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N. KUCHUK, R. ARTIUKH, A. NECHAUSOV

METHOD OF BUILDING THE SEMANTIC NETWORK OF DISTRIBUTED SEARCH IN E-LEARNING

The **subject** matter of the article is semantic networks of distributed search in e-learning. The **goal** is to synthesize a decision tree and a stratified semantic network that allows network intelligent agents in the e-learning to construct inference mechanisms according to the required attributes and specified relationships. The following **results** are obtained. The model of the base decision tree in e-learning is suggested. To simulate the decision tree in e-learning, the logic of predicates of the first order was used, which enabled making calculations both at the nodes of the tree and at its edges, and making decisions based on the results of calculations; applying partitioning operations to select individual fragments; specifying the solutions with further expanding the inference upper vertices; expanding the multi-level model vertically and horizontally. At the first stage of the model formalization, the graph of the base decision tree was constructed, whose nodes represent a substructure capable of performing an autonomous search subtask. The second stage is filling the base tree with semantic information and organizing its interaction with network intelligent agents. To provide the tree branches of decisions in e-learning with information, the process of stratified expansion of the base decision tree was suggested where the components of the decision node were detailed and the links among the received sub-units were established both on the horizontal and on the vertical levels. It is shown that in order to establish a set of goals and search problems on the studied structure, it suffices to determine: the graphs of goals and search problems for each node type; a set of edges that determine the dependence of the execution of search targets for the nodes that are not of the same type; a set of pointers that establish probable relationships for redistributing resources in accordance with the requirements of intelligent agents; communication mapping. The developed mathematical model of the base decision tree enabled a stratified expansion. Determining intensions and extensions allowed stratified semantic networks to be used for searching. **Conclusions.** The method of synthesizing a decision tree and a stratified semantic network is suggested; this method enables considering them as closely interrelated ones in the context of distributed search in e-learning. As a result, the process of searching and designing inference mechanisms can be formalized by the network intelligent agents according to the required attributes and given relationships.

Keywords: stratified semantic network, intension, extension, decision tree, e-learning, intelligent agent.

Introduction

Problem setting. The globalization of the information support of society and the active process of scientific and technological development in the field of information communications contribute to developing a single global information and communication space. One of the basic trends of developing present information and communication networks (ICN) is increasing the availability of information and computational resources of networks for individual abonents. In this context, individual abonents of information and telecommunication networks are becoming increasingly active consumers of their computing resources and participants in the creation of information materials who directly possess the technique of access to ICN information resources. On the other hand, the increased activity of individual abonents of information and communication networks is caused by the distribution of modern ICN information and computing resources. Therefore, the role of communications both at the level of applied tasks and at the level of technical systems increases dramatically in distributed systems.

The rapid development of technical means of information and communication networks and increased activity of access to information and computer resources of individual abonents increased the interest in the problem of efficient access to information resources of the network [1]. The problem of a goal-oriented information retrieval (IR) is of primary importance. IR is complex activity aimed at collecting, organizing, searching, retrieving and spreading information with the help of computer technologies [2]. IR belongs to a class of ill-formalized problems where analytic dependencies or chains of actions that lead to the desired result are not known. The purpose of IR is to meet the information needs of the WEB application in a form that is available for machine processing, for example, in the form of a query written in a natural language (NL). A query can be interpreted in various ways in e-learning space. It can be incomplete or redundant, contain polysemantic words, strongly depend on the context, poorly reflect the information needs, and so on. At the same time, the information demand at every moment of time remains constant, that is it does not admit ambiguous or mutually exclusive interpretations. Although the query rarely matches to information needs, this is the only way of interaction between the user of e-learning and the search engine where the query is used as input data so that the documents relevant to the query can be found. However, the user evaluates the search result in accordance with their information needs but not according to the query entered. In the course of the assessment, they decide if the search result is relevant to their information needs. The relevance calculated by the search engine based on its internal logic cannot correspond to the true relevancy. For example, the documents selected by the search engine can accurately correspond to the topic of the query, but at the same time, it can be completely useless for a specific activity within which the need arose.

In present search engines, the important step of indexing documents precedes the search phase. It consists in the creation of index tables which greatly speeds up the processing of queries. The peculiarity of IR indexing lies in the fact that the index necessary for a full- text search in electronic collections should be the most complete and contain all terms that appear in documents (an inverted file which includes morphological tokens is created). The following characteristics are calculated for each token on a set of documents: a number of documents a specific token appears in; the token rate. Besides, the information

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for a "token-document" pair is stored in the inverted dictionary, this information includes:

- the token rate in the document;
- the token displacement for the beginning of the document.

The inverted file or similar data structure is sufficient for many approaches to the organization of full-text search. But when the documents that are relevant to this request are retrieved, the way of processing a query and calculating the relevance value for each query-document pair should be determined. However, there are a number of obvious drawbacks that make the search for relevant texts difficult, for example:

- redundancy: synonyms or notions that define the same things or ideas are used in the index;
- the words of the text are considered as independent from one another, which does not correspond to the features of a discourse;
- polysemy of words: since polysemantic words can be regarded as the disjunction of two or more concepts expressing different meanings of a polysemantic word, all elements of this disjunction can hardly attract the user's interest.

The so-called concept indexing does not have such drawbacks because the text is indexed according to notions that are discussed in this text but not to words. In the context of this technology, all synonyms are reduced to the same concept; polysemantic words are assigned to different concepts; the relationships between the concepts and corresponding words are described and can be used while analyzing the text.

Literary sources analysis

In order to try to implement the pattern of automatic conceptual indexing and conceptual search, it is necessary to have a resource describing the system of concepts of this domain area. The semantic network (SN) contains such resource. The SN essence lies in automating "intellectual" tasks of processing the meaning (in terms of semantics) of a particular resource that is available in the network [3]. Intelligent agents (IA) that are placed in the network should process and exchange information. A number of standards and recommendations have been developed and many projects have been implemented so far. But, despite some successes, the idea of SN has not been materialized in action yet [4].

To describe semantics in the network, the Resource Description Framework (RDF) [5] was determined. RDF is a simple but powerful resource-specification language that is triple-based on "Subject-Predicate-Object" and URI specifications. Conceptually, RDF provides the minimum level for presenting knowledge in the net and is based on early Web standards. The languages for describing structured dictionaries for RDF – RDF Schema (RDFS) and GRDDL (Gleaning Resource Descriptions from Dialects of Languages) [6]. Their purpose is to provide means for retrieving RDF-triplets from XML and XHTML data. In the area of creating class libraries and reasoning on RDF-rgraphs, Jena Framework is developed. In the area of creating expansion modules for browsers, Simile for Firefox is developed [7]. The language OWL (Web Ontology Language) was given the status of recommendation [8]. It has three dialects (3 sets of organization units) that are used depending on the required expressive power. OWL is actually an add-in on RDF. Many formalisms of knowledge description can be reflected in the OWL formalism. The work on the format of rules exchange – Rule Interchange Format (RIF) started. Its purpose is to combine several formalisms for describing rules in one standard (a nontrivial logical conclusion can be made according to these formalisms). These formalisms are the logic of Horn clauses, the logic of high order, production models, and so on [9]

However, in all of the above-mentioned standards and approaches to the SN construction, there is no clear formalization for identifying functional and logical dependencies at the stage of making the intermediate sequences of conclusion in accordance with the required attributes and set relations that are developed during the process of expanded processing in the conceptual search [10]. This problem is especially acute in e-learning when organizing the distributed search. One possible approach to implementing such formalism in the distributed search involves the combination of a device for constructing decision trees and semantic networks expanded by a stratified structure (stratified semantic networks).

The goal of the article is the synthesis of the decisions tree and stratified semantic network for constructing inference mechanisms according to the required attributes and set relationship by the intelligent agents in e-learning.

Modelling the basic decision tree in E-learning

Decision trees enable determining logical laws among information segments and represent a convenient device that can become a basis for constructing a stratified semantic network (SSN) that allow inference obtained while using decision trees to be stored and processed.

Let the logic of the first-order predicates be used for modelling a decision tree in e-learning, this logic enables [11]:

- making calculations both at the tree nodes and at its edges and making decisions on the basis of these calculations;
- applying portioning operations to select individual fragments;
- specifying the solutions with further expanding the inference upper vertices;
- expanding the multi-level model vertically and horizontally.

As the graph of the modelled decision tree, the tree GX will be considered, its root being

$$GX = \left(\overline{X}, R\right), \qquad (1)$$

where $\overline{X} = \left(X^0, \overline{X}^1, ..., \overline{X}^{m-1}\right)$ is the tuple comprising many nodes of various ranks; X^0 is the tree root; $\overline{X}^i = (X_1^i, X_2^i, ..., X_{\ell_i}^i)$, $0 \le i \le m-1$ is a set of nodes of the ith rank; $R = \left\{r_{j\nu}^i\right\}$; $0 \le i \le m-2$; $1 \le j \le l_i$;

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$1 \le \nu \le \ l_i + 1$ is a set of graph arcs that are directed links among the nodes; i indicates the rank of j vertex from which the connection gets out of; ν is the number of the vertex of the (i + 1)th rank which includes the connection.

At the first stage of formalization, the graph of the basic decision tree $G_X^{(\acute{A})}$ is built; its nodes represent the SSN substructure that is capable of performing the autonomous search subtask (partial decision of partial inference). To do this, the area of inference $D = \{d_k \mid k = \overline{1,m}\}$ is determined, where d_k is the k-th variable of the inference with D_k domain and the area of decisions $X = \{x_\xi \mid \xi = \overline{1,n}\}$, where x_ξ is the ξ-th variable of the decision with X_ξ domain.

While constructing the decision tree, the variables of two types – "decision" (fig. 1, a) and "inference" (fig. 1, b) are considered.

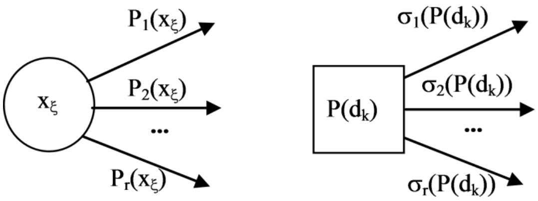

Fig. 1. Nodes "decision" (a) and "inference" (b)

Fig. 1, a shows $P_\zeta\left(x_\zeta\right)$, $\zeta = \overline{1,r}\}$, that is the j-th relationship determined on the domain of the variable x_ζ. And getting to this vertex along the tree means completing the chain

$$P_\zeta\left(x_\zeta\right) \in \ P_\zeta^* = \{P_1(x_\xi), ..., P_r(x_\xi)\} . \qquad (2)$$

Fig. 1, b shows $P\left(d_k\right)$, that is the relationship determined on the domain of the variable d_k, and $\sigma_1\left(P\left(d_k\right)\right)$, $\ell = \overline{1,r}$ is the relationship determined on a set of values that satisfy the relationship P. The incidence is determined as zero only for the inference nodes, that is the operation of expanding the vertex ℑ can be introduced only on this set:

- the parent node is "decision", the child node is "inference" (fig. 2, a):

$$\Im\left(x_\xi\right) \to P\left(d_k\right); \qquad (3)$$

- the parent node is "decision", the child node is "decision" (fig. 2, b):

$$\Im\left(x_\xi\right) \to \left(P_j\left(x_\xi\right) = x_{\xi'}\right); \qquad (4)$$

- the parent node is "inference", the child node is "inference" (fig. 2, c):

$$\Im\left(P\left(d_k\right)\right) \to \sigma_1\left(P\left(d_k\right)\right) \qquad (5)$$

- the parent node is "inference", the child node is "decision" (fig. 2, d):

$$\Im\left(P\left(d_k\right)\right) \to x_\xi \to ... \qquad (6)$$

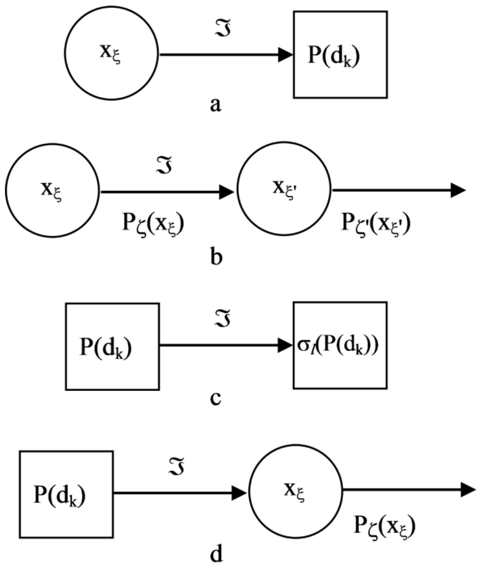

Fig. 2. Operation ℑ – expanding the vertex

The operation of expanding vertices on sets of variables of inference and decision results in creating the basic decision tree ℵ = (ℑ(D), ℑ(X)) with the graph $G_X^{(\acute{A})}$ on which the following branches can be distinguished:

- the fact ℵp (the way from the root node to the final vertex, fig. 3);

- the elementary fact νP ⊂ ℵp (a specific element of the decision way ℵp with the operation ℑ);

- the partial fact ℵr (the way for the tree node to the output node that is not the end one).

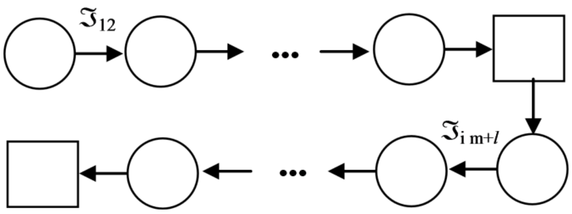

Fig. 3. The formalism of partial decision

The following stage is filling the basic tree with semantic information and organizing its interaction with network intelligent agents.

2. Stratified expansion of the basic decision tree in E-learning

For the information support of the branches of the decision tree in e-learning, the process of the stratified expansion of the basic decision tree ℵ with the graph $G_X^{(\acute{A})}$ should be considered; within the process the decision nodes will be detailed and the links among the obtained subnodes will be established both at the horizontal and vertical levels [12].

Let the isomorphism between the subgraph of the graph $G_X^{(\acute{A})}$ that includes all decision nodes and the graph G_X (1), after that, G_X will be stratified according to the relations determined on the basic decision tree (fig. 4).

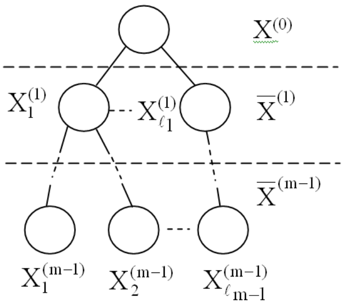

Fig. 4. The graph GX of the stratified tree

Let us assign the graph G_X to the isomorphic graph $G_C(\overline{C},H)$ that has a set of vertices $\overline{C}$ which are search goals that determine the corresponding elements of facts and a set of arcs $H=\left\{h^i_{j\nu}\right\}$ that determine the relations of the conditions of achieving goals of the search for upper level or "AND" conditions. While achieving the basic goal C_0, a set of specifying objectives and tasks arises in the nodes of the $(m-1)$-th rank $\left\{X^{\nu_{m-1}}\right\}$, $1\le\nu_{m-1}\le\ell_{m-1}$, which often lead to the failure to achieve the corresponding goals $\left\{C^{\nu_{m-1}}\right\}$. A set of goals and tasks that are assigned to the nodes $\left\{X^{\nu_{m-1}}\right\}$ can be presented as a set of graphs of objectives and tasks $G^{m-1}_{C_0}=\left\{G^{\nu_{m-1}}_{C_0}\right\}$ (fig. 5):

$$G^{\nu_{m-1}}_{C_0}=\left(\overline{\overline{N}}{}^{\nu_{m-1}}_0,h\right), \quad (7)$$

where $\overline{\overline{N}}{}^{\nu_{m-1}}_0=\left(C^{\nu_{m-1,0}}_0,\overline{\overline{N}}{}^{\nu_{m-1,1}}_0,...,\overline{\overline{N}}{}^{\nu_{m-1,n-1}}_0\right)$ is the tuple that comprises a set of goals of different ranks; $C^{\nu_{m-1,0}}_0$ is the basic goal of the νth node of the $(m-1)$-th rank; $\overline{\overline{N}}{}^{\nu_{m-1,f}}_0=\left(C^{\nu_{m-1,f,1}}_0,...,C^{\nu_{m-1,f,\ell_f}}_0\right)$; $0\le f\le n-1$; f is the rank identifier in the graph $G^{\nu_{m-1}}_{C_0}$; l_f is a number of goals of the f-th rank (wherever the uniqueness of understanding is not interrupted, let us imply that $n^{\nu_{m-1}}$ and $f^{\nu_{m-1}}$); $h=\left\{h^f_{jg}\right\}$, $0\le f\le n-2$; $1\le j\le l_f$; $1\le g\le l_f+1$ is a set of graph arcs that are the relations of the conditions of achieving the goals of the upper level or "AND" conditions.

Any vertex in the graph $G^{\nu_{m-1}}_{C_0}$ can be connected by the edges $h^{f^{\nu_{m-1}}Z^{\alpha_{m-1}}}_{j\Theta}$, where $0\le f\le n^{(\nu)}-1$; $0\le Z\le n^{(\alpha)}-1$; $1\le j\le l_f$; $1\le\Theta\le l_Z$, with one or several vertices in the graph $G^{\alpha_{m-1}}_{C_0}$; $\alpha\ne\nu$; $0\le\alpha,\nu\le\ell_Z$.

Let us assign each link $h^{f^{\nu_{m-1}}Z^{\alpha_{m-1}}}_{j\Theta}$ to a set of tasks in the node of the largest rank of the structure G_X with the subordinate nodes $X^{\nu_{m-1}}$ and $X^{\alpha_{m-1}}$. These are the tasks of the coordination of the nodes $X^{\nu_{m-1}}$ and $X^{\alpha_{m-1}}$ when they are solving the subtasks of search.

Thus, the graph of the search coordination can be created

$$G_{CK}=(\overline{C}_K,S_K), \quad (8)$$

where $\overline{C}_K=(\overline{C}{}^0_K,\overline{C}{}^1_K,...,\overline{C}{}^{m-2}_K)$ is the tuple that comprises a set of coordinating goals of the nodes of different ranks; $\overline{C}{}^0_K=(C^0_{K1},C^0_{K2},...,C^0_{K\ell_0})$ is a set of coordinating goals of the root node X^0 in the graph G_X; $\overline{C}{}^{ij}_K=(C^{ij}_{K1},C^{ij}_{K2},...,C^{ij}_{K\ell_t})$, $1\le j\le l_i$; $0\le m-2$; $1\le t\le l_t$ is a set l_t f coordinating goals of the nodes X^i_j (wherever the uniqueness of understanding is not interrupted, t is understood as t^{ij});

$$S_K=S^T_K\cup S^{TA}_K;\ \ S^T_K\cap S^{TA}_K=\varnothing, \quad (9)$$

where $S^T_K=\left\{S^{Tt_{ij}}_{k\omega_{\tau\gamma}\nu}\right\}$, $1\le t,\ \omega\le l_t$; $0\le I$; $\tau\le m-2$; $1\le j\le l_i$; $1\le\gamma\le l_\tau$; $1\le\nu\le l_m-1$ is a set of non-directed relations between the tth and ω-th coordinating goals of the j-th node of the ith rank and the γ-th control element of the τ-th rank when the νth control element of the (m – 1)-th rank is solving the search task; $S^{TA}_K=\left\{S^{TAt_{ij}}_{k\omega_{\tau\gamma}\nu}\right\}$ is a set of directed (transitive-antisymmetric) relations among the corresponding coordinating goals (fig. 5).

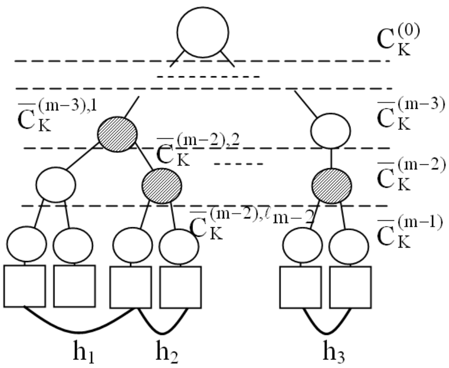

Fig. 5. The graph of the implementation of the coordinating goals and tasks

The coordinating goal C^{ij}_{Kt} relevant to the link $h^{f^{\nu_{m-1}}Z^{\alpha_{m-1}}}_{j\Theta}$ is created in the graph $G^{\nu_{m-1}}_{C_0}$ by the following way: the node with the least value of the i-th rank is determined in the graph G_X; the nodes α and ν of the $(m-1)$-th rank are transitively connected to this node by the relations $R=\left\{r^i_{j\nu}\right\}$.

In the course of the query processing, network resources among the intelligent agents (IA) that participate in the query processing should be redistributed. Let IA To

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achieve the goals of operational control $\overline{C}_0^{\nu_{m-1}}$ of the ν-th node of the (*m* – 1)-th rank, IA requires that the node X_j^i which is transitively connected to the node ν by the relations $R=\{r_{j\nu}^i\}$ solve the task $\overline{C}_R$ of redistributing resources among the nodes with indices ν and α ($1\le \nu,\alpha \le \ell_{m-1}, \nu \ne \alpha$) of the (*m* – 1)-th rank. Let us create the graph of the goals and tasks of operational redistribution of resources (fig. 6):

$$G_{CR} = (\overline{C}_R, S_R), \qquad (10)$$

where $\overline{C}_R = (\overline{C}_R^0, \overline{C}_R^1, ..., \overline{C}_R^{m-2})$ is the tuple that comprises a set of goals for redistributing resources; $\overline{C}_R^0 = (C_{R1}^0, C_{R2}^1, ..., C_{R\ell_t}^{m-2})$, $1 \le t \le l_t$ is a set of goals in redistributing resources that the control element X^0 has.

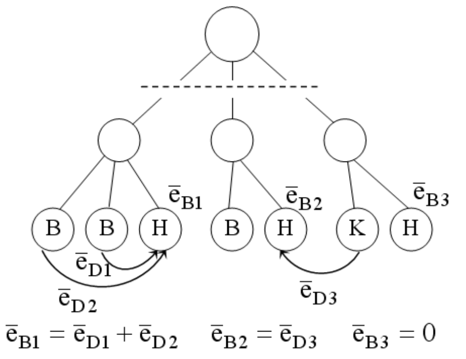

Fig. 6. The graph of resources redistribution

Thereafter, for the nodes X_j^i :

$$\overline{C}_R^{ij} = (C_{R1}^{ij}, C_{R2}^{ij}, ..., C_{R\ell_t}^{ij}); \qquad (11)$$

$$S_R = S_R^T \cup S_R^{TA}; \quad S_R^T \cap S_R^{TA} = \varnothing, \quad S_R^T = \left\{ S_{R\omega_{\tau\gamma}\nu}^{Tt_{ij}} \right\};$$

$1 \le t$, $\omega \le l_t$; $0 \le i, \tau \le m-2$; $1 \le j \le l_i$; $1 \le \gamma \le l_\tau$; $1 \le \nu \le l_m - 1$ are non-directed relations among the tth and ω-th goals in redistributing resources of the *j*-th node of the ith rank and the γ-th node of the τ-th rank to ensure solving the tasks $\nu_m - 1$; $S_R^{TA} = \left\{ S_{R\omega_{\tau\gamma}\nu}^{TA_{ij}} \right\}$ is a set of transitive-antisymmetric relations among corresponding goals in redistributing resources

Let us consider the nodes with indices ν and α ($1 \le \nu_{m-1}, \alpha \le \ell_{m-1}$) of the (*m* – 1)-th rank that have isomorphic graphs $G_{C_0}^{\nu_{m-1}}$ and $G_{C_0}^{\alpha_{m-1}}$ of the goals and tasks as the similar ones.

The set $\overline{X}^{m-1}$ $\{U_1, U_2, ..., U_{\ell_y}\}$ can be partitioned according to the types ($y = \overline{1, \ell_y}$ is a set of the types of nodes of the (*m* – 1)-th rank) in the set of nodes $\overline{X}^{m-1} = \{X^{\nu_{m-1}}\}$, $1 \le \nu \le \ell_{m-1}$.

Thus, to set a set of goals and tasks of the search in the structure G_X , it suffices to determine:

- the graphs of goals and tasks of the search for each type of nodes of the (*m* – 1)-th rank;
- a set of edges

$$h = \left\{ h_{j\Theta}^{f^{\nu_{m-1}} z^{\alpha_{m-1}}} \right\},$$

that determine the dependence of the achievement of search goals for the nodes $X^{\alpha_{m-1}}$ and $X^{\nu_{m-1}}$ which are not similar;

- a set of indicators $d = \left\{ d_{fj}^{\nu_{m-1}\alpha_{m-1}} \right\}$ that set probable relations in redistributing resources in accordance with the requirements of intelligent agents for the nodes α_{m-1}, for the node ν_{m-1} so that it achieves the search goal of the *j*-th rank – *f* in $G_{C_0}^{\nu_{m-1}}$;
- mapping:

$$F_R : d \to \overline{C}_R; \; F_K : h \to \overline{C}_K. \qquad (12)$$

Let us consider that the stratified structure W of goals and tasks of search is set in the graph G_X of the decision tree ℵ = (ℑ(D), ℑ(X)), if the tuple of six elements is determined

$$M = \left\langle G_X, G_{C_0}^{m-1}, G_{CK}, G_{CR}, F_R, F_K \right\rangle. \qquad (13)$$

It is the integration of substructures W_ν that are set in the graph G_X when the search task is solved by each node of the (*m* – 1)-th rank with operational assignment of network resources to the called intelligent agent, that is

$$W = \bigcup_{\nu=1}^{\ell_{m-1}} W_\nu .$$

3. Creating stratified semantic network in E-learning

To deal with the branches of the decision tree ℵ = (ℑ(D), ℑ(X)) expanded by the stratified structure *W*, the following operations are determined:

- partitioning the tree ℜ(ℵ); the operation lies in separating the partial tree ℵ-p in the strata levels of *W* structure (the diagram of the operation is presented in fig. 7) or according to "vertical" identifiers;
- integrating partial trees λ (λ > 1) with the complement $\wp(\aleph_{p_1}, ..., \aleph_{p_\lambda})$ (the diagram extension, Fig.1, a);
- specifying integration $\wp(\aleph_p)$, when the final vertex of the inference of the partial tree is compared to another partial tree whose root vertex is the selected vertex of inference (fig. 8).

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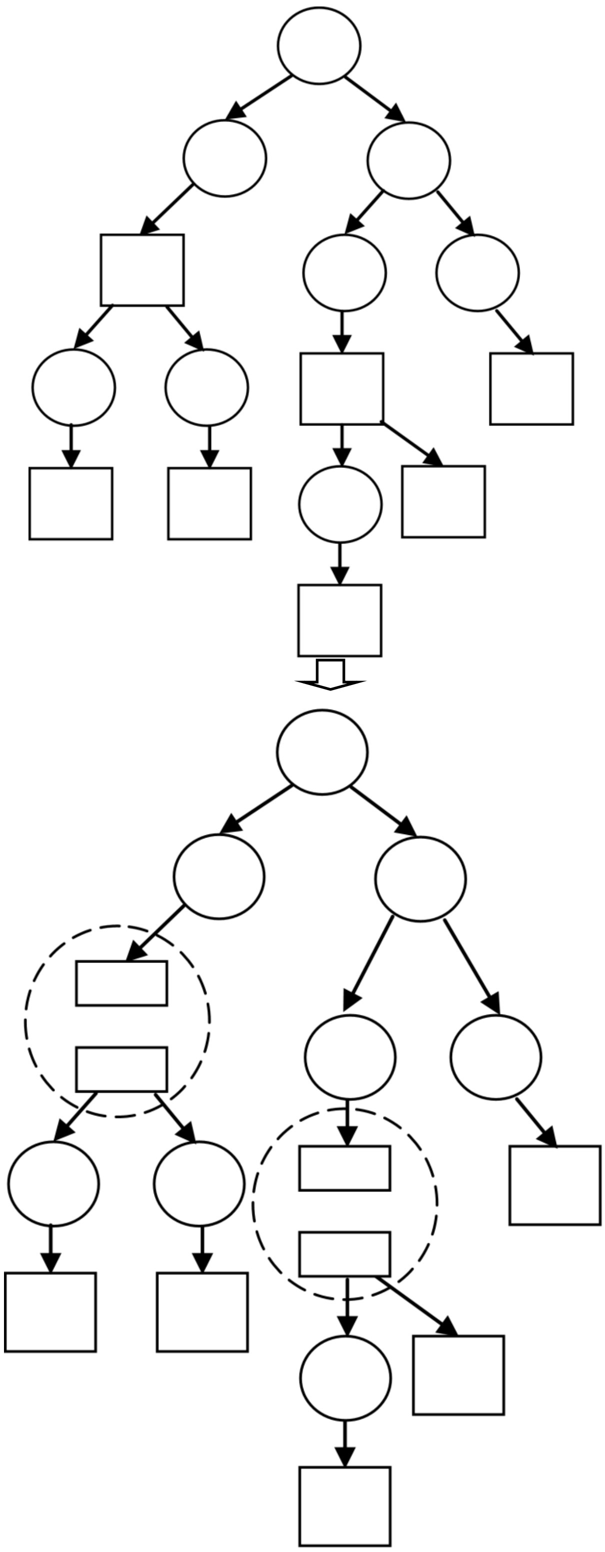

Fig. 7. The operation of partitioning according to strata

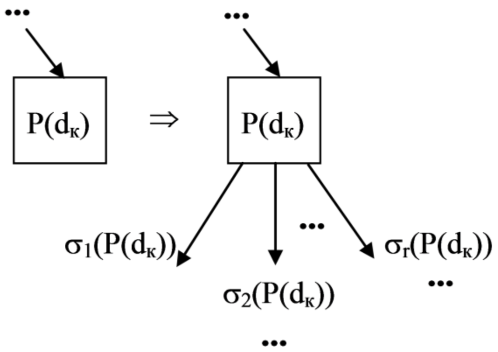

Fig. 8. Integration with specifications

Let us determine a set of attributes of the considered fact obtained on the basis of the structure *W* as $A = (A_1, \ldots, A_\mu)$ and a set of relations connected with this fact as $R = (R_1, \ldots, R_\psi)$; the intension of the relationship Rν ($\nu \in \overline{1,\psi}$) is determined as follows:

$$Int(R_\nu) = \left\{A^{(\nu)} \subset A; dom\left(A^{(\nu)}\right)\right\}, \quad (14)$$

where $A \supset A^{(\nu)}$ is a subset of attributes of the considered relationship; $dom\left(A^{(\nu)}\right)$ are domains corresponding to these attributes whose integration is a basic set for transmitting information to corresponding intelligent agents.

The extension of the relationship R_ν ($\nu \in \overline{1,\psi}$) is determined as

$$Ext(R_\nu) = \left\{F_\theta^{(\nu)}(R_\nu)\right\}, \quad (15)$$

where $F_\theta^{(\nu)}(R_\nu)$ is the expended θ-th elementary fact of the considered relationship that is set by a bunch of attribute pairs according to the structure *W*, that is the specification of this relationship.

Conclusions

Thus, the method for synthesizing the decision tree and the stratified semantic network is suggested; this method enables considering them in close relationship in the context of the distributed search in e-learning, which results in the fact that the search process and the construction of inference mechanisms can be formalized by network intelligent agents according to the required attributes and specified relationships.

References

1. Kuchuk, G., Kharchenko, V., Kovalenko, A. and Ruchkov, E. (2016), "Approaches to Selection of Combinatorial Algorithm for Optimization in Network Traffic Control of Safety-Critical Systems", *Proceedings of IEEE East-West Design & Test Symposium (EWDTS'2016)*, P. 384–389.
2. Gandal, Neil (2013), "The dynamics of competition in the internet search engine market.", *Handbook of Research on Effective Advertising Strategies in the Social Media Age*, Vol. 19, P. 1103–1117, DOI:10.1016/S0167-7187(01)00065-0.
3. Jawadekar, Waman S. (2011), "Knowledge Management: Tools and Technology", *Knowledge management*: Text & Cases, New Delhi: Tata McGraw-Hill Education Private Ltd, 319 p., ISBN 978-0-07-07-0086-4.
4. Voorhees, E.M. (2017), Natural Language Processing and Information Retrieval, available at : http://citeseer.ist.psu.edu/voorhees99.natural.html.

5. Tauber D. (2004), RDF, available at : http://xmlhack.ru/texts//D6-RDF.
6. W3C GRDDL Specification, available at : http://www/w3.org/RDF/YR/GRDDL.
7. Risvik, K.M. and Michelsen, R. (2002), “Search engines and web dynamics”, Computer Networks, Vol. 39, no. 3. P. 289–302.
8. Manner, J. (2004), *Mobility Related Terminology*, Network Working Group, RFC 3753, 224 p.
9. Ian H. Witten, Eibe Frank and Mark A. Hall (2011), *Data Mining: Practical Machine Learning Tools and Techniques*, 3rd Edition, Morgan Kaufmann, 664 p., ISBN 9780123748560.
10. Fridman, A. (2004), “Knowledge Integrating in Situative Modelling System for Nature-Technical Complexes”, *Proc. European Simulation and Modelling Conference* (ESMc2004), Paris, France, 2004, P. 49–58.
11. Kuchuk, G. A., Kovalenko, A. A., Mozhaev, A. A. (2010), "An Approach to Development of Complex Metric for *Multiservice Network Security Assessment", Statistical Methods of Signal and Data Processing* (SMSDP – 2010): Proceedings of Int. Conf., NAU, RED, IEEE Ukraine section joint SP. Kyiv, P. 158–160.
12. Udaya, Sri K. and Vamsi, Krishna T. V. (2014), “E-Learning : Technological Development in Teaching for school kids”, *International Journal of Computer Science and Information Technologies*, P. 6124–6126.

Відомості про авторів / Сведения об авторах / About the Authors

Кучук Ніна Георгіївна – кандидат педагогічних наук, Харківський національний університет імені В. Н. Каразіна, доцент кафедри теоретичної та прикладної системотехніки, м. Харків, Україна; e-mail: nina_kuchuk@ukr.net; ORCID: 0000-0002-0784-1465.

Кучук Нина Георгиевна - кандидат педагогических наук, Харьковский национальный университет имени В. Н. Каразина, доцент кафедры теоретической и прикладной системотехники, г. Харьков, Украина; e-mail: nina_kuchuk@ukr.net; ORCID: 0000-0002-0784-1465.

Kuchuk Nina – PhD (Pedagogy), V.N. Karazin Kharkiv National University, Associate Professor of the Department of Theoretical and Applied Systems Engineering, Kharkiv, Ukraine; e-mail: nina_kuchuk@ukr.net; ORCID: 0000-0002-0784-1465.

Артюх Роман Володимирович – кандидат технічних наук, Державне підприємство "Південний державний проектно-конструкторський та науково-дослідний інститут авіаційної промисловості", директор, м. Харків, Україна; e-mail: roman.artyuh77@gmail.com; ORCID: 0000-0002-5129-2221.

Артюх Роман Владимирович – кандидат технических наук, Государственное предприятие "Южный государственный проектно-конструкторский и научно-исследовательский институт авиационной промышленности", директор, г. Харьков, Украина; e-mail: roman.artyuh77@gmail.com; ORCID: 0000-0002-5129-2221.

Artiukh Roman – PhD (Engineering), State Enterprise "National Design & Research Institute of Aerospace Industries", Director, Kharkiv, Ukraine; e-mail: roman.artyuh77@gmail.com; ORCID: 0000-0002-5129-2221.

Нечаусов Артем Сергійович – кандидат технічних наук, Національний аерокосмічний університет імені М. Є. Жуковського "ХАІ", старший викладач кафедри геоінформаційних технологій та космічного моніторингу Землі, м. Харків, Україна; e-mail: a.nechausov@khail.edu; ORCID: 0000-0001-7216-5566.

Нечаусов Артем Сергеевич - кандидат технических наук, Национальный аэрокосмический университет имени М. Е. Жуковского "ХАИ", старший преподаватель кафедры геоинформационных технологий и космического мониторинга Земли, г. Харьков, Украина; e-mail: a.nechausov@khail.edu; ORCID: 0000-0001-7216-5566.

Nechausov Artem – PhD (Engineering), National Aerospace University – Kharkiv Aviation Institute, Senior Lecturer of the Department of Geoinformation Technologies and Space Monitoring of the Earth, Kharkiv, Ukraine; e-mail: a.nechausov@khail.edu; ORCID: 0000-0001-7216-5566.

МЕТОД ПОБУДОВИ СЕМАНТИЧНОЇ МЕРЕЖІ РОЗПОДІЛУ ПОШУКУ В E-LEARNING

Предметом вивчення в статті є семантичні мережі розподіленого пошуку в E-learning. **Мета** – синтез дерева рішень і стратифікованої семантичної мережі для конструювання мережевими інтелектуальними агентами в E-learning механізмів виведення відповідно до необхідних атрибутами і заданими відносинами. Отримані наступні **результати**. Запропоновано модель базового дерева рішень в E-learning. Для моделювання дерева рішень в E-learning використана логіка предикатів першого порядку, що дозволила: робити обчислення як в вузлах дерева, так і на його ребрах, а на основі результатів обчислень приймати рішення; застосовувати операції розбиття для вибору окремих фрагментів; уточнювати рішення при подальшому розкритті верхніх вершин висновків; розширити по вертикалі і горизонталі багаторівневу модель. На першому етапі формалізації моделі був побудований граф базового дерева рішень, вузли якого представляють підструктуру, здатну виконати автономну підзадачу пошуку. Другий етап - наповнення базового дерева семантичної інформацією і організація його взаємодії з мережевими інтелектуальними агентами. Для інформаційного забезпечення гілок дерева рішень в E-learning запропонований процес стратифікованого розширення базового дерева рішень, при якому деталізувалися вузли типу "рішення" і встановлювалися зв'язки між отриманими Підвузли як на горизонтальному, так і на вертикальному рівні. Показано, що для завдання безлічі цілей і завдань пошуку на досліджуваній структурі досить визначити: графи цілей і завдань пошуку кожного з типів вузлів; безліч ребер, що визначають залежність виконання цілей пошуку для вузлів, які не є однотипними; безліч покажчиків, що встановлюють можливі відносини з перерозподілу ресурсів відповідно до вимог інтелектуальних агентів; відображення зв’язку. Розроблена математична модель базового дерева рішень дозволила побудувати стратифицированное розширення. Визначення інтенсіоналом і екстенсіонали на даному розширенні дозволило використовувати для пошуку апарат стратифікована семантичних мереж. **Висновки.** Запропоновано метод синтезу дерева рішень і стратифікованої семантичної мережі, що дозволяє при розподіленому пошуку в E-learning розглядати їх у тісному взаємозв'язку, в результаті чого з'являється можливість формалізації процесу пошуку і конструювання мережевими інтелектуальними агентами механізмів виведення відповідно до необхідних атрибутами і заданими відносинами.

Ключові слова: стратифікована семантична мережа, інтенсіонал, екстенсіонал, дерево рішень, E-learning, інтелектуальний агент.

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МЕТОД ПОСТРОЕНИЯ СЕМАНТИЧЕСКОЙ СЕТИ РАСПРЕДЕЛЕННОГО ПОИСКА В E-LEARNING

Предметом изучения в статье являются семантические сети распределенного поиска в E-learning. **Цель** – синтез дерева решений и стратифицированной семантической сети для конструирования сетевыми интеллектуальными агентами в E-learning механизмов вывода в соответствии с требуемыми атрибутами и заданными отношениями. Получены следующие **результаты.** Предложена модель базового дерева решений в E-learning. Для моделирования дерева решений в E-learning использована логика предикатов первого порядка, позволившая: производить вычисления как в узлах дерева, так и на его ребрах, а на основе результатов вычислений принимать решения; применять операции разбиения для выбора отдельных фрагментов; уточнять решения при дальнейшем раскрытии верхних вершин выводов; расширить по вертикали и горизонтали многоуровневую модель. На первом этапе формализации модели был построен граф базового дерева решений, узлы которого представляют подструктуру, способную выполнить автономную подзадачу поиска. Второй этап – наполнение базового дерева семантической информацией и организация его взаимодействия с сетевыми интеллектуальными агентами. Для информационного обеспечения ветвей дерева решений в E-learning предложен процесс стратифицированного расширения базового дерева решений, при котором детализировались узлы типа "решение" и устанавливались связи между полученными подузлами как на горизонтальном, так и на вертикальном уровне. Показано, что для задания множества целей и задач поиска на исследуемой структуре достаточно определить: графы целей и задач поиска каждого из типов узлов; множество ребер, определяющих зависимость выполнения целей поиска для узлов, которые не являются однотипными; множество указателей, устанавливающих возможные отношения по перераспределению ресурсов в соответствии с требованиями интеллектуальных агентов; отображения связи. Разработанная математическая модель базового дерева решений позволила построить стратифицированное расширение. Определение интенсионалов и экстенсионалов на данном расширении позволило использовать для поиска аппарат стратифицированных семантических сетей. **Выводы.** Предложен метод синтеза дерева решений и стратифицированной семантической сети, позволяющий при распределенном поиске в E-learning рассматривать их в тесной взаимосвязи, в результате чего появляется возможность формализации процесса поиска и конструирования сетевыми интеллектуальными агентами механизмов вывода в соответствии с требуемыми атрибутами и заданными отношениями.

Ключевые слова: стратифицированная семантическая сеть, интенсионал, экстенсионал, дерево решений, E-learning, интеллектуальный агент.