



25th DAAAM International Symposium on Intelligent Manufacturing and Automation, DAAAM
2014

The Representation of Database Content and Structure Using the NOK Method

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Abstract

This paper presents research results on transformation of database structure and its content into new representation by using the Node of knowledge method (NOK method). It describes the way an Entity-relationship model and its relational database can be transformed into a NOK model. The rules that enable this transformation of entity-relationship concepts into NOK concepts are defined. Research results are important for future development of an intelligent information system.

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Peer-review under responsibility of DAAAM International Vienna

Keywords: Node of knowledge; NOK method; Entity relationship; Database; Knowledge representation

1. Introduction

Language is one of the universal cognitive tools of our mind, a communication tool reflecting our visible and inner life. The semantic aspect of a word – its real meaning – is becoming one of the most fascinating issues in contemporary computational linguistics and artificial intelligence science [1].

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One of the most important fields in the area of artificial intelligence (AI) is knowledge representation (KR). Knowledge can be stored in different ways [2], [3], [4], for example by using: semantic networks [5], [6], frames [7] and ontologies [8].

The Node of knowledge method (NOK method), which belongs to a group of semantic networks, can be used for knowledge representation.

The NOK method is a method for modelling nodes of knowledge and it is used to graphically express knowledge in a form of a diagram, called Diagram of Node of knowledge (DNOK). The method is based on research and analysis of natural human languages, which is important for approaching the topic of human intelligence. NOK method analyses sentences, words and their meaning, as well as the sequence of connecting words into more complex forms [9].

The entity-relationship method, as prescribed by MIRIS - Methodology for Information Systems Development [10], [11] presents a business organization, its parts, relationships between parts and part attributes. A database is a non-redundant set of data on all occurrences of entities, all relationships and all their attributes described in database scheme [10].

Since the database structure is described by the relational model, we analysed the art of transforming database knowledge into NOK model. In this paper we will show how to present database content and database structure using the NOK method. The relational model is based on the entity-relationship diagram (ER diagram). Tables are used for the presentation of database content.

2. Research motivation

Since the early developments in the field of Artificial intelligence, there were many attempts to build an intelligent system based on natural human language (verbalised knowledge) [4]. Some methods are based on natural language processing and on saving verbalised knowledge in the knowledge database.

A few of the most significant models which store stories had been implemented in the programs like MARGIE, SAM and PAM, which are based on the Conceptual Dependency (CD) theory by Roger C. Schank. The programs SAM and PAM successfully showed that knowledge storing is important, but both programs were unable to process data out of their domain. SAM had difficulties with recognition plans and PAM had problems with understanding simple stories with events but without aims [5], [6].

We are currently working on development of an intelligent program based on NOK method. NOK method will enable saving of alternative knowledge in a way different than verbalised knowledge, i.e. knowledge in a human mind, but also in a way that is different than in other existing formalisms. This method starts from a sentence, it finds both explicit and implicit content in the sentence and then enters both of them into a knowledge network. Besides that, the method enables building of contextual knowledge and it connects knowledge contained within a sentence with the contextual knowledge. Only then a system could behave intelligently. We expect that, based on these principles, one could develop a system for the communication between humans and the knowledge network that would be able to solve Turing test [4].

The first problem that arises in the process of program development is that sentences in natural language cannot be entered into a relational database. Only data can be entered, following predefined criteria. This means that the sentences need to be split into smaller parts, i.e. phrases or words which can then be entered into the database.

Since natural language relies on contextual knowledge, sentences do not include enough knowledge and when they are transferred into a computer system, the computer does not possess the contextual knowledge that the human mind has [12], [13]. In other words, databases cannot store sentences in natural language, so our goal is to connect the database with NOK method.

The question is how to represent content and structure of a database using the NOK method.

3. Research methodology

For the purpose of research and representation of knowledge found in natural languages a new method called Node of knowledge (NOK) was developed by a group of authors [9], [14].

Its main features are simplicity, the ability to display many different types of human knowledge, the ability of automatic detection of new knowledge from existing knowledge, the ability of guided input of new knowledge and the ability of simple creation of user queries over the knowledge base [15].

The goal of the method is to enable the formation of a network of knowledge contained within a text written in any human language [9]. The method is used for the modelling of knowledge expressed by human written languages, i.e. knowledge that consists of a set of sentences that can, but do not have to be interconnected. This generality enables modelling of different types of knowledge: knowledge from dictionaries and encyclopaedia, knowledge from existing databases, knowledge from business processes, knowledge from business documents, etc. The NOK method is capable of modelling knowledge in different abstraction levels, from fact knowledge to rule based knowledge [9].







The NOK method first transforms knowledge into the model and then searches knowledge in the model. After that it is able to answer the questions [16].

In the knowledge network, we want to record the knowledge so that any reader, with or without any background knowledge, with or without the possibility of interpreting the meaning of the knowledge network, can extract the same knowledge from some knowledge network diagram (DNOK).

According to the NOK method for knowledge representation, the entire complex human knowledge represents a network of interconnected terms (DNOK). Terms are called *nodes*. The meaning of each term (node) is determined by human intelligence. The meaning of the relationships between nodes is contained in the structure of DNOK in the concept of a link between nodes. Complex human knowledge can be recorded in a diagram that is different from human language in such manner that a single term exists only once in DNOK, but it is connected as many times as needed (unlimited number of connections).

According to [14], the NOK method prescribes the use of concepts: node, link (arc), process node, context node, context link and link role. Besides these concepts, the data node, attribute process node, etc. may also be used. The concepts are shown in table 1.

Table 1. Concepts in the NOK method.

Concept	Symbol
Node	
Process node	
Link	
Context link	
Attribute process node	
Data node	

Let us present the concepts of the NOK method by using a simple example. DNOK for sentence "Iva is writing homework." is shown in figure 1. DNOK consists of two regular nodes: "Iva" and "Homework" and the process node "Is writing". Both nodes are linked with the process node. On each link, two questions that describe the link role are marked. Its role is very important during questioning of knowledge. For example, the node "Iva" and the process node "Is writing" are connected by a link with two roles "What?" and "Who?". If we ask "What Iva?", the answer is "Is writing". If we ask "Who is writing?" the answer is "Iva". The link between the process node "Is writing" and the node "Homework" acts similarly.

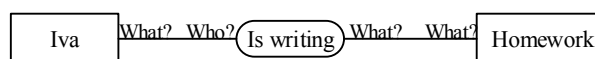


Fig.1. DNOK for the sentence "Iva is writing homework."

If two nodes on different levels are linked, the context link will use an arrow pointed to the node on a lower level [17].

4. Translation of the Entity-relationship method into the Node of knowledge method

The aim of this research was to determine whether it is possible to represent database content and database structure by using the NOK method. This task equals to finding rules for transformation of Entity-relationship method (ER method) to NOK method. This includes studying the ER method with a corresponding database and NOK method in general, but using specific examples as well.

The main hypothesis of the research is: It is possible to translate concepts of the ER method into concepts of the NOK method.

Our future goal is to develop a computer system of knowledge networks, i.e. software that can insert the knowledge from a DNOK into a computer. Each computer system has a database. A database contains the knowledge network in a relationship-based system for database management. Therefore, it is important to translate the concepts of the Entity-relationship method into appropriate NOK concepts.

The following question arises: how to connect an existing information system with its knowledge network. We will show how to connect an information system project (specifically its database part) to a knowledge network by using the NOK method. Every information system project has (or should have) a data model and a process model. The data model is usually presented by some variant of the Entity-relationship method, and the database itself by the relational method.

In order to check the hypothesis, a corresponding NOK method concept needs to be found for every ER method concept. During the reasoning process, we used different examples, starting from simple to more complex ones. One of the examples follows.

Figure 2. shows an Entity-relationship diagram of people working in an organizational unit (OU). The model encompasses data on employees' children, as well as awards received.

The entity type Person holds the data about every particular person, for example John, Maria, Thea, Frank, etc. A person works in an organizational unit. The organizational unit (OU) entity type holds the data of each particular OU (such as Sales, Research and Development, Manufacturing). The OU entity type is hierarchically organized. One person from the Person entity type works in one and only one OU. It is possible that nobody works in an OU (for example if the OU is just formed) or many people (entities) from the Person entity type can work there.

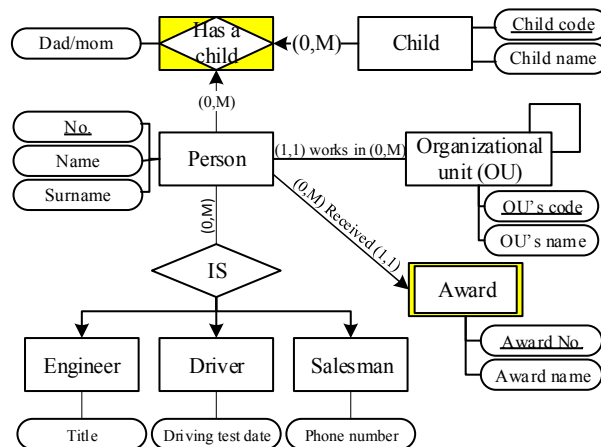


Fig.2. ER diagram Person in an organizational unit.

The weak entity type Award depends on the Person entity type. It consists of every single award received by any person. A person from the Person entity type could receive none or many awards. One single award is received by precisely one person. Engineer, Driver and Salesman entity types are subtypes of the Person entity type.

A person that is familiar with the ER method can read many different sentences based on the ER diagram shown in figure 2. and the database.

Some of the sentences that can be read from the ER diagram are:

- A person has a child.
- A person works in an organizational unit.
- Engineer, driver and salesman are persons.
- A person received an award.

In figure 3. data from the Person database is shown in a form of a DNOK.

NOK enables classification of knowledge to three levels: Language knowledge (LK), General knowledge (GK) and Working knowledge (WK) [9].

Figure 3. shows two levels of knowledge, general knowledge (GK) (above the line) and working knowledge (WK) (below the line). Above the line, a scheme in DNOK is shown, i.e. knowledge which can be interpreted from ER diagram. Below the line, a knowledge network is shown (networked process with interprocesses), i.e. knowledge obtained from data in database.

The dashed line shows the connection between NOK and ER diagram.

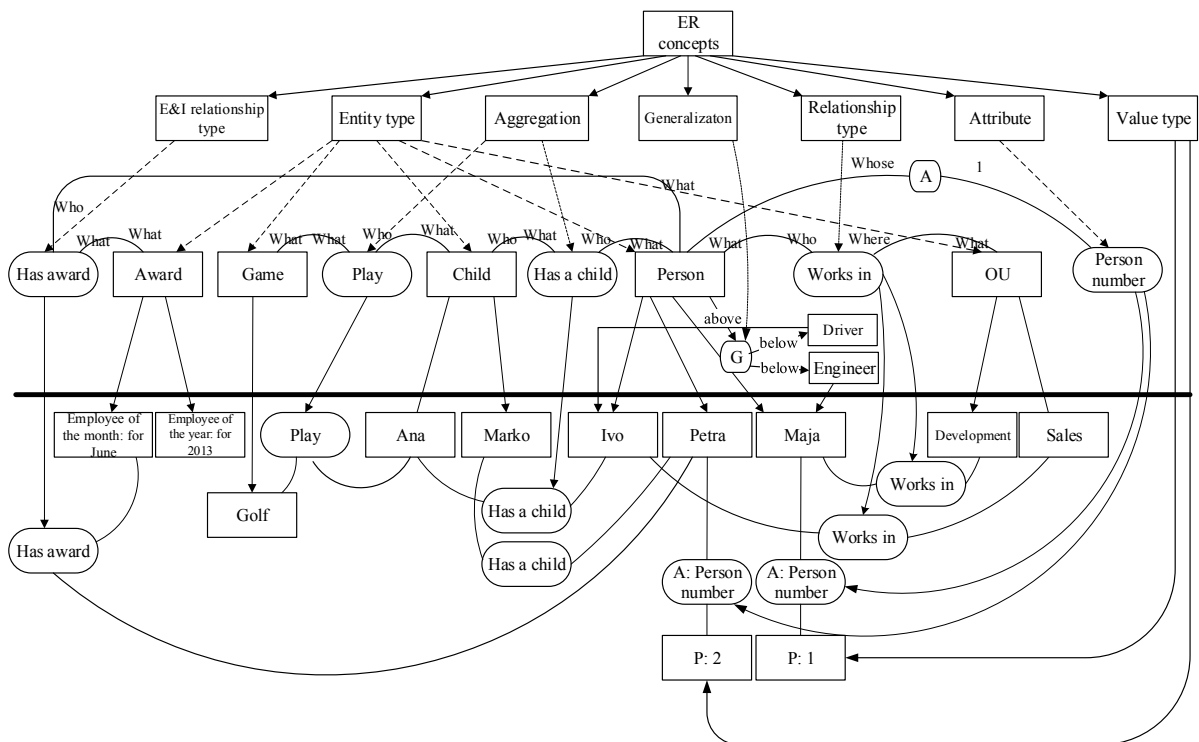


Fig.3. Sentences in DNOK.

Only a part of the figure will be explained. From ER diagram, the following sentence can be obtained: "A person works in an organizational unit." When this sentence is shown in NOK, there is a process node "Works in" and nodes "Person" and "OU". The process node "Works in" is connected to node "Person" with roles "What" and "Who", and to node "OU" with roles "Where" and "What". A concrete example on WK level, using data in database, would be "Ivo works in Sales". "Ivo" and "Sales" are nodes, "Works in" is a process node. The roles in the relationship are the same as on GK level.

Nodes "Person" and "OU" belong to concept "Entity type" on ER diagram, and "works in" belongs to "Relationship type".

Based on various examples and the application of graphical methods, method of analysis and synthesis, and abstraction, it becomes evident how to translate each ER diagram and its relational database into a knowledge network. By using abstraction on multiple levels, translation is generalized, and concepts are grouped into specific groups. General rules for the translation of a database into NOK can be deduced.

Table 2. shows the translation of the Entity-relationship method into the NOK method. Each concept of the ER method can be translated into some concept of the NOK method. For certain concepts there is no corresponding concept in the ER method. For example, Entity type and Entity are translated into Context node and Node, respectively The Question concept from NOK does not relate to any ER concept.

Table 2.ER into NOK translation.

	Entity-relationship method	Nodes of knowledge method
Node	Entity type	Context node
	Entity	Node
	Data	Data node
	Attribute	Attribute process node
Process node	Relationship	Specialized process node
	Relationship type	Specialized process node; Context process node
	Aggregation	Specialized process node, Aggregation process node
	Value	Specialized process node
	Existential and identification (E&I) relationship type	Existential and identification (E&I) process nodes
	Generalisation / Specialisation	Generalisation process node
	Preceding	Preceding process node
Link	Classification	Context link
	Role	Relationship
	Cardinality	Cardinality (on higher levels of DNOK)
	-----	Question (Role name)

Results shown in table 2, and figure 3. which shows sentences obtained from ER diagram and its relational database confirm the hypothesis. We conclude that it is possible to translate concepts of the ER method into concepts of the NOK method.

This example demonstrates the potential of the NOK method. Database content can be transformed into textual form, and the other way around. Besides that, it is possible to enrich knowledge network with new sentences that the existing database does not contain.

NOK offers a simple way of expanding its network with new knowledge. For example, after obtaining some new knowledge NOK will become richer for a sentence. New knowledge could be formed into a sentence: “Person plays game” on GK level and a sentence “Ana plays golf.” in WK level. The knowledge network could be enhanced as shown in figure 3. On the other hand, changing an ER model or a database scheme is not simple.

As prescribed by NOK, the database data is saved in a new form, in the so-called „knowledge networks“ or „DBNOK“. Software that is built upon DBNOK behaves intelligently; it can question, update and conclude based on DBNOK.

The development of such an intelligent IS will require significant further efforts.

Conclusion

This paper presents the way an Entity-relationship model and its relational database can be transformed into a NOK model. It presents the rules or transformation of ER concepts into concepts used in NOK method. By using the

NOK method, the content and the database structure are presented in the form of a NOK diagram. The set hypothesis “It is possible to translate concepts of the ER method into concepts of the NOK method“ is proven by a table of translation and diagrams which show how it is possible to get a NOK diagram based on the starting ER model and its relational database. An example of entity-relationship model is shown which, together with the data in relational database, enables obtaining sentences (knowledge) which can then be shown in DNOK.

The paper briefly described the Node of knowledge method (NOK method) which is a new method for nodes of knowledge modelling. NOK enables alternative knowledge saving in a way different from language and letter, i.e. human mind and different from existing formalisms.

We can conclude that the text composed by words can be shown in an alternative way. This fact has many implications and possible uses. We can perform many experiments and come to new understandings.

The paper has shown that it is possible to transform sentences in a way that they can be entered into a database. The table of transition was used for this purpose. Our future goal is to develop a computer system of knowledge networks, i.e. software that can insert the knowledge from a DNOK into a computer. This includes the development of a database metamodel for software, the development of various algorithms for entering data into the database, reasoning and concluding. Development of intelligent information systems based on the suggested method will require great efforts and further research.

Acknowledgements

The research has been conducted under the project "Extending the information system development methodology with artificial intelligence methods" (reference number 13.13.1.2.01.) supported by University of Rijeka (Croatia).

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