ISSN 0002-306X. Proc. of the RA NAS and NPUA Ser. of tech. sc. 2024. V. LXXVII, N4

UDC 519.175 **MICROELECTRONICS**

DOI: 10.53297/0002306X-2024.v77.4-509

V.S. POGHOSYAN

LATTICE MODELS OF SELF-ORGANIZED CRITICALITY AND FULL INFORMATION DISSEMINATION SCHEMES: APPLICATIONS IN UAV SWARM SYSTEMS

This paper presents a comprehensive review of self-organized systems and gossip-based communication schemes, with a particular focus on applications in UAV swarm coordination and communication algorithms. The proposed UAV coordination strategy employs dynamics of special quasi-random walks to achieve scalable and balanced swarm behavior without centralized control. The developed tool for designing optimal communication schemes, Graph Plotter, supports verification of gossip properties and fault-tolerance. Validated by simulations, a decentralized UAV swarm system has been constructed.

Keywords: exactly solvable lattice models, non-equilibrium systems, self-organized criticality, gossip problem.

Introduction. The relevance of complex self-organizing systems and communication schemes based on lattice models of both non-equilibrium and equilibrium statistical mechanics arises from their widespread applicability in the modeling of complex dynamical processes.

Lattice models have been extensively studied in the context of statistical mechanics, including the Potts spin model, the densely packed dimer model, the totally asymmetric simple exclusion process (TASEP), the Abelian sandpile model, the O(n) loop model, the rotor-router model, and other related systems. Among the combinatorial analytical methods employed are the Bethe Ansatz approach and the enumeration of spanning trees based on generalized Kirchhoff theorem. The analytical results and proposed hypotheses have been validated through simulations using a two-dimensional frontal cellular automata algorithm and the Monte Carlo method. Uniformly distributed spanning trees were generated using Wilson's algorithm, which is based on loop-erased random walks.

The developed methods and algorithms for optimal fault-tolerant schemes of full information exchange have been adapted to construct decentralized, multi-agent, and self-organizing systems, in which potential communication failures caused by external factors are effectively neutralized. To support the design and analysis of such systems, the simulation tool Graph Plotter has been developed, enabling verification of classical gossip properties, broadcast robustness, and k-fault tolerance under various network configurations.

Unmanned aerial vehicle (UAV) swarms represent a promising frontier in autonomous systems, offering a wide range of applications in surveillance, mapping, search and rescue, and environmental monitoring. The effective coordination of such swarms demands robust mathematical models capable of capturing their inherently decentralized and dynamic behavior. The approach presented in this work is grounded in self-organized criticality (SOC) and lattice-based models, such as the Abelian sandpile and rotor-router models, which naturally embody principles of local interaction, robustness, and emergent global structure. The proposed decentralized coordination strategy for UAV swarms is based on the Eulerian properties of rotor-router model. According to this model, UAVs follow quasi-random trajectories within dynamically defined sub-areas, ensuring deterministic yet uniformly distributed coverage. The rotor-router mechanism enables self-organized swarm behavior, eliminates the need for centralized control, and supports balanced task allocation across the operational area. This coordination approach is particularly suited for scalable and resilient multi-agent systems operating in dynamic environments.

Theory of self-organized criticality: review of results. In [1], the q-state Potts spin model defined on anisotropic ladder graphs (lattices) is investigated. Assuming thermodynamic equilibrium, the representation of the partition function (probability generating function) as a sum over all subgraphs of the lattice has been studied. In particular, by using the well-known contraction-deletion property of graph edges for computation, a system of linear recurrent equations (a fixed-size transfer matrix) has been constructed. By solving this system, the exact partition function has been computed, and the Fisher zeros have been constructed in the complex plane. This result generalizes the results of the work [2].

In [3], the totally asymmetric simple exclusion process (TASEP) with a fixed number of particles and discrete time has been considered on finite rings (one-dimensional lattices with periodic boundary conditions). As an example, the backward-ordered sequential update rule has been chosen, which is invariant under parallel translation for periodic boundary conditions. It has been proven that the state update defined in this way leads to a stationary state in which all possible configurations of particles have equal probability. The generating functions of the conditional probability distributions for transitions between states over a time interval T have been calculated, along with the mean velocity of particle flow and the diffusion coefficient at all stages of the evolution. An exact and explicit expression has been obtained for the stationary velocity of TASEP on rings of arbitrary size and particle density. The evolution of small systems toward the stationary state has been clearly demonstrated. By interpreting the generating

function as the partition function of a thermodynamic system, the distribution of its zeros in the complex plane has been studied.

In [4], a generalized form of the TASEP model with particle-dependent jump probabilities is considered. Using the Bethe ansatz combinatorial approach, determinant-form expressions have been obtained for the transition probabilities between non-stationary states over a discrete time interval T. Keeping the number of particles fixed, in the continuous-time and infinite-lattice limit, this result converges to the one presented in the work [5].

In [6], the TASEP model is presented on a ring with discrete time and particle-dependent jump probabilities. The mean flow velocity per particle has been exactly calculated for different types of dynamics at all stages of the evolution, and the relaxation to the stationary state has been explicitly demonstrated. These results constitute generalizations and extensions of the findings presented in the works [7-10].

In [11], the fully packed dimer model (domino tiling) on a two-dimensional square lattice with a single empty site at the center has been analytically studied. By generalizing the spanning tree representation to a spanning webs representation, determinant expressions have been obtained for the random variables describing the mobility of dimers. In the thermodynamic limit of large lattices, these expressions are reduced to the evaluation of Toeplitz determinants and their minors. The probability that the empty site is fully jammed, as well as other characteristics of diffusion, have been exactly calculated. Their values agree with the numerical results and proposed hypotheses presented in work [12].

In [13-17], the probability distribution of height variables in the Abelian sandpile model on a two-dimensional square lattice [18,19], as well as the asymptotic expressions for their two-point correlation functions, have been analytically calculated. The obtained asymptotic expressions exhibit logarithmic behavior, as previously predicted by logarithmic conformal field theory. It has been shown that the probability distribution of site heights in the Abelian sandpile model is directly related to the probability that the trajectory of a loop-erased random walk (LERW) passes through a given neighboring vertex of the starting position (return probability). This fact has been proven through a mapping onto the local monomer-dimer model. The exact values of the listed quantities had remained at the level of conjecture for many years, despite the development of computational methods, their optimizations, high-precision numerical approximations, and numerical simulations, as reported in [20-23].

In [24], the fixed-energy sandpile model on a square lattice with conservative sites (closed boundaries) is considered, and a connection is established between its threshold density $\rho_{th}(h_0)$ and the stationary density $\rho_s = 2.125$ of the Abelian

sandpile model with open boundaries (absorbing dissipative sites). Considering the empty-field initial state ($h_0 = 0$), a slight difference ($\rho_{\{th\}}(0) = 2.125288$ ...) was observed in the works by A. Fey et al [25,26]. In [24], by generalizing the set of initial states, negative initial heights have been considered. A hypothesis was proposed that the difference $\rho_{th}(h_0) - \rho_s$ sharply tends to zero as the initial negative height increases in absolute value ($h_0 \to -\infty$). This hypothesis is proved in the mathematical work by L. Levine [27], where a formal theory is developed and a more general theorem is proved.

In [28], the correlation function of k loop-erased random walk (LERW) paths with starting and ending points grouped at two locations separated by a fixed distance r has been studied. Using combinatorial methods, an asymptotic expression containing a logarithmic factor has been obtained and compared with the corresponding quantities in other models. A connection has also been established with the corresponding conformal field theory.

In [29], exact values of boundary correlations have been obtained on the two-dimensional half-plane for the percolation model ($O(1)$ loop model) and the spanning tree model ($O(0)$ loop model).

In [30], the dense dimer covering model defined on a square lattice placed on a cylindrical surface has been studied. Using the Temperley–Lieb transfer matrix formalism, and by adapting the transfer matrix to classify arrow configurations into different classes according to the number of non-contractible loops arising from the considered topology, the partition functions (probability generating functions) have been calculated. To reveal the occurrence of Jordan cells in the transfer matrix, an extended transfer matrix has been introduced, which not only retains information about the positions of the dimers but also generates colors propagating along the branches of the associated trees.

The rotor-router model (model of multi-Eulerian walkers [31]), which represents a quasirandom walk process of a particle (or information), has been investigated. In [32], certain properties of particle behavior have been studied within a recurrent state environment without absorbing sites. In particular, the correlation between emerging dimers (cycles of length 2) and contours (cycles containing more than 2 vertices), as well as the mean value of the difference in their numbers, has been analytically calculated. The diffusion properties of the particle have also been studied on the infinite square lattice. In [33], a loop reversibility theorem has been proven for the rotor-router model. The model defined on semi-infinite cylindrical lattice is investigated in [34]. The set of labeled vertices on the lattice that generate closed loops through rotor dynamics has been examined in [35]. For these vertices, a hypothesis is proposed that the trajectory

formed by their order of appearance asymptotically takes the shape of an Archimedean spiral. We have shown that this property is directly related to the tree-like structures that describe the evolution of vertex clusters visited during the walk. In the case of the square lattice, we have obtained that the average number of visits to the origin, $\langle n_0(t)\rangle$ at time $t \gg 1$ satisfies $\langle n_0(t)\rangle = 4\langle n(t)\rangle + O(1)$, where $\langle n(t)\rangle$ is the average number of spiral turns.

A comprehensive analysis and the relations between constants obtained explicitly in uniform spanning trees are presented in [36]. The enumeration of spanning trees is employed in the investigation of Abelian sandpile, rotor-router and dimer models.

Optimal information dissemination gossip schemes: review of results. Research has been conducted on the design of network-optimal schemes for full information exchange in multiprocessor systems, as well as on the analytical derivation of formulas for the minimal values of their key characteristics (number of links, number of calls, execution time) [37-41]. To ensure the system's fault tolerance at a given level, several theorems have been proven [42,43]. In particular, the previously obtained upper bounds for the minimal number of calls in such schemes have been significantly improved. Additionally, an exact value has been obtained for the implementation time of k-fault-tolerant gossip schemes with an even number of vertices under minimal time.

A software toolkit (Graph Plotter) has been developed for the design, editing, and analysis of gossip schemes [44]. This tool allows users to verify various characteristics and properties of the constructed schemes. These include: classical gossip property, k-fault tolerance, broadcast, NOHO, NoDup, validation of broadcast schemes in three Messy models, the ability to detect disjoint paths and broadcast sub-schemes, and more.

Using a self-organization model, the well-known problem of minimizing energy consumption in computer networks has been reformulated [45-47]. For certain partial cases of this problem, new algorithms have been developed and implemented for the dynamic optimal distribution of user programs (tasks).

Applications in UAV Swarm Systems. UAV swarm movement is modeled as a multi-particle walk over the mission graph (representing the surveyed area), with the rotor-router deterministic mechanism applied [48]. Based on this approach, a coordination algorithm is designed to ensure the multi-Eulerian property, that is, each directed edge of the mission graph is visited by exactly one UAV (see Fig.). This algorithm satisfies essential self-organization requirements, including decentralized control, resilience to node failure, equitable task distribution, and verifiability of swarm membership [49-51]. Our results on gossip

schemes provide analytic guarantees for the optimality of communication, enabling secure and efficient full information exchange within the swarm, even in the presence of environmental obstacles or disruptions. UAVs exchange not only coordination data but also captured images. Further, the implemented fault-tolerant schemes dynamically adapt the swarm structure in response to UAV loss or interference [52].

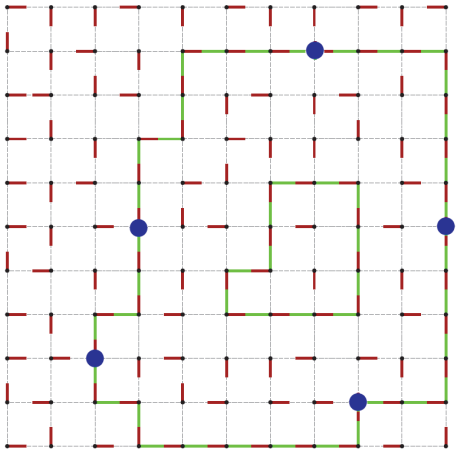

Fig. Demonstration of the multi-Eulerian property in a rotor-router-based UAV swarm on a square lattice. Each edge represents two directed edges, one in each direction. Blue dots represent UAVs navigating the graph deterministically. The external clockwise cycle, highlighted in green, is actively traversed by the UAVs. All (bidirected) edges within this cycle are eventually traversed in both directions, with each direction covered by a unique UAV. While the specific edge traversal patterns are not predetermined for individual UAVs, the system collectively ensures full directional coverage. The interior of the inner anticlockwise cycle (also highlighted in green) remains entirely unvisited, illustrating selective coverage and deterministic exclusion of certain regions

The theoretical foundation developed through spanning tree correspondences and information dissemination theorems has enabled the construction of distributed software-hardware platforms for real-time swarm management. These platforms support encrypted communication [53], navigation along obstacle-aware paths, and automated workload balancing to optimize imaging coverage and minimize mission time. The result is a highly reliable, scalable system architecture suitable for real-world deployment in mission-oriented UAV swarm applications.

Acknowledgements

This work was supported by the RA Science Committee, in the frames of the research projects 21AG-1B052 and 24DP-1B016.

REFERENCES

1. **Poghosyan V.S.** Exact partition functions and Fisher zeroes for anisotropic spin and gauge Potts models // Journal of Contemporary Physics (Armenian Academy of Sciences). - 2005. - Vol. 40, part 4. - P. 1-4.
2. **Shrock R.** Exact Potts model partition functions on ladder graphs // Physica A: Statistical Mechanics and its Applications. - 2000. - 283. - P. 388-446.
3. **Brankov J.G., Papoyan Vl.V., Poghosyan V.S. and Priezzhev V.B.** The totally asymmetric exclusion process on a ring: Exact relaxation dynamics and associated model of clustering transition // Physica A: Statistical Mechanics and its Applications. - 2006. - 368, issue 2. - P. 471-480.
4. **Poghosyan V.S. and Priezzhev V.B.** Determinant solution for the TASEP with particle-dependent hopping probabilities on a ring // Markov Processes and Related Fields. - 2008. - 14, issue 2. - P. 233-254.
5. **Rákos A., Schütz G.M.** Bethe ansatz and current distribution in the ASEP with particle-dependent hopping rates // Markov Processes and Related Fields. - 2006. - 12. - P. 323-334.
6. **Poghosyan V.S. and Priezzhev V.B.** The relaxation dynamics of the TASEP with particle-dependent hopping probabilities on a ring // Reports on Mathematical Physics. - 2008. - 61, No. 2. - P. 237-244.
7. **Evans M.R.** Phase transitions in one-dimensional nonequilibrium systems // Journal of Physics A: Mathematical and General. - 1997. - 30. - P. 5669-5685.
8. **Priezzhev V.B.** Exact Nonstationary Probabilities in the Asymmetric Exclusion Process on a Ring // Physical Review Letters. - 2003. - 91. - P. 050601.
9. **Povolotsky A.M. and Priezzhev V.B.** Determinant solution for the totally asymmetric exclusion process with parallel update // Journal of Statistical Mechanics: Theory and Experiment. - 2006. - P. P07002.
10. **Povolotsky A.M. and Mendes J.F.F.** Bethe ansatz solution of discrete time stochastic processes with fully parallel update // Journal of Statistical Physics. - 2006. - 123. - P. 125-166.
11. **Poghosyan V.S., Priezzhev V.B. and Ruelle P.** Jamming probabilities for a vacancy in the dimer model // Physical Review E. - 2008. - 77. - P. 041130.
12. Random walks, geometry, and irreversibility in square dimer tilings / **J. Bouttier, M.J. Bowick, M. Falcioni, P.Di Francesco, et al** // Physical Review E. - 2007. - 76. - P. 041140.
13. **Grigorev S.Y., Poghosyan V.S. and Priezzhev V.B.** Three-leg correlations in the two-component spanning tree on the upper half-plane // Journal of Statistical Mechanics: Theory and Experiment. - 2009. - P09008.
14. **Poghosyan V.S., Grigorev S.Y., Priezzhev V.B. and Ruelle P.** Pair correlations in sandpile model: A check of logarithmic conformal field theory // Physics Letters B. - 2008. - Vol. 659, issue 3. - P. 768-772.

15. **Poghosyan V.S., Grigorev S.Y., Priezzhev V.B. and Ruelle P.** Logarithmic two-point correlators in the Abelian sandpile model // Journal of Statistical Mechanics: Theory and Experiment. - 2010. - P07025.
16. **Poghosyan V.S. and Priezzhev V.B.** The problem of predecessors on spanning trees // Acta Polytechnica. - 2011. - Vol. 51, No. 1. - P. 59-62.
17. **Poghosyan V.S., Priezzhev V.B. and Ruelle P.** Return probability for the loop-erased random walk and mean height in the Abelian sandpile model: a proof // Journal of Statistical Mechanics: Theory and Experiment. - 2011. - P10004.
18. **Dhar D.** Self-organized critical state of sandpile automaton models // Physical Review Letters. - 1990. - Vol. 64, No. 14. - P. 1613-1616.
19. **Priezzhev V.B.** Structure of two-dimensional sandpile. I: Height probabilities // Journal of Statistical Physics. - 1994. - 74. - P. 955-979.
20. **Piroux G. and Ruelle P.** Logarithmic scaling in the Abelian sandpile model // Physics Letters B. - 2005. - 607. - P. 188-196.
21. **Jeng M., Piroux G. and Ruelle P.** Height variables in the Abelian sandpile model: Scaling fields and correlations // Journal of Statistical Mechanics: Theory and Experiment. - 2006. - P10015.
22. **Dhar D.** Theoretical studies of self-organized criticality // Physica A. - 2006. - Vol. 369, No. 1. - P. 29-70.
23. **Grassberger P. and Manna S.S.** Some more sandpiles // Journal de Physique France. - 1990. - 51. - P. 1077-1098.
24. **Poghosyan Su.S., Poghosyan V.S., Priezzhev V.B. and Ruelle P.** Numerical study of the correspondence between the dissipative and fixed energy Abelian sandpile models // Physical Review E. - 2011. - 84. - P. 066119.
25. **Fey A., Levine L. and Wilson D.B.** Critical densities in sandpile models with multiple topplings // Physical Review Letters. - 2010. - 104. - P. 145703.
26. **Fey A., Levine L. and Wilson D.B.** Approach to criticality in the Abelian sandpile model // Physical Review E. - 2010. - 82. - P. 031121.
27. **Levine L.** Threshold state and a conjecture of Poghosyan, Poghosyan, Priezzhev and Ruelle // Communications in Mathematical Physics. - 2015. - 335. - P. 1003-1017.
28. **Gorsky A., Nechaev S., Poghosyan V.S. and Priezzhev V.B.** From elongated spanning trees to vicious random walks // Nuclear Physics B. - 2013. - Vol. 870, No. 1. - P. 55-77.
29. **Poghosyan V.S. and Priezzhev V.B.** Correlations in the $n \to 0$ limit of the dense O(n) loop model // Journal of Physics A: Mathematical and Theoretical. - 2013. - 46. - P. 145002.
30. **Brankov J.G., Poghosyan V.S., Priezzhev V.B. and Ruelle P.** Transfer matrix for spanning trees, webs and colored forests // Journal of Statistical Mechanics: Theory and Experiment. - 2014. - P. P09031.
31. **Priezzhev V.B., Dhar D., Dhar A. and Krishnamurthy S.** Eulerian walkers as a model of self-organized criticality // Physical Review Letters. - 1996. - 77. - P. 5079-5082.
32. **Poghosyan V.S. and Priezzhev V.B.** Euler tours and unicycles in the rotor-router model // Journal of Statistical Mechanics: Theory and Experiment. - 2014. - P. P06003.

33. **Papoyan Vl.V., Poghosyan V.S. and Priezzhev V.B.** A loop reversibility of the rotor-router walk // Journal of Physics A: Mathematical and Theoretical. - 2015. - 48. - P. 285203.
34. **Papoyan Vl.V., Poghosyan V.S. and Priezzhev V.B.** Rotor-router walk on a semi-infinite cylinder // Journal of Statistical Mechanics: Theory and Experiment. - 2016. - P. 073209.
35. **Papoyan Vl.V., Poghosyan V.S. and Priezzhev V.B.** Spiral structures in the rotor-router walk // Journal of Statistical Mechanics: Theory and Experiment. - 2016. - P. 043207.
36. **Poghosyan V.S. and Priezzhev V.B.** Fundamental constants in the theory of two-dimensional uniform spanning trees // Theoretical and Mathematical Physics. - 2016. - Vol. 187, No. 3. - P. 952-963.
37. **Hovnanyan V.H., Poghosyan Su.S. and Poghosyan V.S.** New methods of construction of fault-tolerant gossip graphs // IEEE CSIT, Revised Selected Papers. - 2013. - Vol. 1, No. 5. - P. 23-27.
38. **Hovnanyan V.H., Poghosyan Su.S. and Poghosyan V.S.** Method of local interchange for the investigation of gossip problems // Mathematical Problems of Computer Science. - 2013. - 40. - P. 5-12.
39. **Hovnanyan V.H., Poghosyan Su.S. and Poghosyan V.S.** Method of local interchange for the investigation of gossip problems: part 2 // Mathematical Problems of Computer Science. - 2014. - 41. - P. 15–22.
40. **Hovnanyan V., Poghosyan S. and Poghosyan V.** Gossiping properties of the edge-permuted Knödel graphs // CSIT. - 2017. - P.1–4.
41. **Poghosyan S.S. and Poghosyan V.S.** Rumor spreading and invasion percolation // Mathematical Problems of Computer Science. - 2019. - 56. - P. 30–42.
42. **Hovnanyan V.H., Poghosyan S.S. and Poghosyan V.S.** Fault-tolerant gossip graphs based on wheel graphs // Mathematical Problems of Computer Science. - 2014. - 42. - P. 43–53.
43. **Hovnanyan V., Poghosyan S. and Poghosyan V.** Open problems in gossip/broadcast schemes and the possible application of the method of local interchange // CSIT. - 2015. - P.66–70.
44. **Hovnanyan V.H., Poghosyan Su.S. and Poghosyan V.S.** Graph Plotter: a software tool for the investigation of fault-tolerant gossip graphs // CSIT, Revised Selected Papers. - 2013. - Vol. 1, No. 5. - P. 20–22.
45. **Poghosyan H.R. and Poghosyan V.S.** Frontal cellular automata for the study of non-equilibrium lattice models // CSIT. - 2015. - P.44–46.
46. **Nahapetyan H.E., Poghosyan Su.S. and Poghosyan V.S.** The investigation of models of self-organized systems by parallel programming methods based on the example of an Abelian sandpile model // CSIT. - 2013. - P. 260–262.
47. **Nahapetyan H.E., Poghosyan S.S., Poghosyan V.S. and Shoukourian Y.H.** The parallel simulation method for d-dimensional Abelian sandpile automata // Mathematical Problems of Computer Science. - 2016. - 46. - P. 117–125.

48. Cloud-based mathematical models for self-organizing swarms of UAVs: design and analysis / **S. Poghosyan, V. Poghosyan, S. Abrahamyan, A. Lazyan, et al** // Drone Systems and Applications. - 2024. - 12. - P.1–12.
49. Self-organizing multi-user UAV swarm simulation platform / **V. Poghosyan, S. Poghosyan, A. Lazyan, A. Atashyan, et al** // Programming and Computer Software. - 2023. - 49(S1). - P.S7–S15.
50. Mission preparation for self-organizing UAV swarms on multiuser platform / **A. Atashyan, A. Lazyan, D. Hayrapetyan, H. Astsatryan, et al** // Programming and Computer Software. - 2024. - 50(S1). - P. S39–S46.
51. **S. Poghosyan, Y. Alaverdyan, V. Poghosyan, A. Lazyan, et al.** Algorithms for operating self-organizing swarms of UAVs implementing full exchange of information // AIP Conference Proceedings. - 2023. - Vol. 2757, No. 1. - P. 070003.
52. Certain methods for investigating epidemics and preventing the spread of viruses in self-organizing systems / **S. Poghosyan, Y. Alaverdyan, V. Poghosyan, S. Abrahamyan, et al** // AIP Conference Proceedings. - 2023. - Vol. 2757, No. 1. - P. 070002.
53. **Alaverdyan Y., Poghosyan S. and Poghosyan V.** Confidential computing in edge-cloud hierarchy // International Journal of Computer Science & Information Technology. - 2023. - 15(3). - P.21.

Insitute for Informatics and Automation Problems NAS RA. The material as is received on 01.06.2025.

Վ.Ս. ՊՈՂՈՍՅԱՆ

ԻՆՔՆԱԿԱԶՄԱԿԵՐՊՎԱԾ ԿՐԻՏԻԿԱԿԱՆՈՒԹՅԱՆ ՑԱՆՑԱՅԻՆ ՄՈԴԵԼՆԵՐ ՈՒ ԼՐԻՎ ԻՆՖՈՐՄԱՑԻԱՅԻ ՏԱՐԱԾՄԱՆ ՍԽԵՄԱՆԵՐ՝ ԿԻՐԱՌՈՒՄՆԵՐ ԱԹՍ-ՆԵՐԻ ԵՐԱՄԻ ՀԱՄԱԿԱՐԳԵՐՈՒՄ

Ներկայացված է ինքնակազմակերպված համակարգերի և GOSSIP հիմքով հաղորդակցման օպտիմալ սխեմաների համապարփակ ակնարկ՝ հատուկ ուշադրություն դարձնելով դրանց կիրառություններին ԱԹՍ-ների երամի համակարգման և հաղորդակցման ալգորիթմների մեջ: ԱԹՍ-ների համակարգման առաջարկվող ռազմավարությունը հիմնված է հատուկ քվազի-պատահական դեգերման դինամիկայի վրա՝ առանց կենտրոնացված կառավարմամբ երամի մասշտաբավորվող և հավասարակշռված վարքն ապահովելու համար: Հաղորդակցման օպտիմալ սխեմաների նախագծման համար ստեղծվել է Graph Plotter գործիքը, որը հնարավորություն է տալիս ստուգելու gossip հատկությունները և վթարակայունությունը: Սիմուլյացիաներով հաստատված ԱԹՍ-ների երամի ապակենտրոն համակարգը նախագծվել և կառուցվել է:

Առանցքային բառեր. ճշգրիտ լուծվող ցանցային մոդելներ, ոչ հավասարակշիռ համակարգեր, ինքնակազմակերպված կրիտիկականություն, GOSSIP խնդիր:

В.С. ПОГОСЯН

РЕШЕТОЧНЫЕ МОДЕЛИ САМООРГАНИЗУЮЩЕЙСЯ КРИТИЧНОСТИ И СХЕМЫ ПОЛНОГО РАСПРОСТРАНЕНИЯ ИНФОРМАЦИИ: ПРИМЕНЕНИЕ В СИСТЕМАХ РОЯ БЕСПИЛОТНЫХ ЛЕТАТЕЛЬНЫХ АППАРАТОВ

Представлен всесторонний обзор самоорганизованных систем и коммуникационных схем на основе gossip-моделей с особым вниманием к их применению в координации и алгоритмах связи роя беспилотных летательных аппаратов (БПЛА). Предлагаемая стратегия координации БПЛА основана на динамике специальных квазислучайных блужданий, что позволяет достичь масштабируемого и сбалансированного поведения роя без централизованного управления. Разработанный инструмент Graph Plotter предназначен для построения оптимальных коммуникационных схем и поддерживает проверку свойств gossip и устойчивости к отказам. На основе моделирования была сконструирована система децентрализованного роя БПЛА.

Ключевые слова: точно решаемые решеточные модели, неравновесные системы, самоорганизующаяся критичность, задача gossip.