Construction of Power Efficient Fault Tolerant Wireless Network Using Cone Based Algorithm

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Abstract **- Fault tolerant topology control for all to one communication holds significance in dynamic wireless networks with asymmetric wireless links. In this paper the author Investigates the various aspects of the problem mentioned above using the cone based distributed topology control algorithm. The topology of a wireless multi-hop network can be controlled by varying the transmission power at each node. If there is a path between receiver base station and the node then it will communicate with the maximum power. The author proposes a set of optimizations. It reduces power consumption and that they retain network connectivity. Dynamic configuration in the presence of failures and mobility of nodes are analyzed. In the proposed system, topology control algorithm controls the connectivity of node to the base station which is maintained during dynamic location of the nodes using Gaussian Distribution. Network Simulator is used to simulate for the connectivity of node and receiver base station. The fault tolerant topology control helps to retain the node within the network .**

Index Terms **- Wireless networks, topology control, fault tolerant.**

1 INTRODUCTION

Mobile computing is that the device when it is being mobile and therefore changing the location from a normal fixed position to a more dynamic position for communication. Wireless Access Point is a small device that bridges wireless traffic to network. Users maintain a continuous connection as they roam from one physical area to another. Mobile nodes automatically register with the new access point. A topology consists of a set of nodes and links, and it describes the connectivity information of the network. Topology control determines the network topology by controlling the transmission power of sending a physical layer broadcast. Battery power consumption is the major concern of mobile nodes in Ad-hoc network. One of the strategy for energy saving is based on the observation that reducing the physical distance between receiver base station and target node in wireless network.

1.1 WIRELESS NETWORK

Using radio frequency spectrum for transmitting and receiving voice, data and video signals for communication is called wireless. The wireless service gives the user value added benefits of mobility in the local or wide area depending on the nature of the network. In recent years, wireless networks have been increasingly deployed for both civil and military applications.

Local area wireless networks based on the IEEE 802.11 standard are becoming increasingly prevalent with a current installed in homes and offices. Wide area wireless networks have many advances in technology and radio spectrum management have led to the development of cellular radio networks. Many different radio technologies can use cellular deployment of radio channels. Nowadays the term cellular refers to mean mobile phone networks such as GSM or CDMA.

Mobile computing is that the device when it is being mobile and therefore changing the location from a normal fixed position to a more dynamic position for communication. Battery power consumption is the major concern of mobile nodes in Ad hoc networks. Dynamic configuration in the presence of failure can occur at the time of mobility of the nodes. A topology consists of a set of nodes and links, and it describes the connectivity information of the network. Topology control determines the network topology by controlling the transmission power of sending a physical layer broadcast.

1.2 MOTIVATION

Multi-hop wireless networks such as radio networks, ad hoc networks and sensor networks are the networks where communication between two nodes may go through multiple consecutive wireless links. Unlike wired networks, which typically have a fixed network topology. Each node in a wireless network can potentially change the network topology by adjusting its transmission power to control its set of neighbors. The primary goal of the topology control is to design power efficient algorithms that maintain network connectivity and optimize performance metrics such as network lifetime and throughput [8].

Wireless networks deployed under a harsh environment. It is surprisingly that the wireless nodes and links experience frequent failures. Such node or link failures often have a significant impact on the performance and reliability of wireless networks and upper level applications. Therefore, ensuring fault tolerance becomes a very important issue in wireless networks. Node power consumption in wireless networks is a challenging one [1].

1.3 PROBLEM DEFINITION

The focus is now turning to deploy the topology control to maintain the connectivity and less power consumption. Today most of the networks have problems in the topology control so that network failures and more power consumptions [5].

To simplify deployment and reconfiguration upon failures and mobility, distributed topology control algorithms that utilize only local information and allow asynchronous operations are particularly attractive [11].

1.4 NETWORK ORGANIZATION

A network consists of nodes and the links connecting them. Nodes functionally classified into two types. They are endpoints (hosts or terminals) that act as source and sink of traffic, and switches (routers) that forward traffic towards its destination. The different requirements of these types of networks give rise to different techniques for network organization such as terrestrial cellular networks and packet radio (ad hoc) networks.

a. TOPOLOGY CONTROL

A topology consists of a set of nodes and links, and it describes the connectivity information of the network. Topology control determines the network topology by controlling the transmission power of sending a physical layer broadcast [2]. The primary goal of topology control is to design power efficient algorithms that maintain network connectivity and optimize performance metrics such as network lifetime and throughput [13].

1.5.1 TOPOLOGY CONTROL PROBLEM

The topology control problem can be taken as, set V of possible mobile nodes located in the plane. Each node $u \in V$ is specified by its coordinates (x(u),y(u)) at any given point in time.

Each node u has a power function p where p(d) gives the minimum power needed to establish a communication link to a node v at a distance d away from u. The maximum transmission power P is same for every node and the maximum distance for any two nodes to communicate directly is R [10].

$$p(R) = P \qquad (1)$$

Every node transmits with power P. Then the induced graph as,

$$G_R = (V, E) \qquad (2)$$

$$E = \{(u, v) \mid d(u, v) \leq R\} \qquad (3)$$

where d(u, v) is the Euclidean distance between u and v.

It is undesirable to have nodes transmit with maximum power for two reasons. First, the power required to transmit between nodes increases as the nth power of the distance between them, for some $n \geq 2$. It may require less power for a node u to relay messages through a series of intermediate nodes to v than to transmit directly to v. Secondly, the greater power with which a node transmits, the greater the likelihood of the transmission interfering with other transmissions.

b. PROPOSED SYSTEM

Topology control has been proposed to save the power consumption of nodes. Each node instead of using its maximal transmission power sets its power to a certain level. If there is a path between receiver base station and the node then it will communicate with the maximum power and to propose a set of optimizations. It reduces power consumption and that they retain network connectivity. Using topology control algorithm controls the connectivity of node to the base station and it is maintained during dynamic location of the mobile nodes. The fault tolerant topology control helps to retain the node within the network without any faults [9].

2 TOPOLOGY CONTROL ALGORITHM

2.1 FAULT TOLERANCE

Some sensor nodes may fail or block due to lack of power, or have physical damage or environmental interference. The failure of sensor nodes should not affect the overall task of the sensor network. This is the reliability or fault tolerance issue. Fault tolerance is the ability to sustain sensor network functionalities without any interception due to sensor node failures [1]. The reliability $R_k(t)$ or fault tolerance of a sensor node is using Poisson distribution to capture the probability of not having a failure within the time interval (0,t).

$$R_k(t) = e^{-\lambda_k t} \qquad (4)$$

where λ_k the failure rate of sensor node k and t is is the time. Gaussian distribution is used to identify the actual distance between the node and the base station.

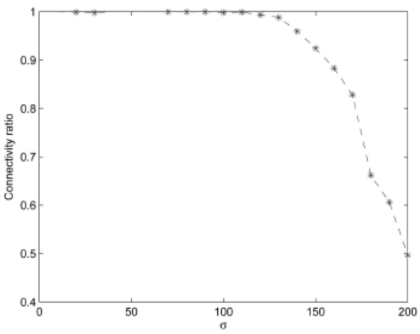

Fig 1. Connectivity in Gaussian Distributed Networks

$$R_k(t) = 1 - e^{-\lambda_{k\pi}^{r} s} \qquad (5)$$

2.2 FAULT TOLERANT TOPOLOGY CONTROL

The hitting radius for the k-connectivity for n randomly and uniformly distributed points in a unit area square C [15].

Take the random point X_n, a homogeneous Poisson point process of rate n, denoted by P_n, on a unit area square C. Let $\sum(k, n, r)$ denote the expected number of points of P_n with degree k in a graph of $G(P_n, r)$. Let D(x, r) be the disk centered at x with radius r. Given a point x, let $v_r(x)$ be the area of the intersection of D(x, r) with unit area square C.

$$\varphi_{n,r,k}(x) = (n \cdot v_r(x))^k \cdot \frac{e^{-n \cdot v_r(x)}}{k!} \qquad (6)$$

Here $\varphi_{n,r,k}(x)$ is the probability that point x has degree k.

$$\varepsilon(k, n, r) = n \int_C \varphi_n, r, k(x) dx \qquad (7)$$

To control the network topology given n nodes, the network that is already k fault tolerant. After selecting the hitting radius for the k-connectivity, the network topology has a unit disk graph (UDG) by scaling the radius to one unit. A unit disk graph is the graph in which two nodes are connected if their distance is not more than one unit [9].

Due to the nodes limited resource in wireless ad hoc networks, the scalability is crucial for network operations. Network topology should not compromise on the fault tolerance and compromise too much on the power consumptions for both unicast and broadcast/multicast communications [6]. A network topology is said to be power efficient if there is a power efficient route to connect any two nodes in the topology.

In the most common power attenuation model, the signal power falls as $\frac{1}{r^\beta}$ where r is the distance from the transmitter antenna and β is a constant between 2 and 5 dependent on the wireless transmission environment. This is called path loss of the signal [4]. Then the power needed to support a link uv is $||uv||^\beta$, where $||uv||$ is the Euclidean distance between u and v.

2.3 CONE BASED TOPOLOGY CONTROL

Cone based topology control (CBTC) is a topology control algorithm which is used for reducing the number of edges in the graph while it preserves the network connectivity [12]. So that it can be capable of minimize the power consumption in the base station to the mobile node.

Cone based algorithm is distributed (execute at every node) and used only on the local information. However, it will take as that direction to neighbors and do the computation.

2.3.1 CONE BASED ALGORITHM

Cone based algorithm requires only the availability of directional information. It must be possible to estimate the direction from which another node is transmitting. The cone based algorithm takes as a parameter an angle α [3]. A node u then tries to find the minimum power $p_{u,\alpha}$ such that transmitting with $p_{u,\alpha}$ ensures that in every cone of degree α around u, there is some node that u can reach with power $p_{u,\alpha}$ where $\alpha \le 2\pi/3$ is sufficient to preserve network connectivity.

G_α be the symmetric closure of the communication graph that results when every node transmits with power $p_{u,\alpha}$ (so that neighbors of u in G_α are exactly those nodes that u can reach when transmitting with power $p_{u,\alpha}$ together with those nodes v that can reach u by transmitting with power $p_{v,\alpha}$). Then if there is a path from u to v in G_R, then there is also such a path in $G_{2\pi/3}$. G_α be the symmetric closure of the communication graph that results when every node transmits with power $p_{u,\alpha}$ (so that the neighbors of u in G_α are exactly those nodes can reach when transmitting with power $p_{u,\alpha}$ together with those nodes v that can reach u by transmitting with power $p_{v,\alpha}$). Then it is shown that if there is a path from u to v in G_α, then there also such a path in $G_{2\pi/3}$. This is for a reasonable class of power cost functions and for $\alpha \le 2\pi/3$.

2.3.2 CONE BASED TOPOLOGY CONTROL ALGORITHM

The following three communication primitives are considered as follows,

- broadcast

bcast(u,p,m) is invoked by node u to send message m with power p. It results in all nodes in the set { v | p(d(u,v)) ≤ p} receive m.

- send

send(u,p,m,v) is invoked by node u to send message m to v with power p. This primitive is used to send unicast messages. i.e. point – point messages.

- receive

recv(u,m,v) is used by u to receive message m from v.

When v receives a message m from u, it knows the reception power p' of message m. This is, in general, less than the power p with which u sent the message, because of radio signal attenuation in space. The transmission power p and the reception power p', u can estimate p(d(u,v)) [7].

The algorithm takes as a parameter an angle α. Each node u tries to find at least one neighbor in every cone of degree α centered at u. Node u starts running the algorithm by broadcasting a "Hello" message using low transmission power, and collecting replies. It gradually increases the transmission power to discover more neighbors. It keeps a list of the nodes that it has discovered and the direction in which they are located.

Then it checks whether each cone of degree α contains a node. This check is easily performed. The nodes are sorted according to their angles relative to some reference node. It is immediate that there is a gap of more than α between the angles of two consecutive nodes if and only if there is a cone of degree α centered at u, which contains no nodes. If there is such a gap, then u broadcasts with greater power. This continues until either u finds no α – gap or u broadcasts with maximum power [12].

$$\text{set } N_\alpha = \{ (u,v) \in V \times V : v \in N_\alpha(u) \} \qquad (8)$$

where $N_\alpha(u)$ is the final set of discovered neighbors computed by a node u at the end of the running of CBTC(α). Let $p_{u,\alpha}$ be the corresponding final power. Graph $G_\alpha = (V, E_\alpha)$ where V consists of all nodes.

$$E_\alpha = \{ \{u,v\} \ (u,v) \in N_\alpha, (u,v) \in N_\alpha \} \qquad (9)$$

for $\alpha \leq 2\pi/3$, G_α is connected if and only if G is connected and the theorem does not work necessarily for $\alpha > 2\pi/3$ and this generalize the property to k-connectivity [8].

3SIMULATION

To evaluate the performance of the proposed model, NS-2 simulator with wireless scenario is used. At first, construct the nodes (mobile nodes and corresponding nodes) and then construct the base stations (Home Agent and Foreign Agent) [14]. Implement the operations on nodes and perform mobility of the nodes in the network area. Make connectivity between the mobile nodes and the base stations [11].

The mobility phenomena influenced by the mobile nodes and the base station can transmit the signal with minimal power usage. If more than one Home Agent is there then the maximal power signal will make the connectivity and others will suspend from that mobile node connectivity.

If the mobile node reached out of coverage then by using fault tolerant topology control and cone based topology control algorithm will control the network connectivity [12]. When the mobile node is reached out of the home agent then the foreign agent will take care of the mobile node and registered in the home agent. The mobile node will always in the network connectivity without any loss of signal or faults in the network.

3.1 IMPLEMENTATION STRATEGY

CONSTRUCT NODE AND BASE STATION

Using NS-2 simulator, the nodes and base stations can be created. Coding is to be done using the Tcl. Nodes are in the circle shape and the base stations are in the Hexagon shape. There is provision to represent Mobile Nodes. Base stations are divided into Home Agent and Foreign Agent.

BASE STATION AND ITS COVERAGE

The base station is used to transmit the signal for its coverage area. In that coverage if any mobile nodes are present then the mobile node can use the signal to maintain their connectivity.

BASE STATION AND ITS DATA PACKET LOSS

The base station can transmit the signal across its coverage area it might have some loss of packets in the network.

MOBILE NODE MOBILITY

The mobile nodes can move anywhere in the network and it can use base station Home Agent and Foreign Agent.The mobile node can use Home Agent when it is in the Home Network and if moves away from the home network then foreign network (Foreign Agent) will take care of the mobile node.

MOBILITY TRACE FILE

Using NS2 and Tcl code are used to trace the network connectivity and signal from base station to the mobile node.

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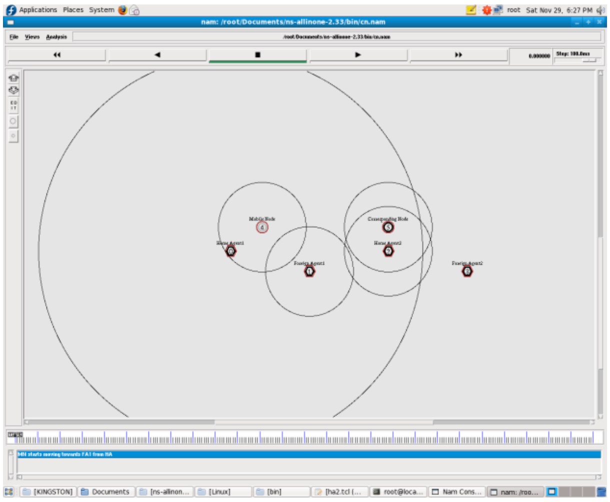

Fig 2. Coverage and Node Mobility

4 CONCLUSION

Wireless networks are becoming popular worldwide. The fault in network adversely affects the network connectivity. The fault tolerant topology control helps to retain the node within the network. Cone based topology control algorithm has two approaches to reduce energy consumption; first it reduces the transmission power of each node Secondly, it reduces the total energy consumption through the perseveration of minimum energy paths in the underlying network. It also provides other metrics such as network throughput and network lifetime. Reducing energy consumption tends to increase network lifetime. Mobile nodes can roam anywhere in the network and can connect with their network connectivity without any delay or failure.

5 FUTURE WORK

Mobile node connectivity and minimal energy consumption controls and their performance of using fault tolerant topology control and cone based topology control algorithm can be analyzed. If topology control is not done carefully network throughput will hurt. Eliminating edges may result in more congestion and hence worse throughput, even if it saves power in the short run. The right tradeoffs to make are very much application dependent.

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