Parallel Genetic Algorithm Optimization in Wireless Communication Network Base Station Site Selection

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Abstract

Locating transmitters optimally in a radio network, to guarantee a stipulated quality of service (QOS), is a network performance (NP) hard combinational problem. Regarding a known area, choosing transmitter locations among alternatives is tackled by a coarse-grained parallel genetic algorithm, which maximize the coverage together with reducing the number of utilized transmitters. In this paper, an effective local search operator is raised, and the affection of the neighbor topology is compared. Simulations on a dedicated cluster demonstrate that contrasting to existent algorithms, the parallel GA improves the optimizing quality and speed greatly.

Key words: Parallel Genetic Algorithm, QOS, GA, Cross over, Mutation

1 Introduction

Wireless networks, especially cellular mobile communication network of rapid growth. The optimal design of wireless networks become increasingly important to optimize the wireless network exists in all levels. Without reducing the signal to noise ratio (SNR) it premises to minimize transmission power[1], increase the bandwidth (bandwidth) utilization[2]; and to ensure coverage at the same time, reduce costs[3]. In this paper attempt to analysis the various performance indicators in order to take the advantage of parallel multi-objective genetic algorithms[4], for optimal bandwidth utilization. It is expected to reduce the costs of wireless network construction such costs, include: base station (transmitter and receiving equipment) and the cost of switching equipment connected[5]. Among them, the base station location, not only determines the wireless network quality of service[6], but also greatly affect the number of devices connected. This in turn determines the construction cost of the network base station positioning for wireless network users. To vary by the density of urban users, the base station must meet the test point distribution of the flow (traffic load) constraints. Sparse in rural areas or on highway users and other open areas around. The main consideration in the premise of a certain signal strength using a small number of base stations under the complete coverage as large as possible[7]. The two previous base station location made a lot of problems, hence the use of coarse-grained parallel genetic algorithm can be used to solve the latter problem. This include the design of an effective local search operator & the comparison of the sub-groups to optimize the quality of connection topology of clusters. To explore the computers on a large number of simulations it needs local search operator which is significantly improved the optimization of the effect of increasing the number of sub-groups of neighbors which could be used for optimization that improve the quality of service.

In this paper first, formal description of the problem will be given, next the local search operator genetic algorithm will be used to solve the problem. Finally, algorithm parallelization will provides the simulation results.

2 Problem Description

A base station coverage area is known as a cellular (cell), the scope of cellular propagation model by electromagnetic waves to estimate the false article and the need to set up cellular coverage areas are discrete, so that cellular and coverage can be abstracted as the lattice-shaped area (grid) using a finite set of based station to complete the open area of coverage, set L = $\{l_i\}$ is the set of required coverage area; M = $\{m_j\}$ is the set of alternative base station location; if lattice regional l_i M_j covered by the base station, you think there is an arc e_{ij}, set E = {eij}. Defined graph G = {M *U*L, E}, to find alternative child of the base

station location set M'⊆M , at the maximum the same time, minimize |M'| ,

which the problem is a network performance (NP) class of combinatorial optimization problems. As in maximize and minimize |M'| contradictory, and for the two to compromise on this article chosen with the literature the same objective function

$$f(M') = \frac{(\text{cover rate})^2}{|M'|} \quad \ldots\ldots\ (1)$$

In order to test the algorithm performance, provides a class of benchmark problems: example 287 × 287 square open area, assuming each base station can cover a square 41 × 41 cellular. Thus, use of 49 base stations (7 × 7 uniform distribution) could reach 100% coverage.

Machine generated C candidate base station location, and location of these 49 positions together constitute the M. that because each base station has a set or two without the possibility to optimize the scale of the problem for the $2^{(49 + C)}$. Pick out when M' is the best time ,

$$f(M') = \frac{(100)^2}{49} = 204.08$$

3 Genetic Algorithm

Genetic algorithm, the initial feasible solution from a set of starting values in the objective function does not require addition of other information outside of the feasible region under the conditions of the global high search feature makes this a good combination of genetic algorithm optimization and function as a powerful tool for optimization and has been successfully used to optimize the design of wireless networks[8]. An operation of genetic algorithm objects are large populations of individuals from the population, all individuals are coded in accordance with the principles and issues a solution corresponding to the number of individuals known as the evolution of population size in each generation[4]:

1) Evaluation of chromosomes that determine their fitness;
2) By selecting the best fitness value will have a higher probability of individuals selected forms;
3) Crossover, mutation and local search such as genetic manipulation to produce offspring;
4) Judgment: If you meet a predetermined stop condition, the end; otherwise, back to 1.

3.1 Encoding

One correspondence with the alternative location, each chromosome contains $|M| = 49 + C$ genes, gene value of 1 or 0, the representative of the corresponding alternative position, with or without the base station will randomly generated chromosomes with each other independence to 0.5 in the probability is 1 or 0 [4] .

3.2 Fitness Calculation

Using (1) to calculate the fitness of each chromosome, then, $|M'|$ value for each chromosome in the number of genes (1)[4], [5] .

3.3Genetic Operation

To reduce the selection pressure, to prevent premature convergence, we use fitness proportional method; cross way for a single crossover point. The mutation, each gene be independent of each other with probability of P_m.

The rational design of partial search operator can improve the search quality and search efficiency. The designed local search operator in the length of each chromosome as a cycle for the 49 + C queue, and selected from a random start to Gene if the gene is 0, will go to the next gene, and if we move with the genes corresponding to the nearest base station location options to increase coverage, the nearest mobile base station move to an alternative position, and then go to the next one gene; or go to the location from recent times of this process and keep going on up to 4 times for each gene, when unable to improve the coverage, will try to cancel the base station, if they can improve the fitness f, the corresponding base station will be canceled, the base station will get minus 1; Otherwise, the base station will be in the same position with such a cycle a total of 49 + C times, once for each gene that is trying to adjust settings for each parameter. The effect of a genetic algorithm optimization is to great influence, but the guidelines did not come to a unified through a lot of simulation experiments, we set p such as op = 160, and the cross-laws are all legal and mutation 1, and pm = 0.05, that is, in every generation, have all been replaced by the entire group and then randomly selected 20% of the chromosome of local search[4],[6].

4Parallel Genetic Algorithm

Coarse-grained parallel genetic algorithm model, also known as a distributed model (distributed style), is the most adaptable and most widely used parallel genetic algorithm. The model is coarse-grained model of randomly generated initial population divided by the number of processors into several sub-groups of the various sub-groups of the different processors in the independent evolution of concurrent execution of operations, after a certain evolution of each generation, will be exchanged between the various sub-groups of individuals to bring in a number of other sub-groups of excellent genes, rich diversity of the various sub-groups. To prevent the occurrence of premature convergence at the same time, the coarse-grained model of the communication overhead will be small, and very suitable for operation in communication with low bandwidth cluster system [7].

4.1 Initialization sub-groups

Each node randomly generated independent initial population themselves, due to concurrent execution, this method used the processor (master node) to generate a large group, and then randomly assigned to each node to save time[7].

4.2 Connection Topology

The connection between the sub-groups, Figure1 including one-way ring topology (the number of sub-groups of neighbors (1). Figure 2 two-way loop (sub-groups of neighbors is (2). (Figure 3) toroidal connection (number of sub-groups of neighbors (4). The large number of experiments compared different topological connections of the quality of the solutions proposed in this paper for such problems, found through experiments, the connection topology is toroidal and it's the best optimization.

4.3 Migration Strategy

Coarse-grained model in a variety of implementations, some selected sub-groups in the best individual out "immigrants"; some of the "immigrant" is randomly selected to move into those to replaced by worst individual groups; some were replaced by randomly selected as the best individual to move out.

Although studies have shown that migration intervals epoch too small, will destroy the diversity among sub-groups, hinder access to high quality solutions [4], but simulation results show that for this problem, the use of the migration of the smallest interval epoch = 1, while ensuring optimal quality, access to the fastest convergence rate also observed a similar phenomenon.

5 Conclusions

In this paper a parallel genetic algorithm was proposed. It uses cluster nodes system in order to deal with the problem. Each node corresponds to a sub-group chromosome as in one-way ring topology. when using processors (each processor corresponds to a sub-group of chromosome, the number generations of evolution reached the fitness after several iterations by using proposed genetic algorithm in local search, After the number of generations of evolution, in the simulation obtain the optimal global. The proposed shows the local search operator in the same time and will be very effective for the open area on location of the base station, and by increasing the number of sub-groups of neighbors, will help to improve optimize the quality of the service .

Results

As shown in (figure 5 & Table1), by specify the population size (number of nodes) and set the number of Iterations will generate the fitness for each location, till generation ends by last iteration. To do comparisons of both Parallel Genetic Algorithm and Genetic Algorithm, to find best fitness by set of different number of iterations; the population in two dimensions of genetic algorithm shown below in figure 6 which show linearity constraints in initial distribution . Figure 6 a plot window appears showing the linear constraints, bounds, level curves of the objective function, and initial distribution of the population, Figure7: The population eventually concentrates around the minimum point.

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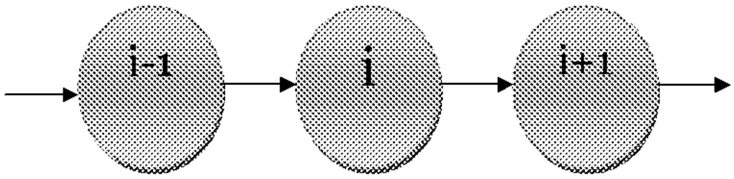

Fig.1: One-way ring

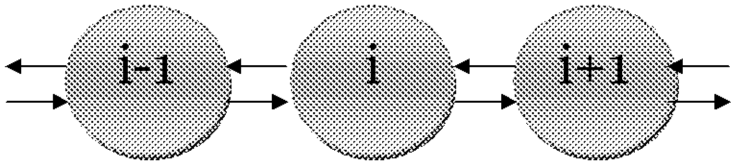

Fig.2:Two-way ring

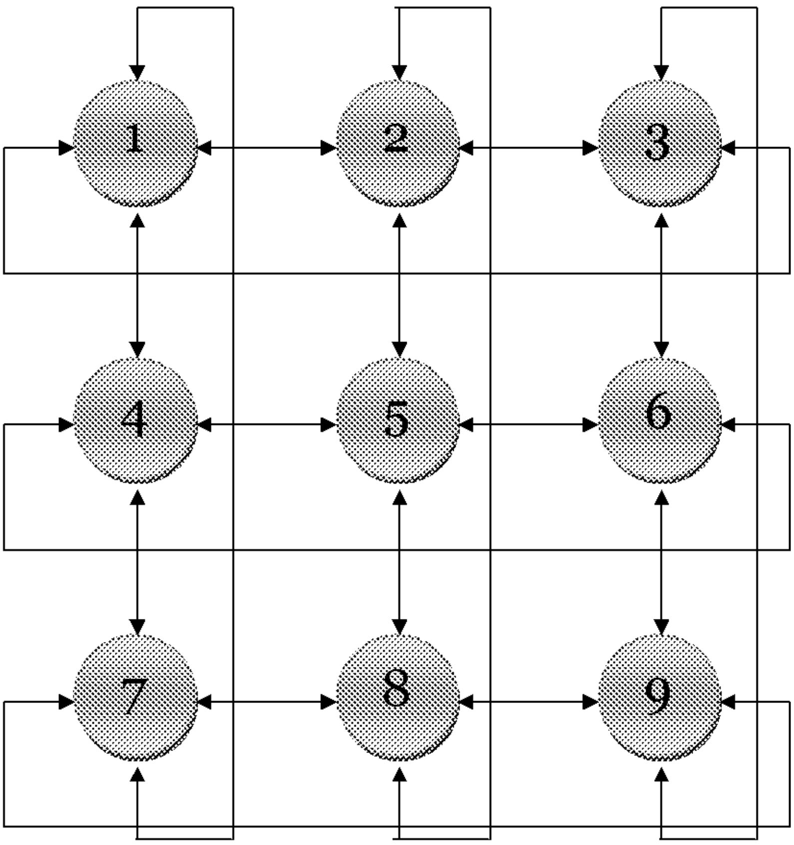

Fig. 3: toroidal connection

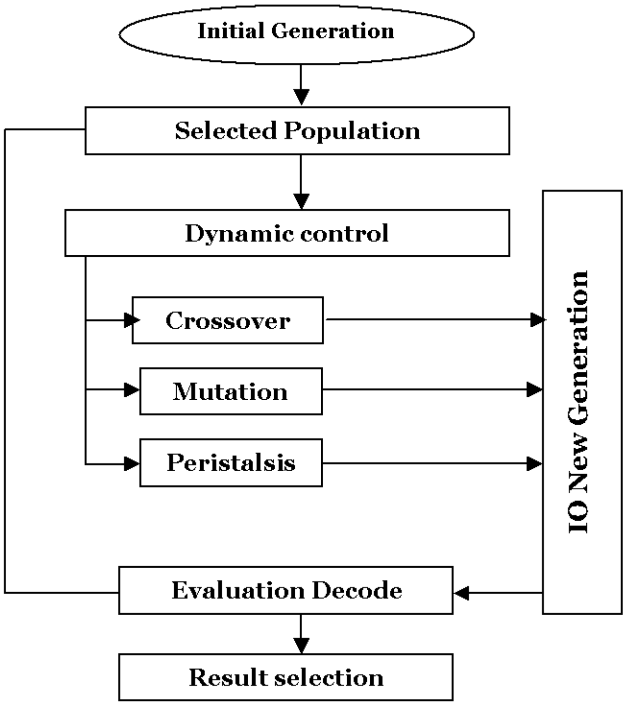

Fig.4 Flow Chart of Parallel Genetic Algorithm

Iteration	Fitness	Dimention1	Dimention2
317	9.4757E-06	0.9919	0.9956
418	6.6222e-06	0.99475	1.0038
272	6.5924E-06	1.0010	1.0046
614	8.9738E-06	1.0023	1.0033
319	9.1116E-06	1.0029	0.9818

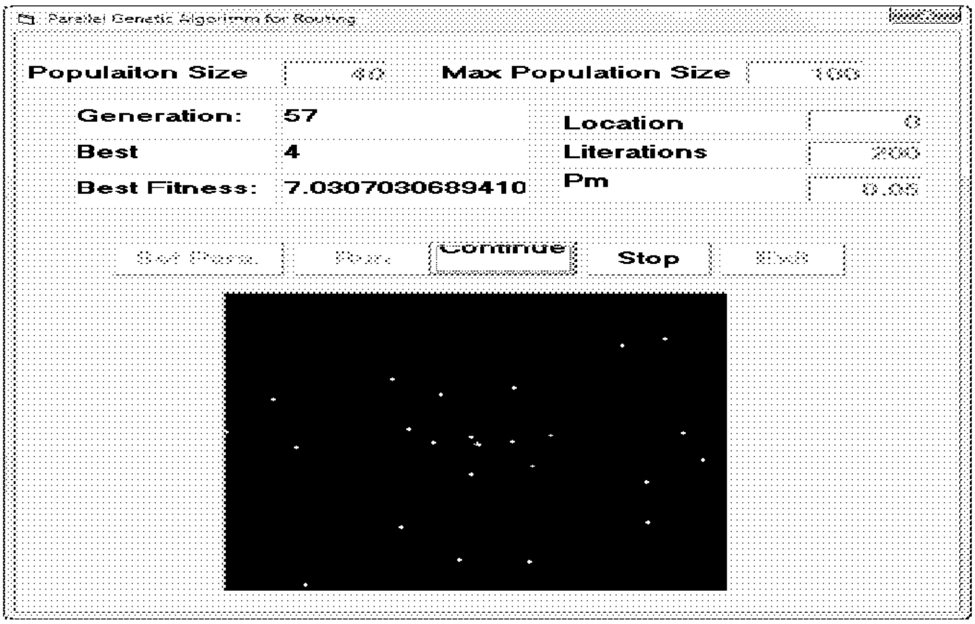

Table 1: Best fitness, dimensions for different iteration in Genetic Algorithm
Fig.5 Form application of PGA

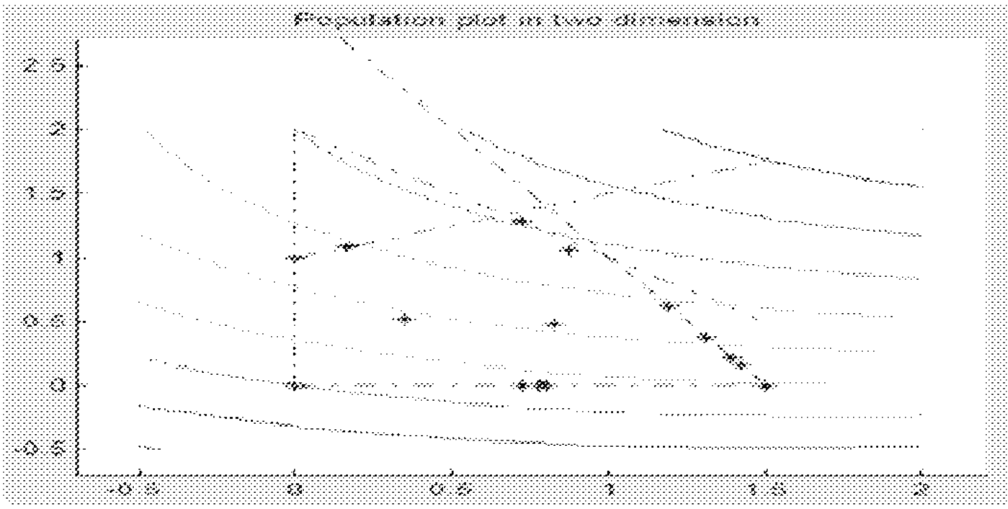

Fig .6: A plot window appears showing the linear constraints

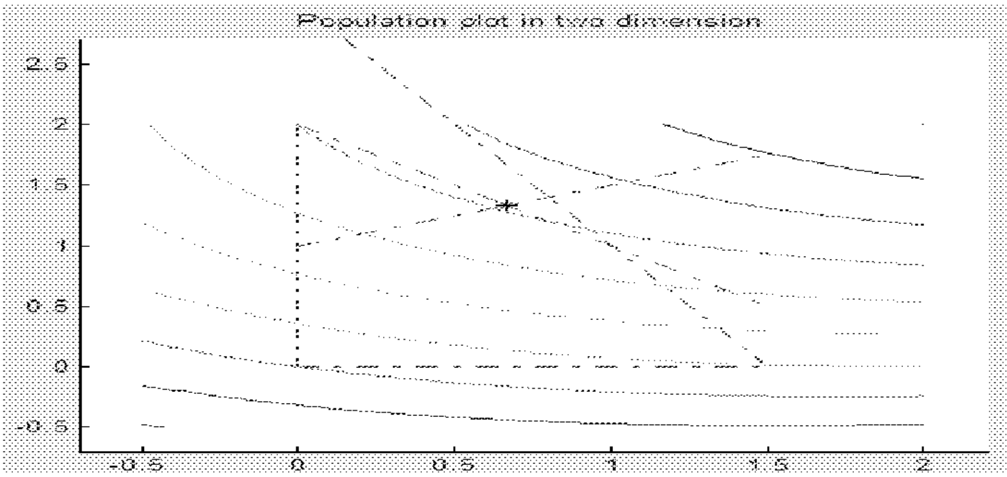

Fig .7: The population around the minimum point

تطبيق الخوارزميات الجينية المتوازية المثلى في شبكات الاتصالات اللاسلكية لاختيار محطة الإرسال الرئيسية

الخلاصة

الهدف من هذا البحث هو لتحديد الموقع الأمثل لمحطات الإرسال والاستقبال (transmitters) في الاتصالات الراديوية للشبكات اللاسلكية ،وكذلك لضمان تحقيق معايير جودة الخدمة المعتمدة لتسخيرها في حل مشكلة التوافقية لأجهزة الاتصال وتحسين أداء الشبكة .إن عملية اختيار مواقع للإرسال ضمن منطقة معلومة من بين عدد من البدائل المتوفرة تتم من خلال تطبيق الخوارزمية الجينية المتعددة (coarse-grained parallel genetic algorithm) والتي تسمح بتحقيق أقصى تغطية ممكنة مع تخفيض عدد المحطات المستخدمة، في تنفيذ الخوارزمية تم اعتماد مشغل بحث محلي فعال (effective local search operator) له القدرة على التعامل مع كافة المحطات المتجاورة لإظهار فعالية البحث في المنطقة المحلية بشكل واضح بالمقارنة مع التراكيب البنيوية المتجاورة. وكذلك تم عمل محاكاة(Simulation) من خلال برنامج مصمم لهذا الغرض ليحاكي تنفيذ الخوارزمية على مجموعة مختارة تحوي عدد من المحطات(dedicated cluster) ، خلاصة لما تقدم ،إن تطبيق الخوارزمية أعلاه قد ساهم بشكل فعال في زيادة جودة الخدمة وبالتالي سرعة الاستجابة ورفع كفاءة الشبكة .