Diseño Inteligente de Redes Inalámbricas de Comunicación
Conserjería de Innovación, Ciencia y Empresa
P07-TIC-03044
`http://diricom.lcc.uma.es`

Málaga, Diciembre 2009

Informe Ejecutivo

Título: AFP-1.2: Métodos de recombinación eficientes el problema AFP

Resumen: Este entregable propone y analiza el comportamiento de varios métodos de recombinación especializados para el problema de la asignación automática de frencuencias (AFP) que se está considerando en el proyecto DIRICOM. Estos operadores especializados tratan, por una parte, de explotar la topología de la red y, por otro, incorporar la planificación de frecuencias de aquellas zonas de la red que menos contribuyen al coste total de la misma.

Objetivos:

1. Diseñar operadores de cruce específicos para el problema AFP.
2. Mostrar la eficacia de estos métodos sobre instancias reales.

Conclusiones:

1. La utilización de operadores específicos permiten obtener mejores planes de frecuencia, en el contexto de la experimentación realizada.
2. Los beneficios los operadores se pueden apreciar más en ejecuciones más largas así como en las instancias de mayor tamaño.

Relación con entregables:

PRE: AFP-1.0, AFP-1.1

CO: —

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Málaga, December 2008

Executive Summary

TITLE: AFP-1.2: Efficient crossover operators for the AFP problem

ABSTRACT: This deliverable proposes and analyzes the performance of several especialized recombination operators for the automatic frequency assignment problem (AFP) that is addressed in the DIRICOM project. These especialized operators are engineered, on the one hand, to exploit the GSM network topology and, on the other hand, to incorporate into the offspring the parent's frequency planning of the network that least contribute to the total cost of the instance.

GOALS:

1. Designing especialized crossover operators for the AFP problem.
2. Showing the efficacy of these methods on real world instances.

CONCLUSIONS:

1. Using especialized operators has allowed to reach better frequency plans in the context of the experimentation performed.
2. The benefits of the crossover operators is more relevant on longer runs as well as on larger instances.

RELATION WITH DELIVERABLES:

PRE: AFP-1.0, AFP-1.1
CO: —

Efficient crossover operators for the AFP problem

DIRICOM

December 2009

1. Introduction

Heuristic algorithms are mandatory when tackling large instances of the AFP problem [1] and, among these kind of techniques, metaheuristics [7] have shown to provide the AFP problem with very accurate solutions [2]. Among this kind of algorithms, Evolutionary Algorithms (EAs) [3] have been widely used because of their ability for performing a robust search. One of the main issues when using EAs for addressing AFP problems is the crossover operator, which is known to perform badly if it is not well tailored [6]. The aim of this deliverable is to propose several especialized crossover operators and evaluate them in the context of the AFP problem addressed in the DIRICOM project [5]. By considering different problem specific information, three different methods have been designed.

The structure of this technical report is as follows. The next section describes the three recombination methods, whereas Section 3 includes the experimentation performed for their evaluation over the real-world instances defined within the DIRICOM project.

2. Crossover methods

Crossover operators are used within EAs in order to combine “good” features of (usually) two given tentative solutions. In this deliverable, a standard steady-state genetic algorithm (ssGA) has been used to evaluate the proposed methods. Its pseudocode is shown in Algorithm 1.

Algorithm 1 Pseudocode for ssGA

```
1: population ← ∅
2: initialize(population)
3: while not time-limit do
4:    parents ← binaryTournament(population)
5:    offspring ← crossover(parents,$p_c$)
6:    offspring ← mutation(offspring,$p_m$)
7:    population ← insert(population,offspring)
8: end while
```

The algorithm starts by creating a population of random individuals, so that all the TRXs of each individual are randomly assigned with one of their valid frequencies. As to the genetic operators, ssGA uses binary tournament as selection scheme (line 4). This operator works by randomly choosing two individuals from the population and the one having the best (lowest) fitness is selected. The mutation operator used is the random mutation in which the frequencies of a set of randomly chosen TRXs of the solution are reassigned with a random valid frequency. The three crossover operators applied are described next.

2.1. Single Point Crossover (SPX)

This is one of the most well known operators within the EA community. It is based on randomly selecting a crossover point of the chromosome. Then, two offsprings are generated by exchanging the genes about this point.

2.2. Site-based Crosssover (SbX)

The TRXs of GSM networks are organized in sectors which are in turn installed in sites (antennae). This crossover tries to exploit this organization. As so, a single offspring is generated in such a way that it contains the entire frequency planning of the site of the parent that most reduces the component cost [4]. That is, given the frequency assignment of a site in the two parent solutions, its component cost is computed. Then, the site having the smallest component cost is transferred to the offspring.

	Seattle			Denver		
Crossover	$\bar{x}$	σ_n	min	$\bar{x}$	σ_n	min
SPX	4418.73	368.13	3696.70	107744.44	1777.92	103337
SbX	4334.92	409.62	3401.68	107589.52	1891.08	102619
CCX	4303.19	361.95	3394.91	107567.21	1841.54	102420

Table 1: Planning costs when ssGA runs for 60s ($p_c = 1{,}0$ and $p_m = 0{,}1$).

	Seattle			Denver		
Crossover	$\bar{x}$	σ_n	min	$\bar{x}$	σ_n	min
SPX	4395.80	440.55	3003.19	108102.75	1544.61	104373
SbX	4318.97	396.15	3318.89	107630.34	1785.02	103495
CCX	4254.57	359.57	3535.73	107669.29	1764.62	102499

Table 2: Planning costs when ssGA runs for 300s ($p_c = 1{,}0$ and $p_m = 0{,}1$).

	Seattle			Denver		
Crossover	$\bar{x}$	σ_n	min	$\bar{x}$	σ_n	min
SPX	4374.55	452.10	3154.10	107968.79	1626.49	104218
SbX	4309.57	394.78	3118.41	107929.24	1789.54	102620
CCX	4331.05	406.94	3473.68	107418.50	2110.95	104426

Table 3: Planning costs when ssGA runs for 600s ($p_c = 1{,}0$ and $p_m = 0{,}1$).

2.3. Component Cost Crossover (CCX)

This crossover operator is also based on the component cost, but at TRX level. It operates by traversing all the TRXs of the solutions, then the frequency of the parent for which the TRX has the smaller component cost is copied to the offspring.

3. Experiments

This section presents the experiments performed to check the efficacy and efficienty of the three crossover operators on two real world instances, namely Seattle and Denver, of the AFP problem (see [5]). Due to the different computational requirements of each method, the stopping condition has been set to reach a given time limit. Three different of such limits have been used: 60, 300, and 600 seconds (very short and a bit long runs).

Tables 1, 2, and 3 display the average, $\bar{x}$, the standard deviation, σ_n, and the best (min) value over 30 independent runs. There is a clear tendency, it is clear that the especialized methods have reached frequency plannings that provoke lower interference in the network. Among the two proposed ones, the results show that CCX is slightly better than SbX. In the case of the smaller instance, i.e., Seattle, the improvements are more relevant in the short term (60 and 300 seconds), but it vanishes in the longer run. For the Denver instance (larger), exactly the opposite scenario appears. The benefits of the CCX operator clearly show up in the longest run, in which the difference in the planning costs are very important (from 107929 to 107418).

Referencias

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