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## Electronic Lexicography: Traditional and Modern Approaches

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**Abstract.** Nowadays there are a lot of modern technologies in electronic lexicography: speech synthesis technology, cross-referencing between dictionary modules, spell-checking functions, etc. The increasing availability of online information has necessitated intensive research in the area of automatic text summarization within the Natural Language Processing community. Belarusian scientists are also interested in this sphere and new lexicographical approaches for creating a linguistic database are shown in the paper. The authors present English-Belarusian-Russian electronic dictionary TechLex. This is the project of the 2<sup>nd</sup> English Department and the Department of Software for Information Systems and Technologies of the Belarusian National Technical University. The linguistic database of the dictionary is compiled not by the traditional method of processing a large number of paper dictionaries and combining the received translations, but by sequential processing of scientific and technical English-language periodicals. While the designing the dictionary the authors have taken into account the analysis of modern electronic multilingual translation dictionaries and created a client-server application in the Java programming language. The client part of the system contains a mobile application for the Android operating system, which has been tested on tablets and smartphones with different screen diagonals. The interface of the TechLex dictionary is designed taking into account the possibility of adding new subject areas and filling them with appropriate lexical material. The main advantage of our dictionary is that it is the first technical multilingual electronic dictionary having a Belarusian version.

**Keywords:** electronic lexicography, Natural Language Processing, linguistic database, terminological system, client-server application, Android operating system

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## Компьютерная лексикография: традиционные и современные методологии

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**Реферат.** В настоящее время существует много научных подходов в области лексикографии: синтез речи, взаимосвязь информационных модулей словаря, корректировка правописания и т. д. Лавинообразный объем различной онлайн-информации в сетях вызвал необходимость создания систем автоматической обработки текстов. Белорусские ученые также ведут работу в этом направлении – новый подход к созданию лингвистической базы данных для такого рода систем рассмотрен в статье. Авторы представляют англо-белорусско-русский электронный словарь TechLex, который является совместным проектом кафедры английского языка № 2 и кафедры информационных систем и технологий Белорусского национального технического университета. Лингвистическая база данных словаря составлена не традиционным методом обработки печатных версий переводных словарей, а путем последовательной обработки

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текстов периодических научных изданий узкой предметной области с последующей систематизацией лексических единиц. В процессе работы авторы изучили имеющиеся многоязычные электронные словари и создали клиент-серверное приложение на языке Java. Клиентская часть системы содержит мобильное приложение для операционной системы Android, которое было протестировано на планшетах и смартфонах с различными диагоналями экранов. Интерфейс словаря TechLex разработан с учетом возможности добавления новых предметных областей и заполнения их необходимым лексическим материалом. Неоспоримым достоинством предлагаемого словаря является тот факт, что это первый технический электронный многоязычный словарь, имеющий белорусскую версию перевода.

**Ключевые слова:** компьютерная лексикография, обработка естественного языка, лингвистическая база данных, терминологическая система, клиент-серверное приложение, операционная система Android

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## Introduction

The term *electronic dictionary* can be used to refer to any data collection in electronic form concerned with the spelling, meaning or use of words [1]. The early use of computers in lexicography Computers were first employed in lexicography in the 1960s. It was the associate editor of the Random House Dictionary of English Language [2]. At the same time the Lexicographic Project at System Development Corporation in Santa Monica, California, developed Webster Dictionary. It was created as a tape version of the paper-based Webster's 7<sup>th</sup> New Collegiate Dictionary and the New Merriam-Webster Pocket Dictionary [3]. Advances in technology in the 1970s encouraged a more extensive use of computers in lexicographical projects. Computer-based compilation systems were employed to sort and check entries in both the first Longman Dictionary of Contemporary English (LDOCE) (1978) [4]. Corpus lexicography began in the early 1980s, with the inauguration of the COBUILD project [5]. Lexicographic information in machine-readable form became increasingly available to lexicographers and researchers. The Diccionario de la Lengua Española (1984) is considered as "the last large European dictionary to be completed using exclusively the traditional methods of handwritten slips and letterpress composition and printing" [6].

The first electronic dictionaries with interfaces designed for human users were an offshoot of a calculator and Personal Digital Assistant technology, and became available in 1978. These were the LK-3000 produced by the Lexicon Corporation, Florida (the rights were acquired by Nixdorf that now is Siemens), the Craig M100 produced by the Craig Corporation, Japan, and "Speak & Spell", an educational toy produced by Texas Instruments [7]. Once the text of the dictionary was digitized and online, it was also available to be published on CD-ROM. The text of the first edition was made available in 1987 [8].

Nowadays there are a lot of modern technologies in electronic lexicography: speech synthesis technology, cross-referencing between dictionary modules, spell-checking functions and etc. [9–11].

The increasing availability of online information has necessitated intensive research in the area of automatic text summarization within the Natural Language Processing (NLP) community. Over the past half a century the problem has been investigated by applied linguistics and addressed from many different perspectives in varying domains and using various paradigms. The subfield of summarization has been investigated by the NLP community for nearly the last half century. Dragomir R. Radev defines a summary as "a text that is produced from one or more texts, that conveys important information in the original text(s), and that is no longer than half of the original text(s) and usually significantly less than that" [12]. Belarusian scientists are also interested in the development of NLP systems. The example of such a system with possibility of translation is TRT [13]. The linguistic base date of the system includes electronic dictionary with semantic codes. This approach makes possible to precisely define semantic functions of the text keywords that are situated in parsing groups and allows the automatic system to avoid typical mistakes [14]. The main part of TRT linguistic database (LD) is an alphabetical-frequency dictionary with semantic codes. It was used as a base for the creation of the electronic English-Belarusian-Russian dictionary. This is the project of the 2<sup>nd</sup> English Department and the Department of Software for Information Systems and Technologies of Belarusian National Technical University.

## Research objectives

The objective of this research is to develop an electronic English-Belarusian-Russian dictionary for helping students to accurately identify the meaning of a word in a short period of time. The research focuses on the following aspects:

- 1) to create LD for the dictionary using English periodicals;
- 2) to develop a software for the dictionary;
- 3) to evaluate the suitability of the dictionary for the students of Belarusian National Technical University on specialty "Informatics" with textbook "English. Computer Engineering" [15] and specialties "Information systems and technolo-

gies”, “Information technology software” with textbooks “The art of unit testing” [16].

### The methodology of a linguistic database development

For the creating of LD for our electronic dictionary, the selection and description of informatics terminology in English, Belarusian and Russian languages was done. Afterwards the comparison of these descriptions and the harmonization of terminological systems of the above-mentioned languages were carried out. At the first stage, we selected and analyzed 30 scientific and technical English articles taken from periodicals “International Journal of Innovative Research in Computer and Communication Engineering”, “Journal of Computer Engineering & Information Technology”, “Journal of Applied & Computational Mathematics”, “American Journal of Computer Science and Information Technology”, “Journal of Informatics and Data Mining”. As a result, 7000 terms were selected for dictionary LB. In the total number of terms were chosen:

- one-component terms: *frame* (англ.) – *фрэйм* (бел.) – *фрейм* (рус.); *storage* (англ.) – *захоўванне* (бел.) – *хранение* (рус.); *subset* (англ.) – *падмноства* (бел.) – *подмножество* (рус.);

- multicomponent terms: *access control* (англ.) – *кіраванне доступам* (бел.) – *управление доступом* (рус.); *information query language* (англ.) – *інфармацыйна-пошукавая мова* (бел.) – *информационно-поисковый язык* (рус.).

Since a significant part of the computer science sublanguage are abbreviations, they were also considered for inclusion in the linguistic database of the dictionary: *AIS/Alarm Indication Signal* (англ.) – *СІАС/сiгнал iндыкацыi аварыйнага стану* (бел.) – *СИАС/сигнал индикации аварийного состояния* (рус.); *BIOS/Basic Input-Output System* (англ.) – *базавая сістэма ўводу-вываду* (бел.) – *базовая система ввода-вывода* (рус.); *GUI/Graphical User Interface* (англ.) – *графічны iнтэрфейс карыстальніка* (бел.) – *графический интерфейс пользователя* (рус.); *TB/terabyte* (англ.) – *тэрабайт* (бел.) – *терабайт* (рус.). The number of abbreviations was 8 % of the total number of selected vocabulary. This is due to the presence of a large number of multi-component technical terms in innovative developments.

The results of our terminological research were placed in Excel table for further filling of English-Belarusian-Russian electronic dictionary LD. A fragment of the table is shown in Fig. 1.

	A	B	C	D	E	F	G
5742	join	1.злучэнне (операцыя рэляцыйнай алгебры); 2.	1.соединение (операция реляционной алгебры); 2.	(операцыя) уключаючае ІЛІ			
5743	journal file	часопіс, часопісны файл	журнал, журнальны файл				
5744	journalizing	журналяванне (запіс інфармацыі аб аперачыі ў	журналізацыя (запіс інфармацыі аб аперачыі ў				
5745	joystick	каардынатная ручка, "джойстык"	координатная ручка, "джойстик"				
5746	jump I	пераход, перадача кіравання	переход, передача управления				
5747	jump II	пераходзіць, выконваць пераход, перадаваць	переходить, выполнять переход, передавать				
5748	jump instruction	каманда пераходу, каманда перадачы кіравання	команда перехода, команда передачи управления				
5749	jump table	табліца пераходаў, пераключальнік	таблица переходов, переключатель				
5750	justification	выраўноўванне [выключка] радкоў	выравнивание [выключка] строк				
5751	justify	выраўноўваць	выравнивать				
5752	Karnaugh map	карта Карно	карта Карно				
5753	Kbit	кілабіт, Кбіт (1024 біта)	килобит, Кбит (1024 бита)				
5754	Kbyte	кілабайт (1024 байты)	килобайт (1024 байта)				
5755	kernel	ядро (аперачыйнай сістэмы)	ядро (операционной системы)				
5756	kernel mode	прывіляваны рэжым, рэжым ядра (аперачыйнае	привилегированный режим, режим ядра (операционной				
5757	kernel operation	аперачыйнае ядра	операция ядра				
5758	key	ключ, клавіша (клавіятуры)	ключ; клавиша (клавиатуры)				
5759	key click	пстрычка пры націску клавішы	щелчок при нажатии клавиши				
5760	key field	поле ключа; ключавое поле	поле ключа; ключевое поле				
5761	key in	друкаваць	печатать				
5762	key sorting	сартаванне па ключы	сортировка по ключу				
5763	keyboard input	увод (дадзеных) з клавіятуры; дадзеныя, якія ў	ввод (данных) с клавиатуры; данные, введенные с клавиатуры				
5764	keyboard	клавіятура	клавиатура				
5765	keyed access	доступ па ключы, ключавы доступ	доступ по ключу, ключевой доступ				
5766	keyed sequential-access method	паслядоўны метад доступу з ключамі	последовательный метод доступа с ключами				
5767	keypad	дапаможная [спецыялізаваная] клавіятура	вспомогательная [специализированная] клавиатура				
5768	keystroke	націск клавішы	нажатие клавиши				
5769	keyword parameter	ключавы параметр	ключевой параметр				
5770	keyword	ключавое слова	ключевое слово				
5771	kill	знішчыць (пра працэс); выдаляць (пра паведам	уничтожить (о процессе); удалять (о сообщении или части текста)				
5772	kit	набор, камплект	набор; комплект				
5773	kludge	варыянтны запіс (якая выкарыстоўваецца для а	вариантная запись (используемая для обхода системы контроля типов)				
5774	knowledge acquisition	збор ведаў; пабудова базы ведаў	сбор знаний; построение базы знаний				
5775	knowledge base	база ведаў	база знаний				

Fig. 1. A fragment of the Excel spreadsheet with the English-Belarusian-Russian translations

### Electronic dictionary software realization

There are two common types of modern electronic dictionary software realization. They are *web application* and *mobile application*. Both are very popular and each of them has its own advantages and disadvantages. A web application is a client-server application (the client is a browser, and the server is a web server). Data in this app is stored mainly on the server and is exchanged over the network [17, 18]. It follows that to work with a web application, the user needs access to the Internet or to the organization local network if the server is located there [19]. The main advantage of choosing the client-server application is the fact that users do not depend on the operating system, so web applications are cross-platform and number of people can use it at the same time. Also, they do not require installation on a computer, tablet or smartphone, i. e. they don't occupy a device memory unlike mobile applications. With mobile applications, the situation is different. For changing the design, making any improvements, developing additional features the user needs to download it himself from the store or another resource. The disadvantage of the client-server solution is its dependence on the network, so it can't be used offline.

The mobile application is installed on a mobile device (tablet or smartphone) by downloading from a suitable resource, afterwards the application works offline. All the data that the mobile application works with is stored on user's device. This approach makes the problem of accessibility easier than web applications do it. Another advantage of mobile applications is the user's confidence in the security of the product, because app developers make thorough checking of the proposed product for viruses. The disadvantage of mobile applications is as a rule a longer and more expensive development process than for client-server development with similar functionality [20]. It should also be noted that the mobile application is almost always in addition to the web application, i. e. the company begins with the development of a web application and only then moves to its mobile counterpart. Therefore, it was decided to use the maximum advantages of the above options and implement the web application to our electronic dictionary with the ability to work in the local

network of BNTU and its mobile counterpart for the Android operating system [21–26].

In the process of English-Belarusian-Russian technical dictionary development, a client-server application was developed. It is created in the Java programming language on the base of the architectural pattern MVC (Model-View-Controller) [27, 28]. The General architecture of the application is shown in Fig. 2.

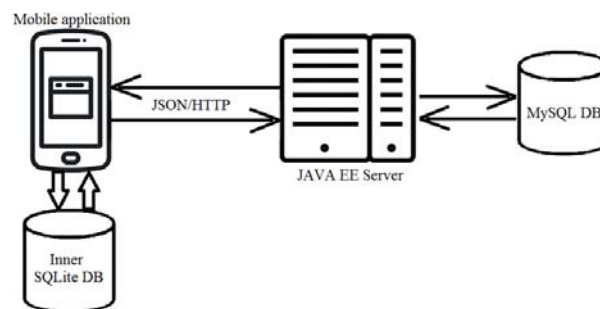


Fig. 2. General architecture of the application

The server part of the developed system contains MySQL database and JAVA EE (Enterprise Edition) server that operates with TomCat servlet container. The client part of the system contains SQLite database and a mobile application for Android operating system. To create and design the mobile application the standard tools of Android Studio development environment were used [29].

### User manual for English-Belarusian-Russian electronic dictionary TechLex

The web application of the electronic dictionary TechLex is deployed in the local network of Belarusian National Technical University [<http://172.16.11.72:4325>], which must be typed in the browser address bar from any University computer. After that, the main dictionary window will be displayed (Fig. 3).

The application interface is created in the Belarusian language. The default translation direction is “Английская мова” → “Беларуская мова”. The subject area “Information technologies” is filled with linguistic terms described above. There is a possibility to provide tabs for other subject areas: “Water Supply”, “Civil Engineering and Architecture”, “Transport Communications”, “Economics”, “Power Plant Construction” and “Pedagogy”.

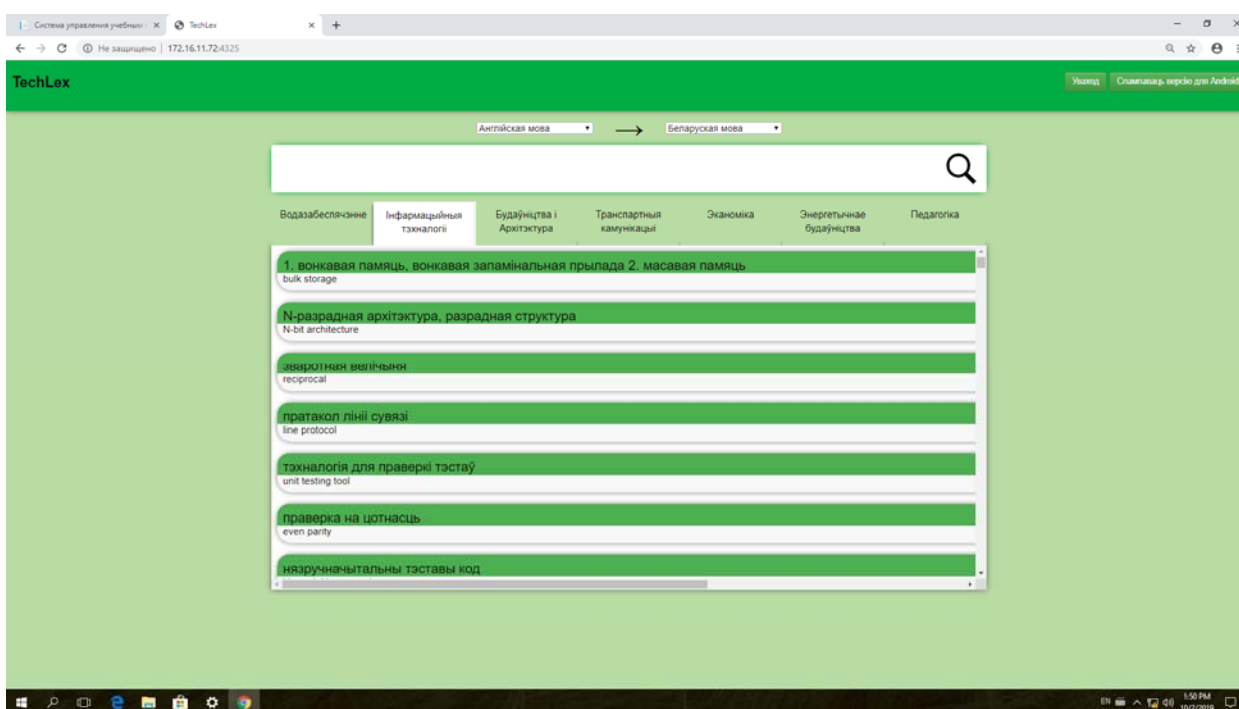


Fig. 3. The main dictionary window of TechLex

To translate word, you need to start typing it in the search field, and all the words and phrases containing the entered part will be displayed in the lines for the translated values. So Fig. 4 shows a copy screen of TechLex for the translation in the direction of “English language” → “Русская мова”

of subject area “Information technologies” for the words with syllable *buf* (the aim of a user is the word *buffer*). The results of the search are five words combinations displayed by the dictionary in the form of a list.

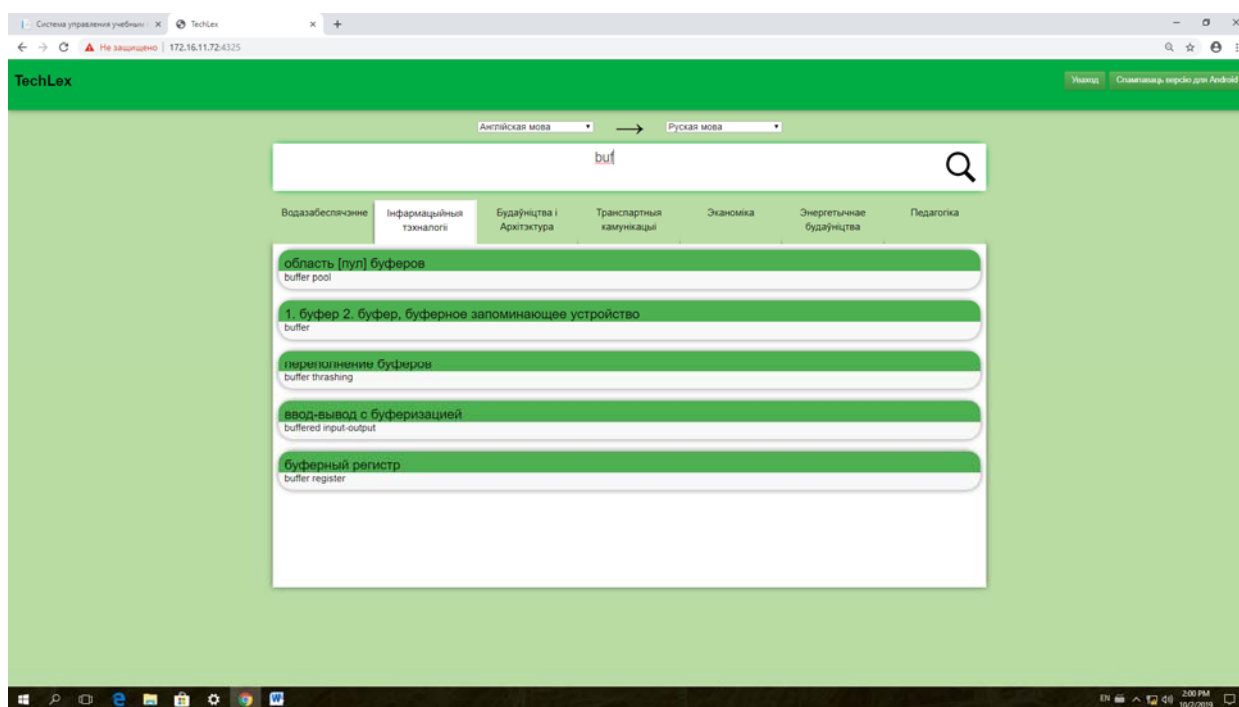


Fig. 4. Searching the translation with the part of a word

To add new words to TechLex database an administration module is provided. For this purpose, in the upper right corner of the dictionary you need to click on the button “Увайсці”. After that, the form shown in Fig. 5 will be displayed. If authentication is successful, the main page of the administration module with the ability to add, edit, delete words from LD will be displayed on the screen. If the login or password is incorrect, an error message will appear.

Fig. 5. The input form of an administration module

It should also be added that after logging into the administration module as an administrator, the user has a possibility to create, delete, and edit extra users. Clicking on the menu item “Дадаць карыстальніка” the form of adding a user is opened (Fig. 6).

Fig. 6. The form for adding a user

## CONCLUSIONS

1. Presented English-Belarusian-Russian electronic dictionary TechLex is a completely new

electronic dictionary and has the following advantages:

- the linguistic database of the dictionary is compiled not by the traditional method of processing a large number of paper dictionaries and combining the received translations, but by sequential processing of scientific and technical English-language periodicals;
- the dictionary database has the possibility of simultaneous work of several users;
- the software of the proposed electronic dictionary is designed taking into account the analysis of modern electronic multilingual translation dictionaries and is a client-server application in the Java programming language;
- the client part of the system contains a mobile application for the Android operating system, which has been tested on tablets and smartphones with different screen diagonals;
- the interface of the TechLex dictionary is designed taking into account the possibility of adding new subject areas and filling them with appropriate lexical material;
- TechLex dictionary is the first technical multilingual electronic dictionary having an English-Belarusian-Russian version.

2. Web-application and mobile version of the TechLex dictionary were tested and included in the educational process of students on the specialty 1-080101-07 “Professional training (Informatics)” (Engineering and Pedagogical Department) for the discipline “Foreign language (English)” (Act approved at the meeting of the 2<sup>nd</sup> English Department, 30.08.2019, Protocol No 1) and the students on specialties 1-40 05 01 “Information Systems and Technologies”, 1-40 01 01 “Information Technologies Software” for the disciplines “Software Testing and Debugging” and “Software Reliability” (Act approved at the meeting of Information Systems and Technologies Software Department, 22.05.2019, Protocol No 11). In the future, it is planned to connect the training component to the electronic dictionary with the possibility of using it in Learning Management Systems [30].

## REFERENCES

1. Nesi H. (2009) Dictionaries in Electronic Form. *The Oxford History of English Lexicography*. Oxford University Press, 458–478.



2. Stein J. (ed.) (1967) *Random House Dictionary of the English Language*. New York, Random House. 2059.
3. Hoboken N. J., Washington D. C. (2012) *Houghton Mifflin Harcourt Acquires Award-Winning Culinary Program, Webster's New World Reference Titles and Cliffs Notes Guides from John Wiley & Sons*. Available at: <https://www.wiley.com/WileyCDA/PressRelease/pressReleaseId-106123.html>.
4. Cowie A. P. (ed.) (2009) *The Oxford History of English Lexicography Oxford*. Oxford University Press, 458–478.
5. De Schryver G. (2003) Lexicographers' Dreams in the Electronic Dictionary Age. *International Journal of Lexicography*, 16 (2), 143–199. <https://doi.org/10.1093/ijl/16.2.143>.
6. Dodd S. (1989) Lexicomputing and the Dictionary of the Future. *Lexicographers and their Works*. Exeter, University of Exeter Press, 83–93.
7. Tsai C. Y. (2004) Oxford Phrasebuilder Genie. *International Journal of Lexicography*, 17 (2), 223–230. <https://doi.org/10.1093/ijl/17.2.223>.
8. Tsai C. Y. (2002). CIDE on CD. *International Journal of Lexicography*, 15 (4), 307–322. <https://doi.org/10.1093/ijl/15.4.307>.
9. Casio Evolution in Electronic Lexicography (電子辞書、気が付けばカシオの独壇場) // Casio Electronic Dictionaries. Available at: <https://toyokeizai.net/articles/-/57340>.
10. Chen Y. (2010) Dictionary Use and EFL Learning: a Contrastive Study of Pocket Electronic Dictionaries and Paper Dictionaries. *International Journal of Lexicography*, 23 (3), 275–306. <https://doi.org/10.1093/ijl/ecq013>.
11. Lew R. (2011) Online Dictionaries of English. *E-Lexicography: the Internet, Digital Initiatives and Lexicography*. London/New York, Continuum, 230–250.
12. Radev D., Jing H., Stys M. (2004) Centroid-Based Summarization of Multiple Documents. *Information Processing and Management*, 40 (6), 919–938. <https://doi.org/10.1016/j.ipm.2003.10.006>.
13. Makarych M. (2012) *Automatic Text Summarization System*. Germany: LAP LAMBERT Academic Publishing. 145.
14. Makarych M. (2016) Modern Approach in Natural Language Processing Systems for Summarization. *Collection of Proceeding XVI Scientific Conferences "Linguistic and Cultural Traditions and Innovations"*. Tomsk, TPU, 303–307.
15. Makarych M. V., Pytko V. V. (2019) *English. Computer Engineering*. Minsk, Vysheyshaya Shkola Publ. 167 (in Russian).
16. Osherove R. (2014) *The Art of Unit Testing*. USA: Manning Publications Co. 261.
17. Benatallah B., Casati F. (2004) Web Service Conversation Modeling: a Cornerstone for E-Business Automation. *IEEE Internet Computing*, 8 (1), 46–54. <https://doi.org/10.1109/mic.2004.1260703>.
18. Dustdar S., Schreiner W. (2005) A Survey on Web Services Composition. *International Journal of Web and Grid Services*, (1), 1–30. <https://doi.org/10.1504/ijwgs.2005.007545>.
19. Preuner G., Schrefl M. (2002) Integration of Web Services into Workflows Through a Multilevel Schema Architecture. *Proceedings Fourth IEEE International Workshop on Advanced Issues of E-Commerce and Web-Based Information Systems (WECWIS 2002)*. <https://doi.org/10.1109/wecwis.2002.1021241>.
20. Sturgis H. E., Mitchell E. (2005) Separating Data from Function in a Distributed File System. *Massachusetts Institute of Technology & Software Patent Institute Overview*, (20).
21. Popova Y. B., Makarych M. V., Shved M. O. (2019) Mobile Application for English-Belarusian-Russian Technical Dictionary. *Tearetychnyya i Prykladnyya Aspekty Etnalagichnykh Dasledavannyau: Zbornik Navukovykh Artykulau* [Theoretical and Practical Aspects of Ethnological Research: Collection of Scientific Papers]. Minsk, BNTU, 426–433.
22. Makarych M. V., Popova Y. B., Shved M. O. (2018) Linguistic Database and Software of the English-Belarusian-Russian Dictionary of Technical Terms. *Sistemnyi Analiz i Prikladnaya Informatika = System Analysis and Applied Information Science*, (4), 74–82. <https://doi.org/10.21122/2309-4923-2018-4-74-82> (in Russian).
23. Shved M. O., Popova Y. B. (2019) Mobile Application for the English-Belarusian-Russian Dictionary of Technical Terms. *Informatsionnye Tekhnologii i Sistemy: Problemy, Metody, Resheniya (ITS-2018): Respublik. Nauch.-Tekhn. Konf., Minsk, 22–23 Noyab. 2018 g.: Sb. Materialov i Dokladov* [Information Technologies and Systems: Problems, Methods, Solutions (ITS-2018): Republican Scientific and Technical Conference, Minsk, Nov. 22–23, 2018: Collection of Materials and Reports]. Minsk, Chetyre Chetverti Publ., 207–210 (in Russian).
24. Shved M. O. (2019) Software Implementation of a Mobile Application for the English-Belarusian-Russian Dictionary of Technical Terms. *Materialy 75-i Studencheskoi Nauch.-Tekhn. Konf.* [Materials of the 75<sup>th</sup> Student Scientific and Technical Conference]. Available at: [http://static.bntu.by/bntu/news/2019/fitr/SNTK2019\\_FITR.pdf](http://static.bntu.by/bntu/news/2019/fitr/SNTK2019_FITR.pdf) (in Russian).
25. Shved M. O., Popova Y. B., Makarych M. V. (2019) Features of the Mobile Application for the English-Belarusian-Russian Dictionary of Technical Terms. *VIII Forum Vuzov Inzhenerno-Tekhnologicheskogo Profilya Soyuznogo Gosudarstva: Sb. Materialov, Minsk, 29 Okt. – 1 Noyab. 2019 g.* [VIII Forum of Universities of Engineering and Technology Profile of the Union State: Collection of Materials, Minsk, Oct. 29 – Nov. 1, 2019]. Minsk, BNTU, 132–135 (in Russian).
26. Shved M. O., Popova Y. B., Makarych M. V. TechLex Linguistic and Electronic Dictionary Software. *VII Mezhdunar. Nauch.-Tekhn. Internet-Konf. "Informatsionnye Tekhnologii v Obrazovanii, Nauke i Proizvodstve", 16–17 Noyab. 2019 goda, Minsk, Belarus'* [VII International Scientific and Technical Internet Conference "Information Technologies in Education, Science and Production", Nov. 16–17, 2019, Minsk, Belarus]. Minsk, BNTU. Available at: <https://rep.bntu.by/handle/data/68247> (in Russian).
27. *Learn Java Programming. The Definitive Guide*. Available at: <https://www.programiz.com/java-programming>.
28. *Design Patterns – MVC Pattern*. Available at: [https://www.tutorialspoint.com/design\\_pattern/mvc\\_pattern.htm](https://www.tutorialspoint.com/design_pattern/mvc_pattern.htm).
29. *Android Studio*. Available at: <https://developer.android.com/studio>.
30. Popova Y. B. (2016) Classification of Learning Management Systems. *Sistemnyi Analiz i Prikladnaya Informatika = System Analysis and Applied Information Science*, (3), 51–58 (in Russian).

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