



The 7th International Conference on Emerging Ubiquitous Systems and Pervasive Networks
(EUSPN 2016)

Novel Optimized Routing Scheme for VANETs

Samira Harrabi^{a*}, Ines Ben Jaffar^b, and Khaled Ghedira^c

^aENSI University of Manouba, Campus universitaire de Manouba 2010, Manouba, Tunisia

^bHigher School of commerce (ESC), University of Mannouba, Mannouba, Tunisia

^cHigher institute of management of Tunis (ISG), University of Tunis, Tunisia

Abstract

The Vehicular ad-hoc networks (VANETs) are a specific type of Mobile ad-hoc networks (MANETs). However, the main problem related to it is the potential high speed of moving vehicles. This special property causes frequent changing in network topology and instability of communication routes. Consequently, some of the challenges that researchers focus on are routing protocols for VANETs. They have proved that the existing MANET proactive routing protocols are the most used for vehicular communication. Yet, they are not as adequate as they are for VANETs. The main problem with these protocols in dynamic environment is their route instability. This paper combines multi-agent system approach and PSO algorithm to solve the above mentioned problems. We carried out a set of simulations tests to evaluate the performance of our scheme. The simulation part shows promising results regarding the adoption of the proposed scheme.

© 2016 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Peer-review under responsibility of the Program Chairs

Keywords: VANET; MAS; PSO; proactive protocol ;

1. Introduction

The main aim of Intelligent Transport System is to provide security and safety for drivers^[1]. VANET is becoming the most appropriate technology in order to achieve this goal. Each vehicle can communicate with others

* Corresponding author. Tel.: +216-22-671-283.
E-mail address: samira.harrabi@gmail.com.

(vehicle-to-vehicle, V2V) to exchange an alert message, traffic jam, etc, or with roadside access points (vehicle-to-infrastructure, V2I) to access internet, etc. Fig. 1 shows an example of VANETs environment.

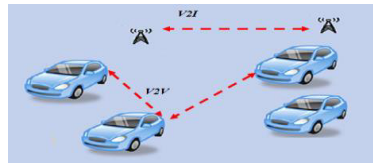


Fig. 1. Architectures of VANET.

Unlike, other types of ad hoc networks, the vehicle is moving with high speed value [2]. This network feature makes the topology very dynamic and increases the probability of communication links failure. Therefore, designing an efficient routing protocol for VANETs is a major challenge. In VANET, the routing protocols are classified into various categories [3]: position based routing protocols, topology based routing protocols and cluster based routing protocols. In position methods [4], each node maintains its geographical coordinates as well as its neighbor's positions using GPS service. It doesn't share any routing information with neighbor nodes or keep any routing table. In order to take a decision, the data from GPS device is used. The pros of position based protocols are that route discovery phase which is not needed. Consequently, it is also appropriate for high speed node. However, this category has needs of position determining services.

Topology based routing protocols are based on exchanging information state about the link in order to deliver the data packets from source node to destination [5]. It can be classified into classes. The first one is reactive protocols that are called also on demand routing approaches [6]. The route is discovered when a node seeks to send a data. The major highlight of this type is that updating routing table that is not needed. Nevertheless, flooding mechanism generates a large volume of overhead [7].

The second category is proactive approaches [8] which is called also table driven based schemes because information about all connected nodes is kept in routing tables. These tables are exchanged between neighbors' nodes. Once topology network is changed, each node updates its table. Since discovery route step is not required, proactive methods are judged as the most suitable category for real time applications with the lowest latency. However, many unused paths are generated which can take up an important part of the limited bandwidth.

In Cluster-based routing protocols [9] the network is divided in different groups (clusters). Everyone has a single manager or cluster-head. It is responsible for managing its cluster members (intra cluster) and its neighbor's clusters (inter-cluster). While the intra-cluster communication is established using direct links, the inter-cluster is performed on the basis of cluster headers links. This kind of protocols is the most important to provide stability of communication link. However, creation of clusters as well as the selection of the cluster-head is a big issue in VANET. The performance of a cluster based approach is too related to the selection manner of the manager node.

Several comparative studies [10], [11], [12] are demonstrated that topology based protocols are the most used category, particularly, the proactive methods which have the superiority of lower delay [13]. However, these protocols are not suitable as they are in vehicular communication. The main problem with these protocols is that the control packets are flooded among every node to discover and keep a link path. Consequently, some of routes are never used. In order to overcome the mentioned shortcoming, many papers [14], [17], [18], [20] deal with improving proactive routing protocols to make them suitable for VANET. However, all these works do not use agent technology to benefit from the agent properties such as learning, cooperation and autonomy. Assigning all these properties to the vehicle may improve routing in VANET. In addition, the related works do not use the clustering method to provide stability of discovered routes.

The remainder of the paper is structured as follows. Section 2 discusses the related works done on enhancing proactive protocols to make them suitable for VANET. Section 3 introduces the proposed approach. Section 4 describes the simulation results. Section 5 concludes the paper and presents the future work.

2. Enhanced Proactive Protocols For VANET

To overcome the mentioned shortcoming of proactive protocols in vehicular scenarios, a lot of studies have been

focused on enhancing this category to make them suitable for VANET. In ^[14], the authors integrated the concept of MOPR^[15] in the proactive routing protocol Optimized Link State Routing (OLSR) ^[16] to predict the next position of the vehicle in order to avoid link failure. However, we think that a prediction approach cannot be the optimal method to ensure the stability of link in dynamic environment. In ^[17], another improved version of OLSR is proposed and it is named FR-OLSR. The authors improved the performance of OLSR by minimizing the uncertainty in the routing information. Simulation part demonstrated a good behaviour in terms of packet delivery and delay. However, stability route is not considered. In ^[18], the authors enhanced DSDV proactive protocol ^[19]. The main idea in this paper is to reduce the update period in order to make the routing table more refresh. But, the authors did not take into account the problem of link failure and its consequences in vehicular communication.

In ^[20], another enhanced version of DSDV is presented by us. We have proposed an improved DSDV protocol based on multi-agent system (MAS). The new version is called MA-DSDV. We have shown that using agent technology can effectively improve routing performance in terms of transmission delay, control packets and dropped packets compared to the traditional DSDV. However, the problem of finding the most stable route is not studied which can justify the huge rate of dropped packets with increasing of number of nodes. Hence, this paper is based on the aforementioned highlights of clustering technique to provide the stability of communication link and on PSO ^[21] algorithm to optimize cluster-head selection phase.

3. Optimal Clustering Method

The movement manner of vehicles on communication environment has an impact on the performance of routing protocols as well as on stability of links. The distribution of vehicles can be characterized by certain factors as the speed value, the number of neighbors of vehicles as well as the distance between them. As a result, providing a stable link and a high connectivity is correlated with these factors.

In our previous work ^[20], each vehicle is acted as an agent. Consequently, every vehicle is able to learn its surrounding environment and take a decision autonomously in case of link failure. However, as it is illustrated in Fig. 2, path is built either in case that some environment has a low density of agents with high speed value and a far distance to its neighbors. As a result, the performance of links is degraded that can justify the huge value of dropped packet rate.

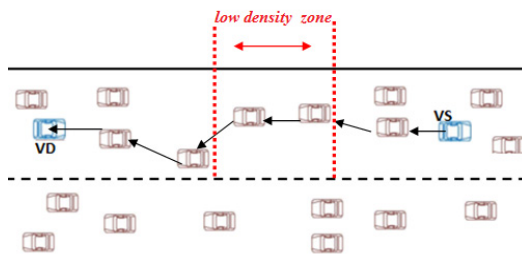


Fig.2. Drawbacks of MA-DSDV.

On the contrary, if in MA-DSDV, the data is forwarded over set of clusters (Fig. 3) that have the optimal cluster-head; it can ensure a good connectivity and stability of links. However, one of the main challenges of clustering in VANET is how to select a cluster head. Therefore, PSO algorithm is applied.

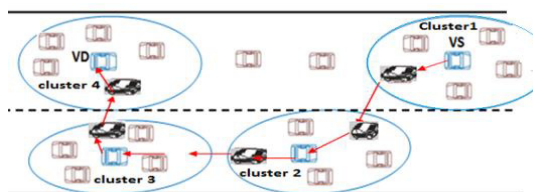


Fig.3. Proposed forwarding data scheme.

Hence, we consider three features in selecting a cluster head. First, the cluster head must have the minimum average distance to its cluster members. Second, the velocity required value must be the closest to the average speed. Finally, the vehicle that can be act as a cluster head must have the maximum value of neighboring vehicles number. On the basis of the above parameters, we define a fitness function F as follows:

$$F = \text{Minimize} \left(\sum_{it=1}^{Nit} \left[W1 \cdot D_{Vi,Vj} + W2 \cdot |Avg_{Vi} - S_{Vi}| + W3 \cdot N_{Neigh_{Vi}} \right] \right) \quad (1)$$

Where:

S_{Vi} is the speed value of vehicle Vi ; N_{neigh} is the number of the neighbors of vehicle Vi ; Nit is the maximum number of iterations; it is the iteration that ranges from 1 to Nit ; $w1$, $w2$, and $w3$ are random constants supplied to the algorithm; $DE_{Vi,Vj}$ is the Euclidean distance between two vehicles (Vi and Vj) communicating with each other at an instant of time. It is defined by:

$$D_{Vi,Vj} = \sqrt{(x_{Vi} - x_{Vj})^2 + (y_{Vi} - y_{Vj})^2} \quad (2)$$

Avg_{Vi} is the average speed of vehicle Vi . It is calculated as follow

$$Avg_{Vi} = \frac{1}{Neigh_{Vi}} \sum_{k=1}^{Neigh_{Vi}} S_{Vi}; Vi \in [1, N] \quad (3)$$

3.1 PSO Optimization Algorithm

The PSO is developed by Kennedy et al., inspired by social behaviour of Ants, bird flocking^[21]. In PSO, a set of particles forms a swarm. Every particle is defined by position and velocity. While the position defines a candidate solution to the problem space, the velocity is utilized to move the particle from position to another. The velocity and the position are represented respectively by (4 and 5):

$$Vi(t+1) = w \cdot Vi(t) + c1 \cdot r1 [pi(t) - xi(t)] + c2 \cdot r2 [pg(t) - xi(t)] \quad (4)$$

$$Xi(t+1) = Vi(t+1) + Xi(t) \quad (5)$$

Where w , $c1$, and $c2$ are known as acceleration coefficients; $r1$, $r2$ are a random values between 0 and 1 at an instant (t); i represents a particle; $pi(t)$ and $pg(t)$ are respectively the personal best fitness value of particle i at time (t) and the global best fitness value among all particles. The position corresponding to the best value is known as $Xpbest$ and the best value among the entire solution is represented by $Xgbest$.

3.2 Cluster Formation Process

To form a cluster, we have to select an appropriate cluster head. In this step, the PSO algorithm is used to choose which vehicle is the most suitable to act as a cluster manager. When the PSO algorithm starts, every particle is arbitrarily initialized with its position and velocity vector. To calculate its fitness value, each particle uses fitness function F . Then, it updates the personal and global best fitness values. Once each particle has evaluated its individual fitness, (5) and (6) are used to update the velocity vector and position. The searching for a best solution is repeated until reached the maximum iterations number. When the cluster head has been selected, it broadcasts a join message to request non-clustered vehicle within cluster transmission range to join it. The join request contains the cluster head ID and the cluster ID. When the non-clustered agent receives the invitation message, it has the ability to take a decision autonomously either to be a member or not to be. In both cases, it must broadcast a decision message.

Once the agent transmits a message to join the cluster head, it becomes a cluster member and it knows on which cluster it belongs to. To manage the inter clusters communication function, each cluster head will look for the farthest member using (2). The cluster head broadcasts a search message to find the farthest one. The agent with the maximum distance will be selected as a gateway. Since the vehicle acts as an agent, there is no need to re-clustering the phase in order to repair the clusters when a cluster-head leaves it.

4. Performance Evaluation and Results

In this section, based on JADE Platform^[22] and MATLAB^[23] tool, we evaluate the performance of both approaches described in the previous section. Then, we present the performance results of our proposed method against MA-DSDV protocol. The parameters of the simulated network are briefly shown in Table 1 and the PSO parameters are shown in Table 2.

Table 1. Simulation parameters.

Parameters	Values
Simulation time	50s
Transmission rate	54Mbps
Simulation area	1300x700m ²
Examined protocols	MA-DSDV, PSO-C-MADSDV
Transmission range	150m

Table 2. PSO parameters.

Parameters	Values
Population size (n)	50
Number of iterations (K)	30
c1,c2	2
r1,r2	0.5
w	0.9

To measure the performance of our proposed method, we have considered two scenarios. In the first one, we study the impact of growing in network size (up to 50 vehicles) on the performance of the proposed approach. However, the second case deals with the influence of the increase in the speed value (up to 60 m/s) on the evaluated results of PSO -C MA-DSDV as well as MA-DSDV. The proposed scheme is evaluated according to the following metrics: rate of dropped packet, average of routing overhead and throughput.

4.1. The First Scenario

In this section, we present the simulation results measured with number of vehicles at [10, 50] interval and the movement speed is held constant at 30 m/s.

- **Comparison of Throughput:** Fig. 4 presents the performance of the MADSDV and the improved version PSO-C-MADSDV protocols in terms of throughput parameter. It shows that PSO-C-MADSDV outperforms MA-DSDV with increasing in the number of vehicles. According to the Fig. 4, the throughput value of PSO-C-MADSDV is more elevated than the basis version. It means that the majority of data packets sent to the destination has been arrived successfully.

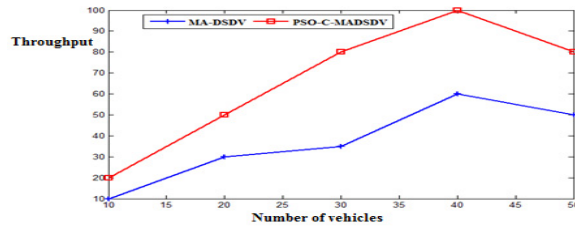


Fig. 4. The throughput vs. number of vehicles.

- Comparison of Rate of dropped packets:** According to Fig.5, it can be seen that at [10, 35] interval there is an ignorable difference between both protocols in term of average of dropped packets. However, as the number of vehicles increases our method performs better than MA-DSDV. Indeed, the rate of dropped packets value of MA-DSDV increases from 20% at 45 vehicles to 30% at 50 vehicles. However, PSO-C-MA-DSDV maintains its good behavior from 15% at 45 vehicles to 18% at 50 vehicles.

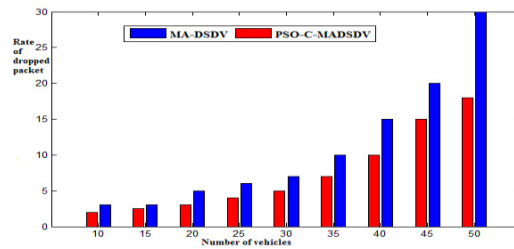


Fig. 5. The rate of dropped packet vs. number of the vehicles .

- Comparison of Overhead:** In this Fig. 6, PSO -C -MADSDV outperforms MA-DSDV in terms of the average of routing overhead. That is because in the improved version, the concept of forwarding the data over a set of vehicles (cluster) reduces the routing overhead compared to MADSDV approach.

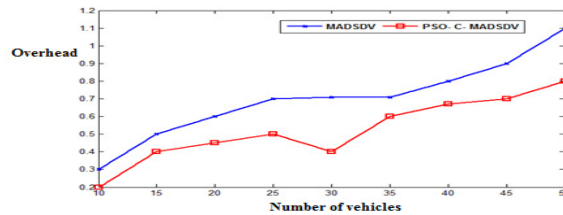


Fig. 6. The overhead vs. number of the vehicles.

4.2 The Second Scenario

In this scenario, the movement speed of the vehicles is varied from 0m/s to 60m/s in steps of 10m/s with fixed number of vehicles of 40 nodes.

- Comparison of Throughput:** As expected from Fig. 7, throughput of both protocols increases with nodes speed at [0, 20] m/s. However, where the mobility value elevates from 30 m/s to 60m/s, the results depict more efficient behaviour of PSO –C- MA-DSDV in comparison with MA-DSDV. Consequently, the improved version is less affected by the increase in the speed value compared to the MA-DSDV method.

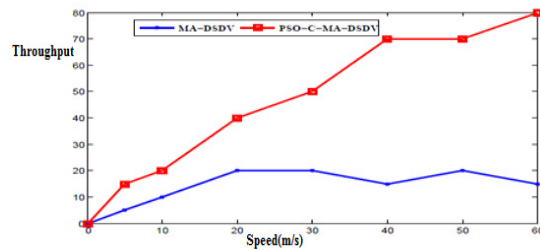


Fig. 7. The throughput vs. speed value.

- Comparison of Rate of dropped packets:** The Fig. 8 shows that both protocols have an efficient behaviour when speed value is at [5, 30]. However, Fig. 8 demonstrates that PSO -C MA-DSDV is less affected with the increasing mobility value than MA-DSDV. That is because clustering structure provides a stable link which is based on an optimal cluster head.

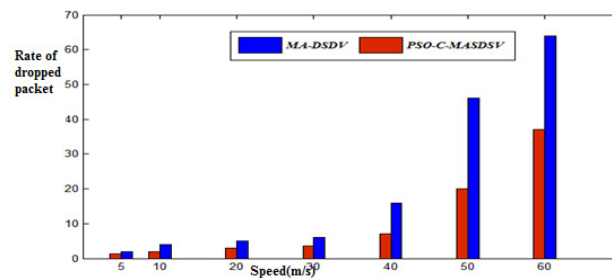


Fig. 8. The rate of dropped packets vs. speed value.

- Comparison of Overhead:** The Fig. 9 shows that the routing overhead of PSO-C MADSDV is less affected by increasing of the speed value compared to MA-DSDV. However, in MA-DSDV the overhead rate increases to reach 2.7% when the speed value is 60 m/s.

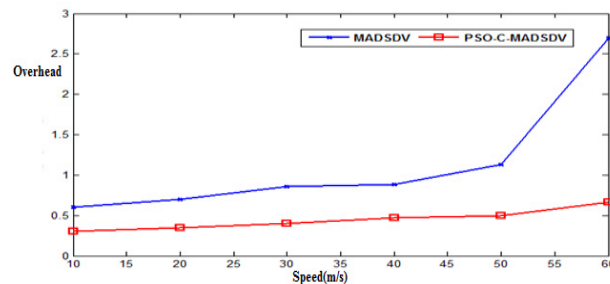


Fig. 9. The overhead vs. speed value.

5. Conclusion

In this paper, we have proposed a novel forwarding method to improve managing distributions of vehicles in VANETs environment. The data is forwarded over a set of groups with an optimal Cluster Head which is selected using PSO optimization algorithm. Vehicles density, speed value and distance between neighbors are used to form a cluster. Consequently, the stability of links is provided. This effectively reduces the average number of dropped packets and decreases the unused paths number. Thus, the throughput is improved as well as the average of routing overhead.

As a future work, we envision adding the vehicle direction to form the clusters and study the number of formed groups.

References

1. Saleh Yousefi, Mahmoud Siadat Mousavi, and Mahmood Fathy, "Vehicular Ad Hoc Networks (VANETs): Challenges and Perspectives", 6th International Conference on ITS Telecommunications Proceedings, 2006, Pp 761-766.
2. M. Torrent-Moreno, M. Killat, and H. Hartenstein, "The challenges of robust inter-vehicle communications," in Proceedings of the IEEE Vehicular Technology Conference – Fall (VTC), vol. 1, 2005, pp. 319– 323.
3. Fan Li and Yu Wang, Routing in Vehicular Ad Hoc Networks: A Survey, IEEE Vehicular Technology Magazine, June 2007, pp. 12-22.
4. Ryu, M. W., Jha, S. H., Koh, J. G., and Cho, K. H., "Position-based routing algorithm improving reliability of inter-vehicle communication," Transaction on Internet and Information Systems (THIS), August 2011.
5. M., and Mahgoub, I., "A Survey of Vehicular Ad-hoc Networks Routing Protocols", International Journal of Innovation and Applied Studies, Vol.3, 2013, pp.829-846.
6. Saurabh Chauhan, Shashi Bhushan Tyagi, "Performance Evaluation Of Reactive Routing Protocols In VANET," International Journal of Innovations and Advancement in Computer Science, Vol. 3, Issue 9, November 2014, pp. 189-193.
7. Naserian, M. Tepe, K.E., "Routing overhead analysis for reactive routing protocols in wireless ad hoc networks," Wireless And Mobile Computing, Networking And Communications(WiMob'2005), 2005, IEEE International Conference on (Vol.3), 22-24 Aug. 2005, pp. 87 – 92, DOI:10.1109/WIMOB.2005.1512889.
8. Rakesh Kumar, Mayank Dave, " A Comparative Study of Various Routing Protocols in VANET," IJCSI International Journal of Computer Science Issues, Vol. 8, No. 1, Issue 4, July 2011, Pp. 643-648.
9. Yuyi Luo, Wei Zhang, Yangqing Hu, "A New Cluster Based Routing Protocol for VANET", IEEE Wireless Communications and Trusted Computing, 2010.
10. Shilpi Dhankhar, Shilpy Agrawal, " VANETs: A Survey on Routing Protocols and Issues," International Journal of Innovative Research in Science, Engineering and Technology, Vol. 3, Issue 6, June 2014, pp 13427- 13435.
11. Jagadeesh Kakarla, S Siva Sathya, B Govinda Laxmi, Ramesh Babu, "A Survey on Routing Protocols and its Issues in VANET," International Journal of Computer Applications, Vol. 28, No.4, August 2011, pp. 38-40.
12. Ahmed Shoeb Al Hasan, Md. Hasan Tareque, and Fatema Tuz Zohra, "Comparison among Different Routing Protocols of Vehicular Ad Hoc Networks," Global Journal of Computer Science and Technology Network, Web & Security Vol. 13, Issue 1, 2013, Online ISSN: 0975-4172 & Print ISSN: 0975-4350.
13. Sheetal Negi, Sudesh Rani, "Comparative Study of Topology based Routing Protocols in VANET," IRACST - International Journal of Computer Science and Information Technology & Security (IJSITS), ISSN: 2249-9555, Vol. 5, No3, June 2015, pp. 290-294.
14. Hamid Menouar, Massimiliano Lenardi, and Fethi Filali, "Improving Proactive Routing in VANETs with the MOPR Movement Prediction Framework", 7th International Conference on ITS Telecommunications, 2007, Sophia Antipolis, 6-8 June 2007, pp. 1 – 6, DOI: 10.1109/ITST.2007.4295909.
15. H. Menouar, M. Lenardi, and F. Filali, "A Movement Prediction based Routing Protocol for Vehicle-to-Vehicle Communications," 1st International Vehicle-to-Vehicle Communications Workshop (V2VCOM 2005), co-located with MobiQuitous 2005, San Diego, California, U.S.A, July 2005.
16. T.H. Clausen, G. Hansen, L. Christensen and G. Behrmann, "The Optimized Link State Routing Protocol, Evaluation through Experiments and Simulation," IEEE Symposium on Wireless Personal Mobile Communications, September 2001.
17. M.Gunasekar and S.J.Hinduja. "Automatic Tuning Of OLSR Routing Protocol Using IWD in VANET", International Journal of Innovative Research in Computer and Communication Engineering, Vol. 2, Special Issue 1, March 2014.
18. Xin Yang, Zhili Sun, Ye Miao, Ning Wang, Shaoli Kang, Yingmin Wang, and Yu Yang, "Performance Optimisation for DSDV in VANETs," 17th UKSIM-AMSS International Conference on Modelling and Simulation, 2015, pp. 514-519, DOI :10.1109/UKSim.2015.29.
19. Charles E. Perkins, and Pravin Bhagwat, "Highly Dynamic Destination-Sequenced Distance-Vector Routing (DSDV) for Mobile Computers", Proceedings of the conference on Communications architectures, protocols and applications (SIGCOMM, 1994), 1994.
20. S. Harrabi, W. Chainbi, K. Ghédira, "A multi-agent proactive routing protocol for Vehicular Ad-Hoc Networks". Proc.of The 2014 International Symposium on Networks, Computers and Communications (ISNCC 2014), Hammamet- Tunisia, 17-19 June 2014. <http://dx.doi.org/10.1109/SNCC.2014.6866523>.
21. Kennedy, J., R. C. Eberhart, " Particle Swarm Optimization," In: Proc. of IEEE International Conference on Neural Networks, 1995, pp. 1942-1948.
22. Fabio Bellifemine, Agostino Poggi, and Giovanni Rimassa, "Developing multi-agent systems with a FIPA-compliant agent framework," Software - Practice and experience, Vol. 31, Issue 2, February 2001, Pp. 103 - 128.
23. MATLAB, URL: <http://www.mathworks.com/products/matlab/> [accessed: 2016-07-14].