SEMANTIC NETWORK AS A FORM OF KNOWLEDGE REPRESENTATION AND KNOWLEDGE MAP*

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Knowledge engineering is a part of discipline of "artificial intelligence" and has a strong connectivity to information technologies. It includes methodological tools for artificial intelligence methods implementation in automatic knowledge processing and creating, on the other hand it is strongly restricted by requirements on standard formalization of knowledge because of its computerized processing. Increasing complexity of real world, problem situations, problems and knowledge for their solution cause, that original knowledge is more and more simplified, when its representations are constructed. Unfortunately, some crucial characteristics of knowledge are sometimes disregarded during simplification process. It may lead to arising gap between knowledge and its representation. Simplification rate is unacceptably high and knowledge "representation" is information only. Then it is sufficient to use methods of information engineering for such representation processing. The problem could be solved by application of some approaches known from a branch of systems engineering. When systems engineering as an applied systems science can introduce systems view of knowledge and its representation, it might improve quality of relationship between these two objects. The goal of this paper is to analyze standard form of knowledge representation – semantic network – from the point of view of systems engineering and its requirements on properties of knowledge object. It allows to decide and differentiate cases when the network includes knowledge and when it does not. General procedure of semantic network with knowledge content is suggested in the paper. The paper also deals with relationships between semantic networks and knowledge maps. It resumes some results of previous part of this work that have specified important properties of semantic networks as a tool for knowledge representation and defined cases, when these networks include information only. These results and adopted general definition of knowledge map have been synthesized and new specific form of well formalized knowledge map based on semantic network has been developed.

knowledge engineering; systems engineering; knowledge; knowledge representation; semantic network; elementary knowledge; knowledge map; support, topology

INTRODUCTION

Knowledge and knowledge representation

In the absence of its established definition, the term "knowledge" is at present difficult to apply. There is a prevailing opinion that knowledge defies any definition and only allows determining its qualities. For example, the following characteristics of knowledge can be found in literature:

"Knowledge is a variable mix of arranged experience, values, related information, expert opinion and substantiated intuition that constitutes the environment and framework for the evaluation and integration of new experience and information." (Gamble, Blackwell, 2001)

"Knowledge is information that has been checked through arrangement and analysis to make it intelligible and applicable for problem solution or decision-making." (Turban, 1992)

"Knowledge is information in motion." (Stuhlman, 2005)

"Knowledge is information applied in the right time at the right place in the right manner." (Folkes, 2004)

"Knowledge is the capability of a man (or an intelligent machine) to use information for problem-solving." (Havlíček, Pelikán, 2007)

Most qualifications of the term „knowledge" show the following common aspects:

– The basis of knowledge is information which is enriched, developed or transformed in some way
– Knowledge is a dynamic quality, it contains dynamics, movement, progress
– Knowledge is associated with the solving of a problem

The fact that knowledge is considered as indefinable causes problems with its representation.

It is unclear how to generally represent an object that lacks an established and recognized definition. Therefore, the relation between knowledge and its representation fits the features of Platon's parable depicting a cave in which one can only observe shadows and describe them in his mind as reflections of genuine and actual ideas. Similarly, some standard representations of knowledge known in the field of knowledge engineering are mere reflections of actual knowledge.

Systems engineering and knowledge

Systems engineering is an application discipline of systems science. The systems science represents an independent discipline which develops methods for defining

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and displaying a system and also for analyzing and optimizing the systems structure and behavior. The basic characteristic of systems science is its interdisciplinary feature, the concept of the system as a common object of examination and the systems approach as a methodology of examination. The goal of systems science is to examine the regularity of objects on a higher level of abstraction than that applied by specialized disciplines (economics, management, informatics etc.). If systems engineering as an application systems discipline is capable of introducing a system view of knowledge and its representation, the abovementioned problem of knowledge engineering can be eliminated.

The systems approach to knowledge engineering has to take two key aspects into account:

1) The feasibility of analysis down to an individual level.

Lacko (2002) alleges that every discipline studies or should study some kind of "individual" or entity – an atom, a cell, a man, a nation etc. Each of these entities behaves in some way – it undertakes an action or change – and this behavior is considered as a link to the entities' environment which enables contact or interaction between them. Therefore, such entity should also be established and defined in the area of knowledge representation.

2) A connection with the intended solution of the problem that knowledge helps to solve.

The aforementioned Turban's qualification of the knowledge concept identifies the relationship between knowledge and the problem solution or its applicability to decision-making. In this regard, Havlíček (2006) takes one step forward by asserting that the relationship between knowledge and problem is truly fundamental in defining the concept of knowledge and that there cannot be any talk about knowledge before the problem to be solved is determined first.

The approach of systems engineering to problem analysis admits certain degree of simplification of the problem or the problem situation by applying the system on a real object to be examined. The simplification has to be specific, which means that its degree as well as its implementation has to conform to the objective of the analysis. This is also why systems engineering puts the greatest emphasis just on precise setting of objectives before the start of an analysis.

No objective, however, stands ever alone. It is always necessary to formulate first the problem and / or the problem situation, which is the subject of examination. It is only the criteria gauging the degree of satisfaction with the given stage of a problem situation that fit the term "objective".

The authors of the article examined the relationship between the problem, the problem situation, the objective of its solution and knowledge in their earlier works Houška, Beránková (2006, 2007) and Houška et al. (2006). Their outcome met Lacko's requirements: the definition of a knowledge object that could be regarded as an "entity" in the field of knowledge science, so-called elementary knowledge. Under the systems engineering concept, this knowledge can be taken for a standard unit of knowledge. It meets the condition of atomisticity (it is impossible or impractical to divide it any further), the condition of expressing dynamism (the sequence of hypothesis – result or action – reaction evidently describes progress) and also the condition of linkage to a problem, in this case to a problem which its solver considers as elementary. Its definition is in the work given above.

The article objectives

The article objective is to analyze the standard and recognized form of knowledge representation in knowledge engineering – the semantic network – from the point of view of its compliance with the requirements for knowledge representation formulated by systems engineering. On a common example of semantic network the authors demonstrate that not every semantic network can be recognized as a genuine representation of knowledge object in the sense of systems engineering.

Furthermore, the authors suggest how to solve this problem. By means of defined knowledge unit (elementary knowledge) and its standard form they show how to construct a semantic network that would surely contain knowledge. From a formal point of view, the semantic network is a graph.

The last objective of the article is to confirm the hypothesis that a semantic network containing knowledge can be appropriately enlarged in order to acquire the quality of a knowledge map.

The achievements are continuously demonstrated on an illustrative example.

MATERIAL AND METHODS

Semantic networks viewed by knowledge engineering

Mařík et al. (2004) states that semantic networks allow describing relatively complex knowledge structures where individual objects possess more qualities and are specifically related to other objects. In such cases it is advisable to combine such qualities into the form of a single description of the complex object. In such situations, the use of semantic networks is a more advantageous way of knowledge representation than that offered by logic formalisms (statement and predicative logic), which are very useful for the presentation of simple facts but insufficient for describing complex structures.

Knowledge in semantic networks is presented as a network. The nodes represent individual entities (objects, phenomena, activities, situations etc.) whereas the arcs correspond to binary relations (relationships) between these entities (multiargument relations can always be converted to a set of the binary ones). The arcs orientation in the network is indicated by an arrow pointing from a specific term to a more common one. Therefore, a semantic network is graphically represented by an orientated graph.

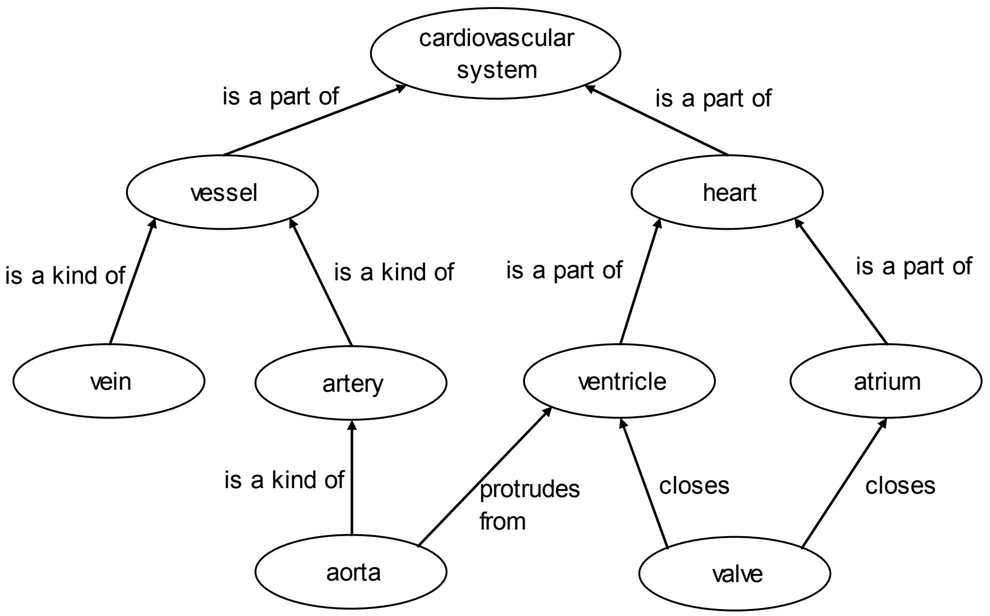

Fig. 1. Example of a semantic network (see Provazník, Kozumplík, 1999)

The most significant relations used to express knowledge by means of semantic networks are relations of the type "is a", "a kind of" and "is a part of", abbreviated in the English literature as ISA, AKO and ISPART (see Giarratano, Riley, 1998)). Of course, other relations such as "has a color", "has" and so on are also permitted. An example of semantic network using relations "is a kind of", "is a part of", "comes forward" or "closes" is shown in Fig. 1.

RESULTS

The semantic network analysis from the viewpoint of the knowledge content

Demands made on the term "knowledge" by systems engineering can be summed up in three points:

1) The basis of knowledge is information, which is enriched, developed or transformed in some way. This implies that a semantic network has to be composed of information and that such information can be interpreted in common language.
2) Knowledge is dynamic or expresses dynamism, motion and progress. This means that the relevant description in common language will be a story or a description of an algorithm in character, it will not be merely a static description of some facts.
3) Knowledge is linked to the solution of a problem, which means that it will be possible to identify a complex problem from the semantic network that will be divisible into partial and / or elementary problems. The semantic network will simultaneously include the way of solving these problems.

Now it is possible to analyze the structure of semantic network according to whether it is capable of graphing out all the abovementioned qualities of knowledge.

First of all, the semantic network will be analyzed from the point of view of the information content. For this purpose, the simplest common semantic network consisting of two objects and one link between them will be used (see Fig. 2).

The entities "Object 1", "Object 2" and the link "is relating to" are in themselves mere data. If the link "is relating to" is used for the qualification of relationship between two objects, it generates information. In common language, this network could obviously be expressed by the statement that "Object 1 is relating to Object 2", the veracity of which can easily be decided. The semantic network clearly contains information and thus satisfies the first demand.

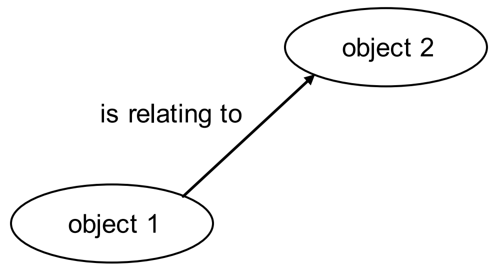

Fig. 2. The simplest common semantic network

Now it is necessary to verify if the semantic network graphs out or can graph out dynamics. The simplest semantic network can be enlarged by more nodes (objects) connected by another type of links.

For example, by means of links used in literature ("is a kind of", "is a part of"), the network that is shown in Fig. 3 may be obtained.

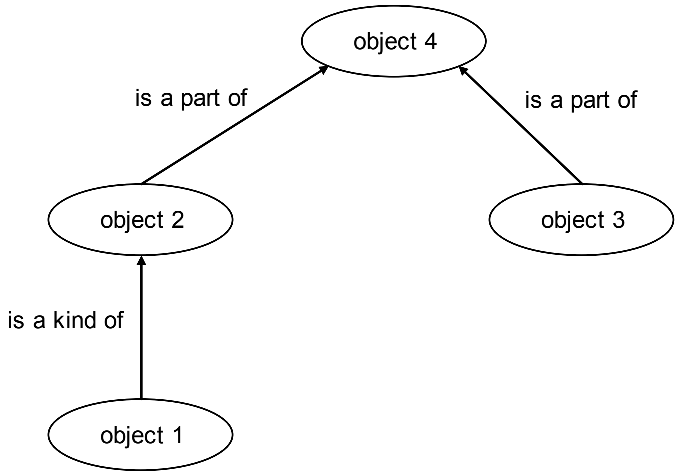

Fig. 3. Semantic network with the most frequent links

The expression of dynamics in a semantic network

As it was shown above, the semantic network contains information. If it has to represent knowledge, it must allow adding dynamics so as to set the information content into motion.

In common language, "motion" is expressed by verbs in active form, hence the verb in a semantic network (or in the description of constructs contained therein) should figure in active form, too. In looking at Fig. 1 it is obvious at first sight that semantic networks use verbs for describing links between objects. Verbs, however, exist both in active and passive forms. Therefore, the semantic network shown in Fig. 1 has first to be analyzed by the types of links used (see Fig. 4).

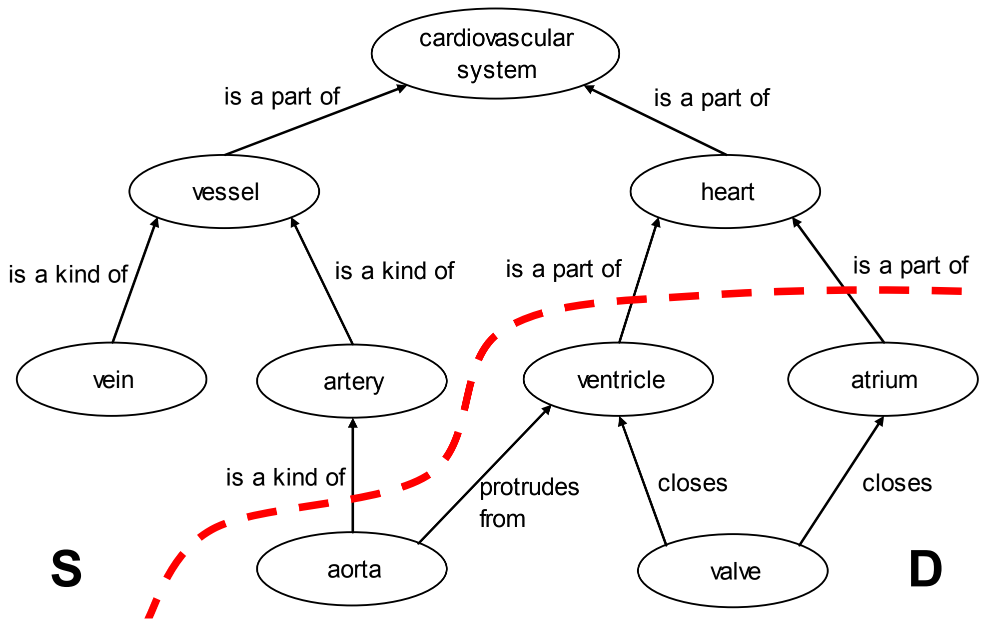

Fig. 4. Static and dynamic parts of a semantic network

Again, such network contains information. It could be circumscribed by the text: "Object 1 is a kind of Object 2 which together with Object 3 is a part of Object 4".

The abovementioned structure, however, merely contains more pieces of information which in themselves, regardless of their interconnection by links, do not add any new quality, that is to say knowledge quality, to the network. The network is static and the links only express an integration of the object into the hierarchic structure of the given problem domain. This is obviously the purpose and idea of creating a common semantic network. Semantics represents the science of meaning of language units and semantic network serves as a means for expressing their relationships. This tool is not primarily designed to express dynamics or links to problems and their solutions. The semantic network, therefore, fails in its role of a tool for knowledge representation in the system engineering concept; for example, the semantic network as demonstrated in the Fig. 1 does not represent any knowledge by itself.

The semantic network can be divided into a static part (S) and a dynamic part (D). The criterion of the differentiation is the form of the verb denominating the link. The passive is typical for a static structure, whereas the active characterizes a dynamic one. From this viewpoint, the terms "active link" and "passive link" in a semantic network can be defined as follows:

Active link in a semantic network is such link between two objects of this network which is described by a verb in active form.

Passive link in a semantic network is such link between two objects of this network which is described by a verb in passive form.

The dynamic part of the semantic network could be verbally described as follows:

"An aorta protrudes from a ventricle. A valve closes the ventricle. A valve closes an atrium."

In themselves, all three simple sentences are information only. They represent statements, the verity of which can be decided, but they do not amount to the quality of knowledge.

Graphing out a link to the problem and its solution in semantic network

The dynamism of links is a precondition for formulating a problem and the objective of its solution and also enriches information so as to transform it into knowledge. The process can be exemplified linking the first identified information reading "An aorta protrudes from a ventricle" to the solution of a problem. For this purpose, the information has, for example, to be amplified as follows:

"The aorta protrudes from the ventricle in order to convey oxidized blood into arteries of the whole body."

Now the information is solving a problem, viz. the physical distribution of blood into the body. This problem may be linked to the objective of "transporting oxidized blood". Using the elementary knowledge format from H o u š k a et al. (2006), we can record knowledge as follows:

X for the performance of the cardiovascular system
Y for the conveyance of oxidized blood into the body
Z for transporting blood from the heart
Q for the aorta protruding from the ventricle
and express it in a sentence:

"When during the performance of the cardiovascular system it becomes necessary to convey oxidized blood into arteries of the whole body, its transport from the heart is provided by the aorta protruding from the ventricle."

The semantic network (or its part) encompassing all components of elementary knowledge might be of the design, as it is described in Fig. 5. In that figure and in the other following figures, we will hold specific graphical symbols for core components elementary knowledge as follows:

- problem situation X – an octagon, red color of borders,
- elementary problem Y – a rectangle with round corners, yellow color of borders,
- objective Z – a blue arrow, arc between problem solution and the problem and
- problem solution Q – a rectangle, green color of borders.

Semantic network for the representation of elementary knowledge

Fig. 6 shows how it is possible to suggest (based of the example shown above) a common form of relationship between a semantic network and elementary knowledge:

Such concept of elementary knowledge representation has inverse logic compared to its representation derived from the production rule. It complies with the chief principle of semantic network formation to graph out objects hierarchically from a common object to a specific one.

The most common object (or component of elementary knowledge) is component X – a problem situation in the framework of which one or more elementary problems are being solved. This object, therefore, has to be placed on the most common level of the hierarchic structure of the semantic network. The elementary problem level (Y) has to follow next to the problem situation level. The relationship X : Y is of the 1 : *m* type, where *m* represents the number of defined elementary problems which are being solved in the framework of the problem situation (X). The relationship X : Y is a passive one and is of the "is being solved in the framework of" type.

Hereafter it is possible to identify the hierarchic level of the elementary knowledge component (Q) representing the problem solution. This component occupies the lowest hierarchic level of the given part of semantic network. The object assigned as support of this elementary knowledge component is linked to the specific elementary problem (Y) by an active link of the "solves from the viewpoint Z" type. This link includes the objective of solving the given elementary problem and as such represents the last component of elementary knowledge. The link Y : Q can also be the 1:*n* link as long as the given elementary problem that is being solved in the framework of identical problem situation can be solved with respect to various objectives. That is why one problem can be linked with one or more successful solutions and the link "1 : *n*" is used. These objectives must not be interdependent or even contradictory. In such cases the problem would not be elementary but a complex one.

A semantic network may include more hierarchic levels that are situated between the Y and Q levels. These hierarchic levels may contain a specification (elaboration, clarification) of the application Q representing a successful solution of the elementary problem Y, by semantically related objects such as those on levels Y and Q. In most cases the specification concerns actions that are needed to be taken for the solution of the problem and the links used are, therefore, active links.

Furthermore it is possible to utilize these inserted levels for the specification of objects which are semantically relevant to objects representing the solution Q. These objects may have semantic relations to more objects Q. Their links to the latter objects can be both active and passive.

The aforementioned way of construction can be demonstrated by adding another component of the dynamic part of the semantic network shown in Fig. 5 to the newly constructed semantic network in Fig. 6. Its verbal description "Valve closes ventricle" can, for example, be extended by the link to an elementary problem as follows:

"A valve closes the ventricle in order to prevent a reflux of blood."

This description could be presented in the form of elementary knowledge:

X for the performance of cardiovascular system
Y for the conveyance of oxidized blood throughout the body
Z for the phrase "to prevent a reflux of blood"
Q for the valve closing the ventricle
and express it in the sentence:

"When in the framework of performance of the cardiovascular system it becomes necessary to prevent a re-

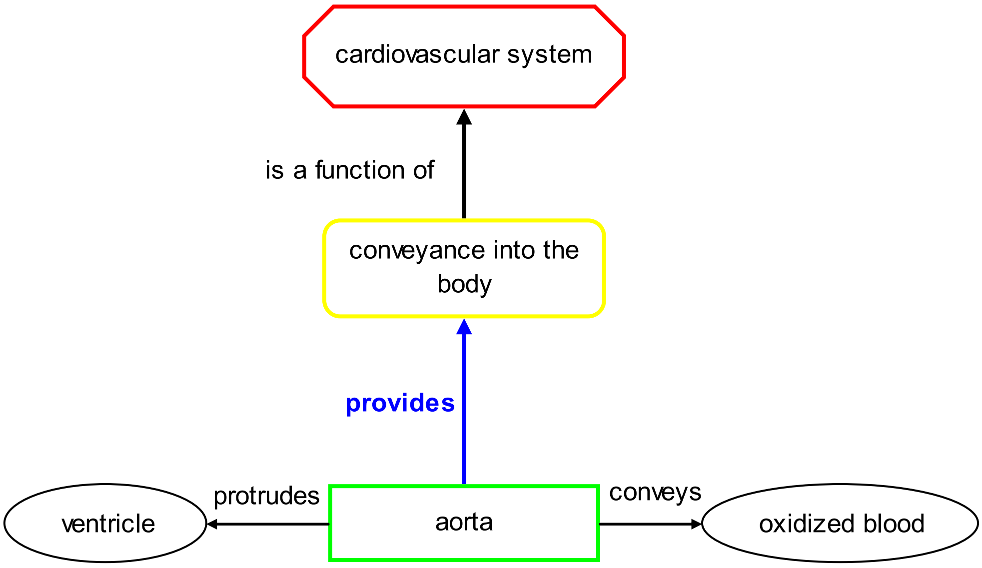

Fig. 5. Elementary knowledge represented by the form of semantic network

flux of oxidized blood, the valve closing the ventricle serves as a stop-valve."

The problem situation remains the same and so does the elementary problem, only the objective is different. The difference lies in the viewpoint from which the solution of the elementary problem is approached and in the solution itself. The semantic network can be complemented as it is described in Fig. 7.

DISCUSSION

The semantic network as a knowledge map

The common semantic network shown in Fig. 6 represents single knowledge. Its essential feature is the main vertical encompassing the concurrence of terms representing the problem situation, the problem, the objective of its solution and the solution proper. Should anything be removed from this vertical, the semantic network ceases to represent knowledge.

The definition of the knowledge map taken from the work Havlíček, Pelikán (2007) can be applied to the common semantic network illustrated by Fig. 6 including its essential parts:

- support
- topology with incident text chains
- free texts

The semantic network is a plane graph to which further knowledge can be added. Therefore, the support of a knowledge map based on the semantic network represents an unlimited part of the plane. This support can be formalized by means of soft formalization both in vertical and horizontal direction.

The unit of vertical direction is the hierarchic level. The orientation of the vertical direction leads from semantically more specific objects towards the semantically common ones, i.e. in the "bottom-up" direction.

The unit of horizontal direction is the identifier of knowledge vertical, which serves for finding knowledge in the knowledge map whenever the knowledge user needs it for the solution of his or her problem.

The vertical is clearly defined by four objects:

- problem situation
- problem
- objective of problem solution
- problem solution

The last two mentioned elements, viz. the problem's objective and solution, are essential for identification. It is possible to solve more problems in the framework of one problem situation, therefore the problem situation itself is insufficient for unequivocal identification of knowledge. Equally insufficient for such identification is the problem alone, because it can be solved from different angles. An example of such situation is shown in Fig. 7, where the problem of "conveyance of blood into the body" is being solved within the scope of the problem situation "performance of the cardiovascular systém", first from the viewpoint (with the objective) of "providing transport" (through aorta), and second from the viewpoint of "preventing reflux of blood" (by a valve).

Semantic network utilizes the apparatus of the graph theory. It consists of nodes representing individual terms of the network, and oriented lines expressing the semantic interrelationships between terms. The line orientation shows the direction of semantically specific term to a common one and has, therefore, to conform to the support orientation. Under the definition of the knowledge map given in chapter 2, topology is thus formalized, too.

Now it is possible to transcribe the semantic network from Fig. 8 into the design of a knowledge map. The knowledge map will be formalized (it will have a formalized support and formalized topology) and will include five hierarchic levels. Besides four basic ones, the level of objects connected semantically (in meaning) with the

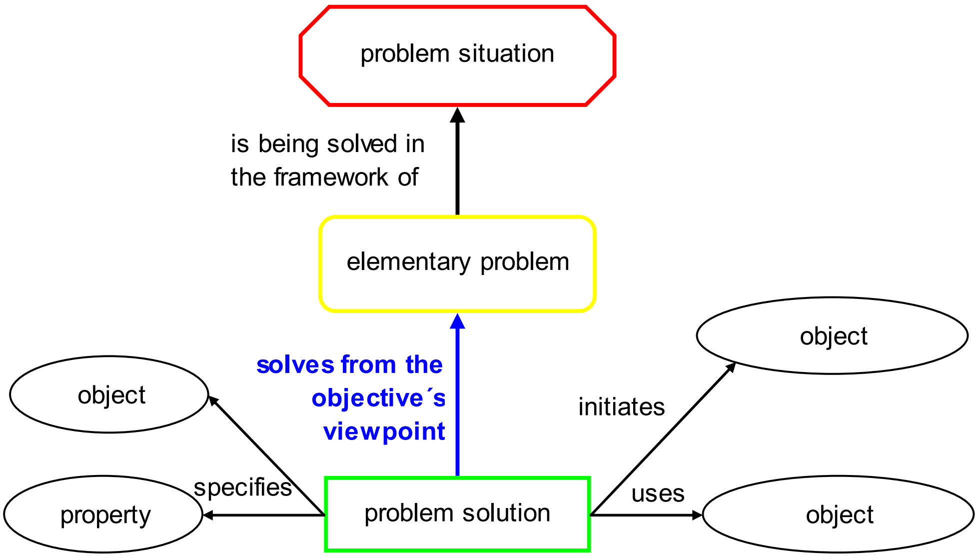

Fig. 6. Common form of elementary knowledge representation by means of a semantic network

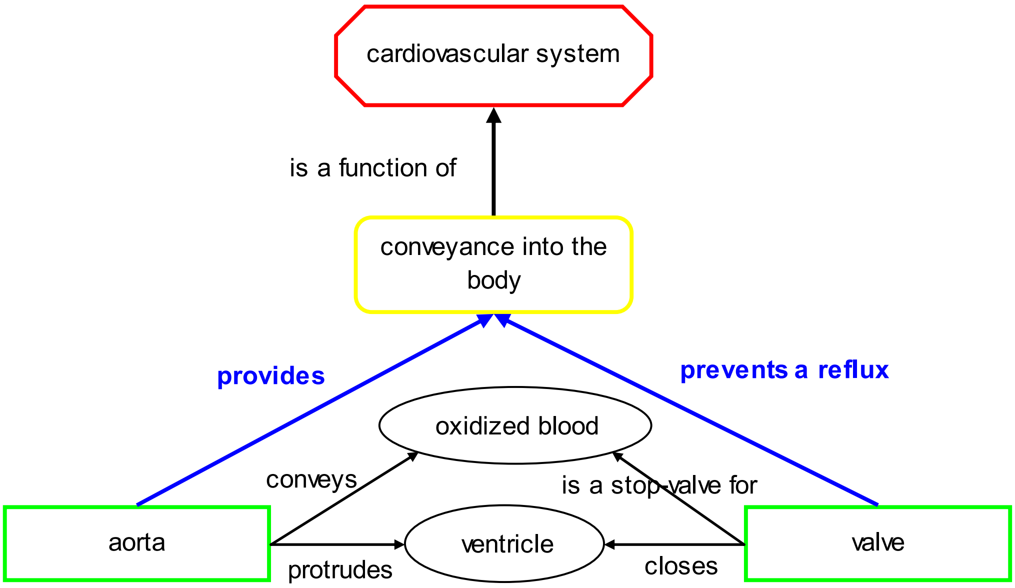

Fig. 7. Complemented semantic network

problem solution will be inserted into the map. Relationships between the problem solution and these objects possess the quality of information.

The transcription of the semantic network containing knowledge (Fig. 7) into the design of a formalized knowledge map looks as it is shown in Fig. 8.

The knowledge map contains two knowledge verticals to which a clear identifier is coordinated on the horizontal axis. From this example it is apparent why only a random part of the vertical does not suffice for its unequivocal identification; both verticals have two elements in common, viz. the problem situation and the problem being solved within the scope of that situation.

CONCLUSIONS

Semantic networks are often used in the area of knowledge engineering and this discipline recognizes them as a form of knowledge representation. However, knowledge engineering as a part of the discipline of artificial intelligence subordinates the formal representation to capacities of automated computerization and sometimes neglects the system aspects of knowledge modeling.

From the viewpoint of systems engineering, therefore, a common semantic network may not always satisfy the demands for knowledge object representation. It can only be regarded as knowledge representation if it is composed of relatively isolated and identifiable entities which are based on information, express dynamics (motion) and are linked to the solution of a problem.

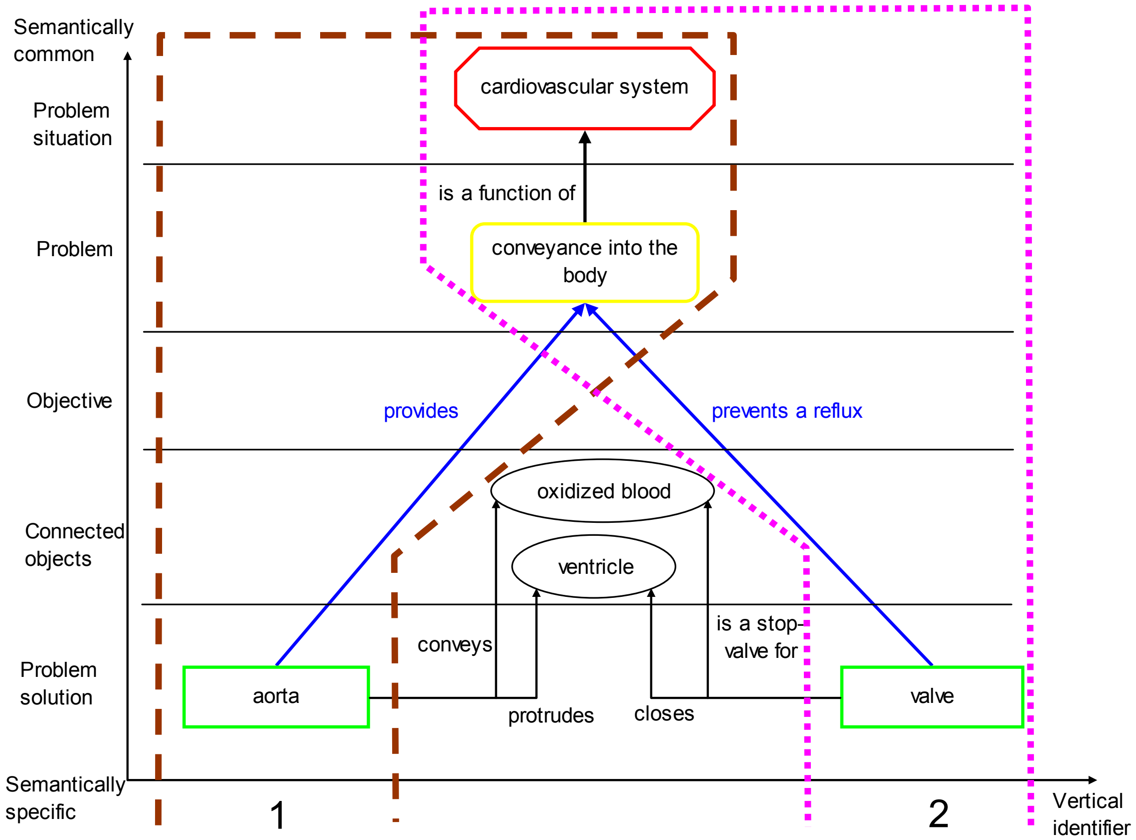

Fig. 8. Example of the semantic network as a formalized knowledge map

In their article, the authors derived such common form of semantic network, which ensures that knowledge is actually contained in the net. To this end, the authors used their concept of elementary knowledge, which they had derived in their earlier work.

This concept is advantageous in that it offers the opportunity of deciding whether the object under examination is a knowledge support or not, regardless of its expression in a verbal or symbolic form. It also enables transcription from one form into another without losing the quality of knowledge or distorting the contents of the knowledge object.

Considering the apparatus utilized by semantic networks for the knowledge visualization, the authors also verified the hypothesis that a semantic network can stand as one of specific forms of the knowledge map. In their article they succeeded in defining the formalized support of knowledge map as a part of plane, and the formalized topology as components of the graph theory used by semantic networks. A successful verification of the hypothesis was demonstrated on an example that was being continuously solved.

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HOUŠKA, M. – BERÁNKOVÁ, M. (Česká zemědělská univerzita, Fakulta provozně ekonomická, katedra operační a systémové analýzy, Praha, Česká republika):

Sémantická síť jako forma reprezentace znalostí a znalostní mapy.

Scientia Agric. Bohem., *39*, 2008: 139–147.

Problematikou reprezentace znalostí se zabývá zejména disciplína znalostní inženýrství. Znalostní inženýrství je částí oboru „umělé inteligence“ a zabývá se aktivitami, jež souvisí s naplňováním znalostních systémů znalostmi. Zejména se jedná o procesy získávání, formalizace, kódování, uchovávání a testování informací a znalostí, které jsou obsaženy ve stanovených problémových doménách. Znalostní inženýrství chápe znalost jako objekt, který může být identifikován, uložen a případně předán k dalšímu použití.

Znalostní inženýrství má stejně jako celý obor „umělá inteligence“ silnou vazbu na informační technologie. Na straně jedné poskytuje metodické nástroje pro možnost implementace postupů umělé inteligence při zpracování a automatizovaném odvozování nových znalostí, na straně druhé je nutné formalizovat znalosti standardním způsobem, aby je bylo možno počítačově zpracovávat.

Sémantická síť byla navržena jako statická struktura pojmů z určité problémové domény, které jsou spojeny vazbami podle jejich významových souvislostí. Sémantické sítě jsou v oblasti znalostního inženýrství často používány a jsou touto vědní disciplínou považovány za formu reprezentace znalosti.

Přestože v současné době převládá názor, že znalost není možné definovat, že lze pouze vymezit její vlastnosti, většina autorů se shoduje na třech základních vlastnostech znalosti:
- základem znalosti je informace, která je nějakým způsobem obohacená, rozvinutá, transformovaná,
- znalost je dynamická, resp. zachycuje dynamiku, pohyb, postup,
- znalost je spjata s řešením nějakého problému.

Tyto tři atributy znalosti jsou klíčové pro vymezení pojmu znalost pohledem systémového inženýrství. Z hlediska této disciplíny je proto obecná sémantická síť jako forma reprezentace znalosti nevyhovující, neboť nemusí vždy zachycovat dynamiku a zejména vazby objektů sítě na problém a jeho úspěšné řešení.

Cíle článku proto jsou:
1) Analyzovat standardní a uznávanou formu reprezentace znalosti ve znalostním inženýrství – sémantickou síť – z hlediska, jak vyhovuje požadavkům na reprezentaci znalostí formulovaných systémovým inženýrstvím. Bude zkonstruována jednoduchá obecná sémantická síť, která bude analyzována z hlediska obsahu informací, zachycení dynamiky a vazby na problém a jeho řešení.
2) Nalézt způsob, jak pomocí sémantické sítě zobrazit jednotku znalosti – elementární znalost. Koncept elementární znalosti autoři navrhli ve svých předchozích pracích, což vedlo ke stanovení objektu, jenž je prokazatelně nositelem znalosti. Tento objekt navíc splňuje podmínku atomičnosti (elementarity), neboť není možné a/nebo účelné provést jeho další dekompozici a zároveň platí, že pokud by z něj byla odebrána libovolná jeho část, přestal by tento objekt reprezentovat znalost.

Vzhledem k aparátu, který sémantické sítě používají pro vizualizaci znalostí, je posledním cílem článku ověřit hypotézu, že sémantická síť může být jednou ze specifických forem znalostní mapy.

Analýza obecné sémantické sítě ukázala, že obecně je taková síť složena z informací a tomuto požadavku na znalostní objekt vyhovuje. Dále se ukázalo, že při používání standardních typů vazeb je sémantická síť pouze statická hierarchická struktura, která nezachycuje dynamiku. Rovněž požadavek na vazbu objektů sémantické sítě na problém a jeho řešení není obecně touto strukturou reflektován.

V článku je ukázáno, jak překonat identifikované nedostatky sémantické sítě jako formy reprezentace znalosti. K tomuto účelu byl použit koncept elementární znalosti a bylo ukázáno, jak elementární znalost pomocí sémantické sítě reprezentovat. Pokud bude sémantická síť složena z elementárních znalostí a jim přidružených objektů, potom také zachycuje dynamiku i vazbu na problém, neboť tyto atributy v sobě explicitně elementární znalost obsahuje.

Podařilo se také ukázat, že sémantická síť, která reprezentuje znalost, je dobrým základem pro tvorbu znalostní mapy. Podařilo se definovat formalizovaný nosič znalostní mapy jako část roviny a formalizovanou topologii jako komponenty teorie grafu, které sémantické sítě používají.

Dosažené výsledky jsou průběžně demonstrovány na řešeném ilustračním příkladu.

znalostní inženýrství; systémové inženýrství; znalost, reprezentace znalosti; sémantická síť; elementární znalost; znalostní mapa; nosič; topologie

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