I T H E A

International Journal INFORMATION THEORIES & APPLICATIONS

2007 Volume 14 Number 1

International Journal
INFORMATION THEORIES & APPLICATIONS
Volume 14 / 2007, Number 1

IJ ITA is official publisher of the scientific papers of the members of the Association of Developers and Users of Intellectualized Systems (ADUIS) and the Association for Development of the Information Society (ADIS)

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.foibg.com/ijita*.
The camera-ready copy of the paper should be received by e-mail: *info@foibg.com* .
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.14, Number 1, 2007

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: **Institute of Information Theories and Applications FOI ITHEA**
Sofia, 1000, P.O.B. 775, Bulgaria. www.foibg.com, e-mail: info@foibg.com

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

PREFACE

Verba volant, scripta manent !

The "**International Journal on Information Theory and Applications**" (IJ ITA) has been established in 1993 as independent scientific printed and electronic media. IJ ITA is edited by the *Institute of Information Theories and Applications FOI ITHEA* in collaboration with the leading researchers from the Institute of Cybernetics "V.M.Glushkov", NASU (Ukraine) and Institute of Mathematics and Informatics, BAS (Bulgaria).

During the years, IJ ITA became as well-known international journal. Till now, including this volume, more than 625 papers have been published. IJ ITA authors are widespread in 39 countries all over the world: *Armenia*, *Belarus*, Brazil, Belgium, *Bulgaria*, *Canada*, Czech Republic, Denmark, Egypt, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, *Israel*, Italy, Japan, Kirghizia, Latvia, Lithuania, Malta, Mexico, Moldavia, Netherlands, Poland, Portugal, Romania, *Russia*, Scotland, Senegal, Serbia and Montenegro, *Spain*, Sultanate of Oman, Turkey, *UK*, *Ukraine*, and USA.

Volume 14/2007 of the IJ ITA contains 60 papers written by 121 authors from 10 countries (marked in italics above), selected from several international conferences, seminars and workshops organized or supported by the Journal.

At the first place, the main source for selection were the ITA 2006 Joint International Events on Information Theories and Applications, (June 20-30, 2006, Varna, Bulgaria):

- XII-th International Conference "Knowledge-Dialogue-Solution" (KDS 2006);
- V-th International Workshop on General Information Theory (GIT 2006);
- IV-th International Conference "Information Research and Applications" (i.TECH 2006);
- IV-th International Workshop on Multimedia Semantics (WMS 2006).

Several papers were selected from the pool of papers directly submitted to IJ ITA.

Main characteristic of ITA 2006 International Conferences was that the papers were combined into thematic sessions. Because of this, the selected papers are published in this volume following the thematic sessions' organisation.

Congratulations to **Juan Castellanos** (Spain) and **Georgi Totkov** (Bulgaria) who were awarded by the International Prize "**ITHEA**" for the year 2006. The "ITHEA" Prize has been established in 1995. It is aimed to mark the achievements in the field of the information theories and applications.

More information about the IJ ITA rules for preparing and submitting the papers as well as how to take out a subscription to the Journal may be obtained from www.foibg.com/ijita.

Krassimir Markov

IJ ITA Founder and Editor in chief

International Prize "ITHEA"

Awarded Scientists till 2006:

1995	*Sandansky*	*K. Bankov, P. Barnev, G. Gargov, V. Gladun, R. Kirkova, S. Lazarov, S. Pironkov, V. Tomov*
1996	*Sofia*	*T. Hinova, K. Ivanova, I. Mitov, D. Shishkov, N. Vashchenko*
1997	*Yalta*	*Z. Rabinovich, V. Sgurev, A. Timofeev, A. Voloshin*
1998	*Sofia*	*V. Jotsov*
1999	*Sofia*	*L. Zainutdinova*
2000	*Varna*	*I. Arefiev, A. Palagin*
2001	*St.Peterburg*	*N. Ivanova, V. Koval*
2002	*Primorsko*	*A. Milani, M. Mintchev*
2003	*Varna*	*T. Gavrilova, A. Eskenazi, V. Lozovskiy, P. Stanchev*
2004	*Varna*	*B. Kokinov, T. Vamos*
2005	*Varna*	*L.F. de Mingo, M. Dobreva*
2006	*Varna*	*J. Castellanos, G. Totkov*

IJ ITA major topics of interest include, but are not limited to:

INFORMATION THEORIES

Artificial Intelligence
- *Computer Intellectualisation*
- *Intelligent Networks and Agents*
- *Intelligent Technologies*
- *Knowledge Discovery and Engineering*
- *Knowledge Acquisition and Formation*
- *Distributed Artificial Intelligence*
- *Models of Plausible Reasoning*
- *AI Planning and Scheduling*

Bioinformatics
Business Informatics
Cognitive Science
Decision Making
Education Informatics
General Information Theory
Hyper Technologies
Information Models
Intellectualisation of Data Processing
Knowledge-based Society
Logical Inference
Natural language Processing
Neuroinformatics
Philosophy and Methodology of Informatics
Quality of the Programs
Software Engineering
Theory of Computation

APPLICATIONS

Business Information Systems
Communication Systems
Computer Art and Computer Music
Hyper Technologies
Intelligent Information Systems
Multimedia Systems
Programming Technologies
Program Systems with Artificial Intelligence
Pyramidal Information Systems
Very Large Information Spaces

BASIC STRUCTURE OF THE GENERAL INFORMATION THEORY

Krassimir Markov, Krassimira Ivanova, Ilia Mitov

***Abstract**: The basic structure of the General Information Theory (GIT) is presented in the paper. The main divisions of the GIT are outlined. Some new results are pointed.*

***Keywords**: General Information Theory.*

***ACM Classification Keywords:** A.1 Introductory and Survey*

Introduction

There exist several common theoretical information paradigms in the Information Sciences. May be, the most popular is the approach based on the generalization of the Shannon's Information Theory [Shannon, 1949], [Lu, 1999]. Another approach is the attempt to be synthesized in a common structure the existing mathematical theories, which are applicable for explanation of the information phenomena [Cooman et al, 1995].

Besides of this, we need to point the diligence of the many researchers to give formal or not formal definitions of the concept "information". Unfortunately, although they are quite attractive in some cases, these definitions did not bring to any serious theoretical results [Abdeev, 1994], [Bangov, 1995], [Markov P., 2002], [Tomov, 1991], [Elstner, 1993].

At the end, there exist some works that claim for theoretical generality and aspire to be a new approach in the Information Science, but theirs authors should clear up what they really talk about [Burgin, 1997].

The theoretical base of the informatics needs the philosophical support and substantiation to become wide accepted scientific paradigm. This way, the closely scientific research in the domain of informatics would be able to leap across its boundaries and to become as elements of the scientific view of life.

Discovering the common philosophical base has exceptional importance.

The philosophical rationalizing and substantiating of the information phenomena become as leading goal of the scientific knowledge.

Starting point need to be the consideration that the General Information Theory (GIT) needs to be established as internal non-contradictory logical system of contentions [Markov et al, 1993]. This rule contrasts the understating of the informatics as a mosaic of formal theoretical works and applications.

Basic requirement is that the GIT needs to explain the already created particular theories and paradigms.

The mathematical structures ought to serve as a tool for achievement the precise clearness of the philosophical formulations and establishing the common information language for describing and interpreting the information phenomena and processes.

The second very important requirement is to build the GIT on the base of the inceptive philosophical definition of the concept "information" using as less as possible the primary undefined concepts with maximal degree of philosophical generalization. This requirement follows the consideration that ***the concept "information" is not mathematical concept.*** The behavior, peculiarity and so on could be described by the mathematical structures but this is another problem. In this case, the accent is stressed on the comprehension that the information has purely material determination and that it is a consequence of the interaction between the material objects as well as of the real processes and phenomena occurred in them and with them.

The presented in this paper General Information Theory (GIT) is based only on primary consideration of the world as variety of entities, which are formed by relationships between entities that form lower levels.

The development of GIT had started in the period 1977-1980. The first publication, which represents some elements of GIT, was published in 1984 [Markov, 1984]. The establishment of GIT was not rectilinear.

Occasionally, the influences of other paradigms have disturbed this process and have turned it to the vain effort [Burgin, Markov, 1991].

The fundamental notion of the GIT is the concept "Information". All other concepts are defined based on this definition. In 1988, the not formal definition of the concept of Information was published in [Markov, 1988]. It became as a fundamental definition for the General Information Theory [Markov et al, 1993], [Markov et al, 2003a]. The translation of the philosophical theory into the formal one is a good approach for verification of the scientific ideas [Markov et al, 2003b], [Markov et al, 2004]. Because of this, the basic concepts of the General Information Theory ware presented philosophically and formally.

This paper is aimed to present the internal structure of GIT in its current state. For this purpose we will remember some main results as well as we will discuss the new achievements of GIT.

The GIT is build by three specialized theories:

- Theory of Information,
- Theory of Infos,
- Theory of Inforaction.

Theory of Information

The fundamental notion of the General Information Theory is the concept "Information". All other concepts are defined based on this definition. The first not formal definition of the concept of Information was published in [Markov, 1988]. The main philosophical explanations were published in [Markov et al, 1993]. Several attempts to develop a formal definition were introduced during the years [Markov et al, 2003b], [Markov et al, 2004].

Entity

In our examination, we consider *the real world* as a space of *entities.* The entities are built by other entities, connected with *relationships*. The entities and relationships between them form the internal *structure* of the entity they build. To create the entity of a certain structural level of the world, it is necessary to have:

- the entities of the lower structural level;
- established forming relationship.

The entity can dialectically be considered as a relationship between its entities of all internal structural levels.

The forming relationship has a representative significance for the entity. The destruction of this essential relationship causes its disintegration. The establishment of forming relationship between already existing entities has a determine significance for the emerging of the new entity.

The forming relationship is the reason for *the emergence* of individual properties, which distinguish the new entity from the forming ones. ***The relationships form and present the entity****.*

Impact, Interaction, Reflection

Building the relationship between the entities is a result of the ***contact*** among them. During the contact, one entity ***impacts*** on the other entity and vice versa. In some cases the opposite impact may not exist, but, in general, the contact may be considered as two mutually opposite impacts which occur in the same time.

The set of contacts between entities forms their ***interaction***. The interaction is a specific ***interactive relationship*** between entities which take part in it.

The contacts of the given structural level are processes of interaction of the entities on the lower levels.

During the establishing of the contact, the impact of an entity changes temporally or permanently the internal structure of the impacted entity. In other words, the realization of the relationships between entities changes, temporary or permanently, their internal structure at one or at few levels.

The internal change in the entity, which is due to impact of the other entity we denote with the notion "***direct reflection***".

Every entity has its own level of sensibility. This means that the internal changes occur when the external influence is over the boundary of the sensibility of the entity.

The ***"reflection impulse"*** for given entity is the amount of the external influence needed for transition from one state to the reflection one.

The entities of the world interact continuously. It is possible, after one interaction may be realized another. In this case, the changes received by any entity, during the first interaction, may be reflected by the new entity.

This means the ***secondary (transitive external) reflection*** exists.

The chain of the transitive reflections is not limited. In general, the concept "transitive impact" (respectively "transitive reflection") of the first entity on the third entity through the second one will denote every chain of impacts (reflections) which start from first entity and ends in the third entity, and include the second entity in any internal place of the chain.

One special case is the ***external transitive self-reflection*** where the entity reflects its own relationships as a secondary reflection during any external interaction.

Some entities have an opportunity of ***internal self-reflection***. The internal self-reflection is possible only for very high levels of organization of the entities, i.e. for entities with very large and complicated structure. The self-reflection (self-change) of the entity leads to the creating of new relationships and corresponding entities in it.

Of course, the internal self-reflection is a result of the interaction provided between entities in the lower levels of the structure of the entity. Such kind of entities has relatively free sub-entities with own behavior in the frame of self-preservation of the whole entity. As a result of the self-reflection, some relationships and corresponding sub-entities are created or changed in the entity.

The combination of the internal and external self-reflection is possible.

Finally let remark that the reflection could not be detected by the entity that contains it. This is dialectical behavior of the reflection - it is only an internal change caused by the interaction.

Information

The real world contains unlimited number of entities. When an entity contacts another, there exists a great possibility to join third entity in this process. It is clear; the third entity may contact and reflect each of others as well as the process of realization of the interaction between them — the process of realization of the contact is a specific (temporal) forming relationship between entities and during the process of establishing the contact the entities form new (temporal) entity which in the same moment may be reflected by the third entity. So, the third entity may reflect any vestiges of this interaction from both first and second entities.

In the special case when the third entity contains reflections of the first entity received by both two different ways:

1. by transitive impact of the first entity on the third one through the second entity,
2. by impact of the first entity on the third one which is different from the transitive one, i.e. it can be direct impact or transitive impact through another entity (-ies)

then the third entity became as an external relationship between first entity and its reflection in the second entity – it became as ***"reflection evidence"*** of this relationship.

✓ The first entity is called ***reflection source;*** the second entity is called ***reflection recipient***; and the third entity is called ***reflection evidence***.

In this special case, when there exist the triple

"(source, recipient: evidence)",

the reflection of the first entity in the second is called ***information*** in the second for the first entity.

Let point one very important case of the real world - simultaneous contacts of the three entities. Every one of them may be source, recipient and evidence in the same time. There exist six cases which represent the simultaneous contacts of three entities. Therefore, the entities $\mathfrak{A}$, $\mathfrak{B}$ and $\mathfrak{C}$ may be in the next six reflection relations: ($\mathfrak{A}$, $\mathfrak{B}$: $\mathfrak{C}$); ($\mathfrak{B}$, $\mathfrak{C}$: $\mathfrak{A}$); ($\mathfrak{C}$, $\mathfrak{A}$: $\mathfrak{B}$); ($\mathfrak{A}$, $\mathfrak{C}$: $\mathfrak{B}$); ($\mathfrak{C}$, $\mathfrak{B}$: $\mathfrak{A}$); ($\mathfrak{B}$, $\mathfrak{A}$: $\mathfrak{C}$).

All reflection relations are equivalent from point of view of the interrelations between reflection source, reflection recipient and reflection evidence. Because of this we will discuss only the case ($\mathfrak{A}$, $\mathfrak{B}$: $\mathfrak{C}$).

For practical needs, it is more convenient to follow the next consideration.

The reflection in the recipient represents both the relationships and the sub-entities of the source. From other point of view, the relationships build up and present the entities. Because of this, the reflected relationships are the essence of the reflection. In other words, iff there exist reflection evidence than the reflection of the forming relationship may be considered as "information" for reflected entity. Therefore, in the sense that the evidence exists to point what relationship (between what entities) is reflected and where it is done, we may say

"***The information is reflected relationship".***

So, the *reflection* of the first entity in the second one is "***information"*** for the first entity if there is corresponded *reflection evidence*. The generalization of this idea leads to assertion that ***every reflection can be considered as information, iff there exists corresponding reflection evidence.***

General Structure of Information

The entities and theirs relationships form space hierarchies. Every entity contains all entities of its low levels. In this sense, we can say that every relationship contains in itself the relationships of low levels of the entity.

As reflected relationship, the Information is reflected space hierarchy of all relationships of this one. From this point of view, we can say the general structure of information reflects general structure of real relationships.

The information of one level contains space hierarchy of information for low levels. Therefore, the main idea is:

The General Structure of Information is a Space Hierarchy.

Information Elements and Information Memory

The triple

***i* = (source, recipient : evidence)**

defines concrete ***(single) information element.*** The triple "**i**" is called ***"information relationship".***

The ***(information) memory*** of the entity is the set of all information elements, which are reflected in the entity.

It is clear, from point of view of the period of existing of the corresponded reflections; the entity memory may be more *temporal* or more *permanent.*

Information Spaces and Information Environment

The information elements are real reflections in the entities and they exist in the real world. This means that for every contact or interaction as well as for every single entity or set of entities the corresponded sets of information elements may exist.

The set of information elements, which is defined by:

- single source and single recipient, is called ***single information space***;
- many sources and single recipient, is called ***common information space***;
- single source and many recipients, is called ***single information environment,*** which contains many information spaces;
- many sources and many recipients, is called ***common information environment***.

Types of the Information

The information is a result from the interaction. It is a kind of the reflection. Therefore, the information has the corresponding properties.

Especially, we have primary interaction, secondary (transitive) interaction, self-interaction etc.

This way, there exist corresponding types of the reflection and the main types of information are:

- direct information;
- transitive information;
- transitive self-information;

- interactive direct information;
- interactive transitive information;
- interactive transitive self-information.

From other point of view, the interaction may be provided on different levels of the structure of the entities. Therefore, we may talk about corresponded types of information.

The types of information memories as well as the structures of the information environments define corresponded types of information, too.

The Further Investigation in the Theory of Information

The further investigation and development of the Theory of Information may be directed towards investigation the types and characteristic of information in correspondence with the specific of entities and relationships as well as characteristics of the environment.

Contacts and Interactions need to be investigated according different types of entities.

The philosophical support is very important so the research need to take in account the "Theory of reverberation" [Pavlov, 1987] as well as the development and extending of ideas about reflection and self-reflection given in this paper.

The main place needs to take the investigation of the types and possible interconnections of the basic information triple ***i* = (source, recipient: evidence)** as well as the types and the characteristics of the direct, transitive, and interactive information and self-information based of the hypothesis about the general structure of information.

Special attention needs to be paid on the basic types of information in closely correspondence of type of interaction and reflection as well as the different levels of the structure of the entities.

As we have seen, the types and the characteristics of the information memories, the information spaces as well as the information environments are another main theme of this theory.

Theory of Infos

The genesis of the concept of **Infos** started from the understanding that the concept **"Information Subject"** is perceived as human characteristic. It is clear that in the nature there exist many creatures which may be classified to this category. To exclude the misunderstandings we decide to introduce new word to denote all possessors of the characteristics of the Information Subject.

This word is **"*Infos*"**.

Activity and Information Expectation

Every forming relationship as well as every relationship unites the entities and this way it satisfies some theirs possibilities for building the relationship by establishing the contact. In other words, for creating the forming relationship we need:

- entities, from which the new entity is able to built;
- possibilities of the entities for establishing the contact by satisfying of which the forming relationship may be originated.

The forming relationship is the aggregate of the satisfied possibilities for establishing the contact.

It is clear that after establishing the relationship we may have any of two cases:

1) all possibilities of the entities for establishing the contact are satisfied by such possibilities of other entities;
2) there are any free possibilities after finishing the establishment of the new relationship - on the low levels of the entity or, if it is a new entity, on the level of the whole entity. Disintegration of the whole entity or any its part may generate any possibilities too.

In the second case, the entity has any ***"free valences"***, which needs to be satisfied by corresponded contacts with other entities. We may say the entity has ***activity*** generated by the free possibilities for establishing the contacts with the entities from the environment.

The process of interaction is satisfying the possibilities for contact of the entities. From point of view of the entity, the interaction may be external or internal.

During the interaction given entity may be destroyed partially or entirely and only several but not all parts of the destroyed entity may be integrated in the new entity. This means that there exist both constructive and destructive processes in the process of interaction between entities. The determination of the type of the interaction depends on the point of view of given entity. The interaction dialectically contains constructive and destructive sub-processes.

If the entity is a complex, it is possible for it to have an opportunity of self-reflection. In such case, it is able to reflect any reflection, which has been already reflected in it. In this case, because of the new internal changes (self-reflection) the entity may obtain any new ***"secondary activity"***.

The secondary activity is closely connected to the structural level of the entity, which correspond to the level of the self-reflection. This way the secondary activity may be satisfied by internal or external entity from point of view of the given entity. In other words, the ***resolving*** of the secondary activity may be ***internal*** or ***external***.

During the establishment of the information relationship it is possible to be generated any secondary free activity (possibilities on the low levels of the entity or on the level of the whole entity) which needs to be satisfied by corresponded contacts with other entities.

The secondary activity generated by the information relationship is called ***"information activity".***

On given level of complexity of the entities a new quality becomes — the existence of self-reflection and internal activity based on the main possibilities for contact of the sub-entities as well as based on the new (secondary) possibilities created after internal self-reflection.

The internal activity may be resolved by:

- the internal changes which lead to partial internal disintegration of the sub-entities and theirs a posterior internal integration in the new structures;
- the external influence on the environment.

The internal changes may lead to removing of some sub-entities if they have no possibilities for integration with the others, i.e. if they have no free valences to be resolved in the process of integration.

The external influence is the most important. The impact on the entities around the entity is the way to resolve its activity. The destroying of the external entities and including the appropriate theirs parts in itself is the main means to exist and satisfy the free valences.

One special kind of activity is the information one. We assume that the secondary activity needs to be resolved by relevant to the information valences corresponded opposite (information) valences which need to be of the same genesis, i.e. generated by any information relationship. So, not every entity may be used for resolving the secondary activity.

This way, the entity expects a special kind of (information) contacts and (information) interaction for resolving the information activity. Because of this the information activity is called ***"information expectation".***

The Information Witness

Let remember the special case from above when the third entity contains reflections of the first entity received by both two different ways:

1) by transitive impact of the first entity on the third one through the second entity,
2) by impact of the first entity on the third one which is different from the transitive one, i.e. it can be direct impact or transitive impact through another entity (-ies).

In this case the third entity became as an external relationship between first entity and its reflection in the second entity — it became as ***"reflection evidence"*** of this relationship.

In addition, if during establishing the information relationship ***i*** = (source, recipient: evidence) in the reflection evidence is generated information expectation (activity) it is called ***"information witness".***

As the information witness is more complex entity so the information relationship may be more complex. In addition, let remark that the complex reflection is time-depended process. In other hand, the memory and actual context determine the result of the complex reflection.

The Information is a Model

As Marx Wartofsky remarks, the concept "**model**" has been used for denotation of the very large class of phenomena: mechanical, theoretical, linguistic, etc. constructions. He gave a good definition of the model relation and made clear the main characteristics of the model [Wartofsky, 1979]. This definition is as follow:

The model relation is triple M:

$$M: (S, x, y)$$

where "S" is subject for whom "x" represents "y". In other words only in this relation and only for the subject "S" the entity "x" is a model of the entity "y".

As we point above, the interaction between two entities is a specific theirs relationship. If there exist information witness (**W**) of the interaction between two entities as well as of the existence of the information about the first entity in the second entity, **W** became as subject for whom the information in the second entity represents the first one. In other words, there exists relation

$$M: (\mathbf{W}_{BA}, I_{BA}, A),$$

where "A" and "B" are entities, and the $\mathbf{W}_{BA}$ is the information witness, which proofs that the assertion "$I_{BA} \subset B$ is information in B for A" is true.

In the relation ($\mathbf{W}_{BA}$, I_{BA}, A) the information I_{BA} is a model of A**.**

The Information Model

The entities of the world interact continuously in the time. It is possible, after any interaction one another may be realized. In this case, the changes received by any entity, during the first interaction, may be reflected by the new entity. This means the ***secondary (transitive, external) reflection*** exists. The chain of the transitive reflections is not limited.

Let A, B and C are entities; A and B interact and after that B interacts with C. If there exist the relations:

- M_{BA}: ($\mathbf{W}_{BA}$, I_{BA}, A), where $\mathbf{W}_{BA}$ is the information witness, which proofs that the assertion "$I_{BA} \subset B$ is information in B for A" is true,
- M_{CB}: ($\mathbf{W}_{CB}$, I_{CB}, B), where $\mathbf{W}_{CB}$ is the information witness, which proofs that the assertion "$I_{CB} \subset C$ is information in C for B" is true,

and if $M_{C(B)A}$: ($\mathbf{W}_{C(B)A}$, $I_{C(B)A}$, A), where $\mathbf{W}_{C(B)A}$ is the information witness, which proofs that the assertion "$I_{C(B)A} \subset C$ is information in C for information in B for A" is true.

In such case, from point of view of the $\mathbf{W}_{C(B)A}$ the information $I_{C(B)A}$ is a model of A. In other hand, because of transitive reflection, $I_{C(B)A}$ is created as reflection of the I_{BA} but not directly of A.

This means that **$I_{C(B)A}$ is a model of the information in B for A**.

In other words the $I_{C(B)A}$ is an ***information model*** in C for A**.**

The collecting of information models for given entity in one resulting entity may exist as a result of the process of interaction between entities. Such process is in the base of the ***Information modeling***.

If an information model **IM** contains information for (reflected from) the two source information models $\mathbf{IM}_1$ and $\mathbf{IM}_2$ than the source information models are "***similar***" in the sense of the model **IM**.

The similarity of the information models causes the establishing the relation of aggregation between them.

The relation of similarity aggregates the similar models in new ***internally determined information model*** in the memory of the information witness.

The aggregation may cause the generating the new information activity, which may be resolved not only in the environment around the information witness. The possibility of self-reflection may cause the generating the new information models in his memory without any external influence and so on.

This process of aggregation and generation of new models is not limited.

The (information) models internally generated via self-reflection are called "***mental (information) models***" of the information witness.

Resolving the Information Expectation

Because of the existing of the information expectation, i.e. the existing of the secondary information activity, the Information Witness "expects" to combine the information valences with any others.

The combining the valences of the information expectation with some others is called ***resolving the information expectation***.

Let "n" is the number of free valences in an information expectation. After the contact some of them are combined as well as the others are not. The new valences, which are generated by the contact, do not belong to the information expectation before contact. They may form new information expectation but the basis for our reasoning will be the starting information expectation.

The normalized by "*n*" number *D'* of the not combined valences is called ***degree of discrepancy*** (**D**) of the incoming reflection to the information expectation, i.e.

$$\mathbf{D} = \frac{D'}{n}$$

The normalized by "*n*" number *C*' of the combined valences is called ***degree of combining*** (**C**) of the incoming reflection to the information expectation, i.e.

$$\mathbf{C} = \frac{C'}{n}$$

There exists the equation: **C + D = 1.**

From point of view of given expectation for contact the number of free valences is fixed. After the contact, as a result of reflection, some of the free valences of the entity may be combined with any new (internal or external) valences. Of course, new free valences may occur. The number "*n*" varies in the process of interaction. Every contact may change it.

The more valences of the information expectation have been resolved, the more qualitative is the incoming information and vice versa.

The difference **A** between normalized number **C** of resolved valences and normalized number **D** of not resolved valences of the information expectation is called ***adequacy of the reflection to the information expectation***, i.e.

$$\mathbf{A = C - D}$$

It is easy to see that the values of adequacy A are in the interval [-1,1].

The Infos

The resolving of the information activity is ***a goal*** of the information witness.

This goal may be achieved by the establishment and providing (information) contacts and interaction.

The entity, which has possibility for:

- ***(primary) activity*** for external interaction;
- ***information reflection and information memory***, i.e. possibility for collecting the information;
- ***information self-reflection***, i.e. possibility for generating "secondary information";
- ***information expectation*** i.e. the (secondary) information activity for internal or external contact
- ***information modeling and resolving the information expectation***

is called ***Infos***.

The Further Investigation in the Theory of Infos

What gives us the concept “Infos”?

At the fist place, this is the common approach for investigating the natural and artificial information agents.

In other hand, this is the set of common characteristics which are basic for all entities, which we may classify to the category of the Infos.

And, at the end, this is a common philosophical basis for understanding the information subjects.

Our main goal is to provoke the scientists to continue the research in this important area and to make the next step.

The concept **"Infos"** is basic for the General Information Theory [Markov et al. 2003a]. Its definition is only the starting point for further investigations and building the ***Infos Theory***.

The variety of types of Infoses in the real world needs to be investigated and classified in the future research. At the first step, we may propose that may be at least two main types of Infoses exist:

- ***infogens*** - the natural creatures;
- ***infotrons*** - the artificial creatures.

Also, the Infos Theory needs to give answers to many other very important questions, such as:

- What is the nature of the activity of the Infos?
- What is the difference between the living level of the Infos and the non-living one?
- Is it true that the boundary between non-living and living entities is self-reflection and internal activity for satisfying the secondary (information) possibilities for internal or external contact?
- Etc.

It is impossible to answer to all questions in a single article. We may make only the next little step. This is the aim of the present paper.

The concept "Information Model" (IM) is fundamental for the Informatics. There exist many approaches to define this concept. As a rule, every definition is based on those concepts, which the concrete scientific paradigm had given. Every new theoretical approach needs to redefine the concepts it uses in the frame of the corresponded to it new paradigm. This way in different paradigms we may have different definitions of the given concepts [Popper, 1968].

There exists a long list of names of scientists who worked to define more precisely the concept "Model" (and respectively - the information model). It contains the names of N.Wiener and A.Rosenblueth [Rosenblueth, Wiener, 1945], V.M.Glushkov [Glushkov, 1986], M.W.Wartofsky [Wartofsky, 1979] and many others.

For long period, the concept "Information model" has been used to denote one of the main activities in using the computer technique. May be, now it is the most popular understanding of it and many scientists are satisfied of the meaning it contains.

Nevertheless, the definition of the concept of information model may and need to be extended to cover the new scientific paradigms, which come from the current Informatics. This is the goal of the Theory of the Infos.

Presented above so simple and clear definition of the concept "information model" has very great impact on GIT and key role for definition and explanation of all subjective information phenomena in the world. In addition, it may be used as a base concept in the area of Artificial Intelligence research.

The information models initiated inside the Infos form subjective information set. Inside his information set, the Infos can build "information spaces". The information space of the Infos is dynamic as a structure and content. When a new information model is generated the Infos compares it with the information models from context and with the information expectation. This is the starting point for the processes of reasoning.

However, the information modeling is only the first part of the complex process of decision making in usual practical situations. The decision making is at least two-level process:

- Collecting information models for given entity in one resulting entity;
- Analyzing and knowledge discovery on the base of given goal, which results aimed to be used for predicting

of any characteristics of the modeled entity.

In everyday language, the concept "Information modeling" is assumed to denote the whole chain of phases of decision making, which we make to solve the problem [Gladun, 1994].

Theory of Inforaction

Information Objects

When the Infos interact with the entities around in the environment, there exist at least two cases of reverberation:

- the contacts and interaction are casual and all reflections in the Infos as well as in the entities have casual origin;
- the contacts and interactions are determined by the information activity of the Infos.

In the both cases, the contacted entity may reflect any information model from Infos. The possibility for reflection of the information model is greater in the second case.

An entity, in which one or more information models are reflected, is called ***"information object".***

The information objects can have different properties depending on:

- the kind of influence over the entities - by ordering in space and time, by partial or full modifying, etc.,
- the way of influence over the entities - by direct or by indirect influence of the Infos on the object,
- the way of development in time - static or dynamic,

etc.

It clear, the Infoses are information objects.

Information Operations

The information is kind of reflection. Therefore, the only way one to operate with information is to operate with the entity it contains. Every influence on the entity may cause any internal changes in it and this way may change the information already reflected. Another type of influence is to change the location of entity or to provoke any contact between given entity and any other.

The influence over the information object is called "***information operation***".

The information operations may be of two main types:

- the Infos internal operations with the sub-entities that contain information,
- external operations with the information objects that contain information.

Internal Operations

The internal operations with the subentities closely depend of the Infos possibilities for self-reflection and internal interaction of its subentities.

The self-reflection (self-change) of the Infos leads to the creating of new relationships (and corresponding entities) in it. These are subjectively defined relationships, or shortly - ***subjective relationships***. When they are reflected in the memory of the Infos they initiate information model too, but on a higher level. These high-level information models may have not real relationships and real entities that correspond to them.

The possibility for creating the relationships of similarity is a basis for realizing such very high level operations as "comparing elements or substructures of the information models", "searching given substructure or element pattern in the part or in the whole structure of the information model", etc.

It is clear, the Infos is built by entities some of which may be also Infoses, but on the lowest levels. So, the internal operations are determined by the concrete internal level but from the point of view of the higher levels, they are assumed as external operations. Because of this, we will concentrate out attention on the second type of operations.

External Operations

The external operations with information objects may be differed in two main subtypes — basic and service operations.

There are two "***basic information operations***" which are called I-operations:

- I-reflection (reflecting the information object by the Infos, i.e. the origination of a relevant information model in the memory of the Infos).
- I-realisation (creating the information object by the Infos);

In the process of its activity, the Infos reflects (perceives) information from the environment (entities O_i, i=1,2...) by proper subentities (sensitive to video, acoustic, tactile, etc. influences) called "***receptors***" R_i (i=1,2...). Consequently, the Infos may receive some information models. This subjective reflection is called "***I-reflection***".

When necessary, the Infos can materialize (realize) in its environment (entities O'_j, i=1,2...) some of the information models, which are in his memory, using some sub-entities called "***effectors***" M_j (j=1,2...). Consequently, new or modified already existing entities reflect information, relevant to these information models. This subjective realization is called ***"I-realization"***.

There are several operations, which can be realized with the information objects: transfer in space and time, destroying, copying, composition, decomposition, etc. Because of the activity of the Infoses, these operations are different from other events in reality. In this case, the Infos determined operations with information objects are called "***service information operations***".

For example, some of the very high-level service operations are based on the external influence on the information object to change any existing reflection: including and removing an element in and from the structure; copying or moving substructures from one place to an other; building new structure using as a basis one or several others; composing or decomposing of elements or substructures; etc.

Information Processes

Let "O" is a set of real information objects and "M" is a set of information models.

We will consider every set of real information objects as an information object, if the opposite is not stated.

Every set of information models we consider as information model.

The *information operations* are:

- the function **r**: $O \rightarrow M$. (*I-reflection)*

- the function **e**: $M \rightarrow O$. (*I-realization)*

- the function **s**: $O_d \rightarrow O_r$ between two sets of information objects, O_d and O_r may be coincidental (*service operation*).

Let t_1, t_2,..,t_n are information operations. The consequence of information operations P, created using the composition, i.e.

$$P = t_1 \circ t_2 \circ \ldots \circ t_n$$

is called "***information process***".

In particularly an information process can include only one operation.

It is clear, the composition of two or more I-reflections as well as the composition of two or more I-realizations are not allowed.

Information Contact

If an information model from the Infos is reflected in another entity, there exist possibility, during the "a posterior" interactions of the given entity with another Infos, to transfer this reflection in it. This way an information model may be transferred from the Infos to another.

If the second Infos has already established information expectation, the incoming reflection will be perceptible for the Infos. The information expectation will be resolved in some degree and the incoming information model and information in it will be received by the second Infos.

Let S_1 and S_2 are Infoses and O is an arbitrary entity.

The composition of two contacts

$$S_1 \xrightarrow{\Theta^{S_1 O}} O \xrightarrow{\Theta^{O S_2}} S_2$$

is called "***information contact***" between Infos S_1 and Infos S_2 iff during the contacts any information model from S_1 is reflected in the Infos S_2 true the entity O. The Infos S_1 is called "***information donor***", the Infos S_2 is called "***information recipient***", and the entity O is called "***information object***".

In this case, when the donor and the recipient are different Infoses the information contacts between them consist of a composition of at least two information operations - I-realization and I-reflection. For the realization of a direct information contact between two different Infoses is necessary the execution of the composition of these two "basic" operations. All the rest information operations are necessary for supporting the basic ones i.e. they are auxiliary (service) operations.

For the realization of one information contact at least one information object is necessary.

This way the elementary communicative action will be provided.

In general, every information process "k", having as a start domain the set S_d (of information models) and as a final domain the set S_r (again of information models), which may be coincidental, we call "information contact":

$$k: S_d \rightarrow S_r$$

S_d is called "Infos-donor" and S_r - "Infos-recipient".

Information Interaction

The set "R" of all information contacts between two Infoses S_a and S_b

$$R= \{k_i \mid i=1,2..; k_i: S_a \rightarrow S_b\}$$

is called "***information interaction***" or simply "***inforaction***".

When S_a and S_b are coincident, we call it Information interaction with itself (in space and time).

The set "B" of all information objects, used in the information interaction between given Infoses is called "***information base***".

Information Society

The **"Information Group"** (IG) is a set of Infoses, with common Information Base of the information interactions between them.

The **"Information Society"** (IS) is a set of Information Groups, with common Information Base of the information interactions between them.

In the small Information Group the service information operations may be provided by the every Infos when it is necessary.

In the Information Society this is impossible or not optimal. In such case, some Infoses or Information Group became as **"information mediators"** between the others. They start to provide the service information operations.

They realize **"Information Service"**.

The Further Investigation in the Theory of Inforaction

For more than twenty years the Theory of Inforaction has traversed the way from the exotic and unusual concepts such as "information contact" and "information object", presented by the authors in 1983, to actual and world-wide investigated area of informatics.

Nevertheless, there exist many problems for future research.

Note that I-realization is not just reflections of information models in material entity. They include both a reflection of the information models of the Infos and a reflection of the state of the Infos in the moment of I-realization.

This means that here we consider the notion of "information objects" as a more general than the notion of "message".

It is possible that the entity of the information object is not able to keep (save) the whole influence of the I-realization. In other hand, the Infos consciously, by proper actions, restricts the I-realization to reflection of information model only by suppressing the reflection of his condition in the moment of I-realization.

In this case, we are near to the notion of "message" as we use it conventionally.

For example, from the point of view of the notion message, the speech of one politician on the meeting and the same speech printed in the paper are the two equal variants of the message. However, the influence and the result from the perceiving of the speech are different in both cases. In the first one (direct contact) the perceiving one can reflect the condition of the speaker (intonation, pauses, etc.) but in the second case (indirect contact) this is almost impossible. From this point of view, there exists a relation between two different information objects.

The Theory of Inforaction closely depends on the results of information operations. After the execution of some of the information operations, a new information object is possible to be created (for example, after the composition or decomposition). In other cases, the operation may not lead to appearance of new information object but to destroying of a certain existing information object.

The Infos is the only one who can determine whether after the execution of one operation (or a consequence of operations) an information object has appeared. Analogously, the Infos is the witness whether a new information object appears, when in the process of I-realization the Infos acts upon entities, which include some reflection of earlier I-realization. That is why, when there is not exact instruction from the Infos, we suppose that all information operations, with the exception of two - "destroying" and "I-reflection" will produce (one or more) information objects. The operation destroying initiates "empty" information object by destroying the starting one. We suppose that the operation "I-reflection" always initiates information model in the memory of the Infos.

Because of the growing of the communicative aspects of the information service now all over the world the everyday concept is the "Information society".

The growth of the global information society shows that the knowledge turns into important and necessary article of trade. The open environment and the market attitudes of the society lead to arising of the knowledge customers and knowledge sellers, which step-by-step form the "Knowledge Markets". As the other markets, the Knowledge Market is the organized aggregate of participants, which operates in the environment of common rules and principles.

Examination of the market demand for various types of courses and training modules is an essential criterion for effectiveness and high efficiency. Market trends, industry requirements, and companies training needs have to be examined on a regular basis in accordance with the Theory of Information Interaction.

Conclusion

The development of the General Information Theory should not become by the single creative impulse. For a long period, the constructive activity of the many researchers is needed for establishing the new common paradigm.

We all need free scientific look at things, which will permit us to build the general theory without partiality, and aberrations taking in account all information paradigms already created and adopted.

During the years, the investigation in the area of the GIT has showed that the received theoretical results may be used for building the ontology of informatics. Our opinion is that the GIT may be used as main classification scheme. The first step is to describe the main divisions of informatics. The further investigation needs integration with other scientific areas and paradigms.

We have made a little walk toward the establishing the new paradigm. It is synthesized in the table below.

Basic Structure of the General Information Theory

✓ Occurrence	✓ Specificity	✓ Subject	✓ Theory
✓ Reflection	✓ Information Relationship	✓ Evidence	✓ Theory of Information
✓ Activity	✓ Information Expectation	✓ Witness	✓ Theory of Infos
✓ Modeling	✓ Information Modeling	✓ Infos	
✓ Interaction	✓ Information Interaction	✓ Society	✓ Theory of Inforaction

Acknowledgements

This paper is the next step of the process of establishing the GIT as common paradigm. It is based on the ideas considered during very creative discussions at the International Conference "KDS 1997" (September, 1997, Yalta, Ukraine) and at the International Conference "ITA 2000", (September, 2000, Varna, Bulgaria) as well as at the previous scientific meetings organized by the International Workgroup on Data Base Intellectualization (IWDBI). The creative discussion at the KDS 2003 International conference, based on the [Markov et al, 2003a] gives us a great impulse to continue working in this very important scientific area. Authors are very grateful to all participants in the fruitful discussions at KDS and ITA International Conferences and to all members of the International Workgroup on Data Base Intellectualization (IWDBI) and the Association of Developers and Users of Intellectualized Systems (ADUIS) for supporting the advance of the General Information Theory.

This work is partially financed by project **ITHEA-XXI** of FOI Institute of Information Theories and Applications.

Bibliography

[Abdeev,1994] R.F.Abdeev. The Philosophy of the Information Civilization. Moscow, VLADOS, 1994. (in Russian)

[Bangov, 1995] I.Bangov. A Graph-Topological Model of Information. Int. J. Information Theories and Applications, 1995, v.3, n.6, pp.3-9.

[Burgin, 1997] M.S.Burgin. General Information Theory. http://www.math.ucla.edu/~mburgin/res/compsc/Site3GTI.htm

[Burgin, Markov, 1991] M.Burgin, Kr.Markov. Formal Definition of the Concept Materialization. Mathematics and Mathematical Education, BAS, Sofia, 1991, pp.175-179.

[Cooman et al, 1995] G.de Cooman, D.Ruan, E.Kerre, Eds. Foundations and Applications of Possibility Theory. World Scientific, Singapore, 1995.

[Elstner, 1993] D.Elstner. About Duality of the Information and Organization. Int. J. Information Theories and Applications, 1993, v.1, n.1, pp. 3-5. (in Russian)

[Gladun, 1994] V.P. Gladun. Processes of New Knowledge Formation. Pedagog 6, Sofia, 1994 (in Russian).

[Glushkov, 1986] V.M.Glushkov. Epistemological Nature of the Information Modeling. In: V.M.Glushkov. Cybernetics, Questions and Answers, (in Russian), Moscow, Science, 1986, pp. 33-41.

[Lu, 1999] C.-G.Lu. A Generalisation of Shannon's Information Theory. Int. J. of General Systems, 28:(6), 1999, pp.453-490.

[Markov, 1984] Kr. Markov. A Multi-domain Access Method. Proc. of Int. Conf. "Computer Based Scientific Research". Plovdiv, 1984. pp. 558-563.

[Markov, 1988] Kr.Markov. From the Past to the Future of Definition of the Concept of Information. Proceedings "Programming '88", BAS, Varna 1988, p.150. (In Bulgarian).

[Markov et al, 1993] Kr.Markov, Kr.Ivanova, I.Mitov. Basic Concepts of a General Information Theory. IJ Information Theories and Applications. FOI ITHEA, Sofia, 1993, Vol.1, No.10, pp.3-10

[Markov et al, 2003a] Kr.Markov, Kr.Ivanova, I.Mitov. General Information Theory. Basic Formulations. FOI-Commerce, Sofia, 2003.

[Markov et al, 2003b] K. Markov, K. Ivanova, I. Mitov, E. Velikova-Bandova. *The Information*. IJ Information Theories and Applications, FOI ITHEA, Sofia, 2003, Vol.10, No.1, pp.5-9.

[Markov et al, 2004] K. Markov, K. Ivanova, I. Mitov, E. Velikova-Bandova. *Formal Definition of the Concept "INFOS"*. Proceedings of the Second International Conference "Information Research, Applications and Education" i.TECH 2004, Varna, Bulgaria. Sofia, FOI-Commerce, 2004, pp. 71-74. Int. Journal "Information Theories and Applications", 2004, Vol.11, No.1, pp.16-19

[Markov P., 2002] P.Markov. Think with Your Mind. Markov College. Sofia, 2002. (in Bulgarian)

[Pavlov, 1987] T.Pavlov. Collection of Selected Works, Vol. II. Theory of Reverberation. Science and Art, Sofia, 1987. (in Bulgarian).

[Rosenblueth, Wiener, 1945] A.Rosenblueth, N.Wiener. Role of Models in Science. Philosophy of Science, Vol.12, No.4, 1945.

[Shannon, 1949] C.E.Shannon. The Mathematical Theory of Communication. In: The Mathematical Theory of Communication. Ed. C.E.Shannon and W.Weaver. University of Illinois Press, Urbana, 1949.

[Tomov, 1991] K.Tomov. The Resomal-Isomorphic Principle. Arges, Sofia, 1991. (in Bulgarian)

[Wartofsky, 1979] M.W.Wartofsky. Models. Representation and the Scientific Understanding. D.Reidel Publishing Company, Dordrecht: Holland /Boston: USA, London: England/, 1979.

[Popper, 1968] K.R.Popper. Conjectures and Refutations: The Growth of Scientific Knowledge. Harper & Row, Publishers, New York and Evanston. 1968.

Authors' Information

Krassimir Markov - Institute of Mathematics and Informatics, BAS, Acad.G.Bonthev St., bl.8, Sofia-1113, Bulgaria; Institute of Information Theories and Applications FOI ITHEA, P.O.Box: 775, Sofia-1090, Bulgaria; e-mail: foi@nlcv.net

Krassimira Ivanova - Institute of Mathematics and Informatics, BAS, Acad.G.Bonthev St., bl.8, Sofia-1113, Bulgaria

Ilia Mitov - Institute of Information Theories and Applications FOI ITHEA, P.O.Box: 775, Sofia-1090, Bulgaria; e-mail: foi@nlcv.net

TECHNOLOGY FOR ONTOLOGICAL ENGINEERING LIFECYCLE SUPPORT [1]

Vladimir Gorovoy, Tatiana Gavrilova

Annotation*: Presented paper describes software system project ONTOLINGE-KAON that provides technological support for the whole lifecycle of ontological engineering. The main stress is put on the evaluation of maturity and quality of ontologies and on the usage of ontologies with the help of automated generation of knowledge portals, based on ontologies. Possibility of creation of knowledge portals built on top of ontologies can become a big step forward in the field of e-learning. The paper presents advantages provided by knowledge portals based on top on ontologies.*

Keywords*: ontological engineering, knowledge engineering.*

ACM Classification Keywords*: H.0 Information systems – General, I.2.6 Artificial intelligence - Learning*

Introduction

ONTOLONGE-KAON is aiming at providing technological support for the full lifecycle of ontological engineering. At present a great number of components and software products are implementing various tasks in work with

[1] The research is partially supported by Russian Foundation for Basic Research (grants **06-01-81005 and 07-01- 00053)**

TABLE OF CONTENTS OF VOLUME 14, NUMBER 1