ISSN 2224-087X. Електроніка та інформаційні технології. 2021. Випуск 15. С. 3–15
Electronics and information technologies. 2021. Issue 15. P. 3–15

ІНФОРМАЦІЙНІ ТЕХНОЛОГІЇ В НАУКОВИХ ДОСЛІДЖЕННЯХ

УДК 621.38 DOI: https://doi.org/10.30970/eli.15.1

EFFECTIVE MIND MAPPING AND ITS IMPLEMENTATION USING NoSQL DATABASE TECHNOLOGIES

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In the course of daily activities, modern man is surrounded by a large amount of information of varying priority and complexity. Based on this, it is necessary to provide an effective tool for organizing user's personal knowledge. So-called mind maps (mind mapping) are used to work with personal information, its systematization, as well as presentation in the most appropriate, individual and user-friendly form.

The use of mind maps is a technique of visualizing thinking, with help of which it is possible to process some information better and more efficiently.

In this paper we consider in more detail the technique of mind mapping, its popularity, analyze advantages of its use in certain conditions. We also define a formal model of knowledge representation in digital format, which can be used to represent and digitize all the necessary categories of personal knowledge, describe and implement our own desktop prototype of effective user knowledge management tool (personal knowledge organization system) and consider NoSQL database technology as a basis for storing and processing information, its benefits in terms of development and prospects for further modernization of the product and mind mapping technique in general.

Keywords: mind mapping, information visualization and systematization, databases, NoSQL databases.

Overview

Introduced and trademarked by Tony Buzan [3], mind maps provide an easy-to-understand, hierarchical, tree-like structure. Labeled branches and sub-branches are drawn extending from a single central node [9]. In its classic form, this technology can be used for purposes such as:

- A tool for easy memorization of large amounts of information. Mind maps allow user to place elements that represent individual knowledge in the appropriate positions, linking them to relationships of various kinds. Thus, looking at the map, user immediately gets a complete view of things.
- It is an effective tool for analyzing information. By drawing a map and building connections between components, user can discover previously hidden details. Thus, mind map provides a better understanding of the subject area for which it is created, is useful in decision-making, and also helps to find non-standard solutions and ideas.

- It can be used by several users at the same time, such as collaborative mind mapping that allows to solve tasks or analyze a specific problem. In addition, they provide an opportunity to conduct effective brainstorming, share ideas and results [8].
- Tools of this kind can be used as regular data warehouses for documents or other important files. In addition, storing data in this format will allow user to easily find useful information in a short time.

In this paper, we describe a tool for managing a user's personal knowledge using mind maps. New knowledge derives from the combination of information, either the juxtaposition of existing information, or the addition of new information to existing knowledge [1]. To improve the efficiency of working with knowledge, it is advisable to provide a quality tool for their storage, processing and systematization. Based on this, we can position our tool as a personal knowledge organization system.

It will also be useful to allow user to use it as a powerful knowledge management system and information in that case can be interesting to user and it is important to maintain relationships between individual knowledge components, or it can be used as a simple data bank or storage device that may not always contain useful information. This is an option that our tool contains as well, because the combination of the work with both knowledge and user information brings personal knowledge organization system to a new level, offering a more versatile solution.

As part of our tool, mind maps are used as the main instrument for storing, analyzing and visualizing of the information. We chose a NoSQL database technology to implement backend part of a tool. A graph data representation model mostly supported by this database type is used to represent user knowledge and perfectly fits in general idea that will be described later.

The main goal of this paper is creation of a personal knowledge organization system based on NoSQL database, which serves as a tool appropriate to the user's style of working with information, which solves modern problems of volume and complexity of information, helps to connect and organize personal knowledge, analyze and effectively work with them, presenting data in a convenient way.

A data representation model

When forming a model, it is important to remember that not all knowledge can be used to work in a personal knowledge organization system. Knowledge is typically divided into two types: tacit and explicit. Tacit knowledge is difficult to articulate and it cannot be converted into words easily. Explicit knowledge is the content captured and stored in tangible forms such as words, audio or video recording, images etc. Examples of explicit knowledge may be customer feedbacks, customer reactions, e-mail conversation, frequently asked questions, weak signals leading to innovation [7].

In the case of using the program as a tool for organizing knowledge, it makes no sense to store all user's knowledge, because how difficult it is to single out some really useful facts. This will complicate the work process with the tool. Therefore, in our opinion, it is necessary to work with user through a certain interface, which will allow him to separate and use only the necessary and useful knowledge. Thus, looking at the created map, user will remember what real knowledge is hidden behind its components and for what purpose they were created [2].

The most appropriate model of knowledge representation is the semantic model. Using such model allows us to consider a user's personal knowledge as an oriented graph, in which vertices are individual records, and edges describe the relationships between records. Thus, this view is closest to the model of the human brain. When building a mind map, we activate various abilities of thinking. When composing branches and keywords, we use hierarchies, for pictures - visualization and associative thinking, in general, we use spatial-figurative thinking. All this activates memory and allows to remember both the data structure and their important aspects.

In a personal knowledge organization system, the information space is flow on workspace on which user can place records. Records are represented by moving elements that can be moved around the workspace. The user can add links between individual records, thus linking knowledge and facts. We propose to use a general model of records that does not burden user workstyle and offers him the following types of records and capabilities.

We present the existing model that reflects the structure of the record in the personal knowledge organization system as a model described by formula N in the form of the following tuple:

$$N = <R, T, D>, \quad (1)$$

where R is an element that represents a generalized record in a personal knowledge organization system, T is the type of the corresponding record R, D is the information carriers of the record R. Lets consider in more detail the set of types T, which is directly used to separate records and consists of ten elements, presented as follows:

$$T = <\text{Person, Group, Project, Doc, Link, Media, Picture, Plan, Important, Other}>, \quad (2)$$

where «Person» - knowledge directly related to a particular person, «Group - a set of several related records «Person», «Project» - a project to which the record relates, «Document» - various kinds of documentation, «Link» - a reference to another record, or information in Internet, «Media» - media resource (-video, -audio, and other multimedia files), «Picture» - digital image, «Plan» - user-planned event, «Important» - another important thing, directly defined by the user, «Other» - secondary and other types of information , which cannot be represented by the already mentioned types. In turn, the element D can be considered a carrier of information type T used in record R, and represented as a set of utilities for storing and presenting this information:

$$D = <\text{Files, Plan List, Date List, Text, Link}>, \quad (3)$$

where «Files» are user-added files, «Plan List» is a list of scheduled events, «Date List» is a list of important dates, «Text» is arbitrary text information, and «Link» is a link to another record or information on the Internet. The described formula of the record structure model (1) is graphically presented in Fig. 1:

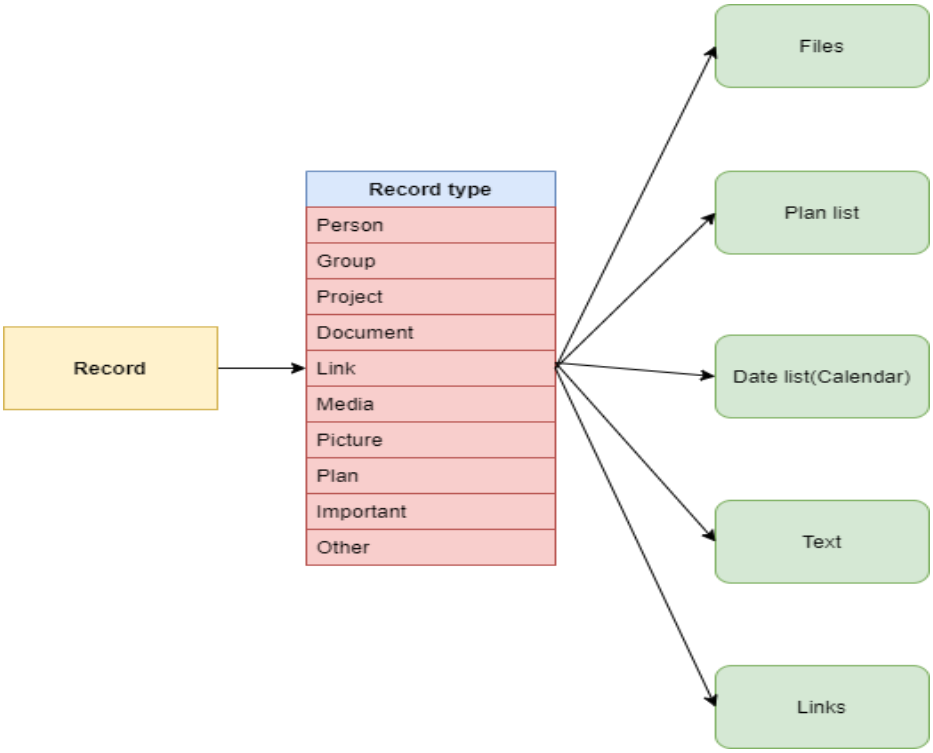

Fig. 1. A model that represents a structure of a record in personal knowledge organization system.

As shown in Figure 1, we can represent and digitize all the necessary categories of personal knowledge, as well as additional files and documents. Each entry has its own unique identifier and can be arbitrarily placed on the canvas, which simplifies both search and presentation.

There are three main types of connections we propose to use to link individual records or facts in a personal knowledge organization system:

- strong - strong connection. Records and facts are intertwined;
- medium - moderate communication. Records and facts are related in a moderate relationship;
- weak - weak connection. Records and facts are linked by weak relationships.

Thus, when adding records and links between them, user forms a graph, vertices of which are represented by records themselves, and the relationship between them is associated with links of different types of complexity. Using connections of different strength together with the general principle of building a mind map helps user to better understand the essence of things. Some connections that come to the fore may lose their relevance over time, or they may need

to be removed. To do this, it is best to change the type of connection, instead of deleting or rearranging the map. It should be noted that joints may also have a name and additional properties to improve flexibility of the map.

Another important component of the software interface of a personal knowledge organization system is search. According to Fig. 2, the search should be carried out according to three main criteria:

- search by record. When searching for an entry, user must enter a name or part of the entry name. If the result is positive, the corresponding entry will be highlighted on canvas and in the appropriate menu;
- file search. When searching for a file, user must enter a name or part of a file name. This search first displays an entry that contains a file (or files) with similar criteria, and then selects the found files;
- text search. Text search is similar to file search. User needs to enter a snippet of text that he associates with some entry. When a match is found, the program displays the record to which the text belongs or contains.

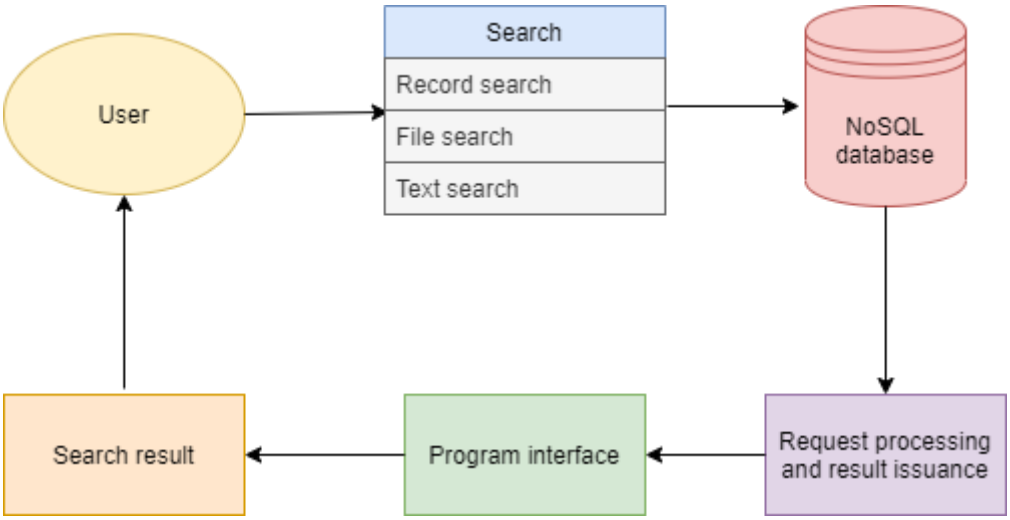

Fig. 2. A search process of personal knowledge organization system.

When working with data, it is important to provide the ability to freely modify the application workspace, namely add/modify records, move them arbitrarily, scale records according to their needs, and always have a complete view of mind map for analysis. So, at the output we get a personal knowledge organization system, with which user can work, as well as modify. Based on this, our tool must meet the requirements of Knowledge Mapping Software [9]:

- Simple Editing: Adding or modifying items without additional interaction needed.
- Connecting External Content (e.g., local files or remote Web pages).
- Focus / Filter: deliberately narrowing down visibility to the essential.

- Integration of Detail and Context through smooth and steady zooming, overview functions, levels of detail.
- Interoperability with other related tools.

Database choice and implementation

Much of the system's work falls on the storage and processing of large amounts of personal data of users. To ensure stable operation of the personal knowledge organization system, it is necessary to deploy it on a reliable platform.

In general, this choice was influenced by the fact that NoSQL systems meet the following requirements necessary for the deployment and maintenance of the system:

- Databases of this type provide a flexible schema, allowing us to store large amounts of poorly structured data. If during the lifecycle there is a need to add a new type or data or attribute - this can be done without changing the structure of the database, all we need is update the application code, if necessary [5].
- The property of horizontal scaling - to increase efficiency it is enough to simply increase the number of server nodes [4].
- Speed - we have some specific types of models and we can optimize them to work with one or another data structure that fits our needs. For the variant with the personal knowledge organization system it is suitable to use several data models in a complex.
- Availability – with sharing and replication processes we get high availability and fault tolerance that in our case is also important.
- NoSQL databases often offer a trade-off by easing the stringent requirements of ACID properties for a more flexible data model that allows for horizontal scaling described before.

The data model used by the system is a graph. A graph model is a network structure consisting of vertices (also known as nodes) connected by edges. The best use of graph database is when stored information can be represented in the form of a graph with interlinked elements, for example, social networking, road maps or transport routes [6]. Graph repositories allow applications to efficiently execute queries that pass through a network of nodes and edges, as well as analyze relationships between entities and execute appropriate queries. This principle corresponds to the data structure of the personal knowledge organization system. Figure 3 shows a model that represents how personal knowledge and information will be digitized. We can also represent this model in the form of the following formula:

$$S = \langle ID, Name, Type, Data \rangle, \quad (4)$$

where «ID» is the unique identifier of the record in the non-relational database, «Name» is the user-specified record name, «Type» is one of the ten record types (2), «Data» represents texts, file lists, plan lists, date lists, links, position as the attached user information that matches a certain type.

Fig. 3. A model representing digitalized personal knowledge.

The graphical model is represented by the concept of the property graph, which defines the following:

- Vertex - an object that can be associated with other vertices and has the following mandatory properties:
  - unique identifier;
  - a set of input edges;
  - a set of output edges.
- An edge is an object that connects two vertices and has the following mandatory properties:
  - unique identifier;
  - reference to the input vertex (head);
  - reference to the source vertex (tail);
  - a label that identifies the type of connection / relationship.

Most of NoSQL databases allows us to define our own properties for any object with a large and sufficient set of data types that can be placed on canvas. This gives great flexibility and allows us to translate user's knowledge into digital form. Representing data in this way, in the NoSQL database they are easy to store, perform various operations and systematization.

Interaction with the system – mind mapping

The most common practical application of a personal knowledge organization system may be its use for compiling and analyzing mind maps. The essence of mind map: it is as voluminous as possible to reveal a specific issue [10].

The mind map reflects the system of the human brain, his consciousness and imagination.

In Fig. 4 shows an example scheme of a simple mid map that user can create, for example as a student. According to this, he should first determine which question he are interested in, which concept he would like to reveal more deeply. Suppose a user wants to create a personal mind map to manage and analyze his personal information. To do this, he need to choose a central word or concept around which other information will grow. As shown in Figure 4, such a central object is a record called "Me". Since the user creates a mind map with his personal information and plans, such choice would be quite appropriate. After selecting the central object and defining it, he can move on to the objects (personal knowledge) of the second level.

The principles of choosing the second level objects can be completely different. But, if user tries to highlight the general rules, he should look for concepts that are most clearly associated with his central image. According to Fig. 4, such records are "Friends", "Plans" and "Studies". He can use other expressions, most importantly to keep track of the connection to the main record. In a personal knowledge organization system, user has the ability to establish connections of three types: strong, moderate, weak. This further expands the capabilities of the mind map, giving more detailed explanations and allowing for more in-depth analysis.

After defining the second level records, user can view each branch and continue it as much as he wants.

It is necessary to ensure that do not deviate from the main topic. In Fig. 4 shows that the records coming from the object "Friends" are three "Names", which can be understood as individuals. One of the features of the tool is that each record can be one of eleven types: person, group, project, document, link, media, picture, plan, important and other. The entry "Me" can be defined as "person", "Friends" - "group" and so on. That’s why friends are joined by a "Meeting" entry.

In addition to identifying and linking records, user can add files, text, to-do list, reminder date list, and links to each record.

The example shown in Fig. 4 represents how we can use a personal knowledge organization system. By looking at the map created by user, we immediately get a complete picture of his personal information and knowledge. After analyzing a set of interrelated records (keys), seeing which ones, user will remember for what purpose they were created and what knowledge is associated with them.

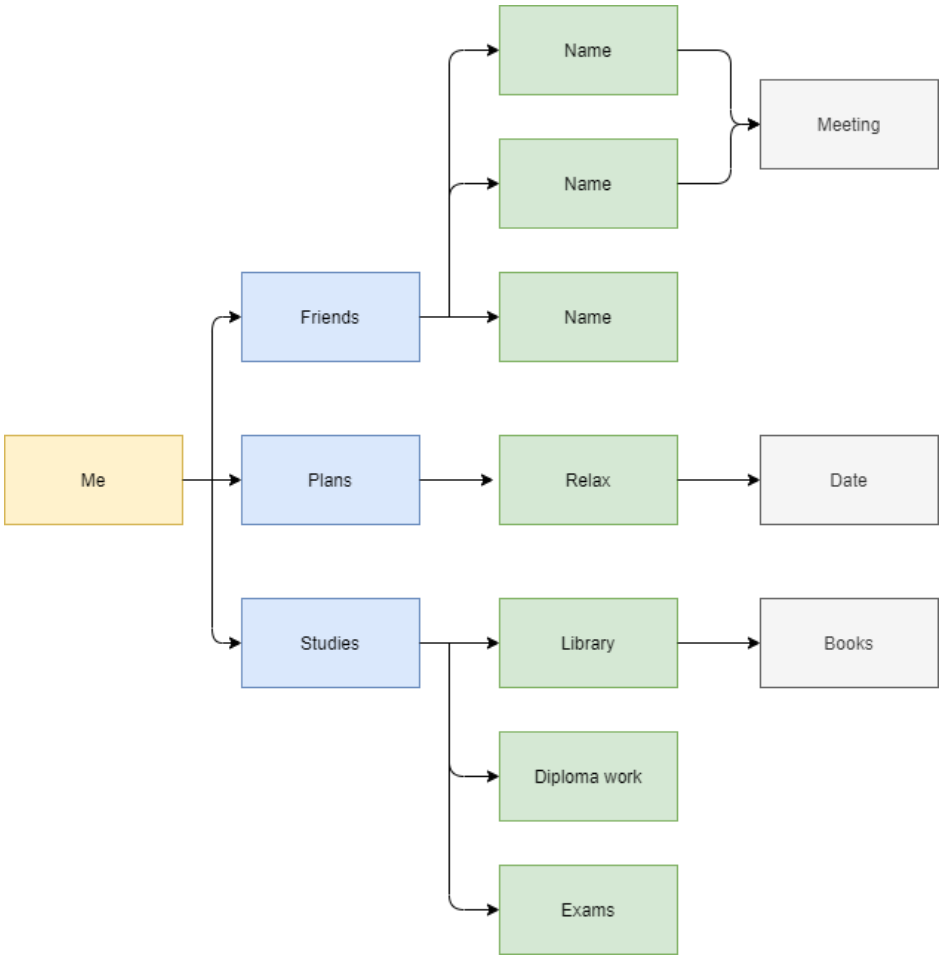

Fig. 4. Example-scheme of a simple mind map of user personal data.

Result

Structure of personal knowledge organization system is shown in Fig. 5. As can be seen from it, the main elements can be represented in two client groups: the actual user interface through which all the interactions are processing, the information processing unit, which actually deals with the conversion of personal knowledge into digital, manages system components and operates database queries. On the remote part there is only the database itself and the authorization system. This model allows us to focus exclusively on database support, without burdening us with technical limitations and calculations - they are carried out on the client side.

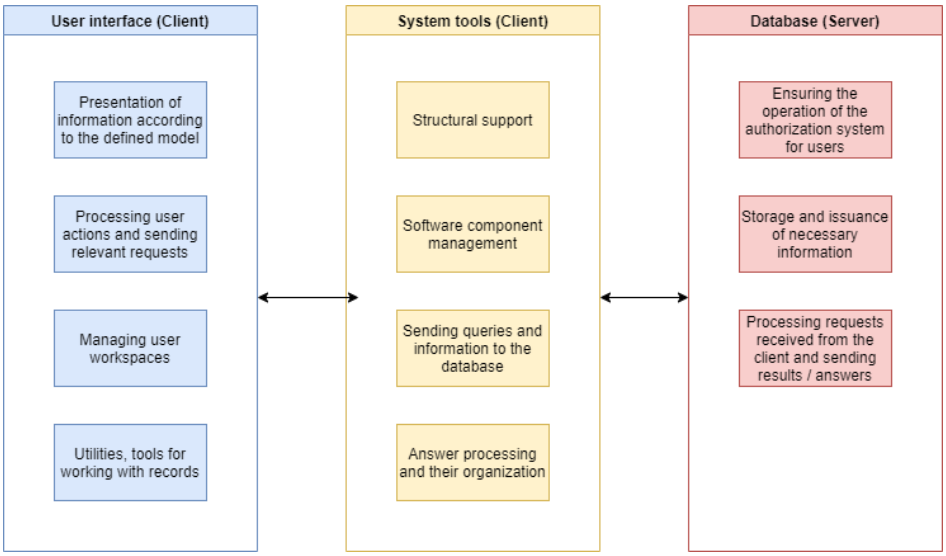

Fig. 5. A structure of personal knowledge organization system.

In Fig. 6 shows what the main canvas of the personal knowledge organization system looks like. As we can see, user can create and work with multiple maps at once using the desktop function. The area where he can place records, as well as their number and content - is unlimited, which corresponds to one of the principles of building a mind map.

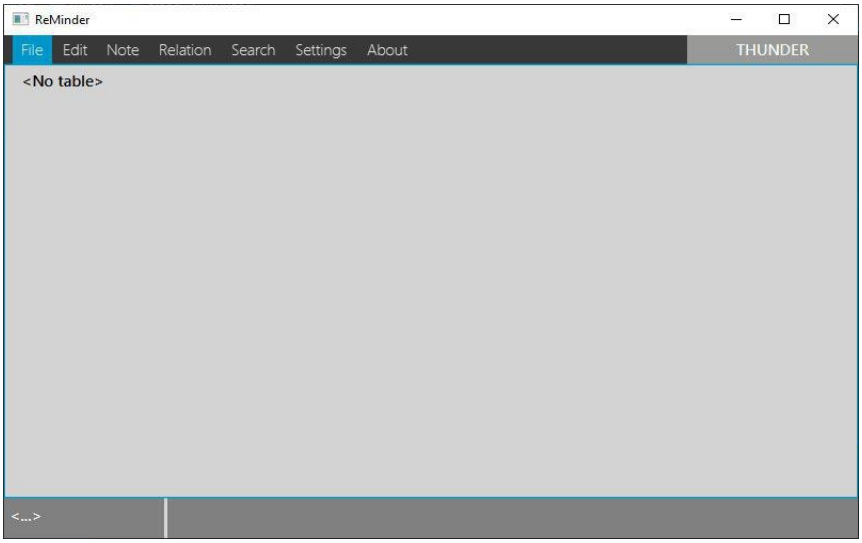

Fig. 6. The main canvas of personal knowledge organization system.

In Fig. 7 shows an already constructed map example, according to Fig. 4. In this case we have a simple person map serving as a reminder.

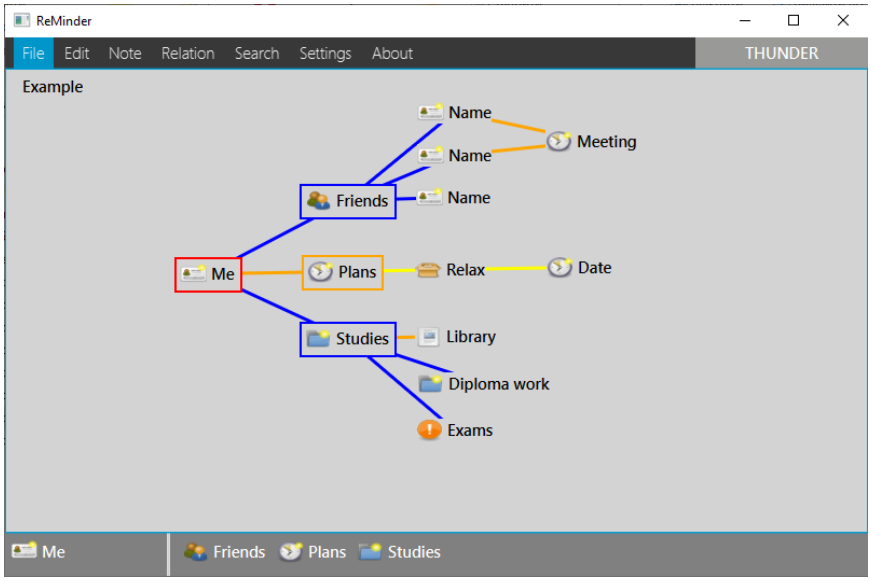

Fig. 7. Example of mind map creation shown in Figure 4.

This method can be used in absolutely any field of activity. This is due to the fact that the personal system of knowledge organization is just a way, i.e. is a tool. Having got used to construction of such cards, user will be able to decompose any concept into components. Among the main use cases of the system are the following:

- analyzing an issues;
- plans creation;
- analyzing and systematization of information;
- brainstorming, group thinking, etc.

When using the system, keep in mind that where there are many pros, there are also many cons. Using the system for the first time requires more time to adapt and build the structure. Also, you need to know the measure in mind map creation. A lot of ideas can be generated when mind mapping, and if one does not take charge of the process, this can lead to an unduly large and populated mind map. Reading such poorly constructed mind maps can be very confusing. Another disadvantage of the system is the availability only on desktop platforms, but in the future this problem can be fixed by launching the platform as a web service.

Conclusion

In this paper, we considered the method of mind mapping, the basic principles of construction, benefits and methods of its application. A formal model of knowledge representation in digital format is proposed, which can be used to represent and digitize all the

necessary categories of personal knowledge, as well as additional files and documents. Based on this, we have proposed a prototype solution with its own interface for presenting and digitizing the personal user knowledge, in order to increase efficiency of his work with acquired and surrounding information. In addition, we have identified the main benefits of using non-relational databases for this purpose.

The result of the paper is creation of a personal knowledge organization system based on NoSQL database technology, which serves as a tool appropriate to user's style of working with information, which solves modern problems of volume and complexity of information, helps to connect and organize personal knowledge, analyze and effectively work with them, presenting data in a convenient way, generate new ideas from the user and helping him to organize his workflow and search for the necessary information.

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ЕФЕКТИВНИЙ MIND MAPPING ТА ЙОГО РЕАЛІЗАЦІЯ ЗА ДОПОМОГОЮ ТЕХНОЛОГІЙ NoSQL БАЗ ДАНИХ

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Сучасна людина в процесі своєї діяльності оточена величезною кількістю різноманітної інформації, як корисної, так і ні. Так звані інтелектуальні карти (mind-mapping) використовуються для ефективної роботи з цією інформацією, її систематизацією, а також подання у найбільш підходящому для користувача форматі.

Використання інтелектуальних карт - це техніка візуалізації мислення, за допомогою якої можна аналізувати деяку інформацію краще та ефективніше.

У цій роботі ми більш детально розглядаємо техніку інтелектуальних карт, її популярність, аналізуємо переваги її використання в різних умовах. Ми також описали та реалізували наш власний прототип ефективного інструменту для управління знаннями користувача (система організації персональних знань), побудованого на принципі використання інтелектуальних карт, а також розглядаємо технологію баз даних NoSQL, як основу для зберігання та обробки інформації, її переваги з точки зору розвитку системи, а також техніки інтелектуальних карт в цілому. Ми також представили свій інтуїтивно зрозумілий інтерфейс, через який користувач матиме змогу ефективно взаємодіяти з системою.

Результатом роботи було створення персональної системи організації знань на базі даних NoSQL OrientDB, яка служить інструментом, що допомагає організовувати особисті знання користувача, аналізувати та ефективно працювати з ними, представляючи дані у вигляді графу. Використання такої моделі дозволяє розглядати особисті знання людини як орієнтований граф, в якому вершини є окремими записами, а ребра описують взаємозв'язки між ними.

Окрім цього, в роботі приведено приклад застосування системи, будуючи просту інтелектуальну карту з різними типами зв’язку.

Ключові слова: інтелектуальні карти, візуалізація та систематизація інформації, бази даних, бази даних NoSQL.

Стаття: надійшла до редакції *02.06.2021,*
доопрацьована *15.06.2021,*
прийнята до друку *18.06.2021*