Optimization of Topology For Multihop Cellular Network Using High Speed Genetic Algorithm

Preet Kamal, Er. Sunita Rani

Abstract— **Genetic algorithm is used in searching a large state-space, multi-model state-space or n-dimensional surface. A Genetic Algorithm may offer significant benefits over more typical search of optimization techniques. The Genetic Algorithm is a popular optimization technique which is bio-inspired and is based on the concepts of natural genetics and natural selection theories proposed by Charles Darwin. The Algorithm functions on three basic genetic operators of selection, crossover and mutation. Based on the types of these operators GA has many variants like Real-coded GA and Binary coded GA. There are various crossover and mutation methods to accomplish Genetic Algorithm (GA), namely, single point, multipoint, uniform, etc. However, these mechanisms are static in nature. This work presents a new crossover mechanism. The purpose of this concept is twofold; to achieve faster transmission rate. The results indicate that for a linear and a nonlinear objective function, it outperforms all static crossover mechanisms. A new algorithm for efficient relaying topology control is presented to jointly optimize the relaying topology, routing and scheduling resulting in a two dimensional or space time routing protocol. The algorithm is aware of inter cell interference (ICI), and requires coordinated action between the cells to jointly choose the relaying topology and scheduling to minimize the system performance degradation due to ICI. In the presented work, we have simulated a new Genetic Algorithm to model the topology network. On the behalf of results of link graphs, we can conclude that in the case of time it is observed that the new crossover technique is better irrespective of function, threshold, and iterations.**

I. INTRODUCTION

The ever growing increase in traffic and data rates for mobile communication systems, at the same time requirement for reduced power consumption, makes Multi-hop Cellular Networks (MCNs) an attractive technology. To exploit the potentials of MCNs a number of new network paradigms are put forward in this thesis. A new algorithm for effective relaying topology control is presented to optimize the relaying topology, routing and scheduling resulting in a two dimensional or space time traffic scheduling. The algorithm makes use of the concept of inter cell Interference (ICI), and requires organized action between the cells to mutually choose the relaying topology and scheduling to minimize the system performance degradation due to ICI.

Manuscript received Nov 20, 2014

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II. MOTIVATION

A Genetic Algorithm (GA) is an optimization method based on natural selection. It effectively seeks solutions from a vast search space at reasonable computation costs [11]. Before a GA starts, a set of candidate solutions, represented as binary bit strings, are prepared. This set is referred to as a population, and each candidate solution within the set as a chromosome. A fitness function is also defined which represents the problem to be solved in terms of criteria to be optimized. The chromosomes then undergo a process of evaluation, selection, and reproduction. In the evaluation stage, the chromosomes are tested according to the fitness function. The results of this evaluation are `then used to weight the random selection of chromosome in favor of the fitter ones for the final stage of reproduction. In this final stage, new generations of the chromosomes are "evolved" through genetic operations which attempt to pass on better characteristics to the next generation. Through this process, which can be repeated as many times as required, less fit chromosomes are gradually expelled from a population and the fitter chromosomes become more likely to emerge as the final solution.

III. MULTI-HOP CELLULAR NETWORKS

Multi-hop cellular networks (MCN) refer to cellular networks where, data from cell phones are relayed to the Base Station (BS) through other cells in multiple hops. The BS however is a dedicated control channel with each of the cell phones in its coverage area and is aware of locations of the cell phones. The service area is split into cells; each served by a centrally located, low power transmitting Base Station, which was assigned a portion of the total number of channels available to the entire system. The low power transmissions led to lesser coverage and lower interference levels. This permitted the resuse of frequency in other cells in the service area [25]. The current scenario demands a further increase in capacity due to increasing number of users and high data rate applications. This necessitates either the installation of more BS or allocation of more spectrums. MCN architecture provides a solution which poses no such demand on the existing framework. In MCN schematic as shown in figure 1.1, node relay data over multiple hops and permit multiple simultaneous short range transmissions with in a cell, similar to transmissions in Adhoc networks but it has advantage over it that this framework limit the path vulnerability observed in adhoc networks.

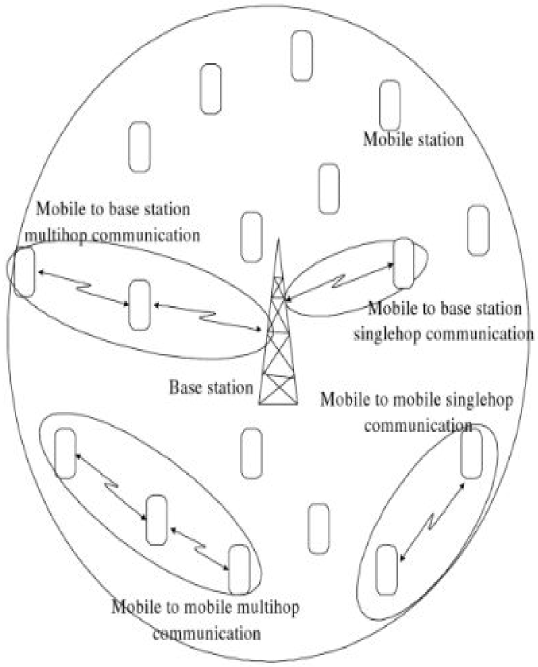

Fig.1: Schematic of a Multihop cellular network

IV. Genetic algorithm for dynamic topology reconfiguration in MCNs

In a real network, where the traffic distribution changes (in time and space) due to the changes in available link capacities and load demands, the network topology should be reconfigured dynamically to track the variations in the network and guarantee good network performance. When considering a multi-cell scenario with non-uniform traffic distribution in MCNs, the search for the optimum topology becomes an NP-hard problem [18]. For such problems, exact algorithms based on exhaustive search are only useful for small models, so heuristic algorithms such as genetic algorithms (GAs) must be used in practice. Topology control in this scenario involves the computation of new topologies, rerouting and rescheduling to dynamically optimize the network performance.

GAs have shown to be efficient in solving problems where the space of all potential solutions is too large to be searched exhaustively in any reasonable amount of time. GAs provides optimal or good suboptimal results in a short period of time. For this purpose, we present a Genetic Algorithm (GA) for joint relaying topology, routing and scheduling optimization in multi-hop cellular network aware of the inter-cell interference and the spatial traffic distribution dynamics [2]. GA dynamically adjusts the relaying topology to the traffic variations in the network, reducing considerably the number of operations required by exhaustive search, and improving the network scalability.

(a) Basic concepts of Genetic Algorithms

The genetic algorithm is a probabilistic search algorithm that iteratively transforms a set (called a population) of mathematical objects (typically fixed-length binary character strings), each with an associated fitness value, into a new population of offspring objects using the Darwinian principle of natural selection and using operations that are patterned after naturally occurring genetic operations, such as crossover (recombination) and mutation. Genetic Algorithms (GAs) are adaptive methods based on the mechanics of natural selection [13]. The basic principles of GAs are described in many texts [9]-[13]. The first step in GA is to encode the problem as a chromosome or a set of chromosomes that consist of several genes. The solution in its original form is referred to as phenotype; whereas it's binary encoded version is called genotype or simply chromosome. Next, a pool of feasible solutions to the problem, called initial population, is created. Each chromosome in the population is associated with a fitness value that is calculated using a fitness function that indicates how good the chromosome is. Genetic operators' selection, crossover, and mutation operate on the population to generate a new generation of population, i.e., a new set of feasible solutions, from the old ones. Good feasible solutions are selected with higher probability to the next generation, in line with the idea of survival of the fittest.

(b) GA cycle of reproduction

Population of individuals

  - ◦ Individual is feasible solution to problem
- Each individual is characterized by a Fitness function
  - ◦ Higher fitness is better solution
- Based on their fitness, parents are selected to reproduce offspring for a new generation
  - ◦ Fitter individuals have more chance to reproduce
  - ◦ New generation has same size as old generation; old generation dies
- Offspring has combination of properties of two parents
- If well designed, population will converge to optimal solution.

V. Problem Formulation and Objectives

The main focuses on GA (Genetic Algorithm) on Xilinx 14.2i and Model Sim 6.2c software. The various crossover and mutation methods to accomplish Genetic Algorithm (GA), namely, single point, multipoint, uniform etc.; exist. However, these mechanisms are static in nature. This dissertation focuses on presenting an improved crossover mechanism to increase the overall transmission rate and hence the speed of the system.

- ➢ Analysis of relaying topology in Multi-hop Cellular Networks.
- ➢ Implementation of Genetic algorithm using improved crossover technique to increase the transfer rate of Multi-hop cellular Networks.

International Journal of Engineering Research And Management (IJERM)
ISSN : 2349- 2058, Volume-01, Issue-08, November 2014

VI. Flow Chart of Genetic Algorithm

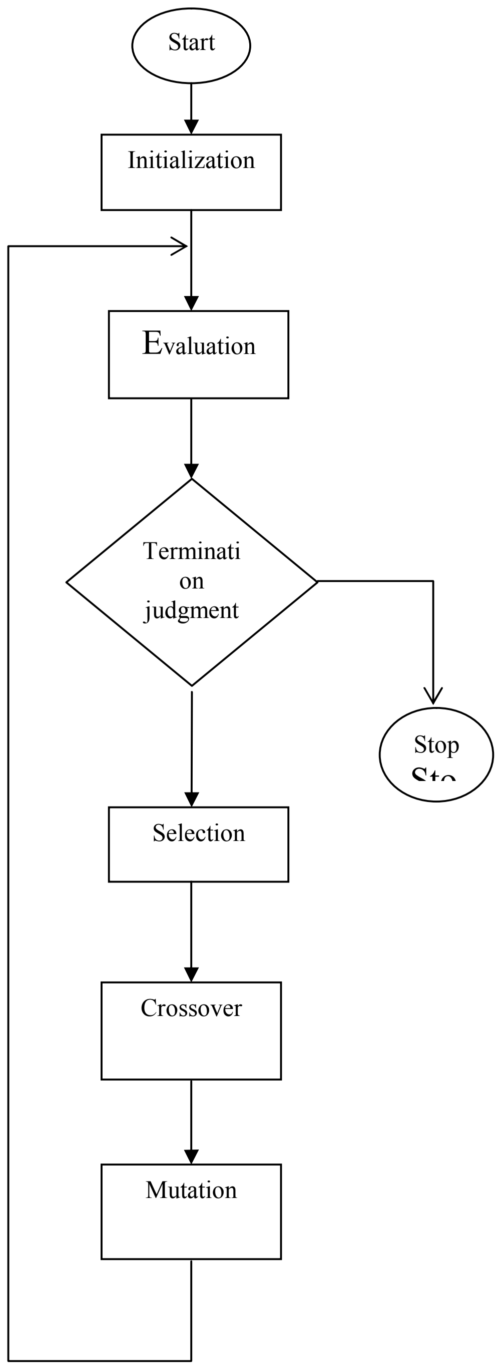

Fig 2: Genetic Loop

- Encoding the topology as a set of chromosomes and new crossover operations.
- To develop the RTL level design for proposed Algorithm using VHDL.
- To compare the parameters for joint relaying topology, routing and scheduling for improving speed of the system and network scalability using suitable appropriate simulator.

VII. Results and Discussions

The proposed method for crossover will make the GA to approach its minima as is shown in the results. It could also be seen that resultant topologies can enhance the delay between transmissions in some cases. The result has been mainly divided into two parts: Link Flow Graph and Waveform. The description of the Link flow graph and waveform graph are given below:

Link Flow Graph: It represents the graphical presentation of the links which are active and which are not active. It generally shows that who is transmitting to whom. It is plotted for a two cell scenario of a multi hop cellular network.

Waveform: It is the simulation waveform obtained from Modelsim SE6.2c software. It gives the digital representation of topology obtained from crossover operation between set of partial topologies.

For topology T[1] = $\{PT^b_\gamma(1)\}$= $\{\{l_1\}, \{l_2\}, \{l_3\}, \{l_7\}, \{l_8\}, \{l_9\}\}$

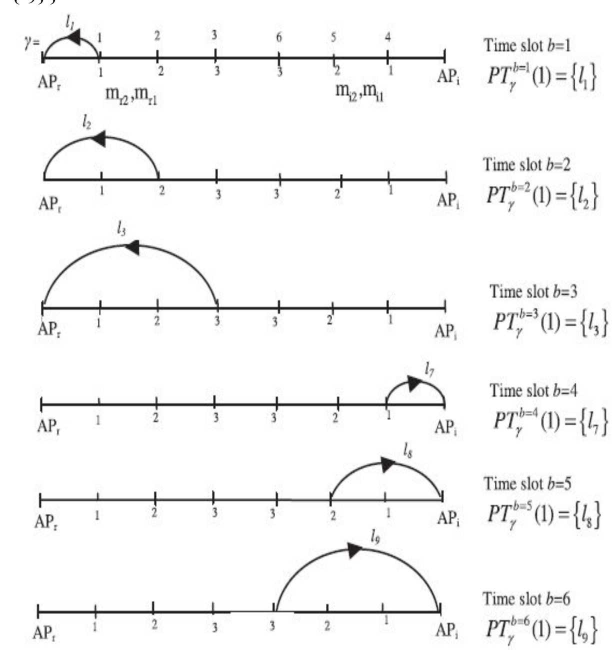

Fig. 3: LFG Transmission pattern for topology T[1]

The initial population is formed by the active links and can be represented by the LFG with the genotype and phenotype for uplink/downlink transmission. For each initial topology we generate a new set of topologies $\{T_{new}\}$ that consist of topologies as a result of new crossover operation between all pairs of chromosomes PT^b_γ that define certain topology T(t). So total time slots needed for complete transmission with this topology is 6 time slots. Every user transmits in a separate time slot directly to its access point. If the new topology is not feasible, it will be excluded from the population. For example, the crossover operation between l_1 and l_2 is not feasible because the access point cannot receive two signals at the same time.

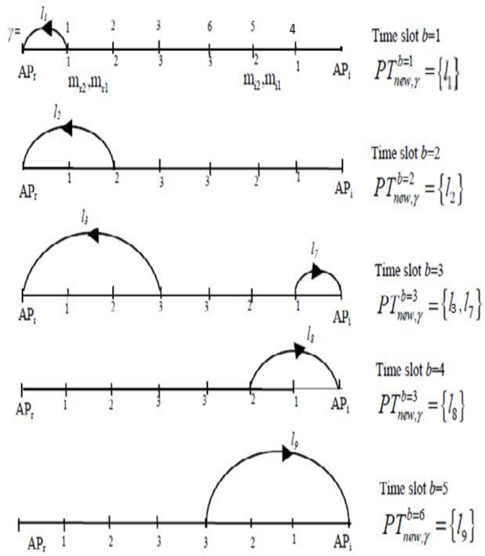

Fig. 4 LFG for topology T[1] after crossover

New chromosomes as a result of the following crossover operation:

$\{T_{new}\} = \{PT^{b}_{\gamma}(t)\} = \{PT^{b}_{\gamma}(t)\}$ OR $\{PT^{b}_{\gamma}(t)\}$

In Fig. 4, the waveform graph obtained after simulation shows the set of chromosomes and this shows that which set of links are active and which are not active. It also shows who is transmitting to whom and the crossover operation is performed between which set of chromosomes at the clock pulse and activation of enable signal. There will be two simultaneous transmissions of links l_3 and l_7 in the third time slot. In the proposed work, both the access points are checked for their activation, priority is given to those partial topologies for which the transmission time is least. That will be considered as the feasible topology. Crossover is performed between l_3 and l_7 and the whole transmission is completed in a minimum of 3 time slots.

Waveform graph T[1]after simulation in binary form and expanded form

There will be two simultaneous transmissions of links l_1 and l_{12} in the third time slot.

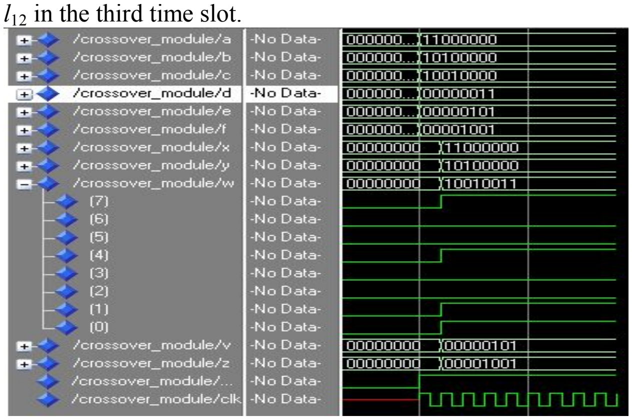

Fig. 5: Waveform graph for Topology T[1]

In the proposed work, both the access points are checked for their activation, priority is given to those partial topologies for which the transmission time is least. That will be considered as the feasible topology. The crossover is performed between l_1 and l_{12} so that the whole transmission is completed in a minimum of 3 time slots.

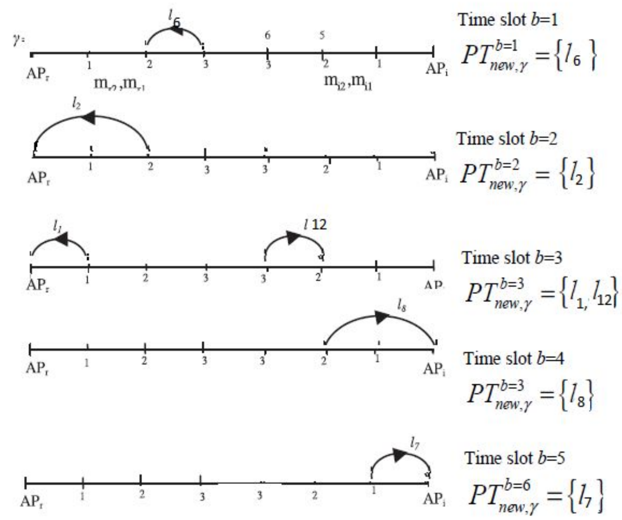

Fig. 6 LFG for topology T[4] after crossover

Similarly we can obtain Transmission pattern for various other feasible topologies T[2],T[3],T[4]so on.

Waveform graph T[4] after simulation in Link Flow Graph and Waveform for Topology

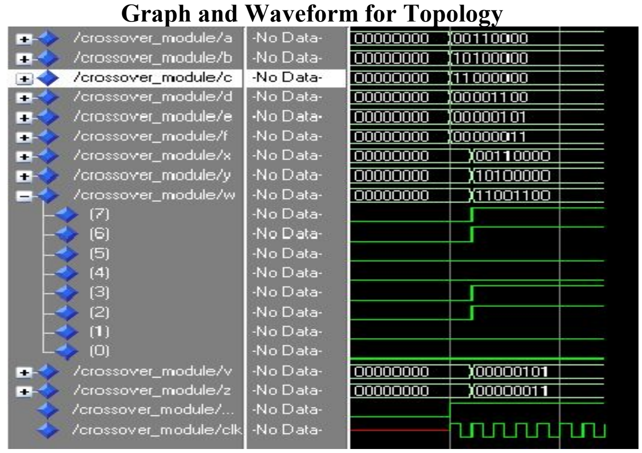

Fig. 7 Waveform for Topology T[4]

CONCLUSION

We developed a genetic algorithm with a new crossover mechanism to exploit the inherent parallel nature. The new crossover mechanism finds near maximum/minimum value of the selected objective function by dividing the entire population into blocks for parallel execution. Our results clearly indicate that the new crossover management is well suited in topology search.

The objectives listed in the problem statement have been carried out properly. In the presented work, we have simulated a new Genetic Algorithm to model the topology network. On the behalf of results of link graphs, we can conclude that in the case of time it is observed that the new crossover technique is better irrespective of function, threshold, and iterations. The author has used the fact that a node cannot receive and transmit the signal simultaneously on the same channel so; only a subset of transmissions can be active simultaneously. So we have included genotype for access points also in the proposed work so that there is no confusion that two access points are simultaneously transmitting or we can say that two mobile users are simultaneously communicating with the base station. This will increase the overall transmission rate and hence the speed of the system.

FUTURE SCOPE

Genetic Algorithm has a bright scope for solving optimization problems. Further many researchers have already found hardware GAs to be faster and more efficient software. Genetic Algorithms comprise just one part of the artificial intelligence field, and embedded systems.

Future work should look towards finding out the best way to implement the topology design. Several improvements must be made in order that GAs could be more generally applicable. Further enhancement in time synchronization technique can be done for detection various topologies and some other performance evaluation matrices like energy consumption, communication cost can be explored.

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