# REVIEW

by Prof. D.Sc. Ph.D. Ivan Tomov DIMOV, Institute of Information and
Communication Technologies - BAS of the dissertation work of
Prof. Ph.D. Stefka Stoyanova Fidanova
to acquire the scientific degree
"Doctor of Science" on topic
"An Ant Method for Solving Combinatorial Optimization
Problems”
in a professional direction
4.6 Informatics and computer science

Pursuant to order No. 92/31.03.2023 of the Director of IICT-BAS, Prof. S. Margenov and decision of the Scientific Council of IICT-BAS (protocol No. 3/29.03.2023) in connection with the procedure for acquiring the scientific degree "Doctor of Sciences" in professional direction 4.6 "Informatics and computer sciences" by prof. Dr. Stefka Stoyanova Fidanova with a dissertation on the topic "Ant method for solving combinatorial optimization problems" I was selected as a member of the scientific jury.

## 1. General description of the dissertation materials

Optimization is an important area of research in informatics and operations research. It has important practical applications in artificial intelligence, as well as in a number of practical areas in economics, finance and social process research.

Stefka Fidanova's dissertation is in the field of informatics. This hot field of modern informatics requires competence in computational mathematics, theory of algorithms and important aspects related to applications.

When evaluating the dissertation work, the conditions of the Law on the Development of the Academic Staff in the Republic of Bulgaria (ZRASRB), the Regulations for its implementation (Decree No. 202 of 10.09.2010, its amendments and additions, State Gazette No. 15 of 19.02.2019) are determining, as well as the Rulebook on the specific conditions in IICT-BAS for the implementation of the law.

The presented dissertation is in the volume of 187 pages, 76 tables, 16 figures, 127 literary sources in the bibliography and includes:
Introduction (Chapter 1), Ant Method (Chapter 2), Ant Method for the Knapsack Problem (Chapter 3), Inspecting a GPS Network (Chapter 4), Building a Wireless Sensor Network (Chapter 5), Hiring Labor ( chapter 6), Passenger Flow Modeling (chapter 7), Conclusion (chapter 8) and Bibliography.

List of publications contains 19 publications, of which:

1 publication is a monograph (No 1), one publication is in a journal with IF 2.9, Q1, 11 publications are in publications with an impact rank in Scopus, 5 publications are in publications referenced in Scopus, 1 publication is in an international journal Studia Informatica.

Three of the posts are standalone (these are posts numbered 1, 3 and 5).

It is important to note that all publications were ppublished in the interval 2016 - 2022 and did not participate in other competitions of the applicant, which is one of the requirements of the law. The candidate has submitted a Certificate of fulfillment of the IICT minimum requirements for the scientific degree "Doctor of Sciences", which shows that the requirements of the procedural rules are covered.

The candidate submitted a **List of Citations**, which contains a total of 1254 citations, of which **52 citations of 13 publications** included in the dissertation are visible in Scopus and WoS. In the list of citations, 7 citations with IF (No. 5,6,13,15,20, 23 and 48) and 1 citation with SJR (No. 43) are presented.

The analysis of the "List of publications" and "List of citations" shows that Prof. Dr. Stefka Fidanova fulfills the requirements for a "Doctor of Sciences" according to the "Regulations for specific conditions in IIKT-BAS".

## 2. Scientific and scientific-applied contributions

In the introduction of the dissertation, the following "Aim and objectives of the dissertation" are formulated, namely "the development of algorithms, based on the ant method, for solving real-life and industrial problems."

To achieve the goal, five tasks have been formulated, namely:

- Development of an algorithm for solving the knapsack problem;
- Development of an algorithm for inspecting a GPS network;
- Development of an algorithm for building a wireless sensor network according to two criteria, minimum number of sensors and minimum used energy;
- Development of an algorithm for hiring labor force;
- Development of an algorithm for modeling passenger flow according to two criteria, travel time and cost of travel.

I will dwell on the individual results obtained in the dissertation.

The introduction (**chapter 1**) of the dissertation deals with basic concepts necessary to present the results of the following chapters. It gives a mathematical interpretation of the main objects in the dissertation. It formulates the goals and tasks of the dissertation work, the research methodology, a brief description of the publications and citations is given.

**Chapter 2** formulates the ant method as part of metaheuristic optimization methods. A metaheuristic is a procedure designed to find, construct, or select a low-level procedure that guarantees finding a sufficiently good solution to an optimization problem. The algorithm itself is also described.

In **Chapter 3**, the multidimensional knapsack problem is considered. The algorithm using intuitionistic fuzziness (intuitionistic fuzzy pheromone) is described. A Hybrid Ant Colony Optimization (ACO) algorithm is described, presenting its structure, graph representation of the problem, and construction of solutions. The pheromone update algorithm is described as well as the starting strategies.

**Chapter 4** examines the task of inspecting GPS networks. The solution is represented by a line graph with weighted edges.

**Chapter 5** discusses an important application for building a wireless sensor network. The results have been published in a series of publications, namely: [50], [53], [57], [63] [107].

**Chapter 6** examines the task of human resource management, namely labor recruitment.

**Chapter 7** deals with the practical task of modeling passenger flow. Original solutions with comparatively low computational complexity were found.

The main scientific and scientific-applied results are formulated in the Conclusion.

In my opinion, they can be represented as follows:

1. A hybrid algorithm for solving the knapsack problem, as a combination between the ant method and a local search procedure.

2. Algorithms based on the ant method for:

    I. GPS network inspection;

    II. building a wireless sensor network;

    III. labor recruitment;

    IV. passenger flow modeling in the presence of various types of transport in one direction.

It should be noted that the developed algorithms are solutions to essential scientific and applied problems.

The **Extended abstract** correctly reflects the main results obtained in the dissertation. The dissertation and abstract are well-formed and properly structured.

The **contributions to the dissertation** are formulated in paragraph 8.1. I will note only the most important ones for me:

**Scientific contributions:**

- Development of a hybrid algorithm for solving the **knapsack problem** by introducing two variants of intuitionistic fuzzy pheromone and using starting strategies.

- Creation of new algorithms for inspecting GPS networks and algorithms for building a wireless sensor network.
- Development of an algorithm for solving the task of hiring a workforce.
- Creation of an algorithm for modeling passenger flow using various types of transport.

The **scientific and applied contributions** consist of software implementations of the hybrid algorithm, of the GPS network inspection algorithm, as well as implementations of the workforce recruitment and passenger flow modeling algorithms.

I have no significant **critical remarks** about the dissertation. It happened over the years that I reviewed works of Prof. Stefka Fidanova and listened to her reports at seminars and conferences. I want to state that she always answered the questions posed very professionally. There are some stylistic inaccuracies in the thesis, which, however, are not essential.

### Personal impressions

I have known Stefka Fidanova for many years. I believe that she has a high standing as a scientist in her scientific community. She is respected and respected as one of the leading researchers in her field. She is a scientist with proven research capabilities in the field of heuristic optimization algorithms with a proven affinity for new, original approaches that lead to important practical implementations.

**Conclusion:** The scientific and scientific-applied results presented in the dissertation, some of which are new to science, and others enrich already known knowledge, give me the reason to conclude that the dissertation "Method of ants for solving combinatorial optimization problems" satisfies the requirements of ZRAS, PPZRAS, as well as the specific requirements of IICT-BAS. Therefore, I strongly recommend that the scientific jury propose to award the scientific degree "Doctor of Sciences" to Prof. Dr. Stefka Stoyanova Fidanova in direction 4.6 Informatics and computer sciences.

18.05.2020                                                    Signature На основание

Sofia                                                             /P. ЗЗЛД