ISSN:2249-5789

Dasari.Venkata Narayana et al , International Journal of Computer Science & Communication Networks,Vol 2(5), 577-583

Self-Directed Reconfigurable ADHOC Networks

Dasari.Venkata Narayana

M-Tech, G.Pulla Reddy Engineering College

Dr. S.Zahoor-ul-Haq

Dept of CSE, G.Pulla Reddy Engineering College

Abstract

Wireless mesh networks (WMNs) have emerged as a key technology for next-generation wireless networking. Because of their advantages over other wireless networks, WMNs are undergoing rapid progress and inspiring numerous applications. Adhoc network is collection of wireless mobile nodes dynamically forming a temporary network without the use of existing network infrastructure of centralized administration. Each node acts as a router by itself and forwards all the packets which it receives. Multi-hop wireless mesh networks (WMNs) experience frequent link failures caused by channel interference, dynamic obstacles and/or applications' bandwidth demands. These failures cause severe performance degradation in WMNs or require expensive, manual network management for their real-time recovery.

This concept is basically useful when there is a very high link failure due to migration of nodes from the available network region. There is a frequent link failure in adhoc networks, which causes packet to be lost or packets doubts to reach destination. In this scenario a different mechanism and scheme is proposed and implemented to make the important time critical data like real time or voice data to reach the destination without any loss. The mechanism used is a special propagation which propagates a unique kind of parallel route discovery for real time application scenario to send the time critical data safely. The scheme used is temporary parallel route recovery builds a temporary parallel path between the nodes during link failure. The important node then forwards the buffered packets to the destination without any loss which is on-demand based on type of information a node forwards.

This paper presents self-directed network Reconfiguration System that enables a multi-radio WMN to self-directedly recover from local link failures to preserve network performance. SRS also improves channel efficiency by more than 90% over the other recovery methods.

I. INTRODUCTION

1.1 Wireless Networks

Wireless networks provide unprecedented freedom and mobility for a growing number of laptop and PDA users who no longer need wires to stay connected with their workplace and the Internet. Ironically, the very devices that provide wireless service to these clients need lots of wiring themselves to connect to private networks and the Internet. This white paper presents a viable alternative to all those wires - the wireless mesh network. Unlike basic Wi-Fi that simply untethers the client; the wireless mesh untethers the network itself giving IT departments, network architects and systems integrators unprecedented freedom and flexibility to build out networks in record time - with high performance and without the expensive cabling.

1.2 Types of Wireless Networks

One of the unique features of wireless networks is compare to wire network is that data is transmitted from one point to another through wireless links i.e. there is no need of wired link between the two nodes for transmission. They just need to be in the transmission range of each other. Wireless networks or divided into two categories. Infrastructure wireless network and infrastructure less or ad hoc wireless network.

1.3 Infrastructure Networks

Infrastructure network have fixed network topology. Wireless nodes connect through the fixed point known as base station or access point. In most cases the access point or base station or connected to the main network through wired link. The base station, or access point, is one of the important elements in such types of networks. All of the wireless connections must pass from the base station. Whenever a node is in the range of several base stations then it connect to any one of them on the bases of some criteria

1.4 Ad-hoc Networks

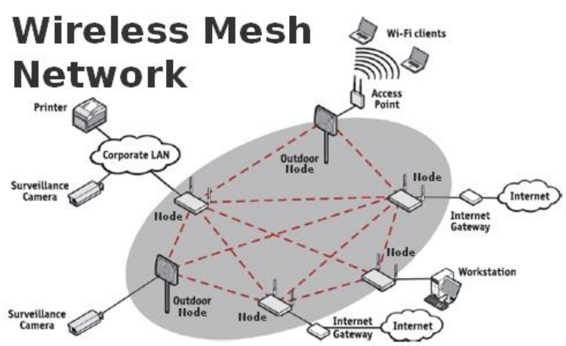
Ad hoc networks also called infrastructure less networks are complex distributed systems consist of wireless links between the nodes and each node also works as a router to forwards the data on behalf of other nodes. The nodes are free to join or left the network without any restriction. Thus the networks have no permanent infrastructure. In ad hoc networks the nodes can be stationary or mobile. Therefore one can say that ad hoc networks basically have two forms, one is static ad hoc networks (SANET) and the other one is called mobile ad hoc networks (MANET). From the introduction of new technologies such as IEEE 802.11 the commercial implementation of ad hoc network becomes possible. One of the good features of such networks is the flexibility and can be deployed very easily. Thus it is suitable for the emergency situation. But on the other side it is also very difficult to handle the operation of ad hoc networks. Each node is responsible to handle its operation independently. Topology changes are very frequent and thus there will be need of an efficient routing protocol, whose construction is a complex task.

A **wireless mesh network** (**WMN**) is a communications network made up of radio nodes organized in a mesh topology. Wireless mesh networks often consist of mesh clients, mesh routers and gateways. The mesh clients are often laptops, cell phones and other wireless devices while the mesh routers forward traffic to and from the gateways which may but need not connect to the Internet. The coverage area of the radio nodes working as a single network is sometimes called a mesh cloud. Access to this mesh cloud is dependent on the radio nodes working in harmony with each other to create a radio network. A mesh network is reliable and offers redundancy. When one node can no longer operate, the rest of the nodes can still communicate with each other, directly or through one or more intermediate nodes. The animation below illustrates how wireless mesh networks can self form and self heal. Wireless mesh networks can be implemented with various wireless technology including 802.11, 802.15, 802.16, cellular technologies or combinations of more than one type.

Wireless networks use some sort of radio frequencies in air to transmit and receive data instead of using some physical cables. The most admiring fact in these networks is that it eliminate the need for laying out expensive cables and maintenance costs.

A wireless mesh network can be seen as a special type of wireless ad-hoc network. A wireless mesh network often has a more planned configuration, and may be deployed to provide dynamic and cost effective connectivity over a certain geographic area. An ad-hoc network, on the other hand, is formed ad hoc when wireless devices come within communication range of each other. The mesh routers may be mobile, and be moved according to specific demands arising in the network. Often the mesh routers are not limited in terms of resources compared to other nodes in the network and thus can be exploited to perform more resource intensive functions. In this way, the wireless mesh network differs from an ad-hoc network, since these nodes are often constrained by resources.

Nodes are comprised of mesh routers and mesh clients. Each node operates not only as a host but also as a router, forwarding packets on behalf of other nodes that may not be within direct wireless transmission range of their destinations. A WMN is dynamically self-organized and self-configured, with the nodes in the network automatically establishing and maintaining mesh connectivity among themselves. Extend the range and link robustness of existing Wi-Fi’s by allowing mesh-style multi-hopping. A user finds a nearby user and hops through it - or possibly multiple users - to get to the destination Every user becomes a relay point or router for network traffic Mesh networks consist of multiple wireless devices equipped with COTS802.11 a/b/g cards that work in ad-hoc fashion 802.11 capable antennas placed on rooftops allow a large area coverage .



II. SYSTEM ANALYSIS

2.1 Existing System

WIRELESS mesh networks (WMNs) are being developed actively and deployed widely for a variety of applications, such as public safety, environment monitoring, and citywide wireless Internet services. They have also been evolving in various forms (e.g., using multi-radio/channel systems to meet the increasing capacity demands by the above-mentioned and other emerging applications.

However, preserving the required performance of such WMNs is a challenging problem, because of heterogeneous and fluctuating wireless link conditions. For example, Some of WMN links may encounter significant channel interference from other coexisting wireless networks. Some areas of networks might not be able to fulfill improving bandwidth demands from new mobile customers and applications. Links in a certain area (e.g., a hospital or police station) might not be able to use some frequency channels because of spectrum manners or regulation.

Limitations of existing system:

First, resource-allocation algorithms can provide (theoretical) guidelines for initial network resource planning. However, even though their approach provides a comprehensive and optimal network configuration plan, they often require "global" configuration changes, which are undesirable in case of frequent local link failures.

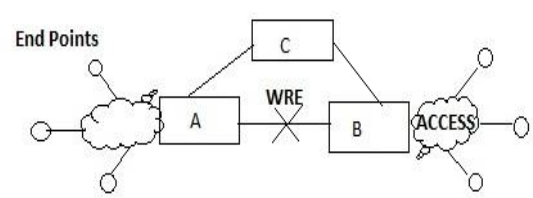
Next, a *greedy* channel-assignment algorithm can reduce the requirement of network changes by changing settings of only the faulty link(s). However, this greedy change might not be able to realize full improvements, which can only be achieved by considering configurations of neighboring mesh routers in addition to the faulty link(s).

Third, fault-tolerant routing protocols, such as local rerouting or multipath routing, can be adopted to use network-level path diversity for avoiding the faulty links. However, they rely on detour paths or redundant transmissions, which may require more network resources than link-level network reconfiguration

2.2 Proposed System

This paper presented an self-directed network reconfiguration system (SRS) that enables a multi radio WMN to self-directedly recover from wireless link failures. SRS generates an effective reconfiguration plan that requires only local network configuration changes by exploiting channel, radio, and path diversity.

Furthermore, SRS effectively identifies reconfiguration plans that satisfy applications' QoS constraints, admitting up to two times more flows than static assignment, through QoS aware planning. Next, SRS's online re configurability allows for real-time failure detection and network reconfiguration, thus improving channel efficiency by 92%. Our experimental evaluation on a Linux-based implementation and ns2-based simulation have demonstrated the effectiveness of SRS in recovering from local link-failures and in satisfying applications' diverse
QoS demands.



III. SRS ARCHITECTURE

3.1 Channels reconfiguration

Based on multiple channels and radio associations available, SRS generates reconfiguration plans that allow for changes of network configurations only in the vicinity where link failures occurred while retaining configurations in areas remote from failure locations.

SRS effectively identifies QoS-satisfiable reconfiguration plans by estimating the QoS satisfiability of generated reconfiguration plans and deriving their expected benefits in channel utilization.

3.2 Self-directed reconfiguration via link-quality monitoring

SRS accurately monitors the quality of links of each node in a distributed manner. Furthermore, based on the measurements and given links' QoS constraints, SRS detects local link failures and self-directedly initiates network reconfiguration.

3.3 Cross-layer interaction

SRS actively interacts across the network and link layers for planning. This interaction enables SRS to include a rerouting for reconfiguration planning in addition to link-layer reconfiguration. SRS can also maintain connectivity during recovery period with the help of a routing protocol.

Algorithm describes the operation of SRS: First, SRS in every mesh node monitors the quality of its outgoing wireless links at every (e.g., 10 s) and reports the results to a gateway via a management message. Second, once it detects a link failure(s), SRS in the detector node(s) triggers the formation of a group among local mesh routers that use a faulty channel, and one of the group members is elected as a leader using the well-known bully algorithm for coordinating the reconfiguration. Third, the leader node sends a planning-request message to a gateway. Then, the gateway synchronizes the planning requests—if there are multiple requests—and generates a reconfiguration plan for the request. Fourth, the gateway sends a reconfiguration plan to the leader node and the group members. Finally, all nodes in the group execute the corresponding configuration changes, if any, and resolve the group. We assume that during the formation and reconfiguration, all messages are reliably delivered via a routing protocol and per-hop retransmission timer.

3.4 Planning for Localized Network Reconfiguration

The core function of SRS is to *systematically* generate localized reconfiguration plans. A *reconfiguration plan* is defined as a set of links' configuration changes (e.g., channel switch, link association) necessary for a network to recover from a link(s) failure on a channel, and there are usually multiple reconfiguration plans for each link failure. Existing channel-assignment and scheduling algorithms seek "optimal" solutions by considering tight QoS constraints on all links, thus requiring a large configuration space to be searched and hence making the planning often an NP-complete problem . In addition, change in a link's requirement may lead to completely different network configurations. By contrast, SRS systematically generates reconfiguration plans that localize network changes by dividing the reconfiguration planning into three processes—feasibility, QoS satisfiability, and optimality—and applying different levels of constraints. SRS first applies connectivity constraints to generate a *set* of feasible reconfiguration plans that enumerate feasible channel, link, and route changes around the faulty areas, given connectivity and link-failure constraints. Then, within the set, SRS applies strict constraints to identify a reconfiguration plan that satisfies the QoS demands and that improves network utilization most.

3.5 Executable Plan Generation

Generating feasible plans is essentially to search all legitimate changes in links' configurations and their combinations around the faulty area. Given multiple radios, channels, and routes, SRS identifies feasible changes that help avoid a local link failure but maintain existing network connectivity as much as possible.

3.6 Preserving network connectivity and utilization

While avoiding the use of the faulty channel, SRS needs to maintain connectivity with the full utilization of radio resources. Because each radio can associate itself with multiple neighboring nodes, a change in one link triggers other neighboring links to change their settings. To coordinate such propagation, SRS takes a *two-step* approach. SRS first generates feasible changes of each link using the primitives, and then combines a set of feasible changes that enable a network to maintain its own connectivity. Furthermore, for the combination, SRS maximizes the usage of network resources by making each radio of a mesh node associate itself with at least one link and by avoiding the use of same (*redundant*) channel among radios in one node.

3.7 Controlling the scope of reconfiguration changes

SRS has to limit network changes as *local* as possible, but at the same time it needs to find a locally optimal solution by considering more network changes or scope. To make this tradeoff, SRS uses a -hop reconfiguration parameter. Starting from a faulty link(s), SRS considers link changes within the first hops and generates feasible plans. If SRS cannot find a local solution, it increases the number of hops so that SRS may explore a broad range of link changes. Thus, the total number of reconfiguration changes is determined on the basis of existing configurations around the faulty area as well as the value.

3.8 Per-link Analyze

Each and every feasible plan, SRS has to check whether each link's configuration change satisfies its bandwidth requirement, so it must analyze link bandwidth. To estimate link bandwidth, SRS accurately measures each link's capacity and its available channel airtime. In multi-hop wireless networks equipped with a CSMA-like MAC, each link's achievable bandwidth (or throughput) can be affected by both link capacity and activities of other links that share the channel airtime. Even though numerous bandwidth-estimation techniques have been proposed, they focus on the average bandwidth of each node in a network or the end-to-end throughput of flows, which cannot be used to calculate the impact of per-link configuration changes. By contrast, SRS estimates an individual link's capacity based on measured link-quality information—packet-delivery ratio and data-transmission rate measured by passively monitoring the transmissions of data or probing packets —and the formula derived in the Appendix. Here, we assume that SRS is assumed to cache link-quality information for other channels and use the cached information to generate reconfiguration plans. If the information becomes obsolete, SRS detects link failures and triggers another reconfiguration to find QoS-satisfiable plans—lazy monitoring.

3.9 Analyze bandwidth satisfiability

Given measured bandwidth and bandwidth requirements, SRS has to check if the new link change(s) satisfies QoS requirements. SRS defines and uses the expected busy airtime ratio of each link to check the link's QoS satisfiability. Assuming that a link's bandwidth requirement is given, the link's busy network time ratio (BNR) can be defined as and must not exceed 1.0 (i.e.,) for a link to satisfy its bandwidth requirement. If multiple links share the airtime of one channel, SRS calculates aggregate BAR of end-radios of a link, which is defined as , where is a radio ID, a link associated with radio , and the set of directed links within and across radio 's transmission range.

3.10 Breaking a tie among multiple plans

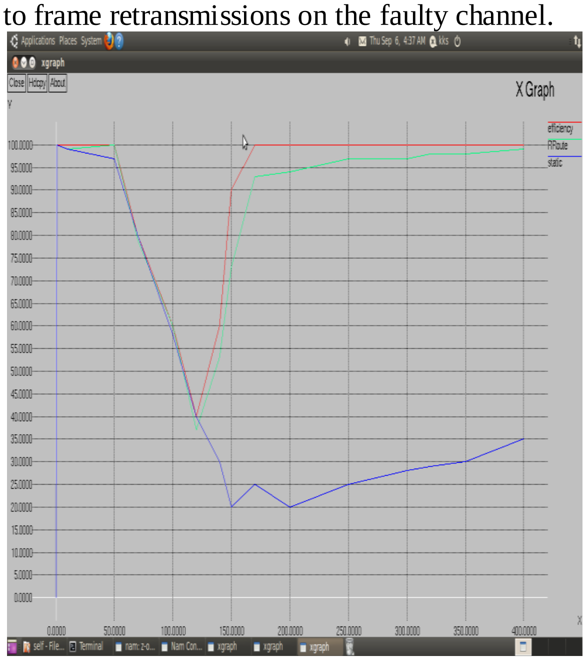
Different reconfiguration plans can have the same benefit, and SRS needs to break a tie among them. SRS uses the number of link changes that each plan requires to break a tie. Although link configuration changes incur a small amount of flow, the less changes in link configuration, the less network disruption

3.11 Complexity of SRS

SRS incurs reasonable bandwidth and computation overheads. First, the network monitoring part in the reconfiguration protocols is made highly efficient by exploiting existing data traffic and consumes less than 12 kb/s probing bandwidth (i.e., one packet per second) for each radio. In addition, the group formation requires only message overhead (in forming a spanning tree), where the number of nodes in the group. Next, the computational overhead in SRS mainly stems from the planning algorithms. Specifically, generating its possible link plans incurs complexity, where the number of available channels and the number of radios. Next, a gateway node needs to generate and evaluate feasible plans, which incurs search overhead in a constraint graph that consists of nodes, where the number of links that use a faulty channel in the group.

IV. RESULTS

SRS method is more efficient than previous method such as re routing and static methods. SRS improves channel efficiency by up to 91.5% over the local rerouting scheme.
On the other hand, using static channel assignment suffers poor channel utilization due to frame retransmissions on the faulty channel.



Similarly, the local rerouting often makes traffic routed over longer or low link-quality paths, thus consuming more channel resources than SRS.

V. CONCLUSION

Self-directed network reconfiguration system (SRS) that enables a multi-radio WMN to self-dejectedly recover from wireless link failures. SRS generates an effective reconfiguration plan that requires only local network configuration changes by exploiting channel, radio, and path diversity. Furthermore, SRS effectively identifies reconfiguration plans that satisfy applications' QoS constraints, admitting up to two times more flows than static assignment, through QoS aware planning. Next, SRS's online re-configurability allows for real-time failure detection and network reconfiguration.
Based on existing MAC, routing, and transport protocols, network performance is not scalable with either the number of nodes or the number of hops in the network. This problem can be alleviated by increasing the network capacity through using multiple channels/radios per node or developing wireless radios with higher transmission speed. However, these approaches do not truly enhance the scalability of WMNs, because resource utilization is not actually improved. Therefore, in order to achieve scalability, it is essential to develop new MAC, routing, and transport protocols for WMNs.

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