

APPLICATION OF FUZZY HEURISTIC TECHNIQUES TO COMPUTER NETWORK DESIGN

S.I. Samoylenko, Moscow, USSR

Paper [2] discussed a solution search method based on fuzzy heuristics. The present paper describes some results obtained by applying the above method to the selection of multipoint communication network topologies.

The problem is formulated as follows. We have an ensemble of $M+1$ sites $S = \{s_1, s_2, \dots, s_{M+1}\}$ with known distances between each pair of the sites. One of the sites is central. It is required to connect M sites to the centre via communication lines so that any line passes through not more than M_0 sites, $M_0 < M$, provided the total length of the lines is minimal.

Problems of this class are usually handled by means of heuristic methods. In the presence of constraints ($M_0 < M$) the heuristic solutions may be significantly inferior to the optimal solution.

Fuzzy heuristics make it possible to expand at the problem solver's discretion the search area in the neighborhood of solutions suggested by the heuristics employed. The procedure is implemented through controlled expansion of the search area circumscribed by heuristics while the extent of the fuzziness of the area may be varied to meet the search time limit or other constraints.

It will be supposed that the procedure of search for a feasible solution $g = (g_1, g_2, \dots, g_M)$ includes M steps, with the local solution g_j selected at each of the steps. When the conventional heuristic search procedure is employed, the selection of g_j with known $g_1, g_2, \dots, g_{j-1}$ is unambiguous, due to which the search procedure produces a single solution. Fuzzy heuristics introduce controlled indeterminism in the selection of g_j and, therefore, can be used to generate a class of suboptimal solutions and improve the solution derived by means of the conventional heuristic search procedure if this solution is not optimal.

Let all the sites of the communication network be divided at the j th search step into the three sets: S_0^j - a set of sites which are not yet connected to the centre, S_1^j - a set of sites which are connected to the centre via lines with the number of sites $< M_0$, and S_2^j - a set of sites connected to the centre through lines with the number of sites equal to M_0 , $j=1, 2, \dots, M$. Then a conventional procedure of heuristic selection at the j th step can consist in selecting a pair of the closest sites $s_i \in S_0^j$ and $s_k \in S_1^j$ and in connecting these sites by a communication line. This procedure will produce a single

solution which will differ from the optimal solution in different degrees depending on a specific problem.

With the method of fuzzy heuristics, the procedure of selection of a local decision at each step is not unambiguous. For example, we may assign to each site $s_i \in S_0^j$ a weighting coefficient w_i proportional to its distance to the nearest site from S_1^j and select connected sites with probabilities $p_i = c_i / w_i$ where c_i is a normalization factor.

The degree of fuzziness of the heuristic search can be varied by modifying the distribution according to which selection of local solutions is performed. If the initial local distribution has the form $P = (p_1, p_2, \dots, p_M)$ at the j th step, the search area can be changed by introducing a modified distribution $\tilde{P} = (\tilde{p}_1, \tilde{p}_2, \dots, \tilde{p}_M)$, in which, for example, $\tilde{p}_i = p_i^L / p_i^L$, $L \geq 0$

where $p_i^L = \sum_{i=1}^M p_i^L$. The search area is narrowed if $L > 1$ and expanded if $L < 1$. With $L=0$ the procedure is transformed into equiprobable selection.

The search procedure was implemented in PL/1 and applied for solving test problems of different dimensionality with $M=25, 40, 60, 100$; $M_0=5-7$. The location of sites was generated by random selection of coordinates within a 1×1 square similar to the procedure employed in [1]. The results obtained were compared with the results derived by the conventional heuristic search procedure described above. The comparison has shown that in all the problems the fuzzy heuristic technique produced solutions superior to those obtained by means of conventional heuristic search. Depending on specific problems, the improvement achieved was within several per cent to about 15 per cent of the total length of the communication lines.

References

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