SOME PRODUCTIVE SCHEMES OF ACADEMIC CONCEPTS RELATIONS

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Abstract

Technical terms are one of the paramount features of the academic discourse and the language of science in general. Academic concepts of a particular domain are interrelated and form its system of knowledge. It is a well-known fact that the systemacy of technical terms reflects the specificity of academic concepts organization that they represent (see Superanskaya, 1989, Leychik, 2006, etc.). New concepts are constructed and integrated into the system based on the already existing knowledge. Understanding the principles of knowledge organization seems to be of great importance for further research and development in the field and may also contribute to certain applied objectives such as the construction of electronic dictionaries, data bases, expert systems, etc. One of the key problems here is to define the adjacent concepts that may belong to one and the same category or different categories and be linked by semantic relations of various types.

This paper is devoted to the study of some productive schemes or patterns of academic concepts organization. Each terminology can be represented as a terminological network where technical terms are vertices and the systemic relations between them are arcs. The types of vertices correlate with the categories of academic concepts that the technical terms express. In a terminological semantic network a concept is linked to a limited number of adjacent concepts by different semantic relations. The analysis demonstrates that the concepts of a certain category are likely to establish semantic relations of certain type with concepts of definite other categories. Consequently, two categories linked by a semantic relation of a certain type form a scheme. The research has demonstrated that a number of them appear to be quite frequent while others are not so regular. Thus, some of such productive patterns are defined and their specificity is discussed. The examples of the interlinked technical terms forming the schemes are mainly taken from the terminologies of nanotechnology and space research. The body of technical terms and their definitions were obtained from terminological dictionaries and data bases as well as fragments of specialized texts.

Keywords: academic concept, definition, technical term, semantic network, semantic relation, scheme, category

1. INTRODUCTION

It is a well-known fact that the systemacy of technical terms correlates with the systemic organization of academic concepts that they represent within a specific field of science (see Superanskaya, 1989, etc.). "The body of technical terms of a terminology system forms a model of a fragment of objective reality that is beneficial for understanding and studying the world we live in" (Leychik, 2006). The important question, in this respect, is how to analyze the systematic character of technical terms and uncover the structures of knowledge that stand behind it. In some earlier papers (see Latu, Levit, 2017) we argued that the place of each technical term within a terminology system is determined by the limited in each case number of adjacent technical terms that it is conceptually related to. Consequently, the specificity of the systemacy of an individual technical term consists in the unique group of adjacent technical terms and the particular character of different types of systemic relations between them. It is proposed that the types of systemic relations that a technical term tends to establish with the adjacent specialized units largely depend on the category of the concept it expresses. This fact also defines to some extent the number of potential other categories that the adjacent academic concepts may belong to.

The organization of technical terms and the concepts they express may be modelled as a terminological semantic network that consists of such basic elements as vertices and arcs between them (Malkovskiy, Solovyev, 2012). As “concepts are the building blocks of knowledge, relations act as the cement that links up concepts into knowledge structures” (Khoo & Jin-Cheon Na, 2006). The division of vertices into types reflects the basic and most general classification of academic concepts into categories, according to the nature of their referents that can be of material and non-material. The group of material referents is in turn subdivided into the ones of natural origin (Natural object/phenomenon, Substance, Locus) and artificial origin (Mechanism, Instrument, Material, Construction/man-made locus). The group of non-material referents is subdivided into the following categories: Process, Characteristic, Actor, Situation/event, Ideal phenomenon. The technical terms that express concepts of these categories can be connected by different types of systemic relations. There are 40 prototypic and most frequent ones that include AKO (“a kind of”), PO (“part of”), Loc (“location”), At (“attribute”), EOp (“opposition”, between hyponyms of the same generic term), R (“result”), S (“subject”), SO (“subject-object”, between the subject and the object of the same process), InstObj (“instrument-object”, between the instrument and the object of the same process), etc. (Latu, 2017). If there are relations between vertices in a terminological network, they appear to be adjacent (Borge-Holthoefer & Arenas, 2010) and represent the so called neighborhood structures (Steyvers & Tenenbaum, 2004). This paper is devoted to the study of some productive schemes or patterns of academic concepts organization that are more complex elements of terminological networks.

2. THE STRUCTURE AND TYPES OF SCHEMES

A scheme represents a pattern of two adjacent academic concepts interaction. Both concepts in this pattern belong to certain categories. Consequently, as far as the structure is concerned, a scheme consists of four basic elements: category of academic concepts 1, category of academic concepts 2, a systemic semantic relation of definite type and the vector that indicates the “route” that is the direction of this systemic relation. The peculiarity of each structural element makes a scheme unique. The elements category 1 and category 2 can be represented by one of the twelve basic categories of academic concepts that are defined and classified according to certain generic features of their referents. These features represent ideas of a very high level of abstraction and identify the referents as material or non-material, natural or artificially made, etc. The scheme elements category 1 and category 2 can be represented by the concepts of one and the same category or the concepts of two different categories.

A systemic relation that links up the concepts of certain categories is another structural component in a scheme. It represents one of the types of prototypic systemic semantic relations that exist between academic concepts expressed by technical terms. It has been revealed that certain categories can be linked together by certain types of systemic relations. Correspondingly, this statement also presumes the opposite fact that not all categories can potentially be linked by all types of systemic relations. This means that certain categories simply cannot be linked together by definite types of semantic relations. It is important to note again in this respect that these two concepts in a scheme (no matter what their category is) are always conceptually adjacent. Two concepts that are not logically linked to one another will not fit the scheme because there is no direct logical relation between them that is normally expressed in various scientific concepts where they are mentioned together.

Another structural element of a scheme is a vector that can be directed from category 1 to category 2 and vice versa, indicating the role of these two elements and showing the course of the systemic relation between them. This element is very important because otherwise it would be difficult to read semantic networks, as well as other schematically depicted patterns and formulas because it would be impossible to identify the primary and the secondary part in a scheme. For example, when two concepts are linked by AKO (“a kind of”) semantic relation, the vector makes clear which one of them is the generic concept and which one is the hyponym. This works similarly for other semantic relations such as PO (“part of”) to show the whole and the part, Loc (“location”) to show the located referent and the exact location, etc.

Consequently, a scheme in terminological networks is formed by a definite category of academic concepts linked by a systemic relation of a certain type to another definite category of academic concepts. According to some earlier research (Latu, 2017; Latu 2017; Latu, Levit, 2017), the productivity of systemic relations may vary for different categories of concepts. One category may be linked by the same systemic relation to several other categories, similarly there are cases when two categories may be connected by several types of systemic relations, depending on the specificity of knowledge that their concepts express. Let us consider some of the productive schemes of academic concepts organization.

Natural object/phenomenon – AKO → Natural object/phenomenon

A number of very productive schemes are based on AKO systemic relation. Both adjacent concepts in these patterns belong to one and the same category. For example, the technical terms **star** and **variable star** express the concepts of the category Natural object/phenomenon. The definitions of the technical term **variable star** suggest that they represent the generic notion and one of its hyponyms and thus are linked by AKO systemic relation: "***variable star** – a **star** that changes its flux over time, which can be hours or years*" (Dictionary of Geophysics, Astrophysics, and Astronomy, 2001), "***variable star** - any **star** that varies in brightness. Two broad categories are recognized: **extrinsic variables**, which vary for a mechanical reason (e.g. rotation); and **intrinsic variables**, which undergo a real change in luminosity of either an individual star or some element in a binary system*" (Oxford Dictionary of Astronomy, 2012). The relationship between the intrinsic and extrinsic variables, on the one hand, and variable star, on the other, also illustrates the discussed scheme. Other examples include the adjacent concepts **planet** and **exoplanet**: "***extrasolar planet** – a **planet** orbiting a star other than the Sun; also known as an **exoplanet***" (Oxford Dictionary of Astronomy, 2012), "***extrasolar planet** (**exoplanet**) – a **planet** in a solar system beyond our own. As of mid-2009, over 350 extrasolar planets had been discovered since the first confirmed observations were made in the early 1990s. The majority of those found so far have been giants, typically much larger than Jupiter*" (Oxford Dictionary of Science, 2010), **planet** and **giant planet**: "***giant planet** – a **planet** of much larger mass and diameter than the Earth, particularly one consisting mostly of gas; also known as a gas giant. In the Solar System the giant planets are Jupiter, Saturn, Uranus, and Neptune, but there are now known to be similar objects around other stars*" (Oxford Dictionary of Astronomy, 2012)", etc.

Process – AKO → Process

Similarly, there are other categories that form such schemes based on AKO systemic relation. For example, the technical terms **epitaxy** and **heteroepitaxy** express concepts of the category Process, one of which is generic and the other is its hyponym: *"**heteroepitaxy** – form of **epitaxy**, in which the growing layer differs in chemical composition from the substrate material"* (Rusnano thesaurus). It is worth mentioning in this respect that the schemes that include AKO systemic relation are more productive for the categories the referents of which are material objects because they are more likely to have multiple hyponyms and form multilevel treelike classifications.

Natural object/phenomenon – PO → Natural object/phenomenon

The concepts of the same category Natural object/phenomenon may also establish another scheme by means of PO systemic relation. This happens when one object is considered to be the constituent element of another object. For example, the referents of both concepts **galaxy** and **star** are astronomical objects. Galaxy is considered to be a complex one that consists of stars together with other structural components that constitute it. This fact is expressed in its definitions: "***galaxy** – a large gravitationally aggregation of **stars**, dust, and gas. Galaxies are classified into spirals, ellipticals, irregular, and peculiar*" (Dictionary of Geophysics, Astrophysics, and Astronomy, 2001), "***galaxy** – a family of **stars**, held together by their mutual gravitational attraction, and with a distinct identity separating it from other galaxies*" (Cambridge Dictionary of Astronomy, 2001). This scheme is also represented by such adjacent concepts as **star** and **binary star**: "***Binary star** – a pair of **stars** bound together by their mutual gravitation, and orbiting their common centre of mass*" (Oxford Dictionary of Astronomy, 2012). A **galaxy** in turn can also be a part of an even larger astronomical object that is **cluster of galaxies**: "***cluster of galaxies** – an aggregation of **galaxies**, which may or may not be bound together by gravity*" (Oxford Dictionary of Astronomy, 2012), "***cluster of galaxies** – a grouping of **galaxies** in space, linked by their mutual gravitational attraction*" (Cambridge Dictionary of Astronomy, 2001).

Natural object/phenomenon ← PO – Natural Substance

Natural objects consist of certain substances. The relationship between these two categories of referents is reflected in another scheme which is also based on PO systemic relation. Apart from definitions and fragments of scientific texts, the relationship may also be reflected in the structure of the technical term itself, for example: "***carbon star** – cool, evolved star of relatively low mass in which sufficient **carbon** has been mixed to the surface for the carbon-oxygen ratio to exceed unity*" (Dictionary of Geophysics, Astrophysics, and Astronomy, 2001), "***carbon star** – a cool red-giant star in an advanced stage of evolution, displaying strong **carbon** features in the form of CN, CH, and C_2 (Swan) bands in its spectrum; also known as spectral type C*" (Oxford Dictionary of Astronomy, 2012). There are also other types of stars that are named after the substance that prevails in their composition: "***barium star** – a red-giant star of spectral type G or K in which heavier elements such as **barium** appear in the spectrum with unusually high abundance; also known as a Ba star or a heavy-metal star*" (Oxford Dictionary of Astronomy, 2012).

Among other examples of neighborhood structures that match this pattern are **olivine** and **chondritic meteorites, iron meteorite** and **siderite, siderophyre** and **nickel-iron**, **bronzite**, **tridymite**:"***olivine** – magnesium iron silicate, the most abundant mineral in **chondritic meteorites***" (Cambridge Dictionary of Astronomy, 2001), "***iron meteorite** – a meteorite composed primarily of **nickel-iron**; also known as a **siderite***" (Oxford Dictionary of Astronomy, 2012), "***siderophyre** – a very rare class of stony-iron meteorite consisting of **nickel-iron** enclosing **bronzite** (orthopyroxene) and **tridymite** (quartz) minerals*" (Oxford Dictionary of Astronomy, 2012).

Material ⟵ PO – Natural object/phenomenon

A material or a substance itself may consist of individual elements, granules, etc. This relationship is also reflected in the scheme where two categories are connected by PO systemic relation, but this time the vector is directed from the category Natural object to the category Material. Thus, **nanopowder** that is "*a solid powder-like substance of artificial origin that contains nanoobjects…, a powder, all particles of which are smaller than 100 nm*" (Rusnano thesaurus) consists of **nanoparticles**. Another example is the relationship between **nanoink** and **nanoparticle**: **"*nanoink*** *– a colloidal solution of **nanoparticles** in a disperse medium (suspension) used for production of nanostructured coatings with specific topology and functional characteristics*" (Rusnano thesaurus).

Material – PO ⟶ Instrument

There are other schemes that are based on PO systemic relation, for example the link between the category Material and the category Instrument that encompasses various objects of artificial nature (except for devices that refer to the category Mechaism): "***nanowire** – a nanoscale rod made of **semiconducting material**, used in miniature transistors and some laser applications*" (oxforddictionaries.com)

Substance – Loc ⟶ Locus

Certain referents may be linked by Loc systemic relation that indicates that one referent is the exact location of the other. This relationship may be established between a number of categories, for example the category Substance and the category Locus: *"the **interstellar medium** is the gas and dust that pervade **interstellar space**: the matter that exists between the star systems within a galaxy. It fills **interstellar space** and blends smoothly into the surrounding intergalactic space"* (Esomba, 2012), *"In astronomy, the **interstellar medium** (ISM) is the matter that exists in the space between the star systems in a galaxy. This matter includes gas in ionic, atomic, and molecular form, as well as dust and cosmic rays"* (Anderson, 2015). As the definitions suggest, the interstellar medium that is a general concept of the category Substance is associated with the interstellar space as it location. Similarly, **plasma** is located in the **corona** that is an outer part of the Sun's atmosphere: *"in a hot tenuous **plasma** such as the **corona** the resistivity is extremely small, because collisions are rare, and the shear viscosity is small because the particles are tied to the magnetic field lines*" (Golub & Pasachoff, 2010).

Actor – SO ⟶ Natural object/phenomenon

The category Actor may be linked to the category Natural object/phenomenon by SO systemic relation forming a unique scheme of academic concepts interaction. This scheme represents the doer and the object the same action: "***astrophysicist** - a scientist who studies the physical and chemical structure of the **stars**, **planets**, etc.*" (Oxford Learner's Dictionary).

Process – EOp ⟶ Process

The concepts of the same category may be linked together by EOp systemic relation that is established between hyponyms that refer to the same generic term and form an opposition. For example, the technical terms desorption and adsorption that belong to the category Process: **desorption** is defined as "*decreasing concentration of a component in the surface layer of a substance as compared to its concentration in each bulk phase. The opposite of **adsorption***" (Oura, 2010). There are other schemes that are based on this systemic relation that links up concepts of other categories, for example, carbon and non-carbon nanotubes, single-walled and multi-walled nanotubes, etc. The list of productive schemes of academic concepts organization discussed in this paper is far from being comprehensive, but it opens doors for further research that may be beneficial for designing ontologies and expert systems.

3. CONCLUSION

As the research has revealed, the academic concepts of a certain category are likely to establish systemic relations of certain types with the academic concepts of definite other categories, establishing more or less productive patterns that can be seen as schemes of academic knowledge organization. Such schemes may be considered more complex components of terminological semantic networks as compared to vertices and arcs. A scheme consists of four structural elements, two of which are definite categories of academic concepts, a systemic relation of a certain type that links them together and a vector showing the direction of the systemic relation. In definitions and other fragments of scientific texts the concepts of certain categories are represented by technical terms while the systemic relations of certain types are expressed by words of general vocabulary. As the analysis demonstrates, a category may establish the same systemic relation with more than one category. At the same time, two categories of certain types may be linked by more than one type of systemic relations. Some schemes appear to be more obvious and productive while others are not so frequent. The accurate statistical analysis is actually beyond the scope of this research and represents the objective for further studies. So does the in-depth analysis of certain combinations of categories based on definite types of systemic relations that are very unproductive, unlikely or impossible.

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