International Journal of Recent Technology and Engineering (IJRTE)
ISSN: 2277-3878 (Online), Volume-8, Issue-1, May 2019

Designing Optimal Network Topology Based on Genetic Algorithm Framework

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Abstract: ***Network infrastructure plays a significant role in performance of enormous scale decentralized systems. Basically, design the optimum network infrastructures is associate degree important problem over various application domains, for instance distributed information systems, content distribution networks (CDN), supply chain networks, transportation networks, and network central warfare (NCW). Optimality of a network depends upon the appliance domain and additionally supported the aim that the network is built. Further, at intervals associate degree application context, there are conflicting performance necessities that require to be adjusted. So coming up with an optimal network infrastructure could be a NP-hard multi-objective optimization drawback. Thus to design associate degree optimum network topologies considering multiple conflicting objective this paper proposes a Genetic Algorithm primarily based framework. The planned Genetic Algorithm method searches the answer house for optimum network topologies considering 3 completely different conflicting objectives like to attenuate the value of communication and maximize network efficiency and hardiness. Series of experiments were applied to seek out completely different optimum topologies at varied purpose within the house fashioned by considering the parameters efficiency, hardiness and price objectives.***

Index Terms: ***Network topologies, Infrastructure, Genetic Algorithm.***

I. INTRODUCTION

One in every of the well-known issues in advanced adaptation systems found in engineering, biology , economic science so on is predicting and optimizing the appearance of self-organized network structures with terribly fascinating properties[1][2]. Such network structure or topologies are found in various applications like in provide chain networks, laptop and communication networks, metabolic networks so on. Recently, there are tries to propose mechanisms for locating optimized topologies for such networks. Completely different optimization formulations are planned to resolve network design drawback. [3,4,5].,

Revised Manuscript Received on 22 May 2019.
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conniving most favorable topological network could be a typical multi objective drawback involving concurrent optimization of value of the network and varied performance criteria like potency, throughput, robustness, responsibilities so on relying upon the appliance domain. As an example, in DHT design
minimizing operation value is that the primary objective, that is to be achieved beneath constraints on most node degree (bookkeeping cost) and bilaterally symmetric operation load on nodes (uniform degree centrality). These disparate necessities create conflicting constraints on network design. Thus, coming up with a network could be a combinatorial multi-objective optimization drawback. Since the planned drawback is NP arduous problem, several researches adopted heuristic techniques wide for resolution these issues. Heuristic strategies embrace techniques, like branch exchange cut saturation, native optimization technique so on. Jan et al. designed a branch and sure primarily based technique to optimize network value subject to responsibilities of constraint [5]. However, these heuristics techniques don't make sure that the solutions obtained are optimum. Also, antecedently researchers have followed completely different approaches to deal with the matter of coming up with optimum network like coming up with network topologies for specific domain dependent performance necessities. Assessment of graphs families to explore specific optimum properties and to include this data in network topology. Efforts towards explaining the theoretical foundations or mechanisms that cause bound optimum properties in networks. Thus during this paper, a different approach is planned from existing approach by using biological process formula to seek out optimum topologies with multiple constraints. Genetic Algorithms are wide utilized in resolution single objective optimization drawback for varied communication network. For instance, Abuali et al .Assigned terminal nodes to concentrator sites to minimize costs whereas considering most capability[6]. White et al. Used GA to design Ring Networks optimizing the one objective of network value [7].In this work, we have a tendency to use Genetic Algorithm to design associate degree optimized network topologies whereas at the same time minimize the value in a very network and to maximize the potency and hardiness subject to satisfaction of multiple constraints.

II. PROBLEM DEFINITION

The most aim of the planned problem is to design associate degree optimum networks
beneath multiple potency

and hardiness constraints by developing a Genetic Algorithm primarily based framework. The planned framework is employed to develop optimum topologies that type optimal topology areas (OTS). The planned drawback is incontestable through graph theory below.

A. Graph Theoretic Formalism

We have a tendency to demonstrate the proposed problem with the help of a straightforward however effective graph theoretic. Think about a network, with N range of nodes. Allow us to assume that the survival of this theoretical network depends on the flexibility of every node to speak or with all alternative nodes in associate degree economical and strong manner. The interactions between the nodes are through the exchange of energy or info. As long as a node is connected to a different node, nodes will communicate and die messages to others WHO are a part of the general network. Therefore, the communication between a try of nodes need not be direct however may occur through one or additional intermediate nodes. The set of nodes indirect communication will modification, so the network is adaptation. Associate degree example of such a system would be a provide chain. This adaptation system may be modeled as a graph S of 'n' vertices and 'e' edges. The vertices represent the nodes and a footing indicates direct communication between the nodes it connects.

Problem:

Think about a network as G (V, E), wherever the amount of nodes is, |V| = n. The matter of optimum network design is to seek out the set of edges or connections, E, by adding specified associate degree objective operate, f(G(V,E)) is maximized, whereas satisfying a collection of constraints, (G(V,E)). The planned framework additionally considers the below assumptions beneath to design optimum network. To design each directed and networks but mixed networks don't seem to be allowed. To topology unlabeled direction and undirected networks, since the ordering of nodes and edges isn't vital. To design powerfully connected undirected networks and directed networks however do think about coming up with disconnected net-works. To design unweight networks. It means, we have a tendency to don't think about node and/or edge weights. To design networks, specified there exist at the most one edge between a try of nodes. And a footing precisely connects 2 distinct nodes. A number of the higher than assumptions don't seem to be the constraints of planned framework, because the framework supports mixed networks, disconnected parts and weighted networks.

III. PROPOSED METHODOLOGY

The most objective of the proposed system is to design associate degree optimum network design victimization biological process formula. In planned framework Genetic Algorithm is used to go looking for associate degree optimum design through exploration. The house for exploration of optimum topology is named topology breeding. In this section, we have a tendency to formally outline the topology breeding method. The planned framework chooses the 3 parameter such as potency, hardiness and price however with multiple constraints like follow potency in terms of properties such as diameter, average path length and closeness spatial relation. Power of patience in terms of properties like degree spatial relation, node spatial relation and edge property. The trade-off between hardiness and potency is set with environmental Variable.

A.Proposed Genetic Algorithm

Genetic algorithm (GA) could be a widespread meta-heuristic technique that work supported the method of Darwin evolution process [8]. In planned framework Genetic Algorithm is used to evolve optimum topologies that are the "fittest" in terms of predefined performance necessities. The planned formula starts from initializing random graphs with capricious fitness and runs through the various stages like formatting, selection, recombination and termination. In general, there's single stage of initialization followed by many iterations of choice, crossover and mutation till a "convergence" is reached, at that stage the method enters termination. Below, Genetic Algorithm method with relevancy our drawback is conferred. Formula FOR coming up with optimum topologies.

B.Algorithm

Begin
Step 1: Generate Initial population with n seeded graph
Step 2:Fi ← value Fitness (ft=αp+1-βk)
Step 3: For i=1 to m
Step 4: choose the high fittest individual supported fitness proportionate choice
Step 5: choose best 2 genetics based on fitness value of the chromosome.
Step 6: Apply Crossover Operators
Step 7: Apply Mutation Operators
Step 8: finish

C.Chromosomal Encoding

In GA, chromosomes may be pictured victimization completely different coding schemes for instance decimal encoding, binary coding and permutation encoding. In planned approach permutation coding is chosen for representing the body and outlined as a mix over the set of all doable edges in n node network with relevancy e and p (e is that the range of edges and P is that the most degree of every edge).

D.Initialization

The formula begins by initializing the body with an oversized range of seed graph as shown in step 1 of figure 1. Since random formatting is that the most important approach for initializing the population in planned approach chromosomes is generated victimization random initialization. The seed graphs are generated haphazardly beneath the p and e constraints. The below figure 2. Shows the Sample body strings appreciate undirected topologies. The chromosomes are pictured as edge lists rather than binary strings for the sake of understanding. The seed graphs were randomly generated with the parameters: n = ten, e ≤ fourteen and p ≤ five. Edge List [102-23-18-32-141-49-110-93-5-64] body one Edge List

[12-231-108-77-191-99-110-93-1-4] body two Figure 2. Sample body three.

E. Fitness operate

When initializing the population the fitness worth of every chromosome is determined victimization the fitness function in eq(1) as shown in step two of figure one. Fitness =αp+1-αn-βk)……Eq(1) wherever in higher than equation, α is an application dependent parameter that acts as a slider between potency and hardiness and β could be a value management parameter. α takes a worth between zero ≤ α ≤ one. High worth of α specifies that a high importance ought to incline on the hardiness of topologies throughout topology breeding. β takes a worth between zero ≤ β ≤ one, is value management parameter .When a high worth is ready for β it helps the GA method to ostracize the foremost efficient topology that reaches a specific potency and hardiness (controlled by α) by removing as several additional edges as doable. Thus, the target of worldwide optimization is to seek out the set of edges to construct the fittest graph.

F. Selection

The choice method selects the body for copy. In planned framework the population contains solely the connected graph and type them supported their fitness to use choice method. Fitness proportionate choice methodology is applied to pick fittest individual. In fitness proportionate choose the fitness of a private body determines the likelihood of its being hand-picked. The choice likelihood of every body is calculated victimization the below equivalent (2). Pi = workness ij=1Nfitnessj)……Eq(2) A sexual activity pool is made specified eightieth of the mates are chosen supported fitness victimization the either fitness proportionate choice and therefore the remaining twentieth of the mating pool is formed by selecting haphazardly among the lesser fit chromosomes. This intermixture choice is applied so as to avoid landing in native minima.

G. Reproduction

The new optimized topologies are searched through reproduction operators like crossover and mutation operator as shown in step vi and step seven of figure one. In planned framework, "all-pairs cross-over" is applied over the sexual activity pool. Also, rather than applying single cross over operator n range of crossover operators is applied to make optimized topologies. Crossover Operators one. One purpose with Equal Edges two. Cut–and–Splice three. One purpose with Equal Nodes four. Copy Edges five.

To make newer topology for each try of mates completely different crossover operators are chosen haphazardly with relevancy p and e constraints. Also, duplicate edges are removed. Associate degree example single purpose equal edges crossover offspring ensuing from the crossover of Seed Graph-1 and Seed Graph two is shown in figure 1.

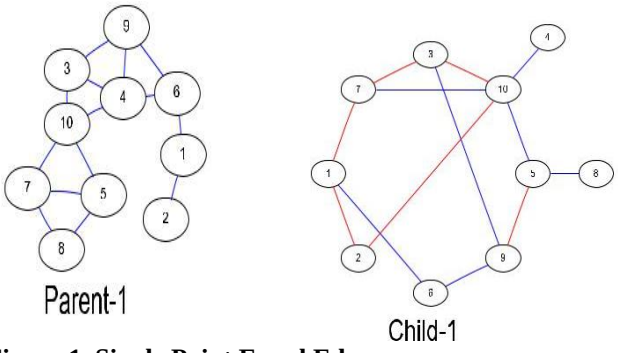

Figure 1. Single Point Equal Edges crossover

H. Termination

Criteria In planned framework the termination criteria depends on 2 parameters:(1) once convergence criteria is met, and (2) most generation is reached. The planned GA process issue the method from step two to step seven of figure one un till termination criteria is met. As a results of the method, topology with the best fitness is chosen because the optimum topology

I. EXPERIMENTAL SETUP

To analyze the performance of the planned approach experiments were conducted with completely different parameter worth. We utilized a tool referred to as Topology Analysis visual image (TopAZ)[10]. TopAZ could be a set of graph design, analysis and visual image libraries. Specifically, the Genetic Algorithm is implemented in a library referred to as prime Breed. TopAZ is offered in Python and Java versions. The experimental setup is named topology breeding and optimum topologies are evolved beneath varied constraints. The topology breeding experiments are conducted victimization completely different design metrics for networks with up to two hundred nodes.

A. Performance Metrics:

To judge the breaded topology 3 parameter like potency, hardiness and price is taken into account in terms of structural or graph notional potency (p): potency measures the value of communication in a very network. There are variety of the way during which potency may be outlined like diameter of a network, average path length, eccentricity per node, and closeness spatial relation worth. Hardiness (n): Robustness measures the resilience of a network within the face of perturbations such as: node and edge failures; and, variable network load. hardiness is outlined in range of the way like Degree centrality, Node Betweenness , Edge property and Node Deletions value (k):In planned approach cost is measured in terms of 2 components: (1)Infrastructure cost as a operate of the amount of edges, e, within the network, and (2)Node level maintenance/"bookkeeping" cost, as a operate of the node's degree, p (in case of directed graphs, out degree, pout).

B. Discussion on Experimental Result

Differing types of structures emerge at completely different points in areas of optimal topologies outlined by the optimization parameters such as most degree (p), most range of edges (e), and therefore the environmental variables. Each purpose in associate degree OTS corresponds to an instance of a topology breeding experiment, associate degreed leads to an optimum topology. Many instances of topology breeding is conducted over associate degree OTS to uncover optimum topologies at completely different points. The experiments were conducted victimization completely different design metrics for networks with up to two hundred nodes. In below, a sample OTS is shown in figure five and figure vi to present undirected OTS fashioned with objective is to attenuate diameter (d), maximize ηd beneath constraints on p, k, and a sure on degree skew (ρp). Here, value management parameter, β = zero and no. of nodes, n = 20. Such way, completely different OTS is made by exploring different constraint. Figure 2. Optimum topology

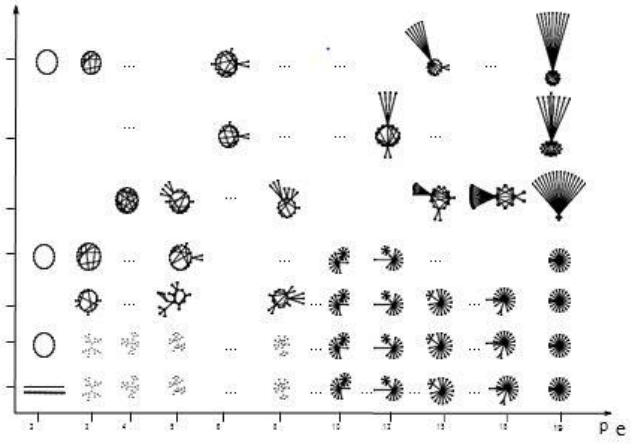

Figure 2: undirected optimum Topology house with stress on hardiness, α = zero and price management parameter, β = 0, for various no. of edges and most permissible degree with no. of nodes as twenty.

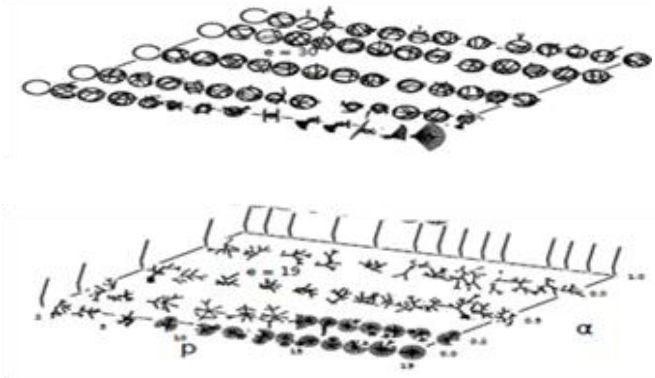

Figure 3. Optimal topology space

IV. CONCLUSION

The problem of coming up with optimum network design supply new and fascinating analysis challenges to applied science. In this paper, a Genetic Algorithm primarily based framework to design optimum topologies supported multiple constraints is planned. The planned framework develop optimum networks topologies beneath completely different trade-offs. From the experimental result, we have a tendency to observe continual pattern structures or topology categories like circular hubs, circular skip lists, symmetric multi-hubs, and hubs–and–spokes which give helpful design tips for a network designer.

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