A Fibonacci Based TGO Methodology For Survivability In Zigbee Topologies.

Shanmuk Srinivas Amiripalli, Veeramallu Bobba

Abstract: Wireless networks gain popularity in recent years with tremendous growth in ZigBee, Bluetooth, 6LowPan, Ethernet technologies. Survivability is a mechanism in which the network has to withstand even some nodes had failed randomly. It is one of the major issues in the design of smart home automation systems. In this paper, the above problem was addressed by using Fibonacci based clustering in TGO topology. The main design goal is to increase the performance of smart home automated systems even though there is a random node failure. The proposed TGO based algorithms are compared with the properties like Edges, average degree, density, diameter, edge connectivity, average clustering, average path length, and transitivity with standard ZigBee topologies.

Index Terms: IOT, Survivability, TGO, Graph Theory, Graph Invariants, Topology optimization, NetworkX.

1. INTRODUCTION

Fibonacci series was applied in solving many engineering and nonengineering problems. This series can be observed mainly in nature and manmade ancient structures. The main motivation for Fibonacci clustering was obtained by studying 3 concepts like the Fibonacci series, the Fibonacci spiral and the golden ratio. Fibonacci series are generated by function Fn= Fn-1+ Fn-2 where F0=0, F1=1. A Fibonacci spiral is a subsequence connection of quarter-circles drawn on a square board with Fibonacci numbers as dimensions. In Golden ratio, if their ratio is the same as the ratio of their addition to the larger of the two quantities and value of the golden ratio is 1.618. Clustering is an important design problem in wireless and telecommunication networks, since the last decade, many researchers have proposed a wide variety of clustering mechanisms based on the Voronoi diagram, Chemical reaction optimization, ML, AI, game theory and graph theory, etc. Clustering was further categorized into two types based on the size of clusters like equal and unequal. Both these clustering have equal importance because for some applications equal clustering or unequal is optimal. In equal clustering size of clusters are the same with a constant value and can be observed in hierarchical networks. In unequal clustering variable size of clusters with scale-free properties like preferential attachment and rich-club coefficient are observed [1], [2]. Unequal clustering was designed based on the Fibonacci series. The size of the clusters of Fibonacci in ascending order is 3, 5,8,13. We have chosen this series because it is one of the optimal techniques found in nature and man-made structures. In table 1 an indirect way of topological graph invariant characteristics is correlated with general features of wireless networks. This method reduces efforts in designing and analyzing networks [3], [4].

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In this paper first time we are articulate Fibonacci series based clustering in solving survivability problem in first part. Rest of the manuscript is explained in the following sections. literature survey is given in second section. Proposed methodology with an algorithm is explained in section 3. Experiment results and analysis is discussion in section 4. Finally, article is concluded in last section.

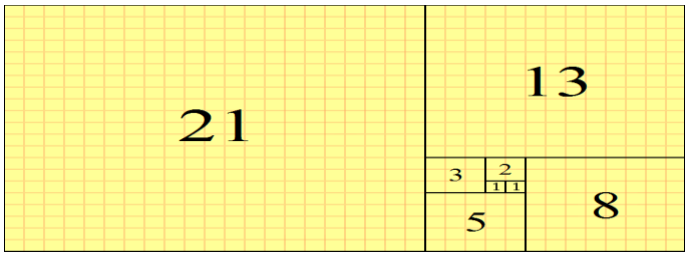


***Fig. 1**. a) Fibonacci Based tiling*

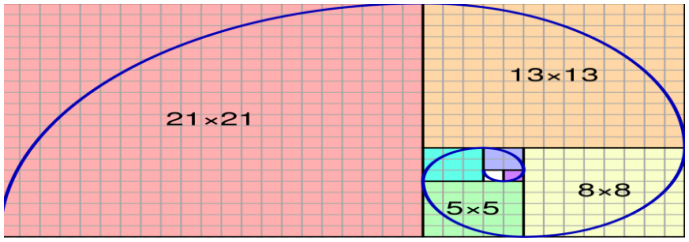


***Fig. 1**. b) Fibonacci Spiral*

2 LITERATURE SURVEY

In [5] author addresses the study of some algebraic properties of the hierarchical product of two or more graphs. In this model the spectrum of the binary hyper tree is fully characterized with different Eigenvalues. By considering some of the parameters like Hierarchical product, Diameter, Mean Distance, Adjacency Matrix, Eigenvalues into consideration the author has proposed some natural generalizations of the hierarchic

product and also some of the well-known properties of the direct product, such as a reduced diameter and simple routing algorithms were also discussed in this model. In [6] the author has numerically studied the critical behavior at the localization transition in the Anderson model on infinite Bethe lattice and on RRG. Different scaling of the characteristic lengths on both sides of the transition is a special feature of the Bethe-lattice and RRG models, by distinguishing them from the previous models the author has mentioned the delocalized side of the transition which resulted in two lengths that control the asymptotic decay of the connected parts of the network. The author has conducted different steps for analyzing critical behavior of the model in different phases. In [7] the author has proposed the neighbor preferential mechanism and constructed the neighbor-preferential growth network model (NPG). The clustering coefficient of the proposed model is close to that of globally coupled network, and the average path length is close to that of star coupled network. Due to the topology of the NPG network, it is so similar to that of the multicenter network, and thus the NPG model is robust against some of the random attacks and is more tolerant to specific failures. In [8] the author provides the basic concepts that are very much helpful to model small world network and provides implementation issues for designing the network and also for applying the small world concept for wireless network topology optimization [9],[10]. Based on the proposed system architecture, the author concludes that the behavior of the small world network was fully confirmed, having highly clustered behavior as the regular lattice and small average path length as the random graphs [11].

TABLE I. NETWORK REQUIREMENTS AND GRAPH INVARIANTS

Feature	Invariant
Cost	Order, size, average degree
Maximum latency	Diameter
Average latency	Average distance
Network Congestion	Edge betweenness and degree variance
Survivability	2-connectivity

3. PROPOSED METHODOLOGY

The main goal of this research is to design the best survivable methodology for ZigBee topologies. star, cluster tree, mesh are the major topologies were used in this technology [12]. In our previous paper TGO model was designed and compared with standard existing models like watts–Strogatz, barabási–Albert, random regular graphs, barbell graph, dorogovtsev_goltsev_mendes_graph, small world graph [13]. TGO model was also compared with different cluster sizes and it was observed that medium clustering is more survivable. In this paper we are proposing a novel Fibonacci clustered based methodology to get better results than medium clustering and comparing with existing ZigBee topologies [14]. The following proposed algorithm takes number of nodes as input and it generates Fibonacci Cluster based network as output. This model is Implemented in python language by using networkX package. In the first step nodes are deployed without any connections and unequal clusters are formed using Fibonacci numbers [15]. The problem we identified in this technique is we cannot create exact Fibonacci cluster for the last node so the solution we had given is left over nodes was added in the last cluster.TGO model requires at least 3 nodes to form a graph, so Fibonacci series stars with 3, 5, 8, 13, 21…In the next step TGO codes was used recursively on each cluster and also on total clusters to form Fibonacci Cluster based network.

3.1 Fibonacci clustered based Algorithm

Input: Number of Nodes
Output: Fibonacci clustered based Graph

1. Start
2. N clusters have to create for the given input nodes.
3. Unequal Size clusters are formed using Fibonacci sequence with 3 nodes.
4. Apply Trimet graph algorithm recursively on each cluster and also on dominant vertices in a network
5. Fibonacci clustered based network is generated.
6. Random function is generated to remove nodes in an iterative process.
7. In each iteration some nodes are removed till the network is disconnected.
8. Final details of the network were collected for the analysis.
9. Stop

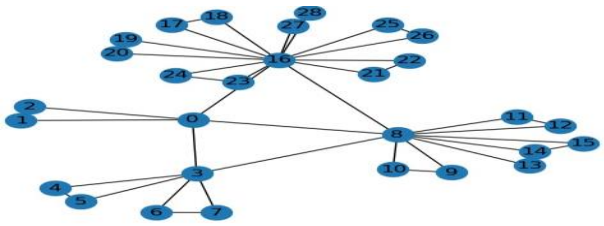
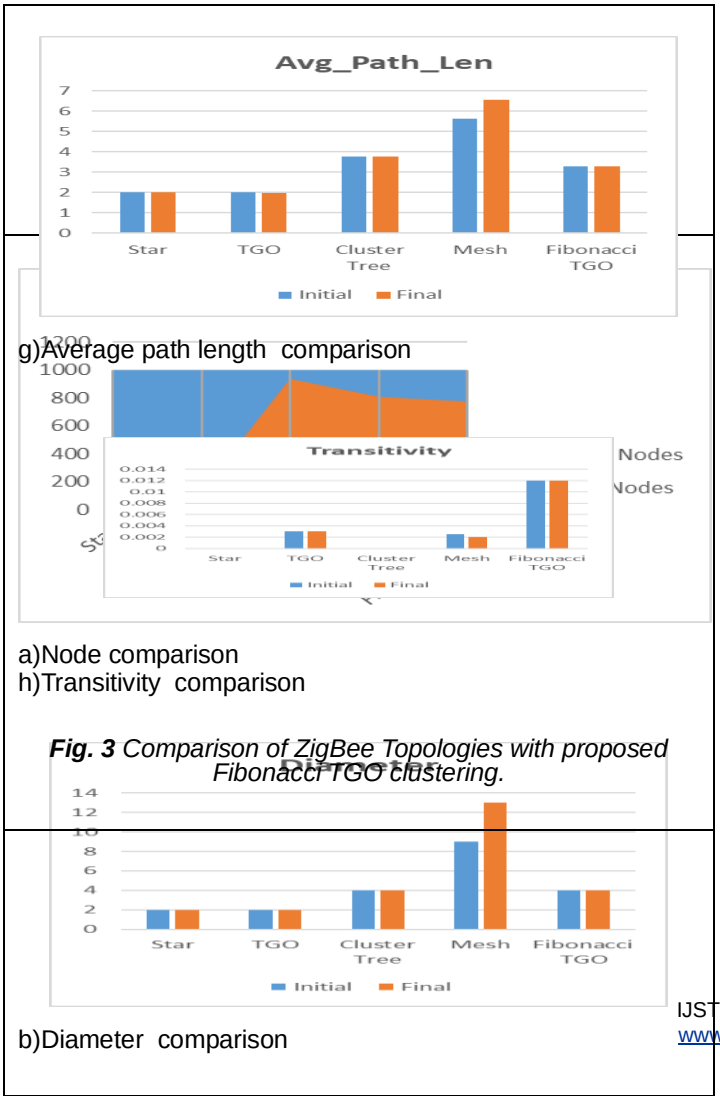


***Fig. 2**. Fibonacci Based Unequal Clustering*

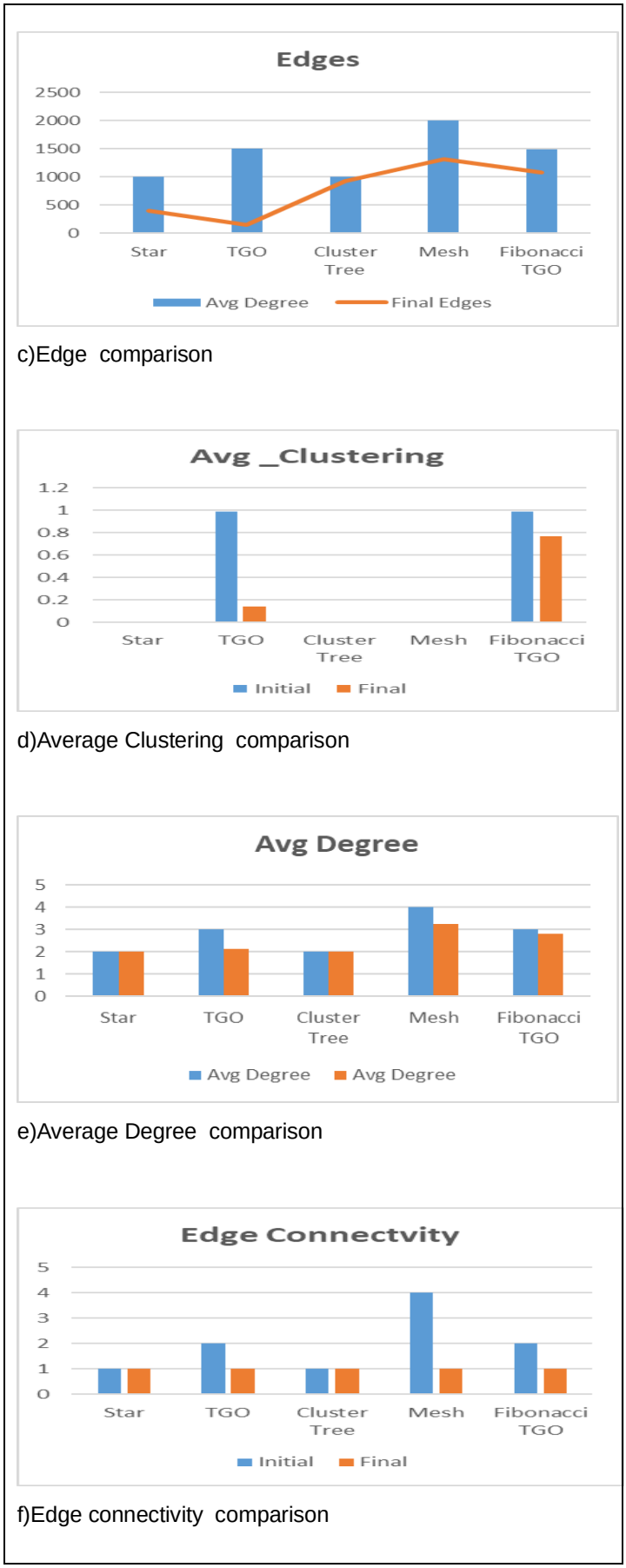
4.RESULTS AND DISCUSSION

In the following results, ZigBee Topologies are compared with proposed Fibonacci TGO model. Properties considered in this comparison are Edges, average degree, density, diameter, edge connectivity, average clustering, average path length, and transitivity [16], [17]. We compared all topologies like star, TGO, cluster tree, mesh and Fibonacci TGO but star and TGO will belongs to one set whereas remains 3 as other set. In figure 3a with initial nodes 1000 experiment was started and in each iteration some nodes are removed. TGO was survived even 861 nodes are removed, whereas star with 594.on the other set Fibonacci TGO having high survivability with 228 followed by mesh and cluster tree. In Figure 3bstar, TGO has equal and low diameter, whereas cluster tree and Fibonacci TGO has diameter 4 but mesh is having high diameter both in initial and final states [18]. In Figure 3c TGO is having less edges at final state followed by star, cluster tree, Fibonacci TGO and mesh [19]. In Figure 3d average clustering is zero for star, cluster tree, mesh. In Figure 3estar, TGO, cluster tree is having low average degree with 2 followed by Fibonacci TGO, mesh more than 2,3 respectively. InFigure 3f all are having 1 edge connectivity in final state. Figure 3g average path length is same for star, TGO in initial and final state with 2 followed by TGO with 3 and cluster tree, mesh with near to 4 ,6 respectively. In Figure 3hFibonacci TGO has high transitivity whereas star and cluster tree is zero.TGO and mesh is having low transitivity [20].



a)Node comparison
b)Diameter comparison
g)Average path length comparison
h)Transitivity comparison

Fig. 3 *Comparison of ZigBee Topologies with proposed Fibonacci TGO clustering.*



c)Edge comparison
d)Average Clustering comparison
e)Average Degree comparison
f)Edge connectivity comparison

5.CONCLUSION

In recent days excuses use of electronic gadgets leads to common issues like scalability and survivability are found in wireless technologies. ZigBee topologies like star, cluster tree, mesh was studied by using graph invariants technique. At the first time this technique was applied to ZigBee technology. In this paper, survivability problem was addressed by novel methodology called Fibonacci based TGO.In our experimental set up random node removal function was used to implement survivability in a network. ZigBee topologies are compared with TGO and Fibonacci TGO methods. Experiment was started with initial nodes 1000 and in each iteration some nodes are removed. TGO was survived even 861 nodes are removed, whereas star with 594.on the other set Fibonacci TGO having high survivability with 228 followed by mesh with 190 and cluster tree with 66. Similarly, TGO and Fibonacci TGO has better performance in Edges, average clustering, average path length, and transitivity. Star, TGO, cluster tree has similar average degree. Mesh is having high diameter and in final state of all topologies having 1 edge connectivity. Finally, TGO and Fibonacci TGO is having better performance in many properties.

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