OFFICIAL TEMPLATE FOR THE SUBMISSION OF PAPERS
II INTERNATIONAL SCIENTIFIC CONVENTION
"II ICC UCLV 2019"

JUNE 23th – 30th, 2019
CAYOS DE VILLA CLARA. CUBA.

INTERNET OF THINGS AND ARTIFICIAL INTELLIGENCE 2019

A Fuzzy Multi-Objective Maximal Covering Location Problem for Wi-Fi antennas location.

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Abstract: The use of networks of Wi-Fi antennas is a key element to provide constant connection to the Internet. The decision regarding the placement of the Wi-Fi antennas in order to allow the best coverage may be modeled as a location problem. This paper introduces a new fuzzy multi-objective model for the Maximal Coverage Location Problem (MCLP) in order to locate the Wi-Fi antennas. Four objectives are optimized: overall coverage, backup coverage, good coverage and minimal coverage. The model was applied to a case study: the location of Wi-Fi antennas in the Faculty of Computer Engineering of CUJAE.

Keywords: fuzzy multi-objective maximal covering location problem | multi-objective metaheuristics | WiFi antennas.

1. Introduction

The quality of the Wi-Fi service depends of the location of the antennas. This is a case of the Maximal Coverage Location Problem (MCLP) proposed by Church and ReVelle [1], which consists in to select the facilities in order to provide the best coverage over demands nodes. This paper introduces a new multi-objective fuzzy MCLP with four objectives: Overall coverage OC: a fuzzy value that indicates the average of coverage over all demands; Backup coverage BC: a fuzzy value that shows the average of backup coverage over all demands; Good coverage GC: a fuzzy value that is the population of demands where the degree of coverage is higher than γ; and Minimal coverage MC: a fuzzy value that is the population of demands where the degree of coverage is greater than β.

2. Fuzzy multi-objective maximal covering location problem (FMo-MCLP)

The new parameters and variables that define the FMo-MCLP are (ignoring the parameters that remain equal to [1]): S^-, S^+: the maximum and minimum distance from a demand node to a Wi-Fi antenna to be considered as covered and not covered at all, respectively. $Y_i, U_i \in [0,1]$: fuzzy degrees of primary and backup coverage of node i that corresponds to the antennas $j^1 \in J$ and $j^2 \in J - \{j^1\}$, respectively. $f_{ij} \in [0,1]$: the fuzzy degree of coverage of the node i provided by an antenna located in site j. The f_{ij}^r is the raw fuzzy degree of coverage of the demand node i provided by an antenna located in site j where: if $d_{ij} \leq S^-$then $f_{ij}^r = 1$, $d_{ij} \geq S^+$ then $f_{ij}^r = 0$ and $f_{ij}^r = (S^+ - d_{ij})/(S^+ - S^-)$ otherwise. The objectives functions (to maximize) and restrictions of the problem are defined as: $OC = \frac{\sum_{i=1}^{I} Y_i}{|I|}$, $BC = \frac{\sum_{i=1}^{I} U_i}{|I|}$, $GC = \frac{|\{i \in I | Y_i \geq \gamma\}|}{|I|}$ and $MC = \frac{|\{i \in I | Y_i \geq \beta\}|}{|I|}$, subject to: $Y_i = X_{j^1} * f_{ij^1}, \forall j \in J[X_{j^1} * f_{ij^1} \geq X_j * f_{ij}]$, $U_i = X_{j^2} * f_{ij^2}, \forall j \in J[X_{j^2} * f_{ij^2} \geq X_j * f_{ij}]$.

3. Results and discussion

We present a case study that aims to decide the best placement of Wi-Fi antennas in the area of the Faculty of Computer Engineering of CUJAE. A set of 15 Wi-Fi antennas are available to provide network access. The set of 411 demand nodes are usual positions of workers and students. The 106 points where the antennas may be placed are all the corners of the offices. The NSGAII [2, 3] was selected to solve the problem. Figure 1 shows the solutions with extreme values of the objective functions (OC, BC, GC, MC). In BestBC, almost all open facilities were located in pairs, thus providing backup coverage. The 15 facilities that were located in BestOC were used at least once more in the other solutions. There are 7 (47%) of the locations used in BestOC that were used in the four solutions while 13 locations (87 %) were used in at least three solutions.

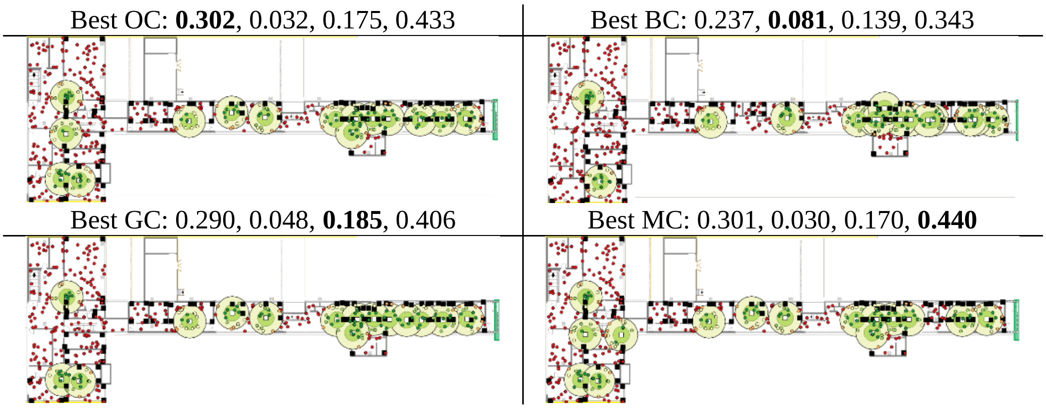

Figure 1: Case study results.

4. Conclusions

This paper proposed a new multi-objective fuzzy MCLP model (FMoMCLP) in order for to locate a set of Wi-Fi antennas with four criteria: overall coverage, backup coverage, good coverage and minimal coverage. A case study is presented that illustrate the application of the model in order to deploy a set of Wi-Fi antennas in CUJAE.

5. Bibliographical references

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