I T H E A

International Journal INFORMATION THEORIES & APPLICATIONS

2009 Volume 16 Number 4

International Journal
INFORMATION THEORIES & APPLICATIONS
Volume 16 / 2009, Number 4

IJ ITA is official publisher of the scientific papers of the members of the ITHEA® International Scientific Society

IJ ITA welcomes scientific papers connected with any information theory or its application.

IJ ITA rules for preparing the manuscripts are compulsory.
The **rules for the papers** for IJ ITA as well as the **subscription fees** are given on *www.ithea.org* .
The camera-ready copy of the paper should be received by http://ij.ithea.org.
Responsibility for papers published in IJ ITA belongs to authors.

General Sponsor of IJ ITA is the **Consortium FOI Bulgaria** (www.foibg.com).

International Journal "INFORMATION THEORIES & APPLICATIONS" Vol.16, Number 4, 2009

Printed in Bulgaria

Edited by the **Institute of Information Theories and Applications FOI ITHEA®**, Bulgaria,
in collaboration with the V.M.Glushkov Institute of Cybernetics of NAS, Ukraine,
and the Institute of Mathematics and Informatics, BAS, Bulgaria.

Publisher: **ITHEA®**
Sofia, 1000, P.O.B. 775, Bulgaria. www.ithea.org, e-mail: info@foibg.com

ISSN 1310-0513 (printed) **ISSN 1313-0463 (online)** **ISSN 1313-0498 (CD/DVD)**

PRESENTATION OF ONTOLOGIES AND OPERATIONS ON ONTOLOGIES IN FINITE-STATE MACHINES THEORY

Sergii Kryvyi, Oleksandr Khodzinskyi

Abstract: *A representation of ontology by using finite-state machine is considered. This representation allows introducing the operations on ontologies by using regular algebra of languages. The operations over ontologies allow automating the process of analysis and synthesis for ontologies and their component parts.*

Keywords: *ontology, operations, finite automata.*

ACM Classification Keywords*: I.2.4 Knowledge Representation Formalisms and Methods; F.4.1 Finite Automata*

Introduction

Of late years in natural sciences and in particular in the theoretical programming so much different directions, trends and theoretical results appeared that it becomes problematic to overcome all field of scientific activity as a whole even in the separately taken areas. One of the approaches to understand interconnections between different trends and theories is the ontological approach [1, 2]. In addition, due to increase of complication of software and hardware systems "intellektualization" of these processes is required and in opinion of many specialists the attaining of such "intellektualization" is possible by using of the ontology-driven systems of searching, mining and processing of knowledge, which are contained in ontologies. Ontological approach of the development of connections between the concepts of some data domain usually is based on the determination of the relation «the data domain – properties – models – applications». In this work the method of representation of ontology via finite-state machines and relations lying in the basis of every ontology are considered. This approach allows entering operations on ontologies using operations on languages and finite state machines. At such approach types of ontologies and their hierarchy are not detailed with the purpose of underlining community of the examined operations. Operations are illustrated by the simple examples of ontologies, related to computer mathematics [3].

1. Presentation of Ontologies in Finite-state Machines Theory

Let us represent ontologies as directed graph of G = (V, E), where the set of vertexes V is the set of data domains and the set of edges E is a binary relation between these data domains.

With each directed graph G = (V, E) we associate finit-state (generally speaking) partial determined machine A = (V, X=v, f, S, F) without outputs, where V is a set of the states which also serves as the source alphabet of this machine, S is a subset of the initial states, F is a subset of the final states (which, in particular, can be empty), and the function of transitions of this machine is determined as follows: f(u,v)= v only in the case when $(u,v) \in E$ and it is not determined in other cases.

Let us consider the example of representation of the fragment of ontology for the data domain «Combinatorics» [5].

Example 1. Let us set the ontology representing small part of the data domain «Combinatorics» as following directed graph:

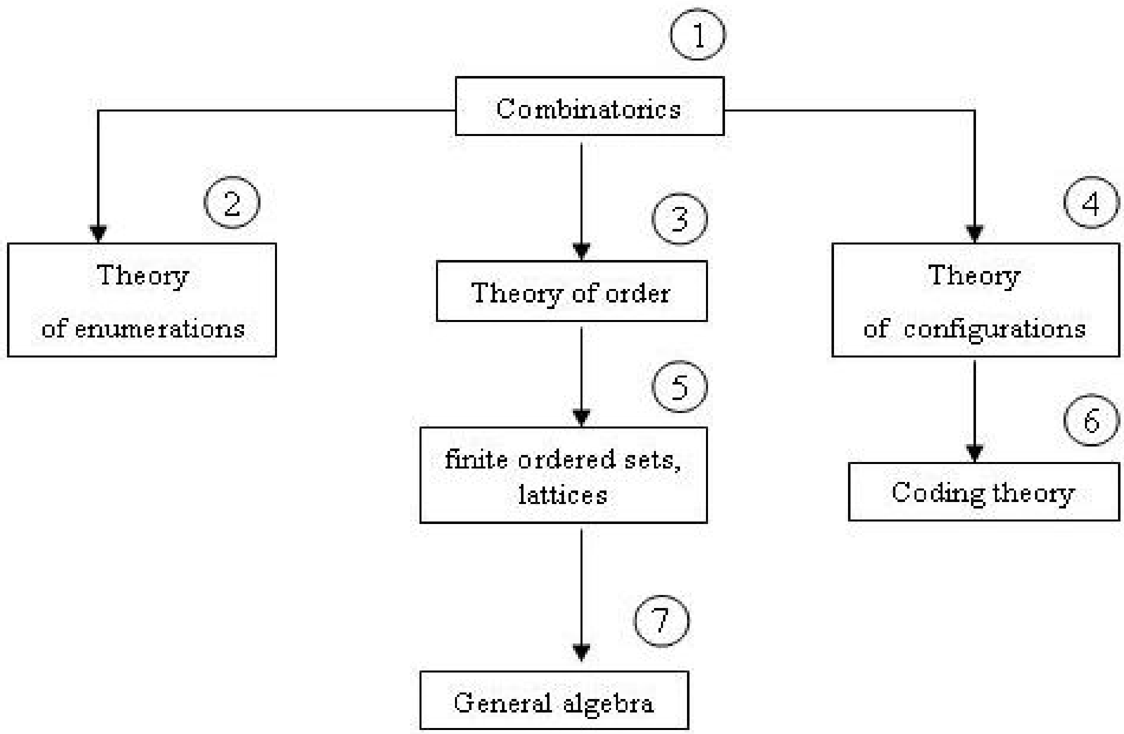

Fig. 1. Ontology O

Finite-state machine, which corresponds to this ontology, is of the following form A = (V = {1,2, 3, 4,5, 6,7}, X = {1,2,3,4,5,6,7}, f, {1}, {7}), where f is determined as following transition graph:

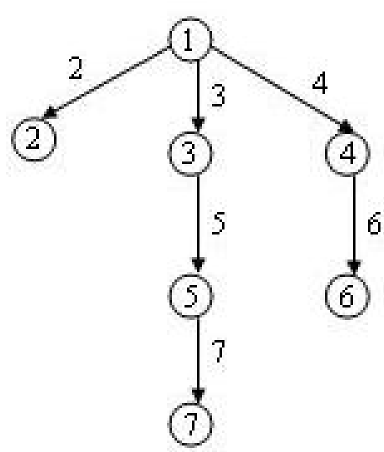

Fig. 2. Finite state machine A for O

It means that f(1,2)= 2, f(1,3)=3, f(1,4)=4, f(3,5)=5, f(5,7)=7, f(4,6)=6. Other transitions in this machine are not determined.

2. Operations on Ontologies in Finite-state Machines Representation

Representation of ontologiy as finite-state machine without output allows entering operations on ontologies. Operations on machines mean operations on regular languages which are accepted by these machines. There are following basic operations:

union is a set-theoretic union of the set of states and the set of transitions of these machines-arguments***;***

intersection is the set-theoretic intersection of the set of the states and the set of transitions replenished by the transitive closure of relation of attainability on machines-arguments;

appending or ***multiplication*** of two machines is the special case of operation of union, when an association is executed only on the great number of the initial states of the second machine;

iteration – repeated eventual number of one times operation of increase, applied within the framework of one ontology with the purpose of clarification and addition to this ontology (this operation means the ontology incremental refinement and addition);

an appeal is an opposite orientation of transitions in an automat, presenting this ontology, i.e. construction of the function of transitions of g(v,u)= u if and only if, when f(u,v)= v and indefinitely in other cases.

Example 2. Let ontology of kind is given

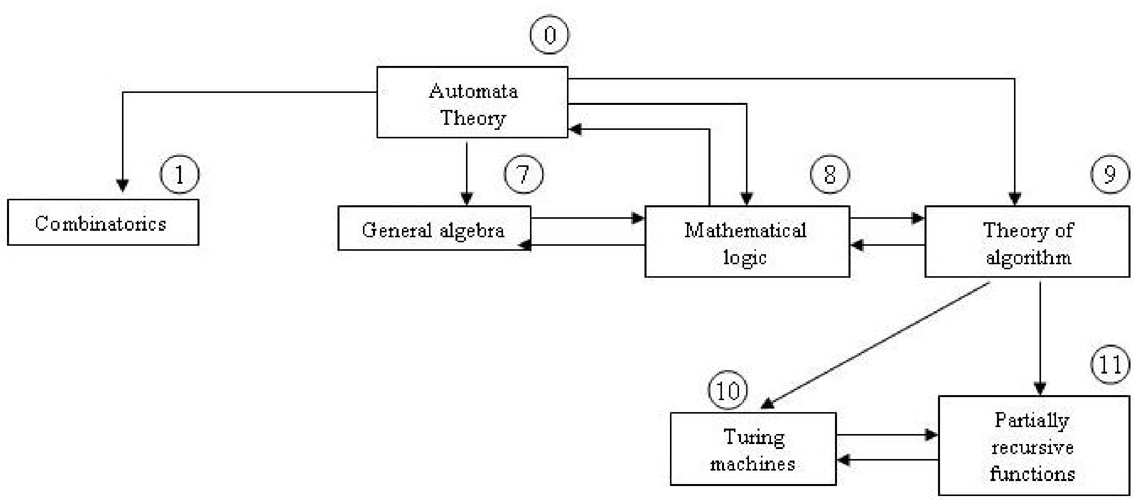

Fig. 3. Ontology O $_1$

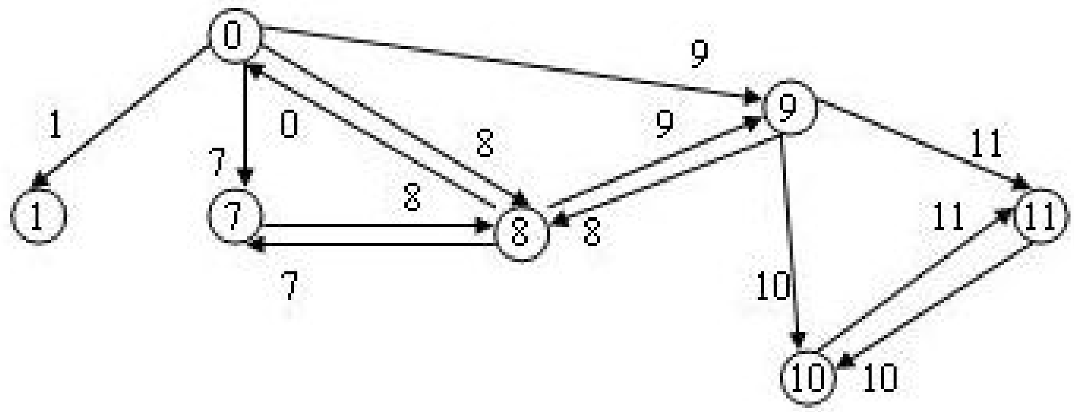

Fig. 4. Finite state machine A_1 ***for*** O_1

where A_1=({0,1,7,8,9,10,11},{0,1,.,11},g,{0},{11}).

If one applies the operations entered above to the automats of A_1 and A from a previous example they give such results.

Union:

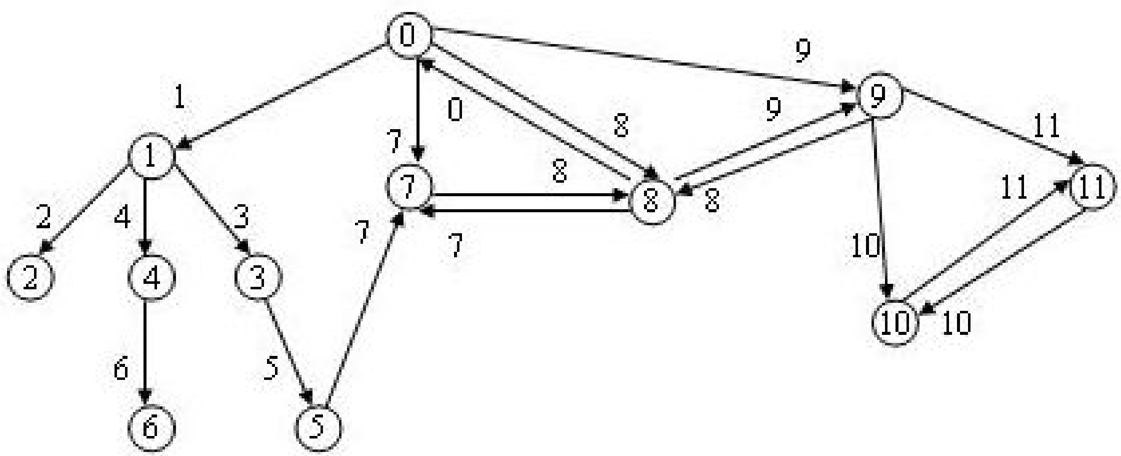

Fig. 5. Finite state machine $A \cup A_1$

Intersection:

Fig. 6. Finite state machine $A \cap A_1$

Iteration: clarification of ontology of O_1:

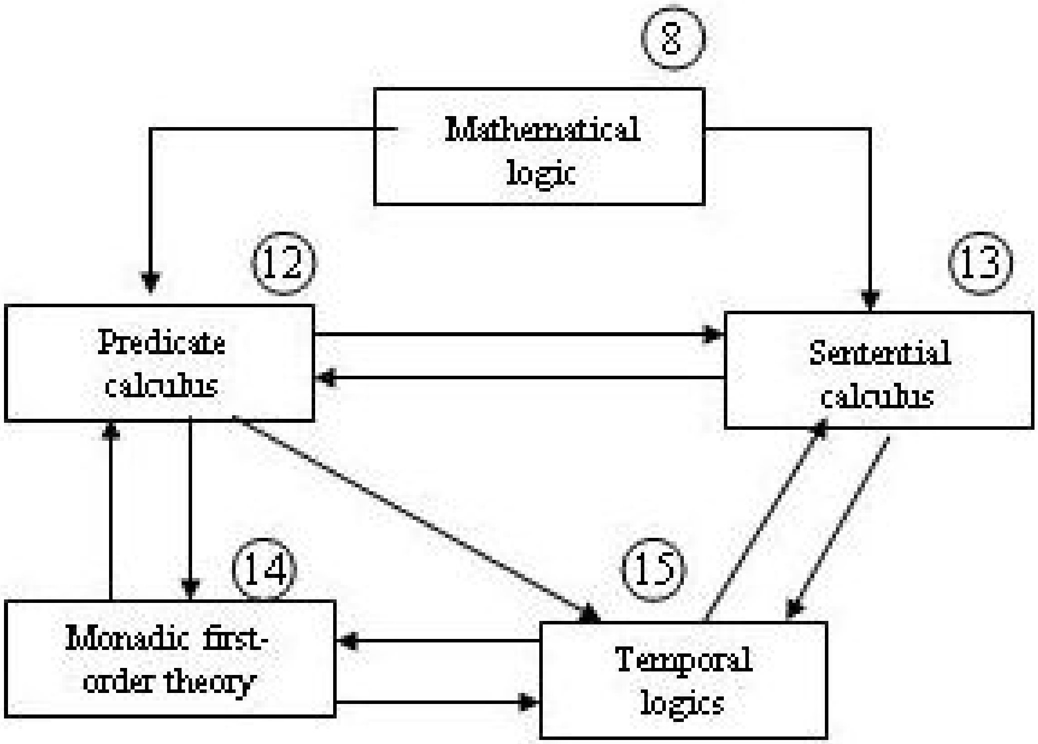

Fig. 7. clarification O_2 of ontology of O_1

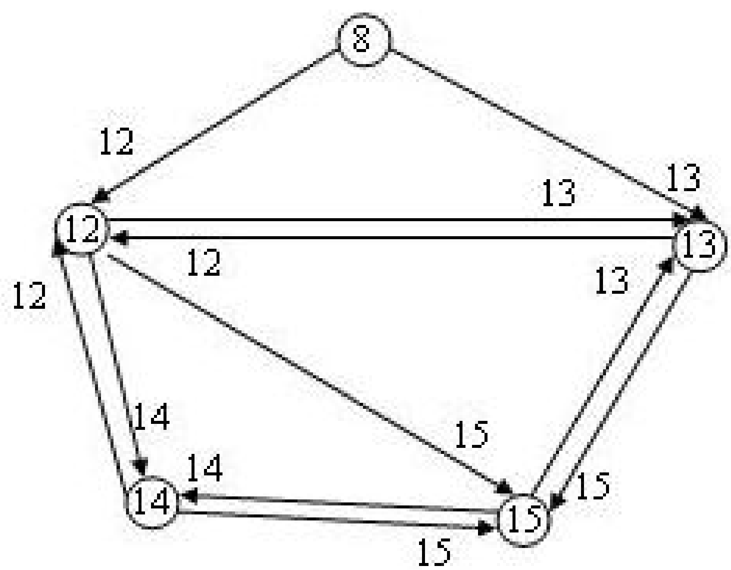

Fig. 8. Finite state machine A_2 for ontology of O_1

Concatenating automats A_1 and A_2 on the initial state 8 automat A_2, get an automat, presenting the specified ontology O_1*O_2 .

Appeal: applying this operation to A1, get an automat:

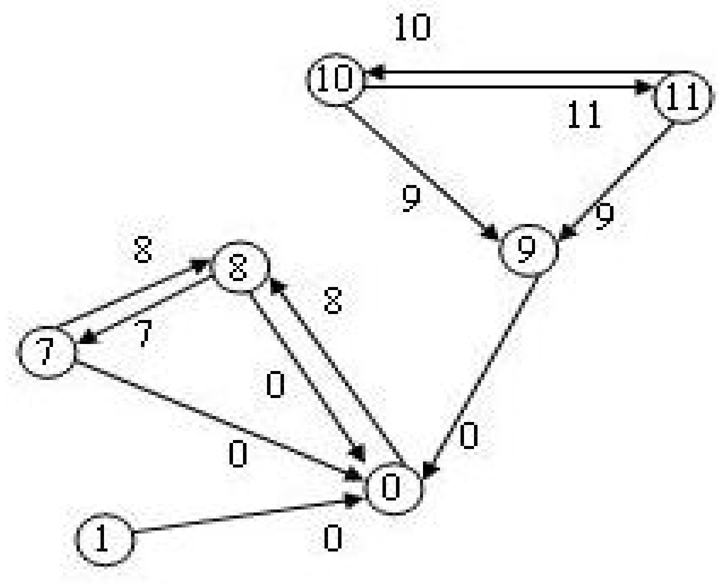

Fig. 9. Converting finite state machine for ontology of O_1

3. Short-story Description of Operations

Algebraic properties of the entered operations on ontologies follow from the proper properties of operations of algebra of regular languages. It means that these operations satisfy the followings laws: commutativity and associativeness of operations of association and crossing, associativeness of increase, distributivity of operation of increase in relation to the operations of association and crossing.

This great number of operations (in the case of necessity) can be extended at least in two directions. One of such directions is expansion operations on columns (introduction and delete of top and rib, connection of counts, isomorphic connection [6], cartesian product, etc.). Other direction is algebra of relations. As every ontology is presentation as some aggregate of relations (in particular: one), it is possible to enter the operations of relational algebra.

What from possible directions will be chosen, depends on the practical necessities of the use of ontologies. To forecast anything does not make sense on that score, because practice appears always richer than any theory. Authors hope that the presented operations above ontologies will appear useful at an analysis, synthesis and manipulation by ontologies and ontological objects.

4. Problems of Realization of Operations

Let us consider now some problems, arising up on the way of realization of these operations.

The first problem (and possibly basic during work with ontologies) is related to that correct implementation of the operations described higher requires creation of some general glossary of subject domains and concepts, which it would be possible to identify proper objects by. Presumably, this problem is not the problem of realization of the entered operations only but also a general issue on the way of construction of ontologies and works with ontologies.

The second problem, arising up during realization of operations, is related to the present hierarchy of areas and concepts. The point is that in different ontologies the same concepts and objects can be on the different levels of hierarchy and it must be taken into account at application of operations. In offered approach this problem is decided by the construction of the transitive closure of accessibility relation on the states of automats, presenting ontology data. However, authors are not sure that this closure is enough for the ptoblem decision. Here it seems that experiments are necessary on real ontologies and their representations.

The third problem is related to completeness of knowledges, presented in given ontologies. This problem is basic in the process of specification and verification of software and hardware systems. Here this problem is related to possibility of the construction of the information system which is in some way complete and guided-by-ontology.

5. Summary

The topic of this work originated from the lectures which were presented on the conferences of KDS-2005 and KDS-2007 (Varna, Bulgaria) [1-4]. An ontologies section of these conferences was one of the greatest and lectures presented in these sections were encouraged for development of presentation of ontology and operations on ontologies with the purpose of automation of process of planning and manipulation by these objects. Possibly, after this attempt to enter operations on ontologies other approaches will appear in order to construct the algebra of ontologies. It would be very desirable and fruitful for further development of this knowledge domain. Our approach, presumably, is not the best, as requires the decision of the problems presented above.

Bibliography

1. Gavrilova T., Puuronen S. In Search of a Vision: Ontological View on User Modeling Conferences' Scope. XII-th International Conference KDS 2007, ITHEA, Sofhia, 2007. Volume 2, p.422-427.
2. Gribova V. Automatic Generation of Context-sensitive Help Using a User Interface Project. XII-th International Conference KDS 2007, ITHEA, Sofhia, 2007. Volume 2, p.417-422.
3. Кривой С., Матвеева Л., Лукъянова Е., Седлецкая О. Онтологический взгляд на теорию автоматов. XII-th International Conference KDS 2007, ITHEA, Sofhia, 2007. Volume 2, p.427-436.
4. Artemieva I. XII-th International Conference KDS 2007, ITHEA, Sofhia, 2007. Volume 2, p.403-411.
5. Кривий С. Л. Дискретна математика. Вибрані питання. Київ. Видавничий дім „Києво-Могилянська академія". - 2007. - 572 с.

Authors' Information

Kryvyi Sergii – Glushkov Institute of Cybernetics of NSA of Ukraine, *Ukraine, Kiev, 03187, 40 Glushkova Street, Institute of Cybernetics, e-mail: krivoi@i.com.ua*

Khodzinskyi Oleksandr – Glushkov Institute of Cybernetics of NSA of Ukraine, *Ukraine, Kiev, 03187, 40 Glushkova Street, Institute of Cybernetics, e-mail: okhodz@gmail.com*