *infer* it from the packet's *flight*. When a packet arrives at a node through an *unusual* interface (through which it would never arrive had there been no failure), corresponding potential failures can be inferred and the next hop chosen avoiding those links. This way under FIR, the next hop for a packet is determined based on not only the destination address but also the incoming interface .FIR-based approaches never guarantee the recovery from dual link failures.

The Internet Engineering Task Force has initiated the IP Fast Reroute framework [8]. To our days, many IPFRR proposals have come to existence, yet the largest industrial backing is undoubtedly behind the technique based on the notion of "Not-via addresses" [13]. we identify high address management burden and computational complexity as the major causes of why commercial IPFRR deployment still lags behind, and we present a lightweight Not-via scheme.Our modified Not-via technique uses the concept of redundant trees. Redundant trees are basically a pair of directed spanning trees, which have the appealing property that a single node or link failure destroys connectivity through only one of the trees, leaving the path along the other tree intact. The concept was first applied to IP Fast ReRoute. Redundant trees gives rise to an easily implementable and deployable "lightweight Not-via" scheme: it significantly decreases the number of Not-via addresses, with clever modifications it reduces computational complexity.

The requirement of a not-via address for every link at a node and that different nodes may have different number of not-via addresses assigned to them does not scale. The scalability issue is even more pronounced when multiple links may fail as a not-via address would be required for every possible failure scenario.

The common feature of all these approaches is that they employ multiple routing tables during transmission. However, they differ in the mechanisms employed to identify which routing table to use for an incoming packet .As author in [14] for a detailed description of the above techniques. It is certainly possible to use fast recovery techniques (irrespective of whether they guarantee recovery from single link failure or not) for multipath routing. However, all the above techniques require a significantly large number of routing tables, hence a large number of additional bits in the packet header.

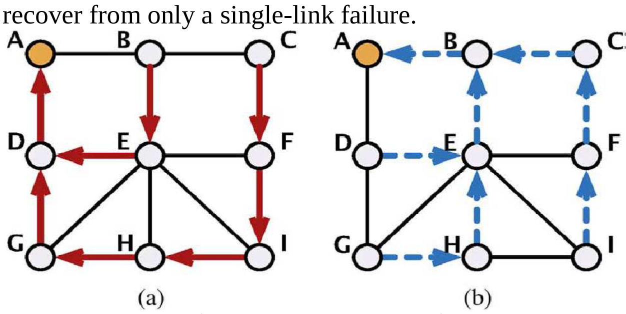
Disadvantages:-

1. In this approach, they employ multiple routing tables during transmission required extra overhead bit in packet
2. Differ in the mechanisms employed to identify which routing table to use for an incoming packet.
3. Do not utilize all possible edges during packet transmission.
4. It can remove only single link failure efficiently.

3.3. Colored Trees (CTs) Approach in Multipath Routing:-

An efficient approach to route packets along link- or node disjoint paths in packet-switched networks with minimum routing table overhead and lookup time is to employ colored trees (CTs). In this approach, two trees, namely red and blue, are constructed rooted at a destination such that the paths from any node to the destination on the two trees are link- or node-disjoint.

In this approach, two trees are constructed per destination node such that the paths from any node to the root on the two trees are disjoint. The trees may be constructed to obtain link-disjoint or node-disjoint paths if the network is two-edge or two-vertex connected, respectively. This approach is similar to those employing multiple routing tables, except that only two tables are required. Every packet may carry an extra bit in its header to indicate the tree to be used for routing. This overhead bit may be avoided by employing a routing based on the destination address and the incoming edge over which the packet was received, as every incoming edge will be present on exactly one of the trees. The colored tree approach allows every node to split its traffic between the two trees, thus offering disjoint multipath routing. In addition, when a forwarding link on a tree fails, the packet may be switched to the other tree. A packet may be transferred from one tree to another at most once as the colored tree approach is guaranteed to recover from only a single-link failure.



(a) (b)

Fig. 2. Illustration of node-independent trees for the example network. (a) Red tree. (b) Blue tree. Node A is the root (destination) node.

Fig. 2 shows an example network where red and blue trees, rooted at node A, are constructed. This tree construction enables recovery from a single-link failure by switching from one tree to another. For example, consider a packet that is forwarded from node F to node A on the blue tree. When there are no failures, the packet would take the path F–C–B–A. If link C–B fails, then node C would reroute the packet on the red tree, thus the packet will follow the path F–C–F–I–H–G–D–A. Assume that a second link failure occurs on link I–H. As only two independent trees were constructed and recovery from arbitrary two link failures cannot be guaranteed, the packet will be dropped when the second link failure is encountered.

Depending on the application [16] for which colored trees are employed, the network may use only one tree at a time or both the trees. For example, when the colored trees are employed for fault tolerance, packets may be routed along the red tree. When a node loses its red forwarding neighbor (due to link or node failure), the node re-routes the packets along the blue tree. When the trees are employed for QoS routing, the two trees may be employed simultaneously to carry different classes of traffic. The two trees may be employed simultaneously to increase the instantaneous available bandwidth by spreading the traffic from a node on the two trees. When employed for security, the traffic from a node may be spread over the two trees. The colored trees are also referred to as "independent trees" in the literature [17]. We will use to the colored trees approach as the independent trees (I Trees) because of their disjointness property.

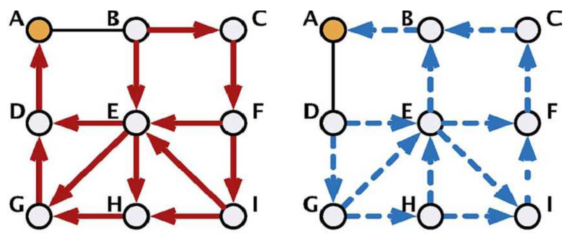


Fig. 3. Illustration of node-independent DAGs in an example network where node A is the root (destination) node. (a) Red DAG. (b) Blue DAG.

One approach to enhance the robustness is to allow the packet to be switched multiple times between the trees. Such an approach will fail in the example considered above. The packet will be rerouted back and forth on the path I–F–C. We may analyze when switching back to a tree would guarantee not encountering a previous failure again [18] by observing the properties of the independent tree construction process. However, the inherent limitation of the tree-based approach is that it utilizes only 2(|*N*|-1) directed edges to route to a destination, where |*N*| denotes the number of nodes in the network. Our goal is therefore to utilize the additional links available in the network to improve robustness. To this end, we seek to construct independent directed acyclic graphs rooted at each node. Fig. 3(a) and (b) shows two independent directed acyclic graphs rooted at node A. Observe that node I has two red forwarding edges available. Thus, in the earlier example, if link I–H fails, the packet may be forwarded on link I–E to reach the destination.

Disadvantages: -

1. In this approach, we recover the dual link failure only, not more.
2. If there is continuous switching between nodes of red and blue tree the performance of packet transmission reduces.
3. It should utilize minimum directed edges to route to destination.

3.4. MARA: Maximum Alternative Routing Algorithm Multipath Routing: -

Study the multipath route calculation by constructing a directed acyclic graph (DAG) which includes all edges in the network. In this [19] define new DAG construction problems with the objectives of 1) maximizing the minimum connectivity, 2) maximizing the minimum max-flow, and 3) maximizing the minimum max-flow as an extension of shortest path routing. Configuring consistent loop-free routes for a destination is synonymous with constructing Directed Acyclic Graph (DAG) .A novel multipath route calculation algorithms called Maximum Alternative Routing Algorithms (MARAs) construct a DAG that includes all edges in the network graph structure, in order to provide a significant number of alternative paths among all nodes to a destination.

When multiple routing tables are employed, a packet has to carry in its header the routing table to be used for forwarding. When the corresponding forwarding edge is not available, the packet needs to be dropped. This dropping is forced due to the potential looping of packets when transferred from one routing table to another. Techniques developed for fast recovery from single link failures provide more than one forwarding edge to route a packet to a destination. The techniques may be classified depending on the nature in which the backup edges are employed. A method to augment any given tree rooted at a destination with "backup forwarding ports." Whenever the default forwarding edge fails or a packet is received from the node attached to the default forwarding edge for the destination, the packets are re-routed on the backup ports.

Maximum Alternative Routing Algorithm (MARA) [19] constructs a DAG that utilizes all edges in the network to increase the number of paths significantly. However, the algorithm does not provide a mechanism for backup forwarding when encountering a single link or node failure. MARAs always calculate the routes using all edges. Migration of the Internet from essentially single-path routing to multipath routing can potentially improve the fault resilience of the network, raise the aggregate bandwidth available between two nodes, and increase the utilization of otherwise idle resources. One step toward the realization of this goal is the development of algorithms for finding the multipath routes on the network graph.

Disadvantages:-

1. MARA approach does not provide a mechanism for backup forwarding when encountering a single link or node failure if occur.
2. Fast recovery from link failure is not possible.

Another approach is to employ multiple pairs of colored (independent) trees, however such a technique will require the packet to carry information on which pair is being used for routing.Our goal is to develop an elegant solution to: 1) achieve multipath routing; 2) utilize all possible edges; 3) guarantee recovery from single-link failures; and 4) reduce the number of overhead bits required in the packet header. Moreover, the use of multiple non disjoint paths is advantageous in load balancing and preventing snooping on data, in addition to improving resiliency to multiple link failures.

3.5. Independent Directed Acyclic Graphs for Resilient Multipath Routing:-

In [1] author introduces the concept of *independent directed acyclic graphs* (IDAGs), an extension of independent trees. Link-independent (node-independent) DAGs satisfy the property that any path from a source to the root on one DAG is link-disjoint (node-disjoint) with any path from the source to the root on the other DAG. Given a network, also develop algorithms to compute link-independent and node-independent DAGs. The algorithm guarantees that every edge other than the ones emanating from the root may be used in either of the two node-disjoint DAGs in a two-vertex-connected network. Similarly, show that only a small number of edges will remain unused when link-independent DAGs are constructed. The edges that will remain unused in both DAGs are defined by the topological limitation of the network. Thus, the algorithms developed in [1] author employ the maximum possible edges in the DAGs. The approach developed in this author requires at most two bits (and may be reduced to one bit when routing is based on destination address and incoming link) even when both DAGs are used simultaneously. Finally, they introduce another approach to exploit all possible links, that is, multiple pairs of colored trees technique to evaluate the performance of the IDAGs scheme. In the multiple pairs of colored trees technique, the red and blue trees are independent in a given pair however we cannot guarantee that trees from different pairs are independent.

3.5.1. Independent directed acyclic graph:-

Multipath routing is the routing technique of using multiple alternative paths through a network, which can yield a variety of benefits such as fault tolerance, increased bandwidth, or improved security. The multiple paths computed might be overlapped, edge-disjointed or node-disjointed with each other. Extensive research has been done on multipath routing techniques, but multipath routing is not yet widely deployed in practice.

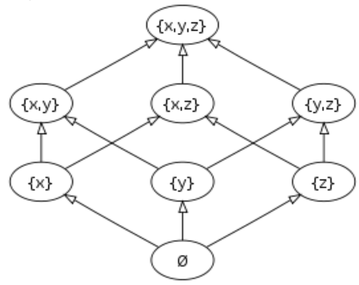


Fig 4.Independent directed acyclic graph

As shown in fig 4. Independent directed acyclic graph each node in directed acyclic graph starting from 0 is directed toward only destination with the pair collection {x, y, z} from any node in between source and destination. Each graph maintains should be link disjoint and node disjoint so it is independent of each other.

3.5.2 Resilient Routing With IDAGs:-

The network is assumed to employ link-state protocol; hence every node has the view of the entire network topology. Every node computes two DAGs, namely red and blue, for each destination and maintains one or more forwarding entries per destination per DAG. The DAGs may be used in two different ways to achieve resilient routing. In the first approach, referred to as Red DAG first (RDF), the packets are assumed to be forwarded on the red DAG first. When no forwarding edges are available on the red DAG, the packet is transferred to the blue DAG. When no blue forwarding edges are available, the packet is dropped. The DAG to be employed for routing is carried in an overhead bit (DAG bit) in every packet header. In the second approach, referred to as Any DAG first (ADF), a packet may be transmitted by the source on the red or blue DAG. In addition to the DAG bit, every packet also carries an additional bit that indicates whether the packet has been transferred from one DAG to another (Transfer bit). A packet is routed on the DAG indicated in its packet header. If no forwarding edges are available in that DAG and if the packet has not encountered a DAG transfer already, it is transferred to the other DAG. If no forwarding edges are available on the DAG indicated in the packet header and the packet has already encountered a DAG transfer, the packet is dropped. In both of the approaches described above, a node may forward the packet along any of the available forwarding edges in the DAG indicated in the packet header.

Note that if the red and blue DAGs are (link- or node-) independent, then the network is guaranteed to recover from a single (-link or -node) failure when the packet is transferred from one DAG to the other. In addition, the network may tolerate multiple failures as some nodes may have many forwarding entries in each DAG.

Given a destination node **d** in the network, we seek to construct two independent DAGs rooted at the destination. Our goal in the construction process is to utilize every edge available in the network in either of the two DAGs. Observe that the edges emanating from cannot be utilized in the DAGs as we require the paths to terminate at **d**. To this end, we first construct two node-independent DAGs in a two-vertex-connected network involving every edge, other than the edges emanating from the destination, in either of the two DAGs. We then construct link-independent DAGs in two-edge-connected networks employing all but a few edges emanating from the articulation nodes. Polynomial time algorithms used by author [1] construct node-independent and link-independent DAGs using all possible edges in the network developed

3.5.3. Node Independent DAG:-

Two-vertex-connectivity is the necessary and sufficient requirement for constructing two node-independent DAGs utilizing all the edges except those emanating from the given destination node. This necessary part of the requirement follows directly from the condition required for constructing two node-independent trees – a special case of DAG.

Initialize the partial order for the nodes on the two DAGs. Compute the first cycle to be augmented. Compute successive paths to be augmented. The path starts and ends at distinct nodes that are already added to the DAGs, hence the paths from every node to the root of the DAG are node-disjoint. Note that the difference between the path augmentation employed for DAG construction here and that employed for tree construction.

3.5.4 Link Independent DAGs:-

Two-edge connectivity is a necessary and sufficient condition for constructing two link-independent DAGs. Similar to the requirement of node-independent DAGs, the necessary part of the requirement follows from the independent tree construction. The procedure to construct two link independent DAGs. Divide the network into two vertex- connected (2V) components. A node may appear in more than 2V-component and the removal of such a node (articulation node) would disconnect the graph. In addition, any two 2V-components may share at most one node in common. Given a destination node d, identify the root node for every component – the unique node through which every path connecting a node in that component and d must traverse. In components that contain node d, the root node is assumed to be d.

Advantages:-

In order to achieve multipath routing during path discovery, we introduce the concept of independent directed acyclic graphs (IDAGs), which has several advantages over other approaches.

1) Used to provide multipath routing;
2) Utilizes all possible edges;
3) Guarantees recovery from single link failure & dual link failure [14];
5) Reduce the number of overhead bit required in the packet header and
6)As Multipath Routing is used, it achieve robustness [2], load balancing [3], bandwidth aggregation [4], congestion reduction [5], and security [6] compared to the single shortest-path routing that is usually used in most networks.

4. CONCLUSION AND FUTURE WORK

In this seminar, we have presented multipath routing in ad hoc networks and also a comprehensive survey of Multipath Routing techniques in wireless Mobile ad hoc networks is specified. We also observe the different issues and fault due to this issues in Mobile ad hoc networks. A mobile ad hoc network (MANET) consists of autonomous mobile nodes, each of which communicates directly with the nodes within its wireless range or indirectly with other nodes in networks. To facilitate secure and reliable communication within a MANETs an efficient multipath routing technique is required to discover routes between mobile nodes. We compare several different multipath routing techniques and analyze the advantages and disadvantages in each technique and find more efficient technique for Multipath Routing i.e. the concept of independent directed acyclic graphs (IDAGs) and developed a methodology for resilient multipath routing using IDAGs is developed. In future work ,we can implement the IDAGs approach performs significantly better than other approaches in terms of increasing number of paths offered, reducing the probability of a two-link failure disconnecting a node from the destination, and average link load. The trees based on the shortest paths on the IDAGs have efficient performance because the average shortest path length on the IDAGs is short.

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