ПРОГРЕСИВНІ ІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ

PROGRESSIVE INFORMATION TECHNOLOGIES

ПРОГРЕССИВНЫЕ ИНФОРМАЦИОННЫЕ ТЕХНОЛОГИИ

UDC 621.396.93:004.032.26

THE CLOUD GNSS DATA FUSION APPROACH BASED ON THE MULTI-AGENT AUTHENTICATION PROTOCOLS' ANALYSIS IN THE CORPORATE LOGISTICS MANAGEMENT SYSTEMS

Burlachenko I. S. – Senior Lecturer of the Department of Computer Engineering, Petro Mohyla Black Sea National University, Mykolaiv, Ukraine.

Savinov V. Yu. – PhD, Associate Professor of the Department of Computer Engineering, Petro Mohyla Black Sea National University, Mykolaiv, Ukraine.

Tohoiev O. R. – Postgraduate Student of the Department of Computer Engineering, Petro Mohyla Black Sea National University, Mykolaiv, Ukraine.

Zhuravska I. M. – Dr. Sc., Professor, Professor of the Department of Computer Engineering, Petro Mohyla Black Sea National University, Mykolaiv, Ukraine.

ABSTRACT

Context. Modern corporate logistics management systems or tracking systems consist of wireless positioning systems. Typically, mobile technologies use signal receivers of satellites of GNSS. However, there is the general problem of data transmitting issues to analytic centers for further in the corporate logistics management systems. The object of the study was to develop the solutions alternative to GNSS.

Objective. The goal of the work is the increasing vehicle location access control accuracy, based on the multi-agent authentication protocols' analysis.

Method. The study proposes the cloud data fusion platform offers to collect and archive data about all movable objects that can be on the road between departments inside the same warehouse area. Since there are operations with different wireless base stations' participation, so, the movable object can don't enough time for a movement trajectory analysis in real-time. Thus, data processing must fulfill in the cloud dispatching center and data flow fusion is needed. An equations system that identifies the vehicles' location based on the method of multi-agent authentication process analysis after the GPS signal loss, was proposed. The multi-sectional configuration of the recursive neural network and the usage of cloud data fusion made it possible to increase the accuracy of vehicle location determination.

Results. The developed method has been implemented in software and investigated for solving the problems of vehicle location control accuracy in the corporate logistics management systems.

Conclusions. The conducted experiments have confirmed the proposed approach and allow recommending it for use in practice for solving the problems of improving the efficiency of vehicle location determination via the role-based access control integrated with multi-agent authentication service.

KEYWORDS: cloud technologies, data fusion, multi-agent analysis, authentication protocol, recursive neural network, management system, corporate logistics.

ABBREVIATIONS

AP is an access point;
API is an application programming interface;
AT is an access token;
BS is a base station;
CDN is a content delivery network;
CP is a control point;
DF is a data fusion;
GNSS is a global navigation satellite system;
GPU is a graphics processing unit;
GRU is a gated recurrent unit;
LSTM is a long short-term memory;
MAAS is a multi-agent authentication service;
MS is a mobile station;

DOI 10.15588/1607-3274-2021-4-9

NS is a navigation system;
NSA is a navigation system antenna;
RBAC is a role-based access control;
RNN is a recursive neural network;
RO is a resource owner;
RTLS is a real-time locating system;
SSO is a single sign-on;
URI is a uniform resource identifier;
UA is a user-agent.

NOMENCLATURE

A_{AT}^{RO} is a set of MAAS agents for serving a protected resource to which the RO has access using ATs;

A_{AT}^{AS} is a set of MAAS agents that verify the validity of the authorization grant, and then sends the AT to other agents;

A_{AT}^{RS} is a set of MAAS agents that provide access to the protected resource to other agents if AT is validated;

A_{RT}^{AS} is a set of MAAS agents that verify the authorization grant is correct and returns the requested refresh token to the agent;

A_{UA}^{RS} is a set of MAAS agents that redirect the RO using the UA to the authentication interface of the authorization server;

C_A is an authorization code;

CH_{cmpr}^{TL} is a tasks' log compressed at the vehicle host's storage;

$DF_{p(\ell n,\ell t)}^{GPS}$ is a qualitative characteristic of the DF at the vehicle's position;

dt is a time offset between the MS and CP;

G_{AU} is an authorization grant;

IT_E is an access error;

$k_i \mid i = 1\ldots N$ are priority coefficients that are configured according to the vehicles' tasks;

KP_{cur}^{A} are key points that planned on the tasks' route;

$p(ln, lt)$ is a vehicle's position during the task completion;

PC_{RO} are credentials;

P_R is a problem range;

R_{AU} is a request to access the required resource;

R_{pld} is a number of a successful request for data;

Rx is a distance from the satellite to NSA;

rx is a distance from BS to NSA;

T_A is an access token;

T_{AC} is an access token with a long time to live;

T_R is a refresh token;

T_r is a task route;

Tx is a time of signal arrival on the MS;

tx is a time of signal arrival on the CP;

v is a value of the speed of radio waves.

INTRODUCTION

Modern corporate logistics management systems or tracking monitoring systems consist of wireless positioning systems. Typically, mobile technologies include signal receivers of global satellites of GNSS. Technical complexity aims to improve GNSS technology were investigated. However, it is the general source of data transmitting issues. The developments with the main goal of GNSS alternative solutions have been reviewed. Thus, the cloud data fusion platform offers to collect and archive data potential techniques from all movable objects that can be on the road and ongoing processing in the cloud dispatching center. There are operations with several times performance and different base stations' participation. The movable object does not have time for a considerable distance movement between departments inside the same warehouse area, so data flow fusion real-time performance is needed.

To automate the determination of mobile object location in the corporate logistics management systems, it is necessary to have an analytic approach of a decision this task after the GPS signal loss.

The object of study is the process of determination of mobile object location building by the solutions alternative to GNSS.

The subject of study is the methods based on the multi-agent authentication protocols' analysis.

The purpose of the work is to increase the vehicle location access control accuracy.

1 PROBLEM STATEMENT

The problem of each company, which manages a large number of vehicles, is to ensure the rhythm of transportation. Besides, goods must be delivered to the destination at the specified time. To make the dispatching management effective, it is necessary to obtain promptly the coordinates (x, y) on the whereabouts of a particular vehicle at any time and, if necessary, to correct T_r. Modern traffic control systems that use satellite-based coordinates can allow quick track of vehicles' movement information, such as forklifts, even without the intervention of drivers. While, the Rx, rx, dt, Tx, tx, v are known.

The problem is the low quality of GPS signal during the management of the barge's construction in the shipyard shown in Figure 1.

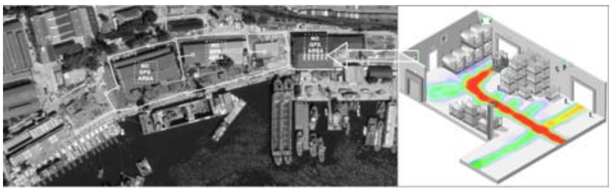


Figure 1 – Warehouses where forklifts cannot be identified by GPS tracked ID

The purpose of the research is to demonstrate the possibilities of vehicle identification, various methods and

DOI 10.15588/1607-3274-2021-4-9

techniques of database analysis, the geo-distributed data, and the selection of parameters visualization in particular.

They can be used to reduce IT_E and improve the operations of corporate logistics systems via applying of the MAAS agents A_{AT}^{RO}, A_{AT}^{AS}, A_{AT}^{RS}, A_{RT}^{AS}, A_{UA}^{RS} and others with analysis of the multi-agent authentication process, determine their tokens T_A, T_R, T_{AC}, etc., and the redefinition T_r as a result.

2 REVIEW OF THE LITERATURE

In recent years, the world has been actively conducting research to improve GPS technology. One of them related to counteraction to generating noise interference technologies and anti-satellite weapons (ASAT, etc.) [1]. Research is also underway to improve satellite protection against space radiation. The development of so-called "radiation tolerance technologies" contributes not only to military communication reliability. However, it can also help to provide missions for commercial use and environmental monitoring [2, 3]. There are a lot of military technologies that lie in civil areas.

In addition to the research aim of GPS improving technology, there is the main goal to replace it with alternative solutions. We should note that such solutions will differ significantly for indoor or outdoor tasks. In the future, external objects can be used for such navigation Earth's magnetic field space orientation systems as MAGNAV, QuASAR, etc. [4, 5]. Nowadays we have devices, which network user coordinates can have 10 meters accuracy determination [6].

Noise-immune solutions [7, 8] will allow the corporate networks' objects interaction. They belong to remote segments connected by heterogeneous solutions [9, 10]. In such a situation, the main issue is the network authentication of remote corporate clients' geography. The devices should have a focus on a web interface that does not have a built-in authorizing. In this case, it is necessary to develop the OAuth 2.0 [11] authorization standard basis for a corporate network authentication service.

At the same time, it is important to improve the accuracy of determining the location of a network object. Precise gyroscopes with a nearly symmetrical mechanical resonator [12] navigation system are the most promising technology for vehicles. However, this method is necessary for the moving hosts of corporate network special equipment.

Most smartphones indeed contain gyroscopes, but their accuracy is low. Therefore, the more relevant and budgetary solution today is indoor Wi-Fi tracking usage. In this case, the minor error occurs – from 2.5 m to 1.3 m [13, 14] – improved with a multi-agent approach [15].

We should take into account the spatial structure of the internal environment. It has more complexity than the external one. It occurs due to the potential conception of people in the premises. In this case, the corporate network hosts' positioning algorithms should have the ability to process large amounts of data [16].

Scientists have systematized user identification, the same as other ways of protection against unauthorized access. Such scientists as V. Makhonin, V. Chudnikov, I. Rudakov have proposed RTLS mobile subscribers coordinates determining method.

To solve the problem of warehouses where forklifts cannot be identified by GPS the large data sets with the help of software tools analysis need to be processed. The developed approach will process the large amounts of data associated with barge construction scenarios.

The software tools should also be able to work with fast-flowing large volume data, the same as with structured and poorly structured data as well. There are a lot of methods and techniques for big data analysis which we consider effective, but machine learning and artificial neural networks will be applied.

3 MATERIALS AND METHODS

The vehicle (car, vessel, drone, etc.) is equipped with an NSA that is used to receive signals from satellites.

This antenna is covered by an optical casing, sealed, protected from the weather. The receiver of the NS installed in the car determines its own coordinates and periodically transmits the data to the CP by the means of the special radio channel. In addition, a display can be installed in the driver's cab, which displays a map of the area of the vehicle's location. In addition, the car position coordinates and speed vector can be indicated on the map.

The proposed system scheme of the cloud GNSS data fusion approach is illustrated in Figure 2.

The process of calculating the coordinates and route displaying is constant, the driver's intervention, as a rule, is not required. By the way, other information can be transmitted to the CP along with the navigation data, for example, information about the fuel level in the tank or tank, a driver's workplace presence status or engine condition, whether the engine switched off or started, etc. Error notification messages can also be displayed automatically, e.g., signals about the unexpected opening of the vehicle door (while driving), messages about the unauthorized transported containers.

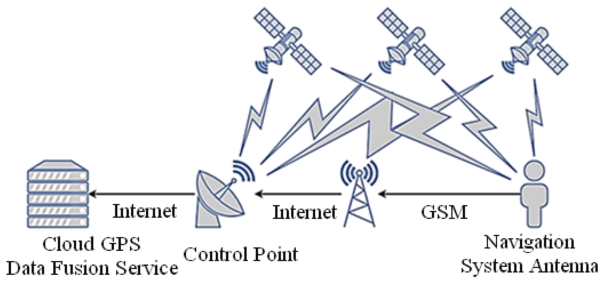


Figure 2 – Graphical scheme of navigational system signal searching process

Thus, the collecting and archiving data from all vehicles on the road is always processing in the dispatching center. The dispatcher can determine the location of each

DOI 10.15588/1607-3274-2021-4-9

vehicle at any time, and make the traffic overall picture or view the schedule of a particular car for any period.

The system components: MS, three satellites, and CP. The coordinates of CP and BS are already known. The clocks of the MS and the measuring station are not synchronized. The first BS sends a pulse to the NS and the CP. On NS and CP the time of arrival of a signal is noted; the time value specified by the NS is sent to the CP (a possible option when the calculations are performed on the NS itself). This operation is performed at least three times with the participation of different BS. Of course, everything needs to be done quickly so that the NS does not have time to move a considerable distance. Once the signal time data has been collected, calculations can begin. To calculate the coordinates of the subscriber it is necessary to solve a system of formula (1):

$$\begin{cases} R1 - r1 = v(T1 - t1 + dt), \\ R2 - r2 = v(T2 - t2 + dt), \\ R3 - r3 = v(T3 - t3 + dt). \end{cases} \quad (1)$$

As we see, in the system there are three unknown quantities (*Rx* can be expressed in terms of *x, y*) – the coordinates of MS (*x, y*) and *dt*, so that the calculation of coordinates becomes a solvable task.

In Figure 3 the diagram demonstrates a general data flow in the corporate cloud platform with data fusion integration. Navigation receiver (so-called “AP”) consists of three main nodes: radio frequency receiver unit; a computing unit in which information is processed and, in fact, finding the coordinates of the receiving point; information display unit.

Figure 4 shows cases when P_R of GPS occurred. The technical characteristics of the navigation receiver have been influenced by the vehicle’s workflow. Therefore, currently produced various AP, designed to work in navigation systems and differ in functionality, characteristics, cost, and appearance. For example, the receivers are placed in moisture-proof enclosures, the receivers are additionally combined with a sounder and receivers for vehicles with space communication devices so that you can send and receive messages.

To analyze the data fusion process, the surface formula (2) was proposed:

$$DF^{GPS}_{p(\ell n,\ell t)} = \sum_{i=1}^{N-1} k_i \cdot f(CH^{TL}_{cmpr}, KP^{A}_{cur} \in T_R) + k_N \cdot \sum_{0}^{t_f} VT_{t_h}. \quad (2)$$

Every vehicle performs current activities as KP^{A}_{cur} that are planned in the T_R.

Figure 5 shows the analytical surface with GPS tracker signals’ losses.

If navigation receivers are designed to work as part of more complex systems, they can be made in the form of boards that are installed in the racks of the main equipment. The specific implementation of such AP depends on where and by whom they will be operated, and each customer can choose a receiver based on their own requirements.

To solve the peaks problem the approach based on analysis of multi-agent authentication protocols was proposed.

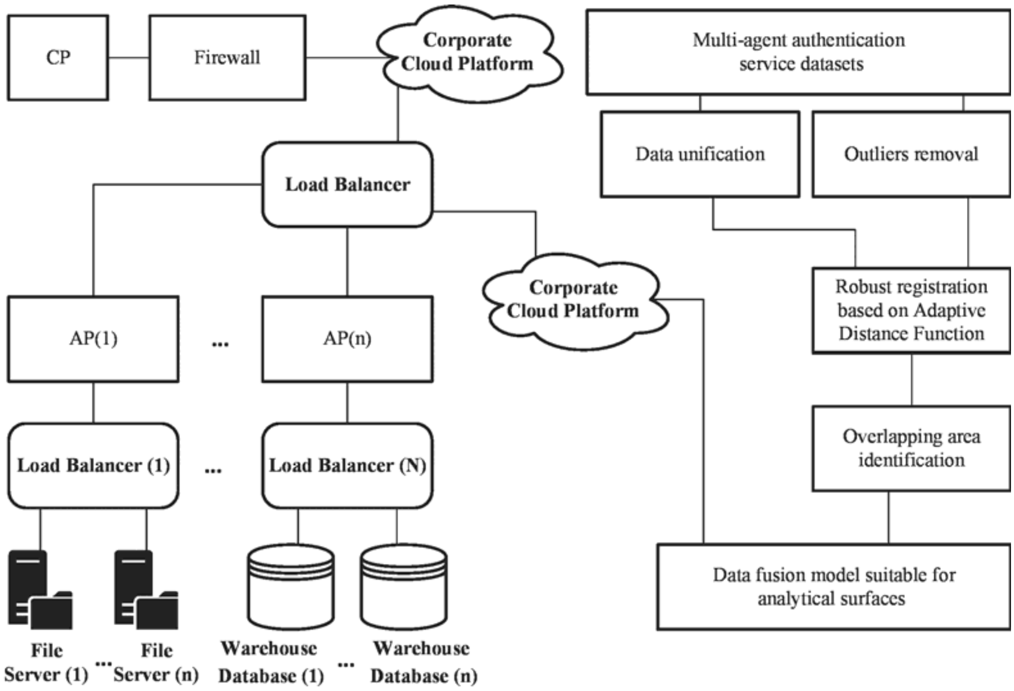


Figure 3 – Cloud GPS Data Fusion Service diagram

DOI 10.15588/1607-3274-2021-4-9

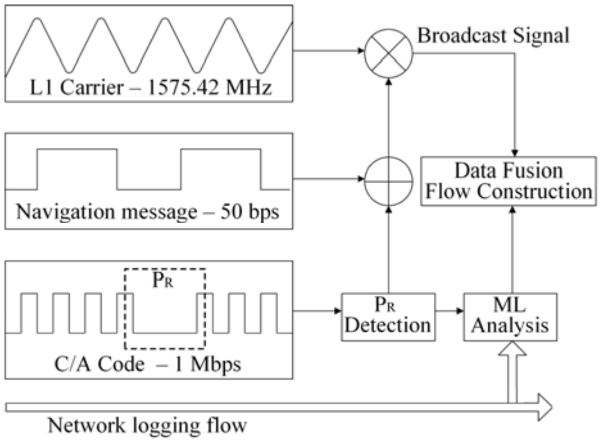


Figure 4 – Detailed GPS signal analysis by Cloud GPS Data Fusion Service

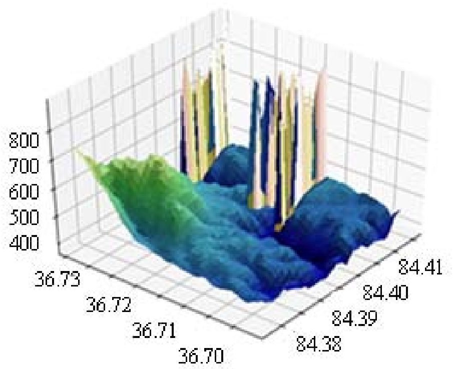


Figure 5 – Data fusion surface with peaks when GPS signal lost

4 EXPERIMENTS

The data analysis can be fulfilled via a multi-agent authentication protocols service.

A MAAS is quite complex, but if software architecture to manage the barge's construction in the shipyard with many services is complex, then OAuth 2.0 will be a base when developing the authentication services need to identify the departments that were involved in the shipbuilding process. The problem of authorization in dozens of services was encountered. This problem was solved with a MAAS. It helped implement seamless authentication across various services and migrate observable agents' data to separate databases to improve the efficiency of the vehicles monitoring during the barge's construction.

The MAAS service has three main tasks:

1) Single point authentication (so-called "Single Sign-On" or SSO) for all system services. Services do not store credentials but trust this to one dedicated service.
2) Safe and granular access to resources. Safe because passwords are stored in one place and are as secure as possible. Granular, since service agents can configure access to resources, based on the data that came from the authentication service.
3) Centralized agent and access management because all information about the agents is stored in the authentication service.

The MAAS defines several roles. A resource owner is an agent that has access rights to a protected resource. An agent can be a user or some kind of system. A protected resource is an agent that handles routes of HTTP endpoints, which can be: API endpoint, file on the CDN, and web service. A resource server is an agent that stores a protected resource to which the resource owner has access. Observer agent is an application that requests access to a protected resource on behalf of the resource owner and with his permission – with authorization. An authorization server is an agent that issues a token to a client to access a protected resource after the successful authorization of the resource owner.

Each agent in the interaction can combine several roles. For example, an agent can be a resource owner at the same time and request access to their own resources. In Figure 6 agents' interaction scheme was considered.

An abstract sequence diagram of MAAS RBAC of interaction between agents includes several objects. The Observer agent sends a request R_{AU} to access the required resource owner agent A_{AT}^{RO}. The A_{AT}^{RO} gives back to the observer agent an authorization grant G_{AU}, which confirms the identity of the A_{AT}^{RO} and rights to the resource that the observer agent is requesting access to. Depending on the flow, this can be a token or credentials. The Observer agent sends the G_{AU} obtained in the previous step to the authorization agent A_{AT}^{AS}, expecting an access token T_{AC} from it to access the protected resource. The A_{AT}^{AS} verifies the validity of the G_{AU}, and then sends the T_{AC} back to the observer agent. After receiving the T_{AC}, the observer agent requests the protected resource from the resource agent A_{AT}^{RS}. The A_{AT}^{RS} verifies the correctness of the T_{AC} and then provides access to the protected resource. Observer agent as part of MAAS can interact with another authentication service of another department inside the same warehouse during the shipbuilding stages.

GPS tracker signal with vehicle identifier is not available, so in Figure 6 agent interaction includes also the observer agent coming with a G_{AU}, to the authorization agent A_{RT}^{AS} and asks to provide the access token T_A and refresh token T_R. The A_{RT}^{AS} makes sure that everything is fine with the G_{AU} and returns the requested T_A and T_R to the observer agent. The observer agent with a T_A requests a protected resource until it receives the first invalid token error IT_E from A_{RT}^{RS}.

After receiving an access error IT_E, the observer agent goes to the A_{RT}^{AS} with a T_R and asks to replace the expired T_A with a new one. In response, the observer agent receives a new T_A, as well as a new T_R, or the lifetime of the old T_R is extended.

The observer agent implemented in the vehicle receives some sort of successful authentication identifier, such as a string, which is associated with the data in the

DOI 10.15588/1607-3274-2021-4-9

database for further analysis. Grant refers to the data that represents the successful authorization of the client by the owner of the resource, used by the client to obtain an access token.

There are several ways to get a grant. Authorization code is used for confidential clients or web services. Clients' credentials are used for confidential clients that request access to their resources or resources previously agreed with the authorization server. Implicit is used by public clients that know how to work with redirection the URIs.

Resource owner password credentials and device authorization are used to authorize devices that can work over the Internet without browsers.

Proposed MAAS can handle described grant types shown in Figure 7.

According to the current MAAS RBAC implementation the first part with resource owner password credentials flow is recommended to be used at agent's interactions that are purely informational but used as an identification criterion of the vehicle inside the warehouse.

Interaction between agents is performed as follows. Resource owner agent A^{RO}_{CGF} passes credentials PC_{RO} to the observer agent. The observer agent uses PC_{RO} to obtain a T_A and T_R. The observer agent redirects the resource owner agent A^{RO}_{ACGF} using the agent A^{RS}_{UA} to the authorization agent A^{AS}_{AC} and specifies the client ID I_{CL} and the redirection URI U_R. Interacting with the A^{AS}_{AC} through the A^{RS}_{UA}, the A^{RO}_{CGF} is authenticated on the A^{AS}_{AC}. A^{RO}_{CGF} checks the rights requested by the observer agent and allows issuance. The A^{RO}_{CGF} is returned to the observer agent using the A^{RS}_{UA} back to the U_R that was specified. As a query parameter, code C_A will be added. With C_A, the observer agent is sent to the A^{AS}_{AC} instruction to receive an access token T_A in response (and a refresh token, if required). The A^{AS}_{AC} validates the C_A, making sure that the T_A is correct, and issues a T_A and optionally a T_R to the observer agent. The observer agent will be able to access the resource that will be used for vehicle location monitoring.

The A^{RS}_{UA} has one requirement: it must be able to work with HTTP redirects. Without this, the A^{RO}_{CGF} will not be able to get to the A^{AS}_{AC} and return with a grant.

Also, MAAS data analysis can use LSTM. According to the proposed MAAS RBAC diagrams, the CH^{TL}_{cmpr} is described by formula (3):

$$CH^{TL}_{cmpr} = \begin{bmatrix} \left\{ \frac{R_{AU}}{G_{AU}}, \frac{G_{AU}}{T_{AC}}, \frac{R_{pld}}{T_{AC}}, R_{pld} \right\} \\ \left\{ \frac{T_{(A)U(R)}}{G_{AU}}, \frac{R_{pld}}{T_A}, \frac{IT_E}{T_A}, R_{pld} \right\} \\ \left\{ \frac{PC_{RO}}{R_{pld}}, \frac{T_{(A)U(R)}}{PC_{RO}}, R_{pld} \right\} \\ \left\{ \frac{C_A}{I_{CL}}, \frac{C_A}{U_R + U_A}, \frac{T_A}{C_A + U_R}, \frac{R_{pld}}{I_{CL}}, R_{pld} \right\} \end{bmatrix}, \quad (3)$$

where R_{pld} needs to be used in LSTM to identify the vehicle's location.

The block diagram of the algorithm that implements the proposed approach is shown in Figure 8.

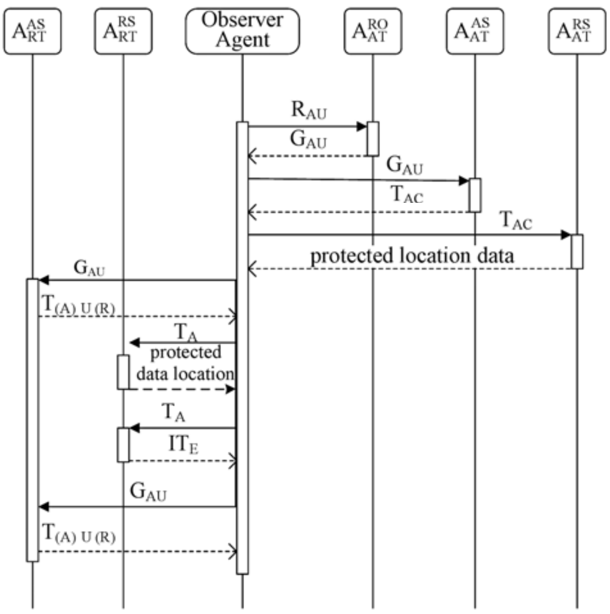


Figure 6 – RBAC scheme in multi-agent authentication service

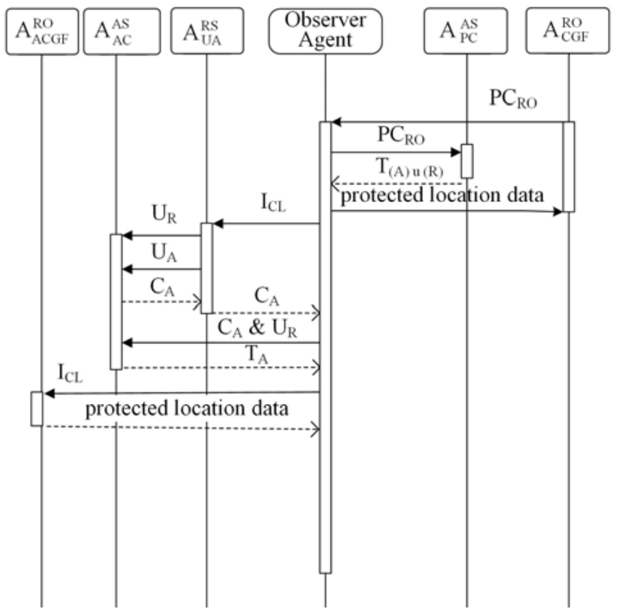


Figure 7 – Communication process between services to analyze protected location's data using MAAS RBAC

DOI 10.15588/1607-3274-2021-4-9

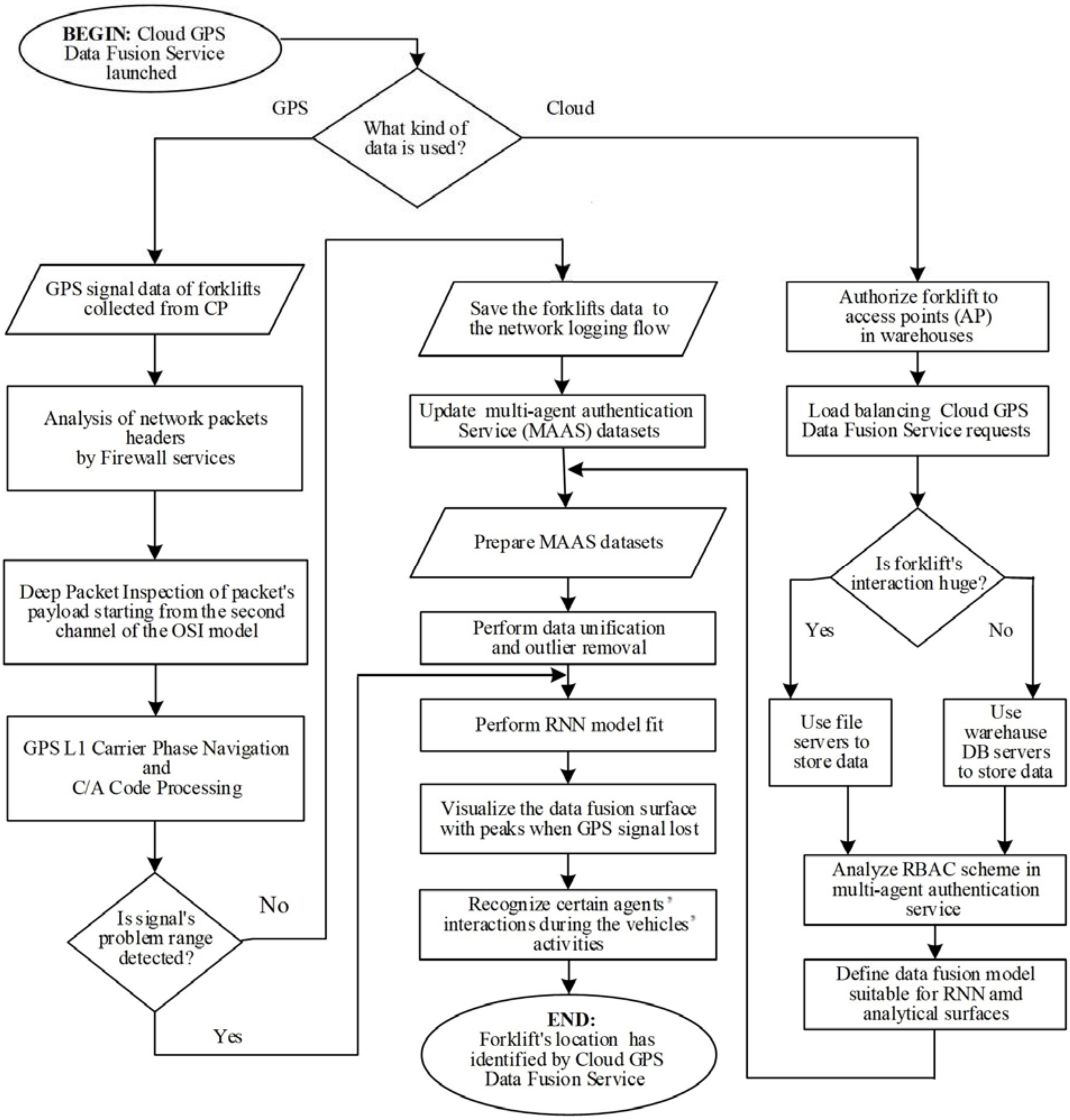


Figure 8 – Block diagram of the algorithm that implements the proposed approach

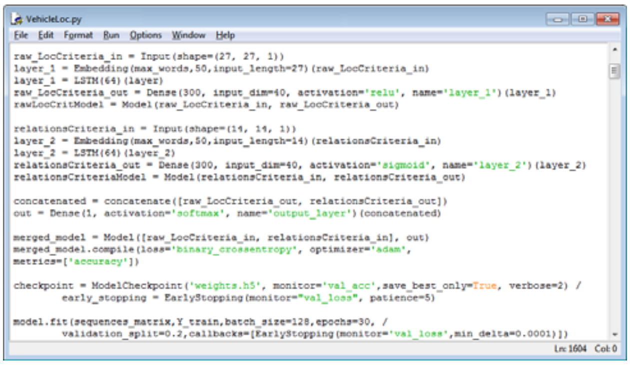
5 RESULTS

As a result of an experiment, a modification was described that solved the problem of long-term memory of the proposed RNN: when neurons remember recently received information well, but they can't store in memory for a long time something that they processed many cycles ago, no matter how important that information may be.

This turns out to be convenient when several vehicles are simultaneously located within the same warehouse. In LSTM networks, internal neurons are equipped with a complex system of gates, as well as the concept of a cell state, which is a kind of long-term memory. The gate determines what information will enter the cellular state, what will be erased from it, and what will affect the result that the RNN will give at an iteration.

In Figure 9 the inputs of the *raw_LocCruteria* section described the raw quantitative values refers to agents' interactions during the vehicles' activities on the planned in the tasks' route T_R. The section *relationCruteria* includes samples with CH_{cmpr}^{TL}.

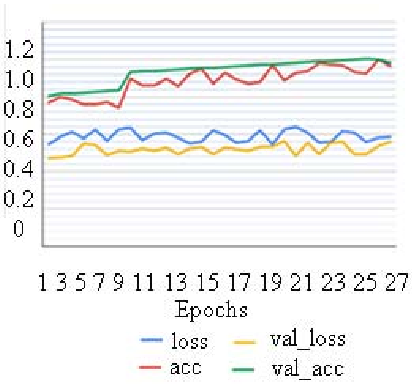
DOI 10.15588/1607-3274-2021-4-9



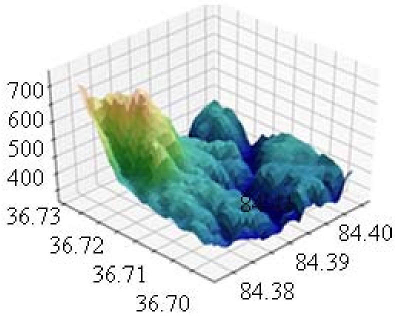

```
raw_LocCriteria_in = Input(shape=(27, 27, 1))
layer_1 = Embedding(max_words,50,input_length=27)(raw_LocCriteria_in)
layer_1 = LSTM(64)(layer)
raw_LocCriteria_out = Dense(300, input_dim=40, activation='relu', name='layer_1')(layer_1)
rawLocCritModel = Model(raw_LocCriteria_in, raw_LocCriteria_out)

relationsCriteria_in = Input(shape=(14, 14, 1))
layer_2 = Embedding(max_words,50,input_length=14)(relationsCriteria_in)
layer_2 = LSTM(64)(layer_2)
relationsCriteria_out = Dense(300, input_dim=40, activation='sigmoid', name='layer_2')(layer_2)
relationsCriteriaModel = Model(relationsCriteria_in, relationsCriteria_out)

concatenated = concatenate([raw_LocCriteria_out, relationsCriteria_out])
out = Dense(1, activation='softmax', name='output_layer')(concatenated)

merged_model = Model([raw_LocCriteria_in, relationsCriteria_in], out)
merged_model.compile(loss='binary_crossentropy', optimizer='adam',
metrics=['accuracy'])

checkpoint = ModelCheckpoint('weights.h5', monitor='val_acc',save_best_only=True, verbose=2) /
        early_stopping = EarlyStopping(monitor="val_loss", patience=5)

model.fit(sequences_matrix,Y_train,batch_size=128,epochs=30, /
        validation_split=0.2,callbacks=[EarlyStopping(monitor='val_loss',min_delta=0.0001)])
```

Figure 9 – Recursive neural network layers for searching vehicle's location based on MAAS protocols logging

LSTM networks are trained using the backpropagation through time algorithm, the idea of which is to expand the computation graph in time. From LSTM networks, we can build multilayer neural networks, passing the output sequence of the next layer to the next one.



a



b

Figure 10 – The accuracy plot of the agent's classification models (a) and smoothed activities surface (b) of forklift vehicle

It should be noted that such active attention to the considered family of models is currently due, in particular, to their high performance in many tasks. Like other recurrent neural networks, LSTM and GRU, especially two- and multilayer ones, are characterized by a rather complex learning procedure. The GPUs can significantly speed up the learning processes of deep neural networks, which is clearly demonstrated by the active implementation (and optimization) of the described recurrent models for GPU computing.

The location identifying uses the proposed method based on analysis of the multi-agent authentication process. As a result, shown in Figure 10b, the analytical surface has the following smoothed form without peaks.

6 DISCUSSION

As evident from Figure 10, the multi-sectional configuration of the recursive neural network and the usage of data made vehicle location possible to achieve an accuracy of 97.8% (Figure 10a) of the classification of forklift vehicles in the warehouse. Current MAAS uses the RBAC scheme, which is based on roles. Usually, the agent's role is given full access to a specific service, instead of being tied to specific functionality. A multi-agent authentication service describes how communication between services should be implemented to ensure secure authorization. Many nuances are described in sufficient detail, for example, the flow of interaction of nodes with each other, but some are left to the mercy of a specific implementation.

We should also note that a significant number of mobile technical systems include various positioning systems. Typically, mobile technologies include signal receivers of GLONASS/GPS navigation systems global satellites. There are several Earth orbit satellites of the satellite navigation system. They include ground system management and subscriber devices (so-called "APs") as special navigation receivers. Their main task is to receive signals from the satellite and determine the distance to the one. Subscriber receivers measure the distance to several currently visible satellites. Their coordinates are extremely accurate and can be reached at any time. The coordinates have equal distance surfaces intersection point calculation.

Three satellites' distance makes possible a single point of Earth's surface coordinates' determination. In this case, the receiving device's three equation data is very important. The subscriber receiver performs instantly automatic measurements and calculations. It increases the calculating of the coordinates' receiving point accuracy.

The proposed system uses several additional measures. This study investigated an equations system, which is used to calculate the current position of a moving object in real-time. As the input data for the calculations, the coordinates of the three satellites relative to the Earth and their distance to the desired object are used. The accurate determination of the moving object coordinates requires the real-time data constantly coming from NS, which is not always feasible due to possible signal interruptions.

Separating the entity of the agent and the application requesting access allowed to analyze data fusion ability. According to asynchronous interactions, developed software can manage vehicle navigation system rights separately from agents' rights. Instead of the credential, which has a certain set of rights and lifetime, we get access to metadata resources generated during the vehicle's movements between departments inside the same warehouse during one technological process, e.g., vessel building stages.

DOI 10.15588/1607-3274-2021-4-9

In this context, the research should also take into account, signals from satellites are emitted at two frequencies. If we compare the time of receiving signals, we can determine and take into account the ionosphere radio signals' delay. They increase the accuracy of measurements. The potential accuracy of determining the coordinates can be increased to several tens of centimeters. Modern navigation receivers can have 12 or more operating channels. They do not only increase the accuracy of coordinate determination but also speeds it up. As a rule, such receivers calculate the speed and direction of movement of moving objects.

However, the large amounts of traffic, receiving signals' difficulties, or data absence can cause functionality losses. Therefore, such conditions (long-distance industrial facilities, quarries, mines, areas with complex terrain, etc.), alternative positioning methods are needed to determine the coordinates and identify mobile objects. One of them is the reception of the signals from the fourth satellite. It can help to eliminate the systematic receiving device and satellite time difference error.

CONCLUSIONS

The actual problem of mathematical support development has been solved to automate defining the trajectory in real-time of the movable object during movement between departments inside the same warehouse area.

The scientific novelty of obtained results is that the method of data flow fusion real-time performance is firstly proposed. An equations system that identifies the vehicles' location based on the method of multi-agent authentication process analysis after the GPS signal loss, was proposed. The multi-sectional configuration of the recursive neural network and the usage of cloud data fusion allow increasing the accuracy of vehicle location determination.

The practical significance of obtained results is that the efficiency of the role-based access control integrated into multi-agent authentication service was improved. as well as experiments to study their properties are conducted. The experimental results allow us to recommend the proposed approach for use in practice, as well as to determine vehicles' location in the warehouse with an accuracy of 97.8%. The location of the forklift is determined by a cloud-based GPS fusion service. Time estimates of the costs of sending data to data centers in comparison with the costs of processing, archiving, and merging these data will be approximately equal. Time costs for data transfer will not take up most of the time, since the cloud infrastructure will be deployed for the local enterprise territory. Local computing and storage resources will be enough to locate the forklift in a time range of up to 15–20 minutes after the GPS signal has been lost.

Prospects for further research are to study the proposed cloud data fusion about the location of vehicles, being at various territorially remote warehouses but providing material support for a common logistical chain.

ACKNOWLEDGEMENTS

The work is supported by NIBULON Company (Mykolaiv, Ukraine) having expanded logistical capabilities. Without the provided datasets of its Integrated Shipyard Management System, without superior knowledge and experience, it would not be possible to obtain qualitative results in the research and therefore their support was very essential.

REFERENCES

1. Koplow D. A. An inference about interference: A surprising application of existing international law to prohibit anti-satellite weapons, *Georgetown Law Faculty Publications And Other Works,* 2014, Vol. 35, pp. 737–827.
2. Navigation and guidance systems, *BAE Systems,* 2019, URL: https://www.baesystems.com/en/product/navigation-and-guidance-systems.
3. Blyukher B., Ivanova L., Malakhov E., Sitnikov V. Probabilistic risk assessment of environmental hazards, *American Society of Mechanical Engineers, Pressure Vessels and Piping Division (PVP),* 2000, Vol. 400, pp. 69–71.
4. Canciani A. J. Absolute positioning using the Earth's magnetic anomaly field : Theses and Dissertations of PhD, 2016. URL: https://scholar.afit.edu/etd/251.
5. Kramer D. DARPA looks beyond GPS for positioning, navigating, and timing, *Physics Today*, 2014, Vol. 10, Issue 23, P. 67. DOI: 10.1063/PT.3.2543.
6. Retianza D. V. Duivenbode J. V., Huisman H., Lomonova E. A. Fault-tolerant controller and failure analysis of automotive electromagnetic suspension systems, *Ecological Vehicles and Renewable Energies (EVER 2019), Proceedings of the IEEE 14th International Conference*. Monte-Carlo, Monaco,·08–10 May 2019, 2019, No. 8813514. DOI: 10.1109/EVER.2019.8813514.
7. Rumiankov D., Zhuravska I., Solobuto L. , Musiyenko M. Reduction of noise similar to solar interference in computer networks based on power line communication, *Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS 2017) : Proceedings of the IEEE 9th International Conference*. Bucharest, Romania, 21–23 September 2017, 2017, Vol. 1, pp. 215–221. DOI: 10.1109/IDAACS.2017.8095079.
8. Ukhina H. Sytnikov V., Streltsov O., Stupen P., Yakovlev D. Stability evaluation based on the sustainability triangle application for transfer functions above 2nd order, *Computer Science and Application Engineering (CSAE 2019), Proceedings of the 3rd International Conference,* October 2019, Article-No. 6, pp. 1–5. DOI: 10.1145/3331453.3361305.
9. Ovchar K., Borodin A., Burlachenko I., Krainyk Y. Automated recognition and sorting of agricultural objects using multi-agent approach, *CEUR Workshop Proceedings*, 2019, Vol. 2546, pp. 76–86.
10. Burlachenko I., Zhuravska I., Tohoiev O., Ukhan Ye., Tiutiunyk Ye. Multi-agent monitoring system for heat loss mapping of multi-story buildings, *CEUR Workshop Proceedings*, 2019, Vol. 2516, pp. 218–225.
11. RFC 8628: OAuth 2.0 Device Authorization Grant, 2019, URL: https://oauth.net/2/device-flow/.
12. McAlpine K. Small, precise and affordable gyroscope for navigating without GPS, Michigan Engineering, 23 March 2020.

DOI 10.15588/1607-3274-2021-4-9

13. Sivers M., Fokin G., Dmitriev P., et al. Wi-Fi based indoor positioning system using inertial measurements, *Next Generation Wired/Wireless Networking : Proceedings of the International Conference, 28–30 August 2017*, 2017, DOI: 10.1007/978-3-319-67380-6_69.
14. Asher V., Thakkar H., Tambe S., Bhavathankar P. Indoor object tracking using Wi-Fi access points, *Inventive Communic. and Computational Technol., LNNS,* 2020, Vol. 89, pp. 687–698. DOI: 10.1007/978-981-15-0146-3_64.
15. Tohoiev O., Burlachenko I., Zhuravska I., Savinov V. The monitoring system based on a multi-agent approach for moving objects positioning in wireless networks, *CEUR Workshop Proceedings*, 2020, Vol. 2608, pp. 79–90.
16. Berg K., Spil T. A. M., Effing R. The privacy paradox of utilizing the Internet of Things and Wi-Fi tracking in smart cities, *IFIP Advances in Information and Communication Technology*, 2019, Vol. 558, pp. 364–381. DOI: 10.1007/978-3-030-20671-0_25.

Received 04.08.2021.
Accepted 01.10.2021.

УДК 621.396.93:004.032.26

ХМАРНИЙ ПІДХІД ЗЛИТТЯ ДАНИХ GNSS НА ОСНОВІ МУЛЬТИАГЕНТНОГО АНАЛІЗУ ПРОТОКОЛІВ АУТЕНТИФІКАЦІЇ В КОРПОРАТИВНИХ ЛОГІСТИЧНИХ СИСТЕМАХ УПРАВЛІННЯ

Бурлаченко І. С. – старший викладач кафедри комп'ютерної інженерії Чорноморського національного університету імені Петра Могили, Миколаїв, Україна.

Савінов В. Ю. – канд. техн. наук, доцент кафедри комп'ютерної інженерії Чорноморського національного університету імені Петра Могили, Миколаїв, Україна.

Тогоєв О. Р. – аспірант кафедри комп'ютерної інженерії Чорноморського національного університету імені Петра Могили, Миколаїв, Україна.

Журавська І. М. – д-р техн. наук, професор, професор кафедри комп'ютерної інженерії Чорноморського національного університету імені Петра Могили, Миколаїв, Україна.

АНОТАЦІЯ

Актуальність. Сучасні корпоративні логістичні системи управління або системи стеження за положенням складаються з бездротових систем позиціонування. Як правило, мобільні технології використовують приймачі сигналів супутників GNSS. Однак, існує загальна проблема передачі даних до аналітичних центрів для подальшого використання у системах корпоративної логістики. Об'єктом дослідження є процес розробки рішень, альтернативних для GNSS.

Мета. Підвищення точності контролю доступу до місцезнаходження транспортного засобу на основі мультиагентного аналізу протоколів автентифікації.

Метод. У дослідженні запропоновано хмарну платформу злиття даних, яка передбачає збирати та архівувати дані про всі рухомі об'єкти, що можуть знаходитися на дорозі між відділами всередині однієї складської території. Оскільки існують операції з участю різних бездротових базових станцій, тож, рухомому об'єкту може не вистачити часу для аналізу траєкторії руху в режимі реального часу. Таким чином, обробка даних повинна виконуватися в хмарному диспетчерському центрі, і необхідне злиття потоків даних. Запропонована система рівнянь, яка визначає місцезнаходження транспортних засобів на основі методу мультиагентного аналізу процесу автентифікації після втрати сигналу GPS. Багатосекційна конфігурація рекурсивної нейронної мережі та використання злиття хмарних даних дозволили підвищити точність визначення місцезнаходження транспортного засобу.

Результати. Розроблений метод реалізований програмно та проведені дослідження для вирішення проблем точності контролю розташування транспортного засобу в корпоративних логістичних системах управління.

Висновки. Під час дослідження ефективність визначення місцезнаходження транспортного засобу була покращена за допомогою керування доступом на основі ролей, інтегрованого з мультиагентною службою автентифікації.

КЛЮЧОВІ СЛОВА: хмарні технології, злиття даних, мультиагентний аналіз, протокол автентифікації, рекурсивна нейронна мережа, система управління, корпоративна логістика.

УДК 621.396.93:004.032.26

ОБЛАЧНЫЙ ПОДХОД СЛИЯНИЯ ДАННЫХ GNSS НА ОСНОВЕ МУЛЬТИАГЕНТНОГО АНАЛИЗА ПРОТОКОЛОВ АУТЕНТИФИКАЦИИ В КОРПОРАТИВНЫХ ЛОГИСТИЧЕСКИХ СИСТЕМАХ УПРАВЛЕНИЯ

Бурлаченко И. С. – старший преподаватель кафедры компьютерной инженерии Черноморского национального университета имени Петра Могилы, Николаев, Украина.

Савинов В. Ю. – канд. техн. наук, доцент кафедры компьютерной инженерии Черноморского национального университета имени Петра Могилы, Николаев, Украина.

Тогоев А. Р. – аспирант кафедры компьютерной инженерии Черноморского национального университета имени Петра Могилы, Николаев, Украина.

Журавская И. Н. – д-р техн. наук, профессор, профессор кафедры компьютерной инженерии Черноморского национального университета имени Петра Могилы, Николаев, Украина.

DOI 10.15588/1607-3274-2021-4-9

АННОТАЦИЯ

Актуальность. Современные корпоративные логистические системы управления или системы слежения за положением состоят из беспроводных систем позиционирования. Как правило, мобильные технологии используют приемники сигналов спутников GNSS. Однако, существует общая проблема передачи данных в аналитические центры для дальнейшего использования в системах корпоративной логистики. Объектом исследования является процесс разработки решений, альтернативных для GNSS.

Цель. Повышение точности контроля доступа к местонахождению транспортного средства на основе мультиагентного анализа протоколов аутентификации.

Метод. В исследовании предложено облачную платформу слияния данных, предложено собирать и архивировать данные обо всех движущихся объектах, которые могут находиться на дороге между отделами внутри одной складской территории. Поскольку существуют операции с участием различных беспроводных базовых станций, поэтому, подвижному объекту может не хватить времени для анализа траектории движения в режиме реального времени. Поэтому обработка данных должна выполняться в облачном диспетчерском центре, и необходимо слияние потоков данных. Предложена система уравнений, которая определяет местонахождение транспортных средств на основе метода мультиагентного анализа процесса аутентификации после потери сигнала GPS. Многосекционная конфигурация рекурсивной нейронной сети и использования слияния облачных данных позволили повысить точность определения местоположения транспортного средства.

Результаты. Разработанный метод реализован программно, проведены исследования для решения проблем точности контроля местоположения транспортного средства в корпоративных логистических системах управления.

Выводы. В ходе исследования эффективность определения местоположения транспортного средства была улучшена с помощью управления доступом на основе ролей, интегрированного с мультиагентной службой аутентификации.

КЛЮЧЕВЫЕ СЛОВА: облачные технологии, слияние данных, мультиагентный анализ, протокол аутентификации, рекурсивная нейронная сеть, система управления, корпоративная логистика.

ЛІТЕРАТУРА / ЛИТЕРАТУРА

1. Koplow D. A. An inference about interference: A surprising application of existing international law to prohibit anti-satellite weapons / D. A. Koplow // Georgetown Law Faculty Publications And Other Works. – 2014. – Vol. 35. – P. 737–827.
2. Navigation and guidance systems // BAE Systems. – 2019. – URL: https://www.baesystems.com/en/product/navigation-and-guidance-systems.
3. Probabilistic risk assessment of environmental hazards / [B. Blyukher, L. Ivanova, E. Malakhov, V. Sitnikov] // American Society of Mechanical Engineers, Pressure Vessels and Piping Division (PVP). – 2000. – Vol. 400. – P. 69–71.
4. Canciani A. J. Absolute positioning using the Earth's magnetic anomaly field : Theses and Dissertations of PhD / A. J. Canciani. – 2016. – URL: https://scholar.afit.edu/etd/251.
5. Kramer D. DARPA looks beyond GPS for positioning, navigating, and timing / D. Kramer // Physics Today. – 2014. – Vol. 10, Issue 23. – P. 67. DOI: 10.1063/PT.3.2543.
6. Fault-tolerant controller and failure analysis of automotive electromagnetic suspension systems / [D. V. Retianza, J. V. Duivenbode, H. Huisman, E. A. Lomonova] // Ecological Vehicles and Renewable Energies (EVER 2019) : Proceedings of the IEEE 14th International Conference, Monte-Carlo, Monaco, 08–10 May 2019. – 2019. – No. 8813514. DOI: 10.1109/EVER.2019.8813514.
7. Reduction of noise similar to solar interference in computer networks based on power line communication / [D. Rumiankov, I. Zhuravska, L. Solobuto, M. Musiyenko] // Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS 2017) : Proceedings of the IEEE 9th International Conference, Bucharest, Romania, 21–23 September 2017. – 2017. – Vol. 1. – P. 215–221. DOI: 10.1109/IDAACS.2017.8095079.
8. Stability evaluation based on the sustainability triangle application for transfer functions above 2nd order / [H. Ukhina, V. Sytnikov, O. Streltsov et al.] // Computer Science and Application Engineering (CSAE 2019) : Proceedings of the 3rd International Conference. – October 2019. – Article No. 6. – P. 1–5. DOI: 10.1145/3331453.3361305.
9. Automated recognition and sorting of agricultural objects using multi-agent approach / [K. Ovchar, A. Borodin, I. Burlachenko, Y. Krainyk] // CEUR Workshop Proceedings. – 2019. – Vol. 2546. –P. 76–86.
10. Multi-agent monitoring system for heat loss mapping of multi-story buildings / [I. Burlachenko, I. Zhuravska, O. Tohoiev et al.] // CEUR Workshop Proceedings. – 2019. – Vol. 2516. – P. 218–225.
11. RFC 8628: OAuth 2.0 Device Authorization Grant. – 2019. – URL: https://oauth.net/2/device-flow/.
12. McAlpine K. Small, precise and affordable gyroscope for navigating without GPS / K. McAlpine // Michigan Engineering. – 23 March 2020.
13. Sivers M. Wi-Fi based indoor positioning system using inertial measurements / [M. Sivers, G. Fokin, P. Dmitriev, et al.] // Next Generation Wired/Wireless Networking : Proceedings of the International Conference, 28–30 August 2017. – 2017. – DOI: 10.1007/978-3-319-67380-6_69.
14. Indoor object tracking using Wi-Fi access points / [V. Asher, H. Thakkar, S. Tambe, P. Bhavathankar] // Inventive Communic. and Computational Technol., LNNS. – 2020. – Vol. 89. – P. 687–698. DOI: 10.1007/978-981-15-0146-3_64.
15. The monitoring system based on a multi-agent approach for moving objects positioning in wireless networks / [O. Tohoiev, I. Burlachenko, I. Zhuravska, V. Savinov] // CEUR Workshop Proceedings. – 2020. – Vol. 2608. – P. 79–90.
16. Berg K. The privacy paradox of utilizing the Internet of Things and Wi-Fi tracking in smart cities / K. Berg, T. A. M. Spil, R. Effing // IFIP Advances in Information and Communication Technology. – 2019. – Vol.558. – P. 364–381. DOI: 10.1007/978-3-030-20671-0_25.

DOI 10.15588/1607-3274-2021-4-9