# Data Transmission Optimal Routing in WSN Using Ant Colony Algorithm

Su Jun, Vasyl Yatskiv, Anatoly Sachenko, Nataliya Yatskiv

*Abstract* - **Ant colony algorithm to search an optimal route of data transmission in Wireless Sensor Network was explored. Correspondent software was designed and the dynamics and the decision search time was investigated for the given network topology.**

*Keywords* - **Wireless Sensor Network, Ant Colony Algorithm, Elite Ants.**

## I. INTRODUCTION

Considerable achievements in analog and digital electronics and wireless communication allowed developing the cheap wireless sensors with low power consumption. As a result the large number of wireless sensors were integrated into network leading to the new technological base – wireless sensor networks (WSN). WSN are broadly used, for example in technological and ecological monitoring, medical care, monitoring system for vehicles, observation of earthquakes, etc. [1].

Various algorithms and routing protocols are developed for wireless sensor networks. These algorithms and protocols are aimed for decreasing of restrictions influence - which are typical for wireless sensor networks – as well as increasing their efficiency [2, 3]. However, a problem is to develop the algorithms of optimal routes search for data transmission from the end unit to a base station. It's shown [4] the algorithms of ant colony are so perspective having low time complexity.

## II. THE MODIFIED ANT COLONY ALGORITHM

The main principles of ant colony algorithms are defined in [5, 6]. Generalized ant colony algorithm for the search of optimal path in WSN consists of the next procedures:

1. Creation of ants. An ant is a simple computational agent in the ant colony optimization algorithm. It must visit each network node exactly once

2 The ants are equally distributed among the network nodes. The initial level of pheromone is specified.

3. Search for solutions. The probability of moving from state $i$ to state j is determined [5]

$$\begin{cases} P_{ij,k}(t) = \dfrac{[t_{ij}(t)]^a \cdot [h_{ij}(t)]^b}{\sum\limits_{l\in J_{i,k}} [t_{il}(t)]^a \cdot [h_{il}(t)]^b}, \quad if \quad j \in J_{i,k} \\ P_{ij,k}(t) = 0, \quad if \quad j \notin J_{i,k} \end{cases} \quad (1)$$

where $\tau_{ij}$ – is the amount of pheromone, $\alpha$, $\beta$ – are the parameters to control the influence of $\tau_{ij}$, $\eta_{ij}$ – is the desirability of state transition, which is inversely to distance between states:

$$\eta_{ij} = {}^{1}/_{D_{ij}},$$

where $D_{ij}$ – is the heuristic distance between states.

4. Pheromone update. Authors proposed to use the elite ants [5, 6] in this procedure. According to modified algorithm the pheromone amount is calculated per each iteration:

– for all found paths:

$$\Delta\tau_{i,j,k}(t) = \frac{1}{L_k(t)},$$

where $L_k$ – is the length of path k; i, j – arcs of the graph of path k;

– for the best found path:

$$\Delta\tau_{i,j,k}(t) = \frac{e}{L_{min}(t)},$$

where $L_{min}$ – is the shortest path distance; ***e*** – is the number of the elite ants;

– for the arcs, which aren't used in any of the found paths:

$$\Delta\tau_{i,j,k}(t) = \frac{1}{1{,}5 \cdot L_{max}(t)}.$$

5. Pheromone evaporation, which is necessary for investigation of all space of solutions. The pheromone updating rule is given by [6]:

$$\tau_{ij}(t+1) = (1-\rho)\cdot\tau_{ij}(t) + \sum_{k=1}^{m}\Delta\tau_{ij,k}(t). \quad (2)$$

where $\rho \in (0,1)$, 1-$\rho$ is persistence rate of previous pheromone, $\rho$ is defined as evaporation rate of pheromone, $m$ – the number of ants in colony.

At the beginning of optimization the pheromone amount is equal to the small positive number $\tau_0$. The authors developed an algorithm and software - based on above procedures(1) -(5) - for the optimal paths search in a case of WSN multipath routing.

## III. THE EXPERIMENTAL RESEARCH

A proper Delphi program was designed and the experimental research was conducted with the possibility of varying: the setup variables, connection radius, the number of nodes, the number of ants and iterations.

In the research with the use of elite ants for 50 iterations optimal route was found with two elite ants – 9 times, with five elite ants – 27 times, with ten elite ants – 33 times, with 15 elite ants – 48 times. At the same time, without elite ants optimal route was found only 6 times (Fig.1).

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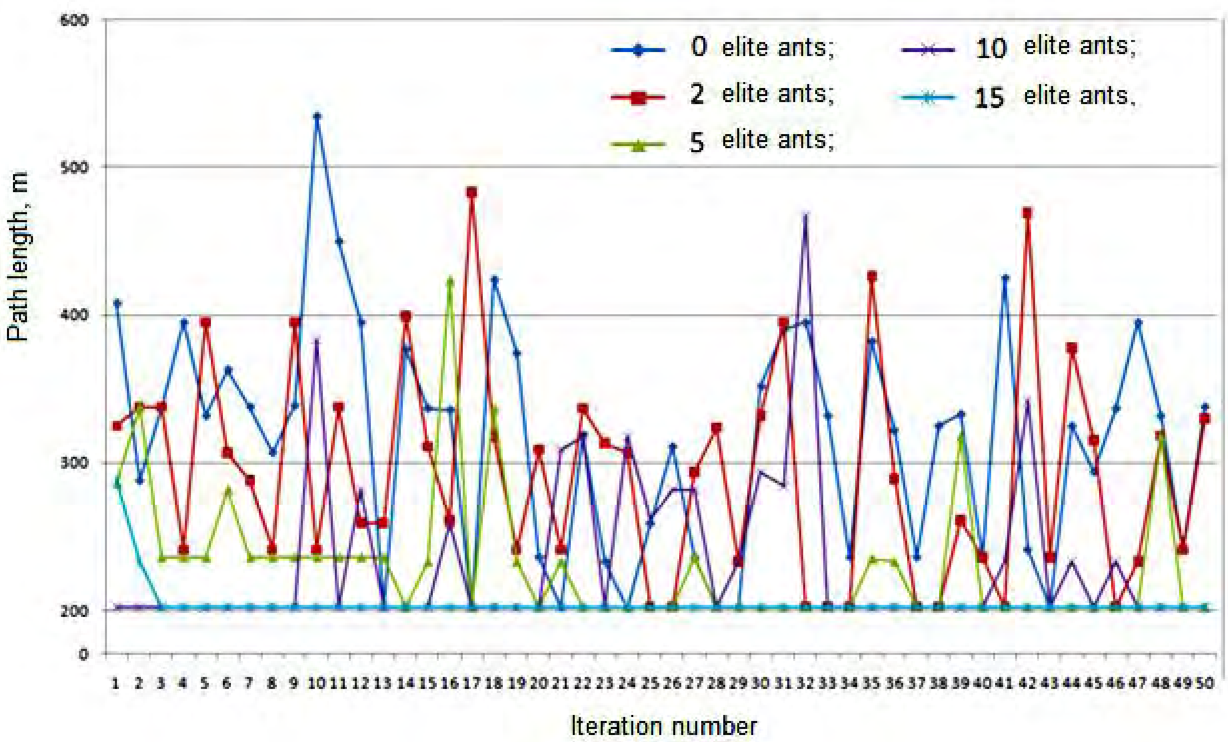


Fig.1. The dynamics of the route searching of ant colony algorithm with the the time of use of elite

In addition, the analysis of the search time of solution in the basic ant algorithm (depend on the number of ants) in comparison with the algorithm with the use of elite ants (Fig. 2) was conducted. As follows from figure 2 the time of solution search is approximately identical, but the number of proper solutions with the use of elite ants increased in 5 – 8 times (see fig.1).

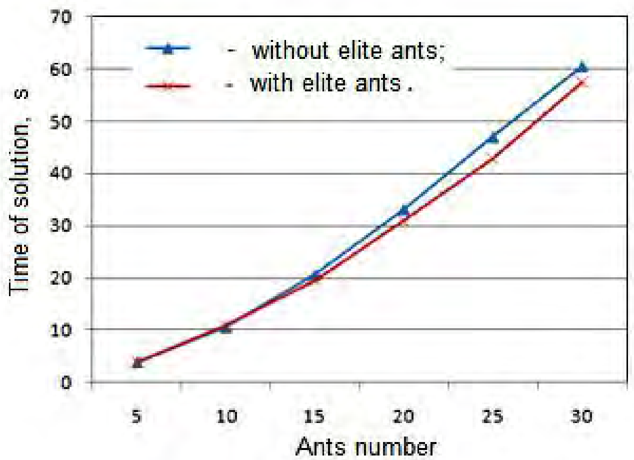


Fig.2. The dependence of the optimal route search time on the number of ants.

## IV. Conclusions

A modified ant colony algorithm and correspond software were developed to search optimal routs of data transmission in wireless sensor networks.

The results of experimental research have shown a proposed algorithm generates new solutions per each iteration, along with increasing the number of ants the generated solutions variation is reduced on average in 7 times.

Use of elite ants leads to a minor change of solution time, but the number of proper solutions is increased in 5 – 8 times.

## References

[1]. Akyildiz I.F., Su W., Sankarasubramaniam Y., Cayirci E. Wireless sensor networks: a survey. *Comput. Netw.* 2002, 38, pp.393 – 422.

[2]. Akkaya K., Younis M. A Survey on Routing Protocols for Wireless Sensor Networks, *Elsevier Ad Hoc Network Journal*, vol. 3, no.3, 2005, pp. 325-349.

[3]. Hussain S., Islam O. Genetic Algorithm for Energy Efficient Trees in Wireless Sensor Networks. *In Advanced Intelligent Environments*, Springer: Boston, MA, USA, 2008, pp. 1-14.

[4]. Su Jun. The Evaluation Criteria for Routing Methods in Wireless Sensor Networks / Su Jun //*The materials of 1 All-Ukrainian workshop of the young scientist and students "The Modern Computer Information Technologies"* (2011 May, 20-21, Ternopil). Ternopil, TNEU, 2011 – P.58-59(in Russian).

[5]. Dorigo M. Ant Colony Optimization /Dorigo M., T. Stützle //*Cambridge, MA: MIT. Press. Bradford Books.* – 2004. – 321p.

[6]. Shtovba S. D. Ant Colony Algorithms: Theory and Use / Shtovba S. D.//*Programming*. –№4. – 2005. – p.1-16 (in Russian).