https://www.proconference.org/index.php/usc/article/view/usc13-01-005
DOI: 10.30888/2709-2267.2022-13-01-005

УДК 004.7

DETERMINATION OF THE OPTIMAL PARAMETERS OF WIRELESS LOCAL NETWORK ON THE CREATED PROGRAM USING THE ANT ALGORITHM

ВИЗНАЧЕННЯ ОПТИМАЛЬНИХ ПАРАМЕТРІВ БЕЗДРОТОВОЇ ЛОКАЛЬНОЇ МЕРЕЖІ НА СТВОРЕНІЙ ПРОГРАМІ ЗА МУРАШИНИМ АЛГОРИТМОМ

Pakhomova V.M. / Пахомова В.М.
c.t.s., as.prof. / к.т.н., доц.
ORCID: 0000-0002-0022-099X
Salohub M.V. / Салогуб М.В
master's degree holder / здобувач ступеня «магістр»
ORCID: 0000-0002-8479-5669
Ukrainian State University of Science and Technology, Dnipro, Lazaryan, 2, 49010
Український державний університет науки і технологій, Дніпро, Лазаряна, 2, 49010

Abstract. *The «WLAN EliteAS» program, created in the JavaScript language of the ant algorithm, determines the optimal number of base stations of wireless local networks and their location on the territory of USUST. Initial data of the «WLAN EliteAS» program: parameters of the territory of USUST (coordinates of vacant places; number of clients that need to be connected to base stations); wireless local network parameters (base station coverage radius, maximum number of clients to one base station); parameters of the ant algorithm (number of ordinary and elite ants, irrigation and evaporation, greed and laziness). The quality of the obtained solutions depends significantly on the choice of parameters of the ant algorithm.*

Key words: *wireless network; base station; coverage radius; ant algorithm; ant; evaporation; greed; laziness.*

Анотація. *На програмі «WLAN EliteAS», що створена мовою JavaScript за мурашиним алгоритмом, визначено оптимальну кількість базових станцій бездротових локальних мереж та їх розташування на території УДУНТ. Початкові дані програми «WLAN EliteAS»: параметри території УДУНТ (координати вакантних місць; кількість клієнтів, що потрібно підключити до базових станцій); параметри бездротової локальної мережі (радіус покриття базової станції, максимальна кількість клієнтів до однієї базової станції); параметри мурашиного алгоритму (кількість звичайних та елітних мурах, зрошення та випаровування, жадібність та лінивість). Якість отриманих рішень значно залежить від вибору параметрів мурашиного алгоритму.*

Ключові слова: *бездротова мережа; базова станція; радіус покриття; мурашиний алгоритм; мураха; випаровування; жадібність; лінивість.*

Introduction

Formulation of the problem. In connection with the merger of higher educational institutions: the Dnipro Institute of Infrastructure and Transport (DIIT) and the Institute of Industrial and Business Technologies (IIBT), there was an urgent need for their interaction as a single unit (Ukrainian State University of Science and Technology, USUST) through the use of wireless networks, when the deployment of a cable system is economically unfeasible in under martial law conditions.

Analysis of the latest research. Wireless local area networks (WLAN) have the following topologies [1-2]: temporary ad-hoc networks (Independent Basic Service Set, IBSS); dependent networks (Basic Service Set, BSS); complex networks (Extended Service Set, ESS). It is known that there are two main deployment methodologies: WLAN with a maximum service area; WLAN with maximum bandwidth. Some scientists have already dealt with the issue of WLAN planning, for the solution of which it is possible to use multi-agent methods of intelligent optimization, which include: bee; ant and others [3-6]. So, for example, in works [3, 5] to solve the problem of location of WLAN base stations (BS) the bee method was used, but today it is also known that the fastest solution is achieved using the ant algorithm, the author of which is Mark Dorigo; in addition, there are several modifications of the ant algorithm: Elitist Ant System; Ant-Q; Ant Colony System; Max-min Ant System; ASrank, which require additional research into its parameters.

The purpose of the work is to determine the optimal WLAN parameters on the territory of USUST using the created program based on the ant algorithm. In accordance with the goal, the following tasks were set: to develop a WLAN planning method based on the ant algorithm; create a suitable program for determining optimal WLAN parameters; conduct additional studies of the parameters of the ant algorithm on the created program.

Setting the problem. Let *L* be the total set of clients that need to be connected to WLAN base stations on the territory of USUST (DIIT or IIBT). Known *M* are candidate places where WLAN base stations can be installed. In addition, all clients must be connected to base stations. Let's introduce the designation $\mathrm{BS}_i(r)^k$ – *i*-th WLAN base station with a coverage radius *r* to which *k* clients are connected, where $i \in [1; M]$; $k \in [1; L]$. If $\mathrm{BS}_i(r)^k = 1$, then *i*-th base station with *k* clients connects to the WLAN, otherwise $\mathrm{BS}_i(r)^k = 0$. As an objective function, consider the function $F = \sum_{i=1}^{M} \mathrm{BS}_i(r)^k \to \min$, and the following restrictions must be met: $r \le r_{\max}$; $k \le k_{\max}$, where r_{max} – the maximum coverage radius of the WLAN base station; k_{max} – the maximum number of clients connecting to WLAN base station.

The «WLAN_EliteAS» program, the structure of which is shown in Figure 1, is compiled according to the elite strategy discussed in [4].

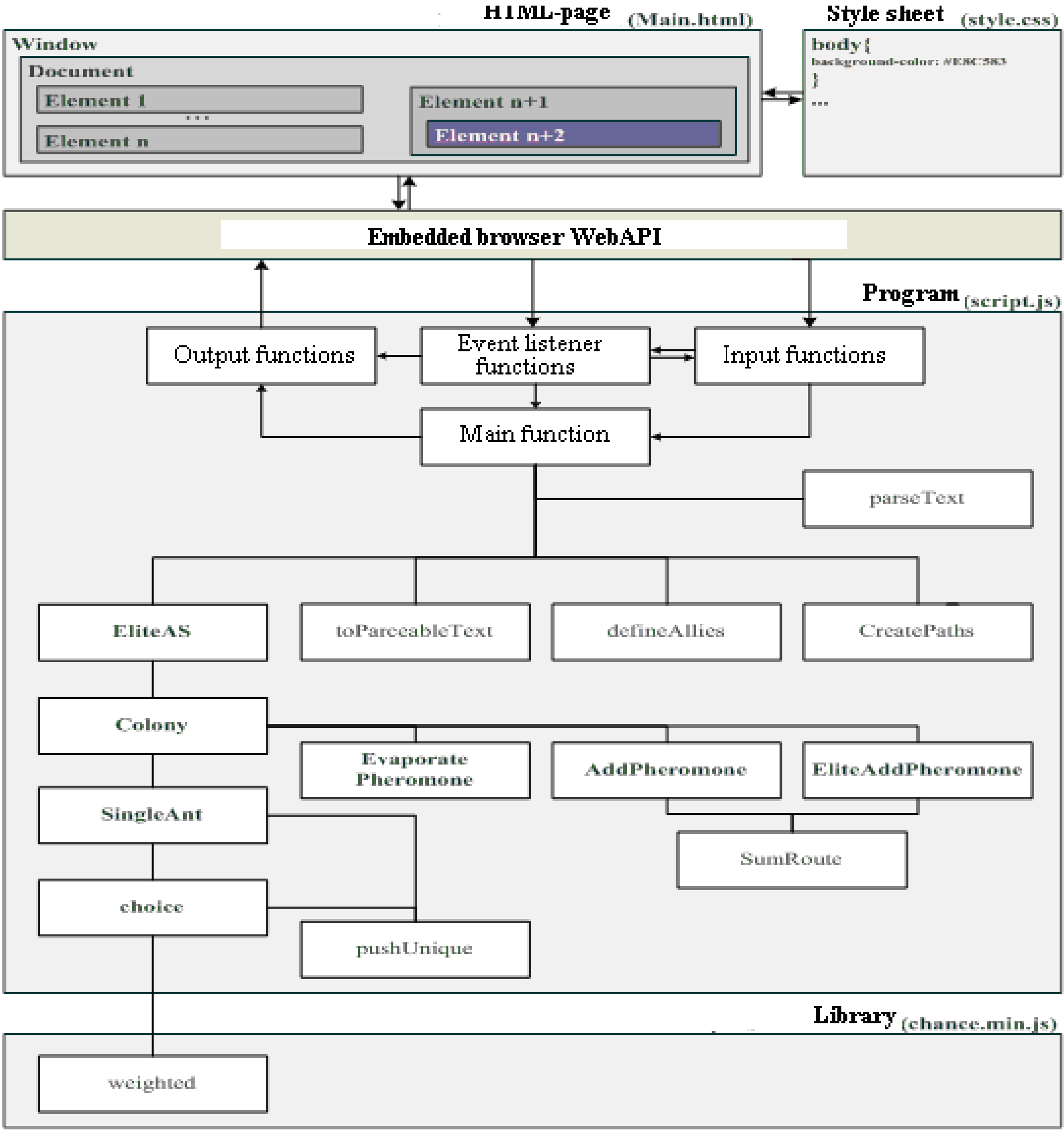

Figure 1 – The structure of the created «WLAN_EliteAS» program
Author's work

Initial program data: ant algorithm parameters (number of elite and ordinary ants, greed and laziness, irrigation and evaporation); WLAN parameters (coordinates of vacant seats, coverage radius and adjacencies). Restrictions imposed on the program: use of the latest browser (Google Chrome, Mozilla Firefox) with HTML-5 support. The main elements of the program are functions of the JavaScript language that interact with the elements of the HTML page (Main.html) through the API (Application Programming Interface).

The display styles of HTML page elements are in the style sheet file. The program uses the additional library «Chance», which is distributed under a free software license. The ant algorithm is implemented by «EliteAS» and its following child functions: «Colony»; «SingleAnt»; «Choice»; «Evaporate Pheromone»; «AddPheromone»; «EliteAddPheromone». For approbation of the «WLAN_EliteAS» program, a grid was generated with the following parameters: grid step - 20, deviation – 0,7. The result of the «WLAN_EliteAS» work is shown in Figure 2.

Figure 2 – Graphical result of the «WLAN_EliteAS» program: (*а*) – placement of BS for DIIT; (*б*) – placement of BS for IIBT

Author's work

Study of the evaporation parameter. So, for example, a grid was generated for the DIIT polygon on the «WLAN_EliteAS» program (grid step – 14; deviation – 0) and 211 points (vacant places) were obtained. When conducting the research, the following parameters of the ant algorithm were taken: initial amount of pheromone –

20; greed – 1; laziness – 1; the number of ordinary ants in the colony is 211 (provided that at least one ant starts its journey at each peak); the number of elite ants in the colony is 50; coverage radius – 50 m (on the map scale); the number of iterations of the algorithm is 50. Studies of the amount of pheromone by iteration at different values of the evaporation parameter (ρ) for irrigation Q=10 were conducted (Figure 3).

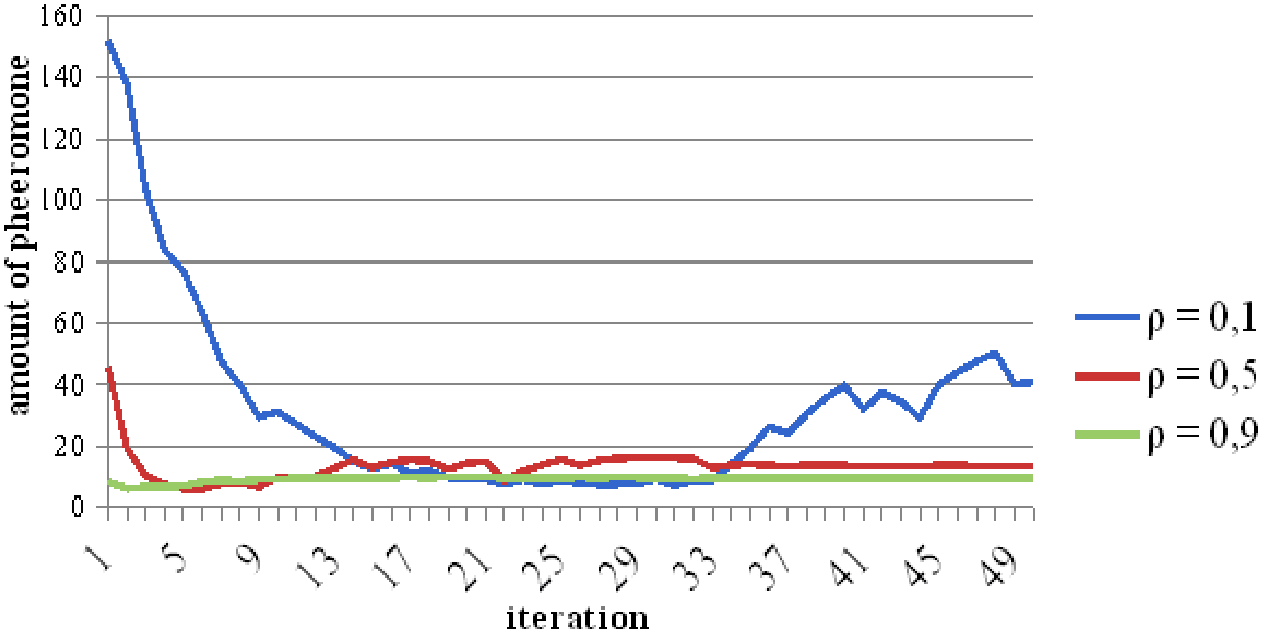

Figure 3 – The amount of pheromone by iterations with different evaporation
Author's work

Regardless of the value of the Q parameter, the following results are obtained: when $\rho = 0{,}9$ the pheromone evaporates faster than it has time to renew itself; when $\rho = 0{,}1$ the amount of pheromone decreases in the initial iterations (ants choose heterogeneous paths), but when the ants find a local optimum, they start to irrigate, due to which the amount of pheromone on this path begins to grow steadily; when $\rho = 0{,}5$ the amount of pheromone changes slightly, but constantly, allowing ants to choose already explored paths, and to choose less profitable but shorter new paths.

Study of the greed parameter. The parameter got its name due to the fact that it affects the ant's choice in the direction of a more pheromone-rich path. The obtained results are shown in Figure 4 ($Q = 1000$, $\rho = 0{,}45$). It can be seen from the figure that although larger values of greed can speed up the search for a shorter path, but for higher values of greed, a situation is likely when the algorithm falls into the local optimum trap, and smaller values of greed allow, after performing a significant number of iterations, to arrive at the optimal result.

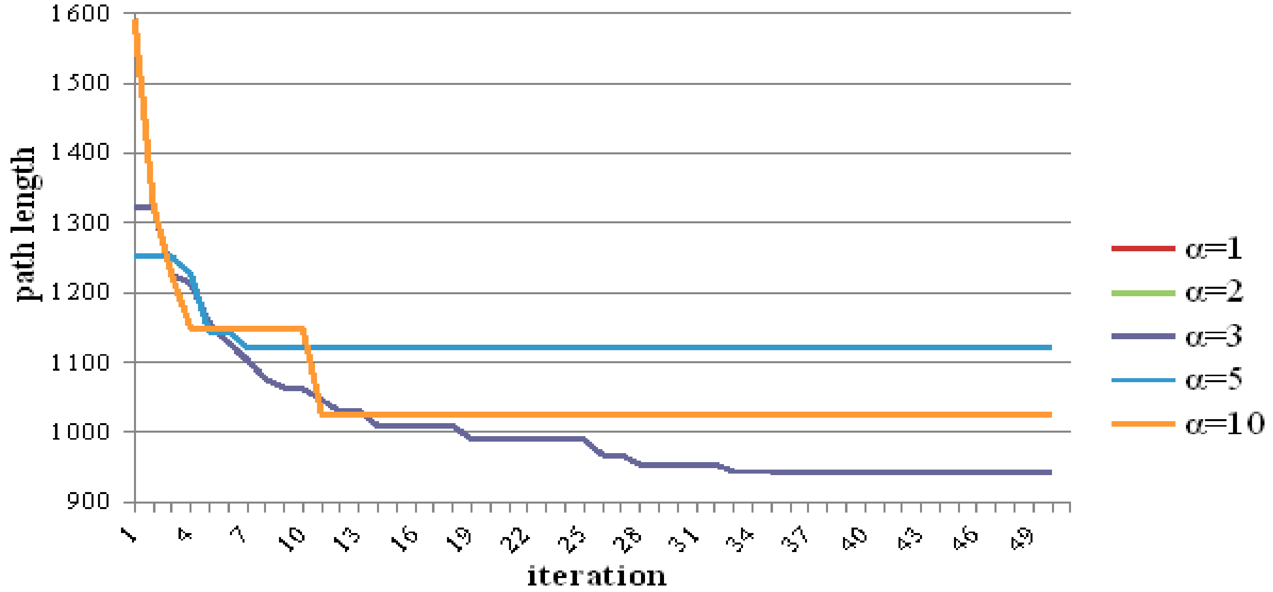

Figure 4 – The path length by iterations with different greed

Author's work

Study of the laziness parameter. The free parameter β got its name because it affects the ant's choice of the shortest path. Larger values of laziness help to reach shorter paths faster (Figure 5). It can be seen from the figure that at $\beta=1$ the ants eventually find the optimal solution, and at $\beta=10$ the ants get stuck at the local optimum.

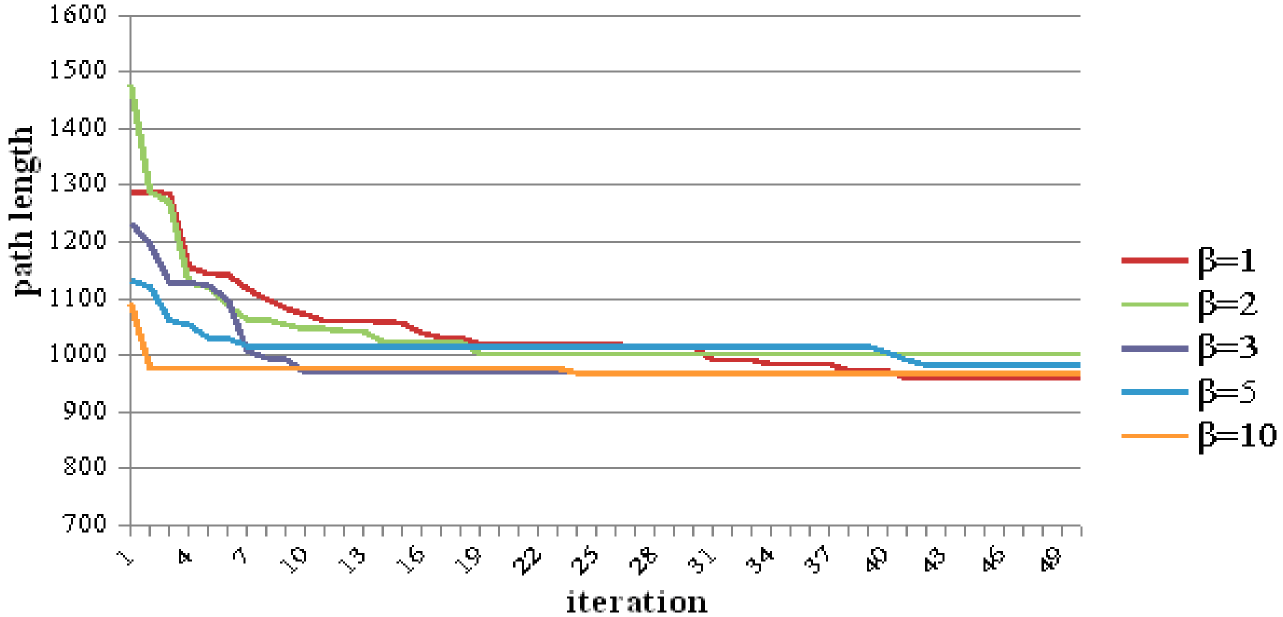

Figure 5 – The path length by iterations with different laziness

Author's work

Conclusions

«WLAN_EliteAS» program was created in JavaScript using the ant algorithm, the input of which is given: polygon parameters (DIIT or IIBT); WLAN parameters; parameters of the ant algorithm (the number of ordinary and elite ants, irrigation and evaporation, greed and laziness), as a result – a graphical representation of the location of WLAN access points. Optimal WLAN parameters were obtained using the created «WLAN_EliteAS» program, as well as studies of the parameters of the ant algorithm were carried out.

References

1. Nurmi, J., Lohan, E.-S., Wymeersch, H., Seco-Granados, G., & Nykänen, O. (2017). *Multi-Technology Positioning*. Springer International Publishing AG. URL: https://doi.org/10.1007/978-3-319-50427-8 (in English)

2. Osterhage, W. (2018). *Wireless Network Security.* Taylor & Francis Group, 14-77. URL: https://doi.org/10.1201/9781315106373-3

3. Pakhomova, V. M., & Nazarova, D. I. (2020). Organizing wireless network at marshalling yards using the Bee method. *Science and Transport Progress. Bulletin of Dnipropetrovsk National University of Railway Transport*. № 2(86). 60-73. URL: https://doi.org/10.15802/stp2020/204005 (in English)

4. Pakhomova, V. M., & Opriatnyi, A. O. (2021). Software model for determining the optimal routes in a computer network based on the two-colonial Ant algorithm. *Science and Transport Progress. Bulletin of Dnipropetrovsk National University of Railway Transport*. № 3(93). 38-49. URL: https://doi.org/10.15802/stp2021/242046 (in Ukrainian)

5. Skakov, E., & Malysh, V. (2016). Bee optimization algorithm for solving wireless network planning problem. *Software products and systems.*, 4(67), 67-73. URL: https://doi.org/10.15827/0236-235X.115.067-073 (in Russian)

6. Ying, Tan. (2018). Survey of swarm intelligence. *Swarm Intelligence-Vol. 1: Principles, current algorithms and methods*, 1-28. URL: https://doi.org/10.1049/pbce119f_ch1 (in English)