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A New Autonomous System (AS) for Wireless Mesh Network

P S Khanagoudar

Abstract:-Multi-hop wireless mesh networks usually experience frequent link failure due to certain reasons such as channel interference, dynamic obstacles occurring in a network and even because of bandwidth demands of applications. Failures in WMN degrade the performance of WMN. Here we are proposing a new Autonomous system for Wireless Mesh Networks. The main objective of Autonomous system for WMN is to reduce manual configuration of network involved in maintenance of WMN. The Autonomous System for WMN is evaluated extensively through ns2-based simulation. The evaluation results show that Autonomous system surpass existing approaches and schemes in failure-recovery. This system helps in improving channel-efficiency by more than 88.6%. It also increases throughput, mean success rate of overall system and meets the various applications' bandwidth demands in the network.

***Keywords* – Multiradio Wireless Mesh Networks (MRWMNS), Wireless Mesh Network; Reconfiguration System, Wireless Link Failures.**

I. INTRODUCTION

Wireless mesh networking (WMN)[1] is an emerging technology that can be applied to provide cost-effective wireless coverage in a large area. Wireless mesh network (WMN) is a radical network form of the ever evolving wireless networks that marks the divergence from the traditional centralized wireless systems such as cellular networks and wireless local area networks (LANs)[1]. The primary advantages of a WMN lie in its inherent fault tolerance against network failures, simplicity of setting up a network, and the broadband capability. Unlike cellular networks where the failure of a single base station (BS)[3] leading to unavailability of communication services over a large geographical area, WMNs provide high fault tolerance even when a number of nodes fail.

A wireless mesh network (WMN) is a communication network made up of radio nodes organized in a mesh topology. WMNs are a promising next generation wireless networking technology. They intend to deliver wireless services to a large variety of applications in personal, local, campus, and metropolitan areas. WMNs are expected to basically resolve the limitations and to significantly improve the performance of wireless LANs, PANs, and MANs. They will have a great impact the development of wireless-fidelity (Wi-Fi), WiMAX (world wide inter-operability for microwave access), Ultra Wide Band (UWB) and wireless sensor networks.

A. Wireless Mesh Network Infrastructure

Wireless mesh network infrastructure is considered as the network providing cost effective and dynamic high bandwidth networks over a specific coverage area. Mesh architecture sustains signal strength by breaking long distances into a series of shorter hops. Intermediate nodes not only boost the signal, but cooperatively make forwarding decisions based on their knowledge of the network, i.e. perform routing. Such architecture may with careful design provide high bandwidth, spectral efficiency, and economic advantage over the coverage area.

The Wireless Mesh Network infrastructure is shown in the Figure 1.The Role of Access Points (APs) in WMN is it provides internet access to Mesh Clients (MCs) by forwarding aggregated traffic to Mesh Routers (MRs), known as relays, in a multi-hop fashion until a Mesh Gateway (MG) is reached. MGs act as bridges between the wireless infrastructure and the Internet. WMNs are comprised of two types of nodes: mesh routers and mesh clients.

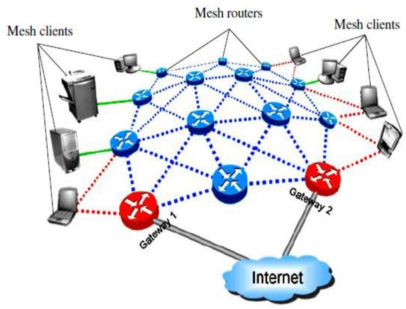

Fig.1Wireless Mesh Network infrastructure

Mesh routers have an additional functionality called Gateway and bridging functionality. This functionality is used to connect WMNs with other preexisting networks like IEEE 802.15, IEEE 802.16, wireless -fidelity (WiFi), WPAN, WLAN, WiMAX (world wide inter-operability for microwave access), WiMEDIA, Internet, Cellular, wireless Sensor networks etc. **Mesh clients** can either be stationary or mobile. These nodes can either form a network of mesh clients or a network comprising of both mesh clients and mesh routers. The client nodes with Network Interface cards (NICs) can connect directly to the mesh routers. The ones without NICs can connect themselves to mesh routers via, for example Ethernet.

II.RELATED WORK

A considerable amount of work has been done to solve the problems in WMNs and to build a healthy wireless network and. Network reconfiguration needs a planning algorithm that keeps necessary network changes (to recover from link failures) as local as possible, as opposed to changing the entire network settings. Existing channel assignment and scheduling algorithms provide guidelines such as throughput bounds and schedulability

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for channel assignment during a network deployment stage.

Limitations of Existing Approaches

Network reconfiguration needs a planning algorithm that keeps necessary network changes (to recover from link failures) as local as possible, as opposed to changing the entire network settings.

Disadvantages of existing approach:

1. Cannot avoid propagation of QoS failures to neighboring links.
2. Unsuitable for dynamic network reconfiguration.

Addressed issues in WMN

- Frequent link failures caused by channel interference, dynamic obstacles, and/or applications bandwidth demands.
- Severe performance degradation in WMNs due to link Failures.
- Expensive manual network management for their real-time recovery.

III.AUTONOMOUS SYSTEM

Some challenges in WMN propelled the ideas towards thinking and achieving gainsays.

A. Motivation

What is the need for Autonomous system?

To improve and maintain the performance of WMN in case of dynamic link failures in the network. To withstand failures by enabling MR WMNs and to autonomously reconfigure channels and radio1 assignments, as in the following examples.

- Due to severe interference from collocated wireless networks the quality of wireless links in WMNs degrades (i.e., link-quality failure). Hence there is a need of recovery system that can successfully recover from link failure.
- Satisfy the QoS demands.
- Maintaining compatibility with different types of network.

Motivated by these three and other possible benefits of using reconfigurable mr-WMNs, This work is proposed.

B. Autonomous System

Algorithm 1: AS Operation at mesh node
Step 1: Generate topology
Step 2: Start flooding information
A: **for every** link/node **do**
B: Exchange neighbor Nodes information.
C: **end for**
D: send neighbor node information to the gateway;
Step 3: Select source node.
Step 4: Establish path from source to destination
Step 5: Start packet transmission.
Step6: Check node/link failures else go to step 10
Step 7: Start reconfiguration and
e) Generate Reconfigure plan.
d) Re-establish path
Step 9: Start packet transmission
Step 10: Receive packets
Step 11: Stop

C. Overview of Algorithm

Algorithm mainly monitors mesh network. And then starts flooding information for every node in a mesh network. On link degradation and link/node failures it starts reconfiguring failure node/link by detecting through continuous monitoring. Here the AS supports reconfigurability via the following distinct features.

- **Localized reconfiguration**: Based on multiple channels and radio associations available, AS 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.
- **QoS-aware planning:** AS effectively identifies QoS-satisfiable reconfiguration plans by: 1) estimating the QoS-satisfiability of generated reconfiguration plans; and 2) deriving their expected benefits in channel utilization.
- **Autonomous reconfiguration via link-quality monitoring:** AS accurately monitors the quality of links in the mesh network.

IV.SIMULATION AND RESULT ANALYSIS

A simulation [4] is, more or less, a combination of art and science. That is, while the expertise in computer programming and the applied mathematical tools account for the science part, the very skill in analysis and conceptual model 1.3 Basics of Computer Network Simulation 7 formulation usually represents the art portion. A long list of steps in executing a simulation process, as given in [8], seems to reflect this popular claim. Basically, all these steps can be put into three main tasks each of which carries different degrees of importance.

According to Shannon [4], it is recommended that 40 percent of time and effort be spent on defining a problem, designing a corresponding model, and devising a set of experiments to be performed on the simulation model. Further, it was pointed out that a portion of 20 percent should be used to program the conceptual elements obtained during the first step. Finally, the remaining 40 percent should be utilized in verifying/validating the simulation model, experimenting with designed inputs (and possibly fine-tuning the experiments themselves), and analyzing the results. Work notes that this formula is in no way a strict one. Any actual simulation may require more or less time and effort, depending on the context of interest and, definitely, on the modeler himself/herself.

A simulation can be thought of as a flow process of network entities (e.g., nodes, packets). As these entities move through the system, they interact within other entities, join certain activities, trigger events, cause some changes to the state of the system, and leave the process. From time to time, they contend or wait for some type of resources. This implies that there must be a logical execution sequence to cause all these actions to happen in a comprehensible and manageable way. An execution

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sequence plays an important role in supervising a simulation and is sometimes used to characterize the types of simulation.

According to Shannon [4], simulation is "the process of designing a model of a real system and conducting experiments with this model for the purpose of understanding the behavior of the system and/or evaluating various strategies for the operation of the system." With the dynamic nature of computer networks, then deal with a dynamic model of a real dynamic system.

A. System Modeling

System modeling [4] refers to an act of representing an actual system in a simply way. System modeling is extremely important in system design and development, since it gives an idea of how the system would perform if actually implemented. With modeling, the parameters of the system can be changed, tested, and analyzed. More importantly, modeling, if properly handled, can save costs in system development. To model a system, some simplifying assumptions are often required. It is important to note that too many assumptions would simplify the modeling but may lead to an inaccurate representation of the system. Traditionally, there are two modeling approaches: analytical approach and simulation approach.

- **ANALYTICAL APPROACH**

The general concept of analytical modeling approach is to first come up with a way to describe a system mathematically with the help of applied mathematical tools such as queuing and probability theories, and then apply numerical methods to gain insight from the developed mathematical model.

- **SIMULATION APPROACH**

Simulation is widely-used in system modeling for applications ranging from engineering research, business analysis, manufacturing planning, and biological science experimentation, just to name a few. Compared to analytical modeling, simulation usually requires less abstraction in the model (i.e., fewer simplifying assumptions) since almost every possible detail of the specifications of the system can be put into the simulation model to best describe the actual system. When the system is rather large and complex, a straightforward mathematical formulation may not be feasible. In this case, the simulation approach is usually preferred to the analytical approach

B. Simulation Environment

In previous section discussed about system architecture and design of the system for the proposed Autonomous system. Now, in this section discuss about simulation environment along with output result analysis, parameters used for simulation and performance analysis with the help of graphs obtained.

GENERATE MESH TOPOLOGY

Build the wireless network according to the mesh topology. Then the process of continuous monitoring of wireless mesh network starts.

NEIGHBOR NODE DISCOVERY

Neighbor node discovery is process of identifying the neighbor nodes in network and then excahnging neighbor node information between the nodes. Once the information between the nodes is exchanged, then with help of this information shortest path from source node to destination node can be easily built.

PACKET TRANSMISSION

Once the path is identified from source to sink node. The packet transmission starts from source to destinstion. For a variety of reasons data in networks is transmitted in packets. Packet consists of data and size of data varies which is to be transmitted over network. One of the reasons to make use of packets is safe and secured transmission of data.

FAILURE DETECTION

Failure detection [9] plays a significant role in the designed autonomous WMN. Figure 2 shows configured WMN. Configuration process consists of various events to be carried. Once the network is fully configured chain of processes starts executing. As the process of data transmission starts from source to destination continuous monitoring of WMN will be done. With continuous monitoring it will be easy to assess the network performance and also to identify with link/node failures in network.

Once the node gets failed autonomous system identifies failures accordingly generates reconfiguration plans. Among the generated plans one of the best plans will be selected with the less number of changes in the network.

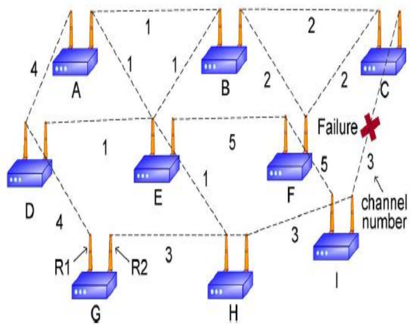

Fig .2 Node failures in WMN

Figure.2 Shows configured WMN with respective channels associated for data transmission. In figure .2 shows failure in channel number 3.

C. Applying Reconfiguration Plans

Once the best plan has been selected then reconfiguration takes place. After reconfiguration re-establishment of path takes place to for packet transmission. This process of self-reconfiguring of failures in the network is carried continuously.

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D. Result Analysis

Final part of our work is result analysis. The following are the equations applied and used for calculation of the results for the proposed autonomous system. There are many different ways to measure the performance of a network, as each network is different in nature and design. Performance can also be modeled instead of measured; various metrics taken into account for result analysis such as mean success, Energy consumption, throughput, link recovery, channel efficiency.

Mean success: Mean success can be defined as average value of successful packet transmission from source to destination in a proposed system for WMN.

Energy Consumption: Energy consumed by the wireless mesh network nodes during the operation of reconfiguration.

Throughput: The word "throughput" refers to the measured performance of a system. Throughput of a network is given by the number of bits that can be transmitted over the network in a unit time period.

Link Recovery: Recovering from link failures occurred in the Wireless Mesh Network due link failures.

Channel Efficiency: Efficiency of channel is ratio of the output to the input of a system.

Mean Success = [(number of paths*single path/path length)/number of nodes]

Energy Consumption = [Number of nodes/ (nodes* Number of source)]

Throughput = [message count/single count]

Link Recovery= [((number of nodes/single count)*(message count/single count))/ (number of nodes)]

Channel Efficiency= [(Single count/total delay)*Average delay]

MEAN SUCCESS

Mean success is taken as one of metric to measure the performance of the proposed system. We compare the mean success between two different WMNs one without AS and another with AS. Outcome of comparison is given in figure .3 from which we can easily distinguish success rates.

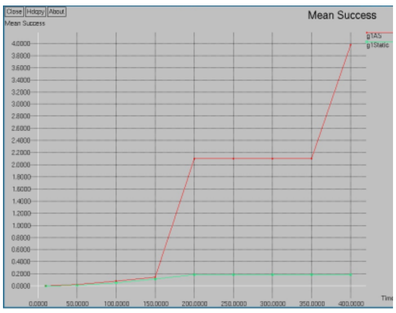

Fig .3 Mean success

The results of comparison in figure 3 evidently describes with details regarding the mean success on making use of AS model i.e. g1AS and g1static shows the mean success rate without using the proposed AS model. Results of comparison reveal mean success rate of proposed Autonomous System is comparatively better.

TIME V/S ENERGY CONSUMPTION

Each and every element in the network needs power/energy to drive appropriately the WMN. We can calculate overall energy consumed by WMN. Here graph in figure 4. Comparison is between two different cases. Case 1: static WMN and case 2: AS WMN.

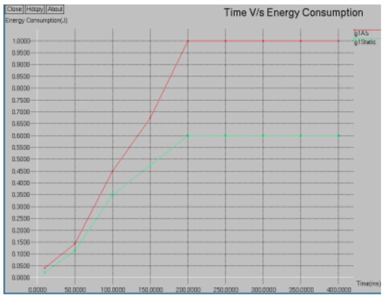

Fig .4 Time Vs/ Energy Consumption

In the graph g2AS shows Energy Consumption when AS architecture is used and g2static shows the energy consumption without the use of AS architecture. Results reveal that energy consumption is more in the WMN which makes use AS and is less in case of WMN which doesn't make use of AS.

TIME VS THROUGHPUT

Throughput is one more metric which is used to measure the performance of the network.

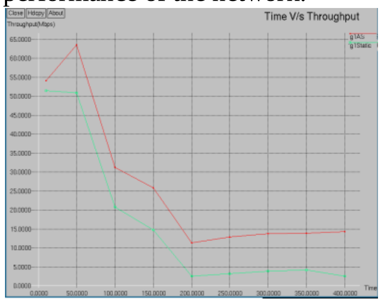

Fig .5 Time Vs Throughput

The figure 5 shows the compared throughput of a two different systems. The throughput of two wireless mesh networks is compared. Where in case 1: The g3AS shows throughput of mesh network when AS is used and in case 2: g3static shows without using AS. From the results it can be easily said that throughput of Wireless Mesh Network which uses AS is better than a simple Wireless Mesh Network. Throughput of a network in case 1 increases because it reduces the link failure and link degradation as a result expected throughput for the system is achieved.

TIME V/S LINK FAIL RECOVERY

Link failure [9] degrades overall performance of the system. Hence to deal with the link failure we considered this as one more metric to measure the performance of system. As soon as Link failure is identified the process of link recovery is executed. We have incorporated a new algorithm for the new Autonomous System as a result algorithm generates recovery plans accordingly, the plan with minimum number of changes will be deployed to the Wireless Mesh Network.

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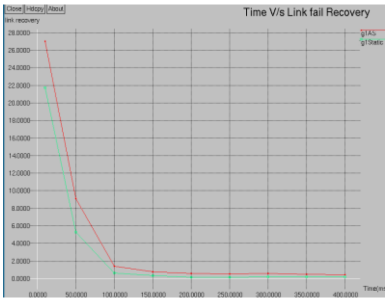

Fig .6 Time V/s Link fails Recovery

Comparison graph for Time V/s Link fail recovery for the two considered cases is shown in the figure 6. Case 1: The g4AS shows Link fail Recovery in case of Wireless Mesh Network when AS is used and case 2: g3static shows Link fail Recovery without using AS. Link fail recovery plays significant role in the AS. This reveals success of the proposed Autonomous system for WMN.

TIME V/S CHANNEL EFFICIENCY

Communication channel refers medium used for transmission of data. Here in case of WMN wireless links are used for communication via channel. As a result there could be any physical obstacles which may result in channel distraction. Channel efficiency is considered as one more metric to evaluate the QoS provided by the AS.

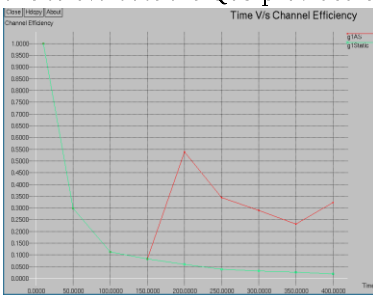

Fig. 7 Time v/s Channel Efficiency

Comparison of Time v/s Channel Efficiency for two different cases is shown in figure 7. case 1: The g4AS shows in Channel Efficiency in case of Wireless Mesh Network when AS is used and caser 2:g3static shows Channel Efficiency without using AS. Graph of comparison shows the channel efficiency is comparatively better in case 1 than in case 2.

E. Applications of the Proposed System

Mesh networks may involve either fixed or mobile devices. The solutions are as diverse as communication needs, for example in difficult environments such as emergency situations, tunnels, oil rigs, battlefield surveillance, high speed mobile video applications on board public transport or real time racing car telemetry. An important possible application for wireless mesh networks is VOIP. By using a Quality of Service scheme, the wireless mesh may support local telephone calls to be routed through the mesh.

Proposed Autonomous system model can be used in various fields such as.

- In Military forces to connect their computers using wireless mesh networking to, mainly ruggedized laptops, in field operations.
- Electric meters now being deployed on residences transfer their readings from one to another and eventually to the central office for billing without the need for human meter readers or the need to connect the meters with cables.
- The laptops in the One Laptop per Child program use wireless mesh networking to enable students to exchange files and get on the Internet even though they lack wired or cell phone or other physical connections in their area.

With the proliferation of Internet, Wireless Mesh Networks (WMNs) have become a practical wireless solution for providing community broadband Internet access services. These networks exhibit characteristics that are novel in the wireless context, and in many ways more similar to traditional wired networks.

V.CONCLUSION AND FUTURE WORK

This paper attempts to build a healthy mesh network through AS. Autonomous System (AS) helps in resolving problems with link failures and recovery. Link failure and link recovery has been done with help of continuous monitoring. Once any changes or failure occur in WMN, Autonomous System (AS) starts reconfiguring the failure links/nodes. Evaluation results shows the success rate, Energy consumption, Throughput, link failure recovery and finally channel efficiency of AS is better than static (without AS) in WMN.

Autonomous system proposed here is to increases the performance of WMN but energy consumption compared to system without using AS is more. Hence Energy consumption can be considered as an issue for the future work. We can solve this energy consumption issue by preserving and fulfilling the demands of WMN. Joint Optimization with Flow Assignment and Routing: AS decouples network reconfiguration from flow assignment and routing. Reconfiguration might be able to achieve better performance if two problems are jointly considered. Even though its design goal is to recover from network failures as a best-effort service, AS is the first step to solve this optimization problem, which could become future work.

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Author's Biography

Mr.Parutagouda.S.Khanagoudar is a computer science and Engg graduate from Karnataka university Dharwad, MTech in Digital Communication and Networking from V.T.U.Belgaum, Karnataka India. Working as a Asst professor at Gogte Institute of Technology, Belgaum, In CSE dept. This year registering for Ph.D at CMJ University, Shilong, Meghalaya.

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