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Self-Healing In Wireless Routing Using Neighbor Nodes

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Abstract

Wireless networking is a new emerging era. It has potential applications in extremely unpredictable and dynamic environments. Individuals and industries choose wireless because it allows flexibility of location, whether that means mobility, portability, or just ease of installation at a fixed point. A flat mobile ad hoc network has an inherent scalability limitation in terms of achievable network capacity. It is seen that when the network size increases, per node throughput of an ad hoc network rapidly decreases. This is due to the fact that in large scale networks, flat structure of networks results in long hop paths which are prone to breaks. The challenge of wireless communication is that, the environment that wireless communications travel through is unpredictable. Wireless networks that fix their own broken communication links may speed up their widespread acceptance. The changes made to the network architectures are resulting in new methods of application design for this medium. The long hop paths can be avoided by using neighbor nodes concept. In this paper, a self healing scheme for large scale networks with mobile neighbor nodes has been proposed.

Keywords: MANET, routing, ADOV, Self healing network

I. INTRODUCTION

There is tremendous technological advance in producing small and smart devices. The number of embedded devices in appliances and vehicles is increasing at a rapid rate. Thousands of such devices can be used for applications[1] like: environmental data collection, weather forecasting, measuring toxicity levels at hazardous sites etc. It is a natural consequence that such devices work in a collaborative way. However, users carry around many such smart devices and they are not fixed in the sense of a desktop computer. Hence, there is a need for networking such mobile devices without any infrastructural support. There is a growing demand of using networks of mobile devices[2] anywhere and anytime. Cellular Phones and Internet provide some soluiton, but Cellular phones work with infrastructural support like mobile phone towers and satellite communication. However, such support comes at a cost like pre-registration with a mobile service provider etc. In many situations, the Internet may not be an efficient solution. For example, a collection of people trying to communicate in a hotel or conference hall. Adhoc network provide a solution to these problems. An ad hoc network is a collection of autonomous nodes, which may move arbitrarily so that the topology changes frequently. In contrast to conventional wireless networks, the nodes in Mobile ad hoc network communicate using wireless links without any fixed network infrastructure and centralized administrative support. A node act both as source/destination for messages and as a switching or routing node. The purpose of an ad hoc network is to set up (possibly) a short-lived network for a collection of nodes. If all the wireless nodes are within the transmission range of each other, routing is easy. Every node can listen to all transmissions. However, this is not true in most situations, due to short transmission range. Hence, most ad hoc neworks are multi-hop [3]. A message from a source node must go through intermediate nodes to reach its destination. All nodes cooperate in delivering messages across the network. A major problem is ad hoc network is route stability as mobility has a significant effect on network integrity. Link failures lead to a considerable packet loss in data transmission. In this paper a new proposal based on neighbor ndoes has been introduced to make route stable and follow the cocnept of self healing. Rest of paper is organised as : Section 2 highlights major issues of ad hoc network, Section 3 gives a detailed survey of self healing networks with techniques, proposed scheme is part of section IV and results and discussion have been made in section V.

II MAJOR ISSUES IN AD HOC NETWORKS [4,5]

- Most nodes in an ad hoc network are powered by batteries. Batteries cannot be recharged easily in many cases. Each node participates in two kinds of

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activities, sending and receiving messages useful for itself and forwarding messages for other nodes.

- Mobile communication is needed. Communication must take place in a terrain that makes wired communication difficult or impossible. A communication system must be deployed quickly.
- Communication facilities must be installed at low initial cost. The same information must be broadcast to many locations. Operates in a less controlled environment, so is more susceptible to interference, signal loss, noise, and eavesdropping.
- Network support for user mobility
- Efficient use of finite radio spectrum
- Integrated services (voice, data, multimedia)
- Maintaining quality of service over unreliable links
- Security
- Cost efficiency
- The issue of the reliability

III Self Healing Network

In developing broadband digital networks, a short service-outage such as a link failure or a node failure can cause a serious impairment of network services. It is due to the volume of network traffic carried by a single link or node. Moreover, the outage can stimulate end users to try to re-establish their connections within a short time. The retrials, however, make the problem worse because the connection establishment increases the traffic volume further. Fast restoration from a network failure becomes a critical issue in deploying high-speed networks. Self healing algorithms have been recognized as a major mechanism for providing the fast restoration. A self-healing system [6] should recover from the abnormal state and return to the normal state, and should start functioning as it was prior to failure. One of the key issues associated with self-healing networks is to optimize the networks while expecting reasonable network failures [6,7,8]. Self-healing network (SHN) [9] is designed to support transmission of messages across multiple nodes while also protecting against recursive node and process failures. It will automatically recover itself after a failure occurs. The problem of self-healing is in networks that are reconfigurable in the sense that they can change their topology during an attack. One goal is to maintain connectivity in these networks, even in the presence of repeated adversarial node deletion. Modern computer systems are approaching scales of billions of components. Such systems are less akin to a traditional engineering enterprise such as a bridge, and more akin to a living organism in terms of complexity. A railway over bridge must be designed in such a way that, key components never fail, since there is no way for the bridge to automatically recover from system failure. In contrast, a living organism cannot be designed so that no component ever fails: there are simply too many components. For example, skin can be cut and still heal. Designing skin that can heal is much more practical than designing skin that is completely rigid to attack. Unfortunately, current algorithms ensure robustness in computer networks through hardening individual components or, at best, adding lots of redundant components [10].

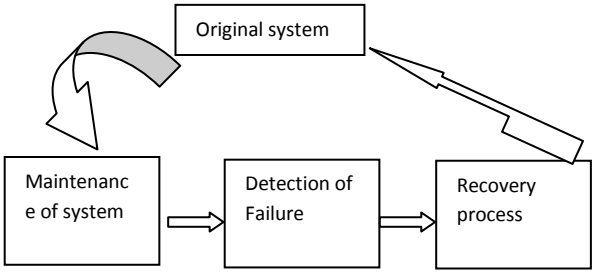

Figure 1: Self healing cycle

Self healing cycle has been shown in Figure 1. Critical issues [11] in self-healing systems typically include; Maintenance of system health, recovery processes to return the state from an unhealthy state to a health one. Self-healing components or systems typically have the following characteristics [11]: (a) perform the productive operations of the system, (b) coordinate the activities of the different agents, (c) control and audit performance, (d) adapt to external and internal changes and (e) have policies to determine the overall purpose of the system. Most of the self-healing concepts are still in very early stages; still some possible areas explored are Grid computing, software agents, middleware computing, ad hoc networks. Emphasis here is on ad hoc network self healing characteristic. This section provides an analysis of various schemes that can be used as self healing schemes.

a) Self Healing in Routing

The most promising developments in the area of self-healing wireless networks are ad hoc networks. They are decentralized, self-organizing, and automatically reconfigure without human intervention in the event of degraded or broken communication links between transceivers. Automated network analysis through link and route discovery and evaluation are the distinguishing features of self-healing network algorithms. Through discovery, networks establish one or more routes between the originator and the recipient of a message. Through evaluation, networks detect route failures, trigger renewed discovery, and—in some cases—select the best route available for a message. Because discovery and route evaluation consume network capacity, careful use of both processes is important to achieving good network performance.

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b) Self healing in RF

Environmental radio-frequency (RF)[12] "noise" produced by powerful motors, other wireless devices, microwaves—and even the moisture content in the air—can make wireless communication unreliable. Despite early problems in overcoming this pitfall, the newest developments in self-healing wireless networks are solving the problem by capitalizing on the inherent broadcast properties of RF transmission. The changes made to the network architectures are resulting in new methods of application design for this medium.

c) Self healing in Power efficiency

As the network is always on, conserving power is more difficult. One solution is **On-demand discovery [11].** It establishes only the routes that are requested by higher-layer software. On-demand discovery networks are only "on" when called for. This allows nodes to conserve power and bandwidth and keeps the network fairly free of traffic. If, between transmissions, the link quality between nodes has degraded, however, on-demand networks can take longer to reconfigure and, thus, to deliver a message. Once routes have been established, they must generally be maintained in the presence of failing equipment, changing environmental conditions, interference, etc. This maintenance may also be proactive or on-demand. Another solution can be **Single-path routing [11].** As for routing, network algorithms that choose single-path routing, as the name suggests, single out a specific route for a given source-destination pair. Sometimes, the entire end-to-end route is predetermined. Sometimes, only the next "hop" is known. The advantage of this type of routing is that it cuts down on traffic, bandwidth use, and power use. If only one node at a time needs to receive the packet, others can stop listening after they hear that they're not the recipient.

3.1 Self-Healing Technologies

Dynamic Source Routing (DSR)

DSR uses dynamic source routing [13] and it adapts quickly to routing changes when host movement is frequent, however it requires little or no overhead during periods in which host moves less frequently. Source routing is a routing technique in which the sender of a packet determines the complete sequence of nodes through which to forward the packets, the sender explicitly lists this route in the packet's header, identifying each forwarding hop by the address of the next node to which to transmit the packet on its way to the destination host. The protocol is designed for use in the wireless environment of an ad hoc network. Route cache is maintained to reduce cost of route discovery. Route Maintenance is used when sender detects change in topology or source code has got some error. In case of errors sender can use another route or invoke Route Discovery again. The DSR is single path routing.

Temporary Ordered Routing Algorithm (TORA)

TORA [14] **uses** the Link reversal technology. It is structured as a temporally ordered sequence of diffusing computations; each computation consisting of a sequence of directed link reversals. It is based on LRR (Link reversal routing). The protocol is highly adaptive, efficient, loop free and scalable. Important concept in its design is that it decouples the generation of potentially far-reaching control message propagation from the rate of topological changes. It reduces energy consumption without diminishing the capacity or connectivity of the network.

Ad hoc On demand Distance Vector (AODV)

Ad Hoc On Demand Distance Vector (AODV) [15] is pure on demand routing system The AODV routing protocol is intended for use by mobile nodes in an ad hoc network characterized by frequent changes in link connectivity to each other caused by relative movement. It offers quick adaptation to dynamic link conditions, low processing and memory overhead, low network utilization, and establishment of routes between sources and destination which is loop free at all times. It follows quick adaptation to changes. It has low memory overhead.

IV PROPOSED SCHEME

The objective of the proposed self healing scheme is to design a scalable routing protocol for large scale networks. It uses concept of Neighbor nodes network.

4.1 Mobile Neighbor Networks (MNNs):

A neighbor network is a network consisting of a large area with hundreds of nodes. There are two types of nodes in these networks: neighbor nodes and regular nodes (RNs). Since the NNs are also mobile and keep joining and leaving the neighbor network in an ad hoc manner, the neighbor network is actually a MANET.

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Thus, there are multiple MANETs in a multi-level MNN. All nodes in a network operate in the same channel but these networks operate in different channels to minimize the interference across levels. There are three critical issues involved in building a MNN as

1. Number of neighbor Nodes
2. Deployment of neighbor Nodes
3. Routing Protocols

4.1.1 Number of Neighbor Nodes

Optimal number of neighbor nodes has been calculated with the aim of maximizing per node throughput. In general, the network is designed such that it has sufficient number of NNs to cover the whole network.

4.1.2 Deployment of neighbor Nodes

Ideally, neighbor node (BNs) should be deployed such that the number of NNs to cover the whole network is optimal. This could be done by pre-assigning NNs and scattering them around the terrain at the time of network initialization. However, this may not be worth because these NNs are also moving, and may go down which may leave some Routing Nodes having no NNs to associate with. The typical solution is to deploy redundant Nodes in the network and elect some of them as NNs. The task of selecting NNs from network is called neighbor election. When all NNs move out of the reach of a network then that network changes its status. Hence, management of number and deployment of NNs are completely distributed, dynamic and self-organized. It is desired to perform in a distributed manner and dynamically in such a manner that the NNs are scattered in the terrain.

4.1.4 Routing Protocols

After a set of NNs is elected and these NNs are connected through a high power radio to form the neighbor network, the one critical issue remained is routing. There are ample choices available to select a routing protocol. Apart from the application, the one of the most important consideration while choosing a routing protocol is that it should be able to utilize the short cut and additional bandwidth provided by the separate high power links among NNs. AODV has been used as base protocol and changes have been made to it. In this paper a new scheme, known as the Neighbor nodes network [16] has been suggested which would allow mobile nodes to maintain routes to destinations with more stable route selection. This scheme responds to link breakages and changes in network topology in a timely manner. It uses concept of neighbor nodes network as explained earlier. This makes route maintenance and recovery phase more efficient and fast. This neighbor nodes network helps in reconstruction phase in the fast selection of new routes. Each route table has an entry for number of neighbor nodes attached to it. Whenever need for a new route arises in case of route break, check for neighbor nodes are made, and a new route is established. Same process is repeated in route repair phase. Route tables are updated at each hello interval as in AODV with added entries for neighbor nodes. These are nodes at the one hop distance from its neighbor. Neighbor nodes are those nodes which are not participating in route process currently or nodes which enter the range of transmission during routing process. As nodes are in random motion for a scenario, so there is every possibility that some nodes are idle and are in the vicinity of the routing nodes. Whenever a break in the route phase occurs due to movement of participant node, node damage or for other reasons; theses idle nodes which have been termed as neighbor nodes take care of the process and start routing. The whole process becomes fast and more packet delivery is assured. The changes in the existing protocol are required at route reply and route recovery phases. In these phases the route table is updated with entries of neighbor nodes. Each route table has an entry for number of neighbor nodes surrounding it and their hop distance form the node. For simplicity of the protocol the distance has been assumed to be one hop.

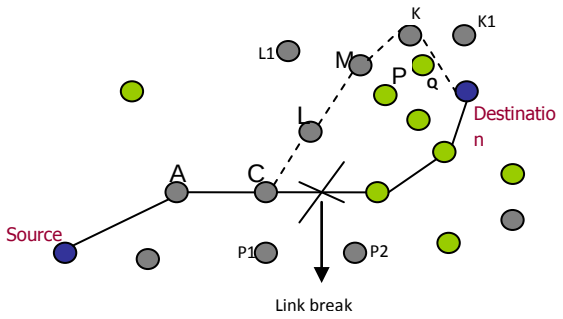

Figure 2: Local repair

Figure 2 gives an idea of self healing process. Initial path from source node 'Source' to destination node 'Destination' is shown via solid lines. When link breaks at node C, route repair healing starts, node C starts searching for new paths. Node C invokes Route Request phase for 'Destination'. Now neighbor nodes are selected and proper selection of nodes is done. Path selected becomes [**C - L – M – K – Destination].**
If any NN has not been on active scale, it is rejected and a new node is searched. In addition to power factor, efforts are made to keep the path shortest. This healing process attempts are often invisible to the originating node.

V. Conclusion

In this paper a new scheme has been presented that utilizes neighbor network. The scheme can be incorporated into any ad hoc on-demand protocol to heal link failures. It will improve reliable packet delivery even in route breaks. As a case study, the proposed scheme has been incorporated to AODV and it is expected that the performance improves. Study is going on currently investigating ways to make this new scheme robust to traffic load. The proposed scheme gives a better approach for on demand routing protocols for route selection and maintenance. It is expected that overhead in this protocol will be slightly higher than others, which is due to the reason that it requires more calculations initially for checking neighbor nodes. This also may cause a bit more end to end delay. The proposal is to check this scheme for more detailed and realistic channel models with fading and obstacles in the simulation. Efforts are on to simulate the scheme using NS2 and compare results with existing schemes.
Self-healing systems are relatively new both for the academia and the industry. However, hope is to see a large number of systems, software and architectures that borrow from nature, ideas and concepts very quickly in future. Modeling computer security using biology as a motivation can help in creating adaptive systems that provide functionality despite the possibility of disasters. The obvious goal is to generate a technique that will reveal that Self-healing networks are designed to be robust even in environments where individual links are unreliable, making them ideal for dealing with unexpected circumstances. The dynamic nature that gives these networks their self-healing properties, however, also makes them difficult to test. Even after multiple deployments and thorough simulation, it's difficult to predict how these systems will work (or fail) in actual emergencies. Though the best uses for technologies are often difficult to predict, still one can almost certain that the self-healing networks is waiting to be developed and getting popular.

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