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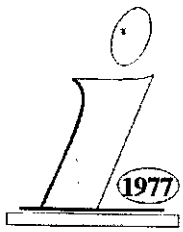
Profiles: Hubert L. Dreyfus
Distributed Mutual Exclusion Algorithm
Principia Cybernetica Project
Telecommunications in Slovenia



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EDITORIAL PROGRAM OF INFORMATICA

For the readers and editors of Informatica it may be important to know which criteria of successfulness (scientific significance) of the journal in the international context are we pursuing. Which are the criteria of excellence for editors and what kind of activity do we expect from our authors and readers?

Certainly, editors of Informatica have been chosen on the basis of their scientific (publishing, research, and organizational) activity in the global and European environment. The choice was made intuitively considering the available public references and personal communication. We began with publishing of profiles of our distinguished editors (e.g., T. Winograd, J. Šlechta, and H.L. Dreyfus) and will continue with provoking interviews. But, in the coming period we should appreciate to have the evidence concerning, for example, the ten most important articles in the last ten years for each of our editors. Such an overview would be extremely interesting for our readers, for it would show the complexity of themas pertaining to the fields of computation, artificial intelligence, robotics, informatics, and the revived area of cybernetics.

The second important goal of Informatica is to get a firm position in the so-called citation index and reviewing ambience (e.g. data bases such as SSCI, SCI and TCI, and special reviewing journals). Since Informatica covers different, in an interdisciplinary manner connected scientific domains, the citation index for an author could be multiplied over several disciplines, bringing him or her a higher score (citation value) of publications. This perspective of disciplinarily interwoven regions (e.g., computing, mathematics, philosophy, robotics, cybernetics) concerns both editors and authors and would represent an advantageous challenge in promotion and circulation of the journal.

My advice to the editors, authors, and readers of Informatica is to use as much as possible citations from Informatica, even of the papers belonging to the author himself/herself, but published in another scientific journal. Informatica will collect such data at the end of every fiscal year and use them in a competition for financial support of its donators.

The publishing program of Informatica remains as it was traced in the previous Editorials. We are an international interdisciplinary scientific journal, joining several areas of science and philosophy—concerning computation, informatics, robotics, mathematics, and cybernetics. We foster some new disciplines belonging to the field of the informational, for instance, the theory of chaos, photonics, quantum dynamics, social informatics, economy theories, new formalisms, etc. Our goal is not to become a journal with the so-called hard-disciplinary orientation, which are nowadays numerous and still popular, but do not consider the phenomenon that is already happening on the global scene: a changing paradigm of sciences and their future significance for the mankind. Simultaneously, we have to observe the globally relevant projects which may change the nowadays understanding substantially in the direction of the cybernetical, formalistic, and technological. All these projects could importantly improve the scope of the informational. I expect the help and understanding of the international community of Informatica, building up a new opportunity for publishing of interdisciplinary achievements in the broad realm of informatics.

—*Anton P. Železnikar,* Editor–in–chief

PROFILES

The introduction of the position and the work of professor Hubert L. Dreyfus (e.g., his curriculum vitae in a factical form), the most famous criticizer of the computer and artificial intelligence conceptualism and philosophy (hopes, beliefs, technology), is anything but a simple task. To write down an analytical version of his curriculum vitae would take a substantial effort concerning the analysis and interpretation of the positions, attitudes, and work of professor Dreyfus. It would be possible right now to pick out some of his significant achievements, but this would make the whole story shortened and deficient. From informative point of view, I believe very much, the readers of Informatica will appreciate to have as complete as possible data of his activity on this and the next pages. After a time and by the help of additional sources, I will make an attempt to write an exhaustive analysis and interpretation of the listed data and evaluate the significance of them for the philosophy, practice of computation, artificial intelligence, and informatics in the coming epoch.

Hopefully, the reader will be able to get his/her own overview of professor Dreyfus' academic, philosophical, and scientific activity from the listed data.

Hubert L. Dreyfus

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—*Instructor in Philosophy*, Brandeis, 1957–59.
—*Assistant Professor of Philosophy*, M.I.T., 1960–66.
—*Associate Professor of Philosophy*, M.I.T., 1967–68.
—*Associate Professor of Philosophy*, University of California at Berkeley, 1968–72.
—*Professor of Philosophy*, University of California at Berkeley, 1972 to present.
—*Director*, N.E.H. Summer Institute, University of California, Berkeley, 1980.
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—*Visiting Professor*, Frankfurt University, Summer 1989.
—*Co-Director*, N.E.H. Summer Institutes, University of California, Santa Cruz, 1990, 1992.
—*Visiting Professor*, Ecole Normale Supérieure, Paris, May 1991.
—*Visiting Professor*, Technical University, Vienna, June 1991.

HONORS AND AWARDS

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—Harvard Sheldon Traveling Fellowship, 1953–54, (Freiburg).
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—French Government Grant, 1959–60 (Ecole Normale Supèrieure, Paris).

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—NSF Grant: January 1968–September 1968; Research Associate in Computer Sciences, Harvard Computation Laboratory.
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—ACLS Grant, 1968–1969.
—Guggenheim Fellow, 1985.
—NEH Basic Research Grant, 1988–1989.
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—Phi Betta Kappa Lecturer, 1992–93.

PUBLICATIONS

Articles:

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—(with Samuel J. Todes) "The Three Worlds of Merleau-Ponty", *Philosophy and Phenomenological Research* (June 1962).
—(with Joseph Pequigney) "The Landscape of Dante's Inferno", *Italian Quarterly* (Spring 1962).
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—(with Joseph Pequigney) "Landscape and Guide: Dante's Modifying of Meaning in the Inferno", M.I.T. Publication in the Humanities, Number 66.
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—"Philosophical Issues in Artificial Intelligence", M.I.T. Publication in the Humanities, Number 80.
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—(with Stuart and Renee Dreyfus), "Skillfully Coping with the World: Man vs. Machine", *Museum Studies Journal*, (1988).

—(with Stuart Dreyfus), "On the Proper Treatment of Smolensky", *Behavioral and Brain Sciences*, (1988).

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—(with Stuart Dreyfus), "What is morality? A Phenomenological Account of the Development of Ethical Expertise", *Universalism vs. Communitarianism*, ed. David Rasmussen, The MIT Press, (1990). Revised and reprinted in *Revisioning Philosophy*, James Ogilvy, edt., State University of New York Press, (1992).

—(with Jerome Wakefield), "Action and the First Person", *John Searle and his Critics*, E. Lepore and R. Van Gulick, eds., Basil Blackwell, (1990).

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Naturwissenschaften Distinction Revisited", *Einheit der Wissenschaften: Internationales Kolloquium der Akademie der Wissenschaften zu Berlin*, Walter de Gruyter, (1991). Reprinted in *The Harvard Review of Philosophy*, (1991).
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—Review of Langan's *The Meaning of Heidegger*, *Philosophical Review* (July 1961).
—Review of Sartre's *Search for a Method*, *Philosophical Review* (October 1966).
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An $O(\sqrt{N})$ Token Based Distributed Mutual Exclusion Algorithm

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In this paper, we present a token based distributed mutual exclusion algorithm for a distributed computer system of N sites. The proposed algorithm is based on timestamps and the theory of finite projective planes. It also makes use of a "Token Queue" which is part of the token and contains a list of all sites which are requesting the token. The algorithm is deadlock free, free from starvation, and requires no message exchange in the best case, and $4\sqrt{N} - 2$ message exchanges in the worst case per critical section execution.

1 Introduction

One of the most interesting and fundamental problems in the area of distributed systems is the problem of mutual exclusion. The problem is to guarantee the integrity of a shared resource called *critical section* (CS) by restricting the use of such a resource to one site at a time in a distributed computer system which consists of a set of N distinct sites that communicate with each other only by sending messages over a communication network. In such systems, due to the lack of shared memory and a global clock and due to an unpredictable message delay, the task of designing a distributed mutual exclusion algorithm that is free from deadlock and starvation is much more complex. Over the past several years many algorithms to achieve mutual exclusion in distributed computer systems have been proposed [1, 8, 6, 12, 13, 14, 9, 16, 15, 11, 17, 21, 18, 19, 23, 24, 25]. These algorithms are briefly discussed in the next section.

In this paper, we present a token based distributed mutual exclusion algorithm for a distributed computer system of N sites. The proposed algorithm is based on timestamps and the theory of *finite projective planes*. It also makes use of a "Token Queue" which is part of the token and contains a list of all sites which are requesting the token. The algorithm is deadlock free, free from starvation, and requires no message exchange in the best case, and $4\sqrt{N} - 2$ message exchanges in the worst case per critical section execution.

The remainder of this paper is organized as follows: In the next section we provide a brief overview of related work. In section 3, we give the preliminaries for our algorithm. The description of the algorithm is given in section 4, followed by the correctness of the algorithm in section 5. Section 6 discusses the performance analysis of the algorithm. We conclude with some final remarks.

2 Related Research

During the last decade, a significant amount of effort has been focused on the development of the efficient distributed mutual exclusion algorithms. One of the earliest efforts in the area was by Alsberg and Day [2]. They appoint a central node to manage the access to a shared resource and the sites wishing to enter their critical sections need to get permission from this central site. This solution is highly efficient in that it requires only three messages per critical section execution, regardless of the size of the system or the density of requests. However, an obvious drawback of this solution is that the central site is unfairly burdened with responsibility and with message traffic. Thereafter many distributed mutual exclusion algorithms have been proposed. In general, these algorithms can be classified into two groups [23] *permission based* and *token based.* In the following subsections we describe the characteristics of each group and briefly survey some of the representative algorithms from each group.

2.1 Permission Based Algorithms

In permission based algorithms, in order for a site to gain access to the critical section, permission must be requested from some well defined set of sites referred to as its *request set.* The requesting site may enter its critical section as soon as it receives a reply to each one of its requests, and must send a release message to each site in its request set when it is finished, allowing them to permit other sites to enter the critical section.

In permission based algorithms, in order to ensure that every site resolves conflicting requests in the same way, a unique timestamp is included in each critical section request message to create a logical consistent ordering of requests. In such algorithms, a site which is not currently requesting will send replies to all requests that it receives. A site which is requesting will immediately send replies to those requests which are timestamped before its own request, and will delay replies to other sites until after it is finished with its own critical section.

Lamport [6] was the first to design a fully distributed permission based mutual exclusion algorithm using logical timestamps. In his algorithm each request set is the entire network. Then, if N is the number of sites in the system, and if self-messages are not counted, the algorithm requires $N-1$ requests, $N-1$ replies, and $N-1$ releases; or $3(N-1)$ messages per critical section execution. Ricart and Agrawal [18] realized that if all sites must grant permission by sending replies, then the release messages are superfluous, since a reply involves an implicit release. Therefore, they have reduced the number of messages in Lamport's algorithm to $2(N-1)$. Carvalho and Roucairol's algorithm [4] has further improved the number of messages in Ricart and Agrawala's algorithm by avoiding some unnecessary requests and reply messages. The idea behind this algorithm is that, if site i has not received a request message from site j, and since site i has executed the critical section last time, then site j has implicitly given permission to site i. Since site i does not have to ask permission from such a site j, the number of messages is reduced. They have shown that the number of messages exchanged per critical section execution in their algorithm is between 0 and $2(N-1)$.

Maekawa [8] further reduces the number of messages per critical entry to $c\sqrt{N}$ (where c is a constant between 3 and 5) by imposing a logical structure on the network. Maekawa's algorithm is significantly different from the others. In his algorithm, in order for a site to enter the critical section, a site must get permission from some set of sites. Maekawa uses the theory of finite projective planes to group the sites. The interesting aspect of Maekawa's algorithm is that the size of each of these sets is $\sqrt{N}$, where N is the number of sites in the network. Maekawa's algorithm is prone to deadlock because a site is exclusively locked by one requesting site at a time, and requests can arrive in any order. Since our algorithm utilizes some of the concepts used in Maekawa's algorithm, a detail description of this algorithm is given in section 3.

Sanders [22] developed a unifying framework for a large class of the permission based algorithms by defining the information structure that each site maintains. In this framework, when a site wants to enter the critical section, it sends request messages to a set of sites specified by its information structure and it may enter the critical section only when it receives permission from all the sites in this set. The concept of *information structure*

Year	Discoverer	# of Messages Best Case	# of Messages Worst Case	# of Messages Average
1978	Lamport	$3(N-1)$	$3(N-1)$	$3(N-1)$
1981	Ricart and Agrawala	$2(N-1)$	$2(N-1)$	$2(N-1)$
1983	Carvalo and Roucairol	0	$2(N-1)$	—
1985	Maekawa	$3\sqrt{N}$	$5\sqrt{N}$	—
1991	Agrawal and Abbadi	$O(logN)$	$(N+1)/2$	—
1992	Singhal	0	$2(N-1)$	$(N-1)$

Table 1. Chronological Order of Permission Based Distributed Mutual Exclusion Algorithms

was later employed by Singhal [24] who proposed a dynamic information structure algorithm which reduces message traffic by cleverly initializing an information structure and updating it as the algorithm evolves. In fact, Singhal's dynamic information structure algorithm uses a similar strategy to reduce the number of messages as in Carvalho and Roucairol's algorithm. Singhal's algorithm requires between 0 and $2(N-1)$ messages and on the average in light traffic, requires $(N-1)$ messages.

More recently Agrawal and El Abbadi [1] have presented an efficient algorithm for solving this problem. The algorithm imposes a logical tree organization on the site of the network. They show that their algorithm requires $O(logN)$ messages per critical section execution in the best case and $O(N)$ messages per critical section execution in the worst case. Table 1 lists some of the permission based mutual exclusion algorithms in a chronological order.

2.2 Token Based Algorithms

In the token based algorithms the token is a "unique and singular" message (also known as the PRIVILEGE [25]) which circulates among the sites. Only the site which possesses the token may enter its critical section. The various token based algorithms are distinguished by the methods for determining how a site obtains the token, and where a site sends the token when it is finished with its critical section.

One of the earliest token based mutual exclusion algorithms is by LeLann [7]. In this algorithm a token circulates on a ring of sites. A site wishing to enter the critical section simply waits for the token to arrive, it captures the token from the ring, it enters the critical section and then it simply passes the token back to the ring. This rather simple scheme results in requiring one constant size message (the token) being transferred per critical section invocation when all sites are waiting to enter to their critical sections. Otherwise, if m sites are waiting to enter to their critical sections in one complete cycle of the token all of these are satisfied in N messages or on the average N/m messages per critical section invocation is required.

Suzuki and Kasami [25] present a token based distributed mutual exclusion algorithm which is an improvement over the well known Ricart and Agrawala [18] permission based algorithm. Suzuki and Kasami's algorithm assumes a logically fully connected network topology and the existence of a token queue. In this algorithm a requesting site sends request messages to all other sites in the system. This guarantees that the site possessing the token will receive a request message and will enqueue it into the token queue. Each request is labeled with a sequence number, and the token message also contains an array with the sequence numbers of the last request satisfied at each site. As such, late arriving messages (i.e., requests which arrive after the requesting site has been serviced) can be ignored. In this algorithm the number of messages per critical section execution is $N-1$ request messages plus 1 token message or N messages per each critical section entry. Their algorithm was later improved by Ricart and Agrawala [19]. Ricart and Agrawala's algorithm [19] also requires N messages per critical section invocation. The main difference is that there is no token queue.

In recent years some very efficient token based algorithms have been proposed. One of the earliest one is due to Naimi and Trehel [17] which does not use sequence numbers. Instead, they organize the sites into a dynamic, logical, rooted tree. When a site invokes mutual exclusion, it sends its requests to the site which is possibly holding the token. When a site receives a request message, it will either forward this request message to another site possibly holding the token (if it is not requesting and it does not hold the token) or add all incoming request messages to its queue and appends the queue to the token message. Here there is no guarantee that a request will, in one step, reach a site that is expecting the token, but a request is guaranteed to reach the token in a finite amount of time. Performance of the algorithm will depend on the average height of the tree and on the extent to which requests need to be forwarded. This algorithm requires between 0 and N messages and on the average $O(logN)$ messages per critical section execution.

Another tree based mutual exclusion algorithm is due to Raymond [21]. In this algorithm the network topology is assumed to be a static unrooted tree (a spanning tree of the actual network) and it uses this tree for locating the token. Each site communicates only with its neighboring sites and holds information about its neighbors. In addition, each site knows which of its neighbors is on the path to the root where the token is. This site is referred to as *Near*. A site requests the token by sending a request message to its Near site. A sequence of request messages are sent between the requesting site and the site holding the token until a request message arrives at the site holding the token. Then the token is passed along the same path in the reverse direction. As the token passes through, the direction of the edges traveled by the token is reversed such that every path always leads to the site holding the token.

An interesting characteristic of this algorithm is that each site needs to know only its neighbors in the tree. In the best case, this algorithm requires no messages per critical section execution, since the token may be available locally. Raymond shows that for a radiating star topology, the number of message exchanges per critical section is $O(logN)$ on the average. However, in the worst case the number of messages per critical section is proportional to the diameter of the network which can be $O(N)$.

Singhal [23] developed a heuristically-aided algorithm to achieve mutual exclusion which uses state information to reduce message traffic. In this algorithm the sites maintain information about the probable location of the token and when a site wants to enter its critical section it uses a heuristic to guess which sites are likely holding the token and send the token request messages only to those sites rather than to all of the sites. The number of messages exchanged per critical section execution in this algorithm is between 0 and N and the average number of messages exchanged in light traffic is $(N+1)/2$.

Recently Makki et al. [12] also proposed an algorithm which achieves mutual exclusion in a distributed system. The proposed algorithm makes use of a "Token Queue" which is a part of the token and contains a list of all sites which are requesting the token. The token and queue are sent to the first site on the token queue followed by the second and third etc. Also each site maintains a record of which site is a good site to request the token from, so that a single token request can be made in order for a site to be placed on the token queue. Periodic update messages are sent to sites which are not on the token queue to inform them whenever the good site changes.

In general, the algorithm requires $(N/m)+1$ messages per critical section where m is the number of sites on the token queue. The performance of the algorithm improves from $N+1$ messages per critical section in an extremely light token request environment, to 2 messages per critical section in an extremely high token request environment. Table 2 lists some of the token based mutual exclusion algorithms in chronological order.

3 Preliminaries

Given a distributed system with N sites, Maekawas's algorithm [8] divides the sites into N subsets numbered 1 to N each containing $\sqrt{N}$ sites. In fact, at least one site is common between the subsets associated with any two sites. The subsets are chosen so that each subset is represented by at least one member of every subset. Each subset is usually referred to as a "request

Year	Discoverer	# of Messages Best Case	# of Messages Worst Case	# of Messages Average
1978	LeLann	1	N	N/m
1982	Suzuki & Kasami	N	N	N
1983	Ricart & Agrawala	N	N	N
1987	Naimi & Trehel	0	N	$O(logN)$
1989	Raymond	0	$O(N)$	$O(logN)$
1989	Singhal	0	$O(N)$	$(N+1)/2$ light traffic
1991	Makki et. al.	2	$N+1$	$N/m+1$

Table 2. Chronological Order of Distributed Token Based Mutual Exclusion Algorithms

set," R_i, for $i = 1$ to N. In this algorithm a site i can enter its critical section only when it receives permission from all the sites in its request set R_i. Mutual exclusion is enforced because a site gives permission to only one site at any time. Formally, the subsets must satisfy the following four properties:

1. For any combination of i and j, $1 \leq i, j \leq N$,

$$R_i \cap R_j \neq \emptyset$$

2. R_i, $1 \leq i \leq N$, always contains i.
3. The size of R_i, $\mid R_i \mid$, is k for any i, that is $\mid R_1 \mid = \mid R_2 \mid = \mid R_3 \mid = ... = \mid R_N \mid = k$ (where N is related to k by $N = k(k-1)+1$).
4. Any j, $1 \leq j \leq N$, is contained in the k, R_i's $1 \leq i \leq N$.

The selection of R_i's is not unique. There exists a number of ways to select these subsets, that satisfy the above properties. Maekawa showed that the problem of finding such subsets that satisfy the above conditions, is equivalent to finding a finite projective plane of N points. He also showed that with a fractional error, k equals $\sqrt{N}$. An example of the request is given below.

Example: (Request sets for $N = 7$ (where $k = 3$):

R_1={ 1,2,3 } R_5={2,5,7}
R_2={ 1,4,5 } R_6={3,4,7}
R_3={1,6,7} R_7={3,5,6}
R_4={2,4,6}

In Maekawa's algorithm when a site i wants to enter the critical section, it needs only to send requests to all the sites that are in its request set R_i. When a site finishes with the critical section, it sends a release to all the sites in its request set. This in essence sends a release to all subsets. The algorithm requires $O(\sqrt{N})$ messages per critical section execution because the size of a request set is $\sqrt{N}$.

Chang and Singhal [5] have shown that in Maekawa's algorithm there is always a danger of deadlock when more than one site is simultaneously requesting mutual exclusion. Even though he has tried to eliminate the deadlock by using the concept of a "timestamp," one can still construct an example which leads to a deadlock. In the following subsections we state the basic model, assumptions, concepts and definitions used in our proposed algorithm.

3.1 Model and Assumptions

We take a **distributed system** to mean a collection of N geographically dispersed autonomous computer sites which communicate with each other only by sending messages. The sites do not share a common memory. We are assuming that the sites are numbered from 1 to N. No assumption is made regarding the underlying network topology. However, it is assumed the underlying network is reliable and sites do not crash. Also we assume a message transmission time delay is finite and messages may not be delivered in the order sent.

Our proposed token based mutual exclusion al-

gorithm uses the property of **"finite projective planes"** [3] utilized in Maekawa's algorithm [8] to create the request sets, R_i's. Also it uses the **timestamp** concept of Suzuki and Kasami [25]. In our algorithm, the token maintains an array LN of N entries which contains the most recent request fulfilled for each of the N sites. The token also has a queue of requests that need to be fulfilled.

Also each site maintains a queue of all outstanding requests in timestamp order. In addition, each site has a variable called HOLDER which indicates the location of the token. When a site j in a request set R_j holds the token, all other sites in R_j will store the value of j in their HOLDER variables.

3.1.1 Message Types

Five types of messages are used in our algorithm. These are:

1. TOKEN message: This message has the form TOKEN(Q,LN) where Q is a queue of requesting nodes and LN is an array of size N such that LN[j] is the timestamp of the request of node j granted most recently.

2. REQUEST message: This message has the form REQUEST(j,T) where j is the site number of the site sending the request and T is the timestamp of the request. The message is sent from a site j which is requesting TOKEN to all the sites in its request set R_j. If this message is received by site i, then site i appends that to its local queue.

3. INFORM message: This message is sent from a site j which receives a REQUEST message and does not have the TOKEN to the site that holds the TOKEN in its request set, R_j.

4. HAVE-TOKEN message: This message is sent from a site j holding the token to all other sites in its request set R_j. The sites set their HOLDER variables to j. The purpose of this message is to inform all other members of R_j that j has the token, so that when requests arrive at their sites they can rout them to the site which holds the token. Site j also sets its HOLDER variable to j.

5. FORWARD-REQUESTS(j) message: This message is sent from a site j holding the token to all other sites in its request set R_j. The purpose of this message is to ask all other members of R_j to send their queues of messages to site j. Site j can then add all these requests to the token queue and forward the token along with the token queue to the first eligible requesting site. The first eligible requesting site is either the site at the head of the token queue if there are sites on the token queue, or the requesting site with the lowest timestamp among the newly arrived requests.

6. QUEUE-OF-REQUESTS(j) message: This message is sent from each site in a request set (except the site that has the token) to the site in that request set which holds the token. A QUEUE-OF-REQUESTS message type contains a list of all requests which have been arriving at a particular site.

4 Description of the Algorithm

In our algorithm, every site needs to maintain only information about the sites that are in its request set. This means that every site needs to know about the same number of sites. Also each site executes an identical procedure for handling the critical section. As in Suzuki and Kasami's algorithm [25], the privilege to enter the critical section equates to the possession of a token. The TOKEN message is always held by one site (except for the transient state when the token message is in transit from one site to another.) When no site wishes to enter the critical section, the last site to use the TOKEN continues to hold it. The token queue holds the numbers (identifiers) of the sites waiting to enter the critical section.

4.1 Initialization

In order to initialize the system the token must be created with an empty token queue and every site must have an empty local queue. This is to say that no sites are requesting the TOKEN. Initially one site in one of the request sets is holding the TOKEN. We assume that site 1 in the request set R_1 initially holds the TOKEN and the

HOLDER variable of every site in the request set R_1 is set to one.

4.2 The Algorithm

In this section, we present the algorithm executed by each site to achieve mutual exclusion. In this algorithm, when a site l wishes to enter the critical section, it sends REQUEST messages to all other sites in its request set R_l. These REQUEST messages are appended to the local queue of each site. Assuming a site i in the request set R_i gets the TOKEN, site i immediately sends HAVE-TOKEN(i) to all the other sites in its request set R_i and sets its HOLDER variable to i. Also every site in R_i sets its HOLDER variable to i as soon as it receives a HAVE-TOKEN message sent by site i. Now we have the following two cases:

CASE 1: If this is the initial state of the system then site i waits until it either receives an INFORM message from the sites in its request set R_i, or receives REQUEST messages from other sites. However, during this waiting period if site i wishes to enter the critical section, it does so and then goes back to its waiting mode.

CASE 2: If this is not the initial state of the system, then when site i finishes executing its critical section, the array LN, contained in the TOKEN message is updated to indicate that the current request of site i has been granted. Then, based on the content of the token queue, the following two actions will be taken:

CASE 2.1: The token queue is empty.
In this case, site i waits until it either receives an INFORM message from the sites in its request set R_i or receives REQUEST messages from other sites. However, during this waiting period if site i wishes to enter the critical section, it does so and then goes back to its waiting mode.

CASE 2.2: The token queue is not empty.
In this case, site i sends a FORWARD-REQUEST(i) message to all the sites in its request set R_i and then waits to receive all the QUEUE-OF-REQUESTS messages from the other sites in R_i. Meanwhile it updates the array LN, contained in the TOKEN message to indicate that the current request of site i has been granted. Next, each request is appended to the token queue from a site j such that its timestamp is after the timestamp of the most recently granted request (based on the content of array LN); this includes its own request for the TOKEN if there is one. (The token queue holds the identifiers of the sites waiting to enter the critical section). Finally, site i removes the identifier of the site found at the front of the token queue k, and sends the TOKEN along with the token queue and array LN to site k.

4.3 A Detail Description of the Algorithm

The following procedures give a detail description of the algorithm:

```
Procedure Initialize(1);
   begin
     Site 1 holds the TOKEN;
     HOLDER := 1;
     for each J in R1 do
         Send (HAVE-TOKEN(1),j);
     wait for either an INFORM message
         or a REQUEST message;
   end.


Procedure Request-Token(i);
   begin
     for each j in Ri do
        Send (REQUEST(i,T),j);
   end.
```

The procedure "Request-Token" is called when a site i wishes to enter its critical section. The request for token is sent to all other sites in its request set, Ri.

```
Procedure Receive-Token-Request(j);
   begin
      Receive(j,REQUEST(i,T));
      Enqueue(REQUEST(i,T),
          Local-queue(j));
      Send(INFORM(j),1);
   end.
```

This procedure is called when a site j receives a REQUEST message from a site i. This request will be appended to the local queue of site j. Also site j sends an INFORM message to a site l which holds the token.

```
Procedure Receive-Token(i);
   begin
     Receive(TOKEN);
     HOLDER := i;
     for each j in Ri do
        Send (HAVE-TOKEN(i),j);
     Call critical section;
     Update array LN
     If token-queue(i) is empty
        then
           if local-queue(i) is empty
              then
                 wait for either
                 an INFORM message
                 or a REQUEST message;
              else
                 x := Dequeue(
                      local-queue(i));
        else
           x := Dequeue(token-queue);
     for each j in Ri do
       Send (FORWARD-REQUESTS(i),j);
     for each j in Ri do
       Receive(i,QUEUE-OF-REQUESTS(j));
     Append all the requests that site i
     has received and the requests in the
     local-queue(i) to the token-queue;
     HOLDER := -1;
     Send(TOKEN,x);
   end.
```

This procedure is called when the TOKEN is received by site i;

```
Procedure Receive-Have-Token(j);
   begin
      Receive(j,HAVE-TOKEN(i));
      HOLDER := i;
   end.
```

This procedure is called when a site j receives a HAVE-TOKEN message from a site i. Upon receiving this message each site j sets its HOLDER variable to the identifier of the site which is currently holding the TOKEN.

```
Procedure Receive-Forward-Request(j);
   begin
      Receive(j,FORWARD-REQUESTS(i));
      HOLDER :=-1;
      Send(QUEUE-OF-REQUESTS(j),i);
   end.
```

This procedure is called when a site j receives a FORWARD-REQUESTS message from a site i. Upon receiving this message each site j sets its HOLDER variable to -1 (undefined). Also each site j sends a queue of the requests which has received so far to the site i which is currently holding the TOKEN.

5 Correctness of the Algorithm

To show that the algorithm is correct, we have to prove that: (1) at most one site in the system is executing the critical section at one time (i.e., achieves mutual exclusion); (2) there is no deadlock; and (3) there is no starvation. The following theorem, show that our algorithm achieves mutual exclusion and is free from deadlock and starvation.

Theorem 1: The algorithm achieves mutual exclusion and is free from deadlock and starvation.

Proof. To show that the algorithm achieves mutual exclusion, we have to prove that at most one site holds the TOKEN at one time. In our algorithm, a site can enter the critical section if and only if it possesses the TOKEN. In order to prove this theorem, we consider the following two cases:

CASE 1: The TOKEN is in transit. In this case no sites have the TOKEN.

CASE 2: The TOKEN is not in transit. In this case at most one site can have the token at one time.

Deadlock would occur if there was a circular waiting among the sites requesting mutual exclusion. We show that this is not possible. Assume that all the sites want to enter their critical sections but none of them has the TOKEN, so they are all awaiting for its arrival. The TOKEN is therefore in transit. After some finite time, the TOKEN will arrive at one of the sites and unlocks that site.

Starvation would occur when some sites repeatedly enter their critical sections while some other

sites wait indefinitely to enter into their critical sections. We show that this is not possible. Assume that site i in the request set R_i wishes to enter to its critical section but needs the TOKEN. It sends REQUEST messages to all the other sites in its request set R_i. One of the sites in one of the request sets, say site j, is holding the TOKEN. Based on our algorithm, when site j collects all the requests from the sites in its request set and appends them to the token queue, it will also receive and append the request from site i. The reason site j will receive the request from site i is because based on the finite projective planes property each site in R_i is also in several other request sets, and all the sites in R_i are collectively in all the request sets. Hence, site i will eventually receive the TOKEN and execute its critical section. Therefore, every REQUEST for the critical section execution will be satisfied. □

6 Performance Analysis

Performance is measured by the number of messages required per critical section execution. In measuring the performance of the algorithm we consider the following three cases: (a) Best case performance, (b) worst case performance, and (c) average case performance.

Theorem 2: In the best case the algorithm requires 0 messages and in the worst case the algorithm requires $4\sqrt{N} - 2$ messages per critical section execution.

To show that the algorithm requires no messages per critical execution in the best case, we consider the case when the site holding the TOKEN is waiting either for an INFORM message or a REQUEST message. In that case, when the site itself wishes to enter the critical section, it checks the HOLDER variable of itself and realizes that it has the TOKEN and there are no outstanding REQUEST messages from other sites. Therefore, it can immediately enter the critical section without any message transfer.

To prove the worst case performance of the algorithm, we assume site i in the request set R_i is holding the TOKEN and waiting for REQUEST messages. Site j in the request set R_j wishes to enter its critical section and sends REQUEST messages to all the other sites in its request set R_j. This takes $\sqrt{N} - 1$ messages. One of the sites in R_j, which is also in R_i, will send an INFORM message to i upon receiving the REQUEST message from site j. When site i receives this INFORM message it immediately sends $\sqrt{N}-1$ FORWARD-REQUEST messages to all the other sites in its request set R_i. After that, it waits to receive $\sqrt{N} - 1$ QUEUE-OF-REQUESTS messages from these sites. Then it sends the TOKEN to site j. Site j, after receiving the TOKEN, it sends $\sqrt{N} - 1$ HAVE-TOKEN messages to all the other sites in its request set R_j. It then executes its critical section and waits for the REQUEST messages. Therefore, all together in the worst case it needs $4\sqrt{N} - 2$ messages per critical section execution. In fact, if the requesting site is also in the request set R_i, then it does not need to send $\sqrt{N} - 1$ REQUEST messages. Hence, only $3\sqrt{N} - 1$ messages per critical section execution is required. □

7 Concluding Remarks

In this paper, we have proposed a simple and efficient token based distributed mutual exclusion algorithm, a simple and efficient token for a distributed computer system of N sites. The proposed algorithm is based on timestamp used in Suzuki and Kasami [25] and the theory of "Finite Projective Planes" used in Maekawa [8]. The proposed algorithm requires no message exchange in the best case and $4\sqrt{N} - 2$ message exchanges in the the worst case per critical section execution. Our algorithm is more efficient than Maekawa's permission based algorithm which requires between $3\sqrt{N}$ and $5\sqrt{N}$ message exchanges per critical section execution.

We showed that our algorithm achieves mutual exclusion and is free from starvation. Unlike Maekawa's algorithm, the proposed algorithm is not prone to deadlocks. Here, we did not discuss any failures (such as site failure or Token loss) or detection and recovery issues. However, the algorithm can be modified to incorporate failure recovery techniques commonly used for token based algorithms [20]. Therefore, one possible extension to this work is to make our algorithm fault-tolerant. Note that if our network were to allow multicasting (sending one message to many addresses,) then the number of messages required per critical section execution in the al-

gorithm would be reduced to a constant value, since each $\sqrt{N}$ messages can be considered as one message [10].

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QUALITY OF DECISION RULES: EMPIRICAL AND STATISTICAL APPROACHES

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It is useful within certain classification procedures that each decision rule induced by a learning algorithm be associated with a numerical factor which can express its properties and characterize a measure of belief in correctness of the rule, its power, predictability, reliability, likelihood, etc. A collection of these properties is symbolized by a function commonly called the rule quality.
The paper presents two approaches to the definition of the rule quality: empirical and statistical. Overview of several practical formulas of rule quality used in inductive learning algorithms are introduced and their characteristics compared.
General characteristics of a function which may be used as rule quality are pointed out, namely its monotony towards the consistency and completeness of decision rules. Statistical tools such as contingency table, measure of association, measure of agreement are introduced as suitable vehicles for depicting a behaviour of a decision rule.

1 Introduction

Many learning systems inducing decision rules have been developed within the past few years [11], [6]. A set of decision rules may be directly exploited by a classifier as its decision scheme. A learning algorithm may create either an ordered or unordered set of decision rules. If the decision set is *ordered*, then classifying an unseen object is quite straightforward: the classifier goes through the list of rules and looks for the first rule that matches ('fires') the given object; it is then categorized into the class attached to the rule.

However, classification exploiting an *unordered* set of decision rules exhibits a significant deficiency, not immediately apparent. Three cases are possible:

a) If the unseen object satisfies one or more rules of the *same* class, then the object is categorized to the class assigned to the rule(s).

b) If the unseen object is *not covered* by any rule, then either the classifier informs the user about its inability to decide, or the object is assigned by default to the majority class in the training set, or some similar techniques are invoked.

c) Difficulty arises if the object satisfies more rules assigned to *different* classes. Then some schemes (discussed below) have to be applied so as to assign the unseen object to the most appropriate class.

It is useful if each rule is associated with a numerical factor which can express its properties so as

to characterize a measure or belief of the rule, its power, predictability, reliability, likelihood, etc. A collection of these properties is symbolized by a function commonly called the *rule quality.*

One classification scheme exploiting rule quality orders the decision rules into an ordered list according to their qualities, and looks for the first rule satisfied by the object. Another scheme also considers rule quality, but goes through the entire set of rules, sums qualities of the matched rules of the same class, and assigns the unseen object to the class for which the *quality sum* reaches a maximum.

We are faced by these questions: How to define rule quality and how to combine rule qualities for several rules. This paper focuses on the first question.

A general characteristic required for the rule quality is its *monotony* towards its arguments. Its common arguments are the *consistency* and *completeness* factors of decision rules. The reason of exploiting the above characteristics is obvious. Any machine learning algorithm dealing with real-world noisy data is to induce decision rules that cover larger number of training examples even with a few negative ones (not belonging to class of the rule). In other words, the decision set induced must be not only reliable but also powerful. Its reliability is characterized by a consistency factor and its power by a completeness factor.

Behaviour of a decision rule R for the class C (on its right-hand side) can be formally depicted by the 2*2 *contingency table* [3], which is commonly used in machine learning [14], [12]:

	class C	not class C	
rule R covers	rc	$r\bar{c}$	r
does not cover	$\bar{r}c$	$\bar{r}\bar{c}$	$\bar{r}$
	c	$\bar{c}$	K

where

rc is the number of training examples that are covered by the rule R and belong to the class C;

$r\bar{c}$ is the number of examples covered by the rule R but not belonging to the class C, etc.;

$r = rc + r\bar{c}$ is the number of examples covered by R;

$c = rc + \bar{r}c$ is the number of the training examples of the class C, etc.; and

$K = c + \bar{c} = r + \bar{r}$ is the number of all training examples in the given task.

Using the elements of the contingency table, we may define the *consistency* of a rule R (also called the *sensitivity* [18]) as

$$cons(R) = \frac{rc}{r}$$

and its *completeness* (*coverage*, or *positive predictive value*) as

$$compl(R) = \frac{rc}{c}$$

Notice that the terms 'consistency' and 'completeness' (not only in this paper but also in other publications) have two meanings: Property or a numerical factor, but one may easily find the right meaning.

Some formulas for the rule quality introduced in this paper require *relative* rather than absolute frequencies in the contingency table:

	class C	not class C	
rule R covers	f_{11}	f_{12}	f_{1+}
does not cover	f_{21}	f_{22}	f_{2+}
	f_{+1}	f_{+2}	1

where

$$f_{11} = \frac{rc}{K}, \quad f_{12} = \frac{r\bar{c}}{K}, \quad f_{21} = \frac{\bar{r}c}{K}, \quad f_{22} = \frac{\bar{r}\bar{c}}{K},$$

$$f_{+j} = \sum_i f_{ij},\ j = 1,2; \quad f_{i+} = \sum_j f_{ij},\ i = 1,2$$

and

$$\sum_{i,j} f_{ij} = 1$$

2 Empirical Formulas

The problem of defining rule quality remains an interesting issue in machine learning. Several attempts to define such a criterion have been made [1], [13], [4], [17]. However, the majority of these formulas represent an empirical, ad-hoc approach to the definition of rule quality. We emphasize the term 'empirical' here, since the work is based on intuitive logic and not necessarily backed by statistical or information theories.

The two characteristics of consistency and completeness can be combined to yield a single number, the rule quality. The meaning of the result should be more or less understandable to human experts. The common policy is to use a weighted sum or multiplication of the above components.

(1)

Rule quality as a *weighted sum* of the consistency and completeness has the form (named after one of its authors):

$$Quality_{\text{Michalski}}(R) = w_1 * cons(R) + w_2 * compl(R) \quad (1)$$

where $w_1, w_2 \in (0;1)$ are user-defined weights, usually $w_1 + w_2 = 1$.

Formula (1) is used in [1] as part of a more complex scenario which also comprises comprehensibility and the cost of concept description. However, [1] does not state how to determine the above weights; only an 'experimental' determination of the weights is proposed.

Formula (1) is also used in the CN2 unordered algorithm [5], and in CN4 with an unordered mode [8] as one of the selectable formulas. An interesting application of the weighted-sum formula for rule quality is used in the incremental learning system YAILS [17]. The weights in YAILS are not user-defined but specified by the algorithm itself:

$$\begin{aligned} w_1 &= 0.5 + \tfrac{1}{4} * cons(R) \\ w_2 &= 0.5 - \tfrac{1}{4} * cons(R) \end{aligned} \quad (2)$$

These heuristic formulas follow from the results of experiments in [17] and emphasize consistency. Here, the weights are made dependent on consistency, which introduces a flexibility into the procedure: the larger the consistency value, the more influence consistency has on rule quality.

(2)

Rule quality as a *product* of consistency and completeness has the form (named after one of the authors):

$$Quality_{\text{Brazdil}}(R) = cons(R) * f(compl(R)) \quad (3)$$

where f is an increasing function. Appropriate determination of f may, similarly to (2), prefer the consistency. The completeness works here as a factor that reflects a *confidence* to the consistency of the given rule. This scenario corresponds to the noisy-data processing paradigm, mentioned above.

A large number of experimental tests performed in the knowledge integration system INTEG.3 [4] led its authors to the following form of the function f in the formula (3):

$$f(x) = \exp(x - 1)$$

3 Statistical Formulas

The empirical formulas for rule quality are easy to understand and provide quite comparative results. On the other hand, they are ad-hoc ones, without any theoretical support. Nevertheless, they may be interpreted and/or modified as reasonable schemes for defining rule quality. This paper discusses three such sources.

(A)

The theory on *contingency tables* seems to be one of these sources, since the performance of any rule can be characterized by them. Generally, there are two groups of measurements (see e.g. [3]): association and agreement.

(1)

A measure of *association* indicates a relationship between rows and columns in a $2 * 2$ contingency table so that the i-th row may be 'associated' with the j-th column. In other words, this measure reflects an 'association' on both diagonals of the contingency table.

Measures of association are described in details in [3]. We have found that the following two statistics may serve as reasonable schemes for the rule quality:

—the Pearson χ^2-square statistic applied to the $2 * 2$ contingency table:

$$\begin{aligned} Quality_{\chi^2}(R) &= \sum_{i,j} \frac{(f_{ij} - f_{i+}f_{+j})^2}{f_{i+}f_{+j}} \\ &= \frac{(rc * \overline{r}\overline{c} - r\overline{c} * \overline{r}c)^2}{c * \overline{c} * r * \overline{r}} \end{aligned} \quad (4)$$

—the $G2$-likelihood statistic

$$Quality_{G2}(R) = \quad (5)$$
$$2 * \left(rc * \ln \frac{rc * K}{r * c} + r\overline{c} * \ln \frac{r\overline{c} * K}{r * \overline{c}} \right)$$

where logarithm here is to the base e.

Both statistics are distributed asymptotically as χ^2 with one degree of freedom.

It should be noted that the *J-measure* introduced in [16] and often quoted as one of the most promising measures [9], in fact, is equal to the $G2$-likelihood statistic divided by $2K$:

$$Quality_J(R) = \frac{Quality_{G2}(R)}{2 * K}$$

From the viewpoint of machine learning, the above formulas work properly only if the class C is the majority class of examples covered by the rule. If not, then the rule quality symbolized by any measure of association may yield the largest values for the rule that does not cover any example of the class C. One may easily prove that both statistics reach its maximum for $rc = 0$.

(2)

A measure of *agreement* is a special case of association that indicates an 'association' of the elements of a contingency table on its main diagonal only. The simplest measure proposed in [3] is the sum of the main diagonal:

$$f_{11} + f_{22}$$

Cohen [7] suggests to compare the *actual* agreement $Aagree = \sum_i f_{ii}$ with the '*chance*' agreement $Cagree = \sum_i f_{i+} f_{+i}$ which occurs if the row variable is independent of the column variable, i.e., if the rule's coverage does not yield any information about the class C. The difference

$$Aagree - Cagree$$

is then normalized by its maximum possible value. This leads to the measure of agreement that we interpret as rule quality (named after its author):

$$Quality_{\text{Cohen}}(R) = \frac{\sum_i f_{ii} - \sum_i f_{i+} f_{+i}}{1 - \sum_i f_{i+} f_{+i}}$$

or, if absolute frequencies are used:

$$Quality_{\text{Cohen}}(R) = \quad (6)$$
$$\frac{K * rc + K * \overline{rc} - r * c - \overline{r} * \overline{c}}{K^2 - r * c - \overline{r} * \overline{c}}$$

or introducing consistency and completeness:

$$Quality_{\text{Cohen}}(R) = \quad (7)$$
$$\frac{K * cons(R) * compl(R) - rc}{K * \frac{cons(R) + compl(R)}{2} - rc}$$

Note that the formulas (6) and (7) depend on four variables: r, c, rc, K, or $cons(R)$, $compl(R)$, rc, K, respectively.

Cohen's statistic provides a formula which responds to the agreement on the main diagonal of the contingency table, i.e. when both components rc and $\overline{rc}$ are reasonably large. Coleman [3] defines a measure of agreement that indicates an 'association' between the first column and any particular row in the contingency table. For the purpose of the rule quality definition, the agreement between the first column ('example from the class C') and the first row ('rule R covers an example') is the proper one. The formula follows the Cohen's statistic in principle by normalizing the difference between the 'actual' and 'chance' agreement. Hence, Coleman's formula for the rule quality is

$$Quality_{Coleman}(R) = \frac{f_{11} - f_{1+} f_{+1}}{f_{1+} - f_{1+} f_{+1}}$$

or, using the absolute frequencies,

$$Quality_{\text{Coleman}}(R) = \frac{K * rc - r * c}{r * \overline{c}} \quad (8)$$

or, introducing consistency and completeness,

$$Quality_{\text{Coleman}}(R) = \quad (9)$$
$$\frac{K * cons(R) * compl(R) - rc}{K * compl(R) - rc}$$

Coleman's statistic intuitively exhibits necessary properties of a rule quality: agreement between 'rule covers' and 'example from class C'.

Nevertheless, one can find by simple analysis that Coleman's formula does not properly comprise the completeness of a rule; substituting rc by $c * compl(R)$ changes (9) to

$$Quality_{Coleman}(R) = \frac{K * cons(R) - c}{K - c}$$

On the other hand, Cohen's statistic is more completeness-based. Therefore, we have modified Cohen's formula in two ways to obtain these definitions:

$$Quality_{\text{SKIB1}}(R) = \quad (10)$$
$$Quality_{\text{Cohen}}(R) * \frac{2+Quality_{\text{Coleman}}(R)}{3}$$

$$Quality_{\text{SKIB2}}(R) = \quad (11)$$
$$Quality_{\text{Cohen}}(R) * \frac{1+compl(R)}{2}$$

where the coefficients 2, 3 and 1, 2 have been added to normalize the statistics.

(B)

Information theory [15] is another source of statistical measurements suitable for defining rule quality. Following this theory, Kononenko and Bratko [10] define the so-called information score for a classifier when classifying an unseen object; their formula can be also applied to rule quality:

$$Quality_{\text{IKIB}}(R) = -\log_2 \frac{c}{K} + \log_2 cons(R) \quad (12)$$

where the logarithm here is of base *2*. More precisely, this formula is valid only if

$$cons(R) \geq \frac{c}{K}$$

which could be interpreted as a necessary condition for the reliability of a rule.

(C)

The vehicle of the *confidence sets* can be also exploited. The unknown conditional probability

$$p = P(\text{example of } C | \text{ rule } R \text{ fires})$$

has $cons(R) = \frac{rc}{K}$ as its estimate. The random variable

$$Y^2 = \frac{(rc - r * p)^2}{r * p} + \frac{(r\bar{c} - r * (1-p))^2}{r * (1-p)}$$

has a χ^2 distribution with one degree of freedom. Hence,

$$P(Y^2 \leq \chi_1^2(\alpha)) \doteq 1 - \alpha$$

for the selected factor α.

The borders of the confidence interval $\langle p_1, p_2 \rangle$ for the unknown probability p are given by the solution of the following equation:

$$\frac{(rc - r * p)^2}{r * p} + \frac{r\bar{c} - r * (1-p)^2}{r * (1-p)} = \chi_1^2(\alpha) \quad (13)$$

and rule quality can be characterized by the lower bound p_1 of the confidence interval. Quadratic equation (13) has two solutions p_1, p_2 and the lower result is

$$Quality_{Conf}(R) = \quad (14)$$
$$\frac{rc^2 + S - r\bar{c}^2 - \sqrt{(r\bar{c}^2 - rc^2 - S)^2 - 4 * S + rc^2}}{2 * S}$$

where

$$S = r * (r + \chi_1^2(\alpha))$$

4 Analysis

Figures 1 to 4 exhibit the values of the rule quality for various formulas. Each formula is depicted by two figures for various values of c, and each figure represents the quality as a function of rc and r. Figures 5 to 7 show the rule qualities for various formulas so as to compare their behaviour. Particularly, the rule quality is shown as a function of consistency, completeness, and rc, respectively, with other parameters being fixed.

a)

Statistical formulas for the rule quality exhibit the so-called *independence* property: they yield zero value if and only if the rule does not have any expressive capability, i.e., if its distribution equals to the distribution of the entire training set. The

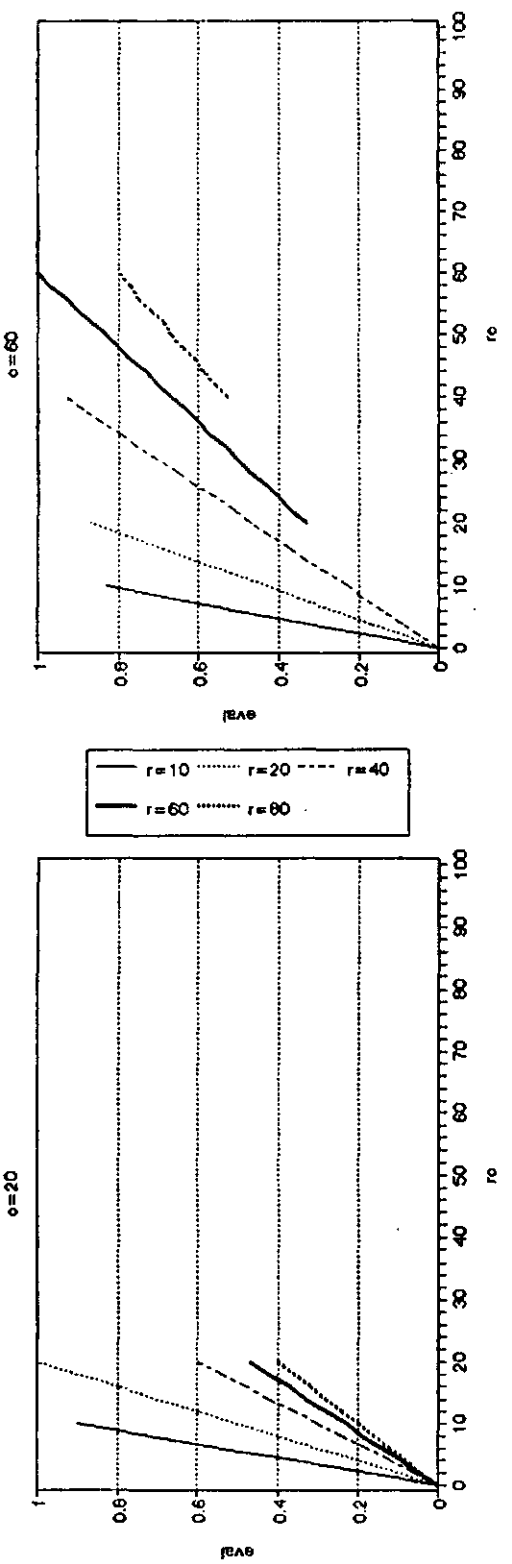

Figure 1: $Quality_{\text{Michalski}}$ for $c = 20$ and 60 as a function of rc for various values of r.

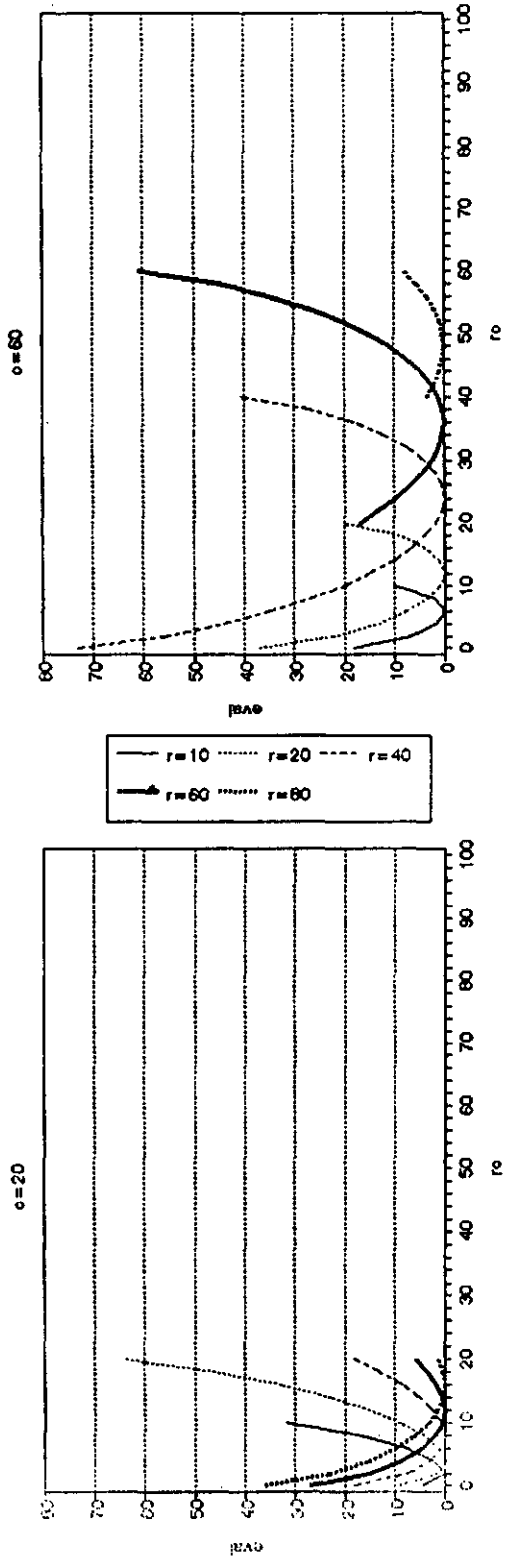

Figure 2: $Quality_{G2}$ for $c = 20$ and 60 as a function of rc for various values of r.

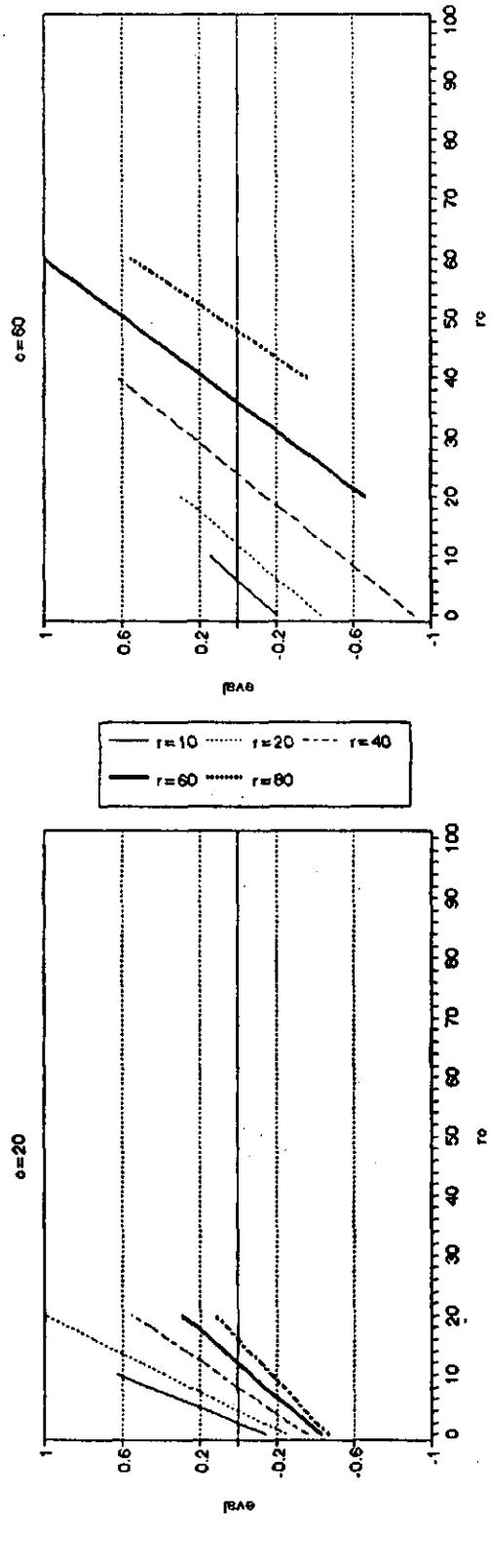

Figure 3: $Quality_{\text{Cohen}}$ for $c = 20$ and 60 as a function of rc for various values of r.

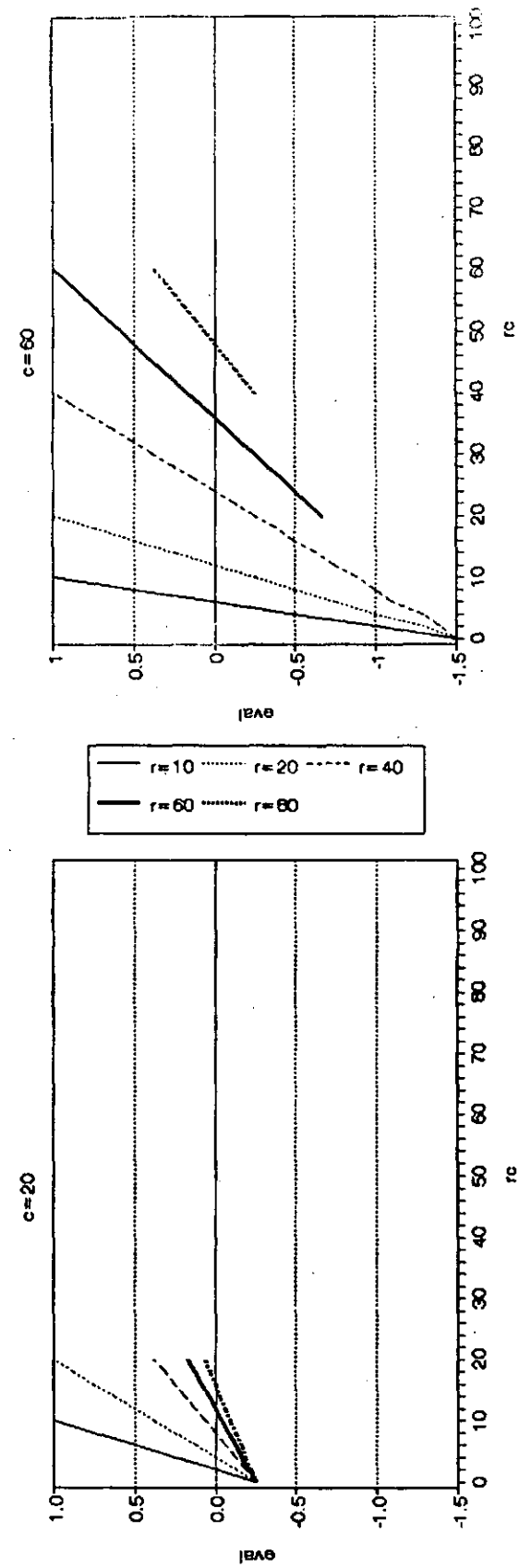

Figure 4: $Quality_{\text{Coleman}}$ for $c = 20$ and 60 as a function of rc for various values of r.

independence property can be also expressed by the consistency or completeness; it arises if

$$cons(R) = \frac{c}{K}$$

$$compl(R) = \frac{r}{K}$$

The name is derived from the fact that the columns and rows in the corresponding contingency table are independent if and only if the formulas yield zero value.

b)

One may easily prove that the empirical, agreement-based, and information-based qualities are non-decreasing functions of consistency and completeness. The Fig. 5 and 6 depict the same property.

c)

Coleman's statistic does not comprise the completeness of the rule. As we have already mentioned, this was the reason for its modification, see (10), (11). The formula (14) exhibits the same property.

d)

Fig. 5 indicates that the behaviour of the agreement-based qualities as a function of consistency is almost identical and also, those of empirical qualities are comparable. We may find that all formulas for rule qualities are applicable and comply with the properties required for the rule quality definition.

Moreover, Fig. 7 shows that certain formulas exhibit similar dependencies. Namely, the following pairs can be detected: formulas for $Quality_{Michalski}$ and $Quality_{Brazdil}$, $Quality_{SKIB1}$ and $Quality_{SKIB2}$, $Quality_{\chi^2}$ and $Quality_{G2}$.

e)

Ranges of values of various formulas are also worth mentioning. The empirical formulas yield values between 0 and 1, so as the χ^2 statistic, whereas the $G2$-likelihood gives nonnegative values. Cohen's statistic yields values between -1 and 1; the lower bound -1 comes with the table

$$\begin{bmatrix} 0 & \frac{K}{2} \\ \frac{K}{2} & 0 \end{bmatrix}$$

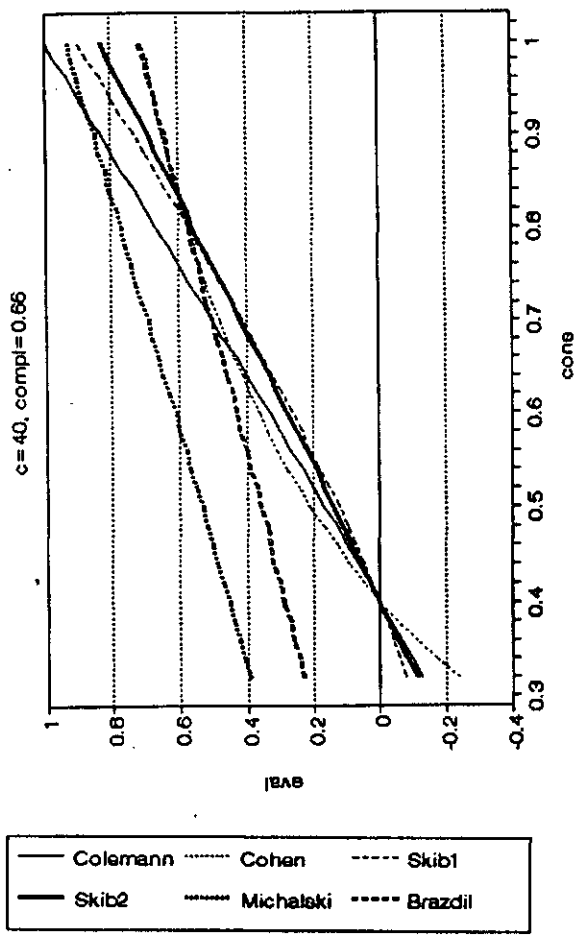

Figure 5: Rule qualities as functions of *cons* for $c = 40$, $compl = \frac{2}{3}$.

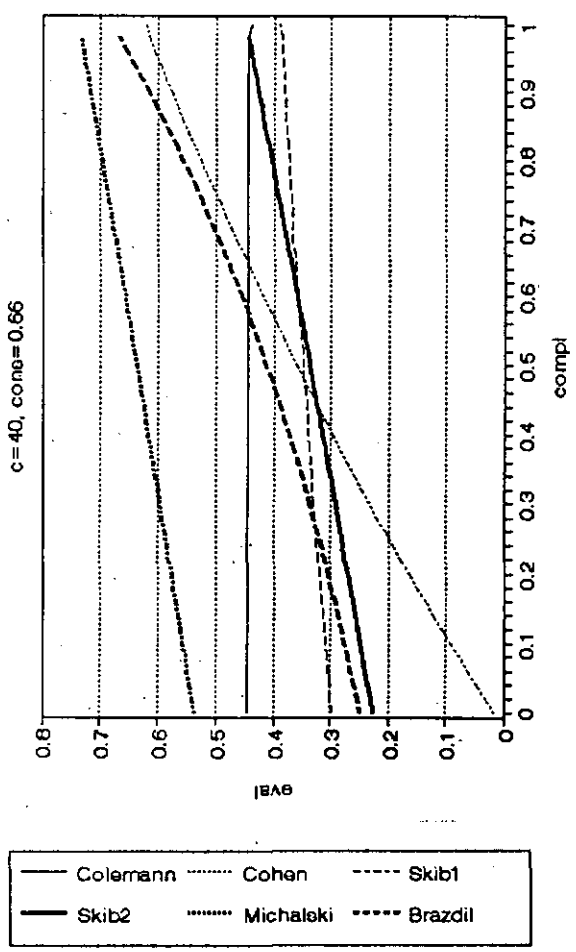

Figure 6: Rule qualities as functions of *compl* for $c = 40$, $cons = \frac{2}{3}$.

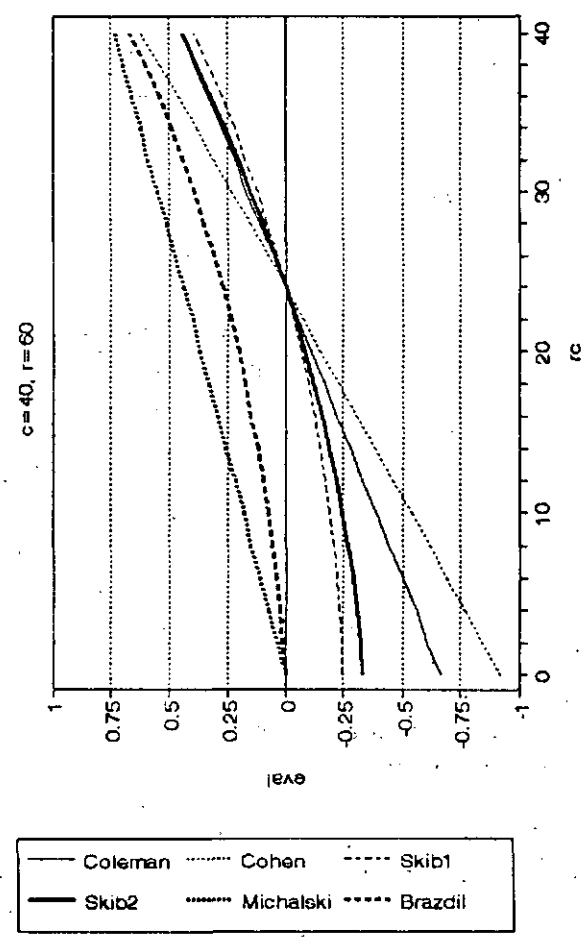

Figure 7: Rule qualities as functions of rc for $c = 40$, $r = 60$.

Coleman's upper bound is 1 and its lower bound is $-\frac{c}{\bar{c}}$ for $rc = 0$; especially, the absolute minimum is $-(K-1)$ for $\bar{c} = 1$. Due to normalization the upper bound of the statistics (10) and (11) is 1.

The differences in the ranges of various formulas are not worth mentioning, because a user selects a particular formula for a task and the algorithm compares only the values of the formula. The monotony of these functions is what is important.

5 Conclusion

The purpose of this paper was to introduce and discuss various approaches to the definition of rule quality. Comparing the above definitions for various data sets was not the aim of this paper.

One may observe that all formulas are applicable. Although the empirical formulas are not backed by any statistical theory, they work quite well. On the other hand, they do not exhibit the independence property which is evidently very expressive from the statistical viewpoint. The formulas with the independence property have the advantage that the threshold of meaningful rules is expressed clearly.

To be more precise, even the statistical formulas used in machine learning are applied mostly in an ad-hoc, empirical fashion, since most algorithms do not check the conditions or assumptions of their applicability. Unlike the genuine empirical formulas, however, we are aware of the error we have made when the conditions of applicability are not checked. If needed, the condition checking could in principle be embedded into an algorithm.

The paper focuses on exploiting rule quality from the classification viewpoint. Two classification schemes utilizing rule quality have been discussed. The learning phase has been considered as more or less independent of the classification scheme. In other words, evaluation heuristics invoked by an inductive algorithm are more or less expected to have no connection with the rule quality invoked by a classification scheme. For instance, the CN2 algorithm exploits the Laplacian estimate formula for evaluating complexes and the $G2$-likelihood statistic as a stopping condition; on the other hand, a classifier using unordered decision rules may exploit any of the above formulas for rule quality.

It would be natural that the heuristics of a learning algorithm and the rule quality of a classification scheme be selected together in accordance with the demands of a 'client', the user of a classifier. The most appropriate scenario exploits any rule quality formula both within classification and within inductive learning as evaluation heuristics. The above scenario is embedded in POSEIDON [2]. The authors of this paper plan to adopt this scenario in their CN4 learning algorithm in the near future. One may find that some formulas (particularly the agreement-based ones) may be employed not only as an evaluation heuristic but also as a significance statistic to stop further induction.

Under the above scenario, the weighted-sum rule quality exhibits, to a certain extent, a quite good vehicle for a user who knows how to set up the weights. It is especially useful when choosing between the two strategies:

- By selecting w_1 much greater than w_2 in (1), the user supports consistency and thus forces the system to induce only the most reliable rules that could be invoked when deciding about quite serious cases, i.e., when verifying a hypothesis.

- By selecting w_2 much greater than w_1 in (1), the user supports completeness of the decision set. The learning algorithm is thus forced to induce robust decision rules that could be capable of recognizing a great variety of objects (instances). It could be used to obtain an overview about the entire problem domain with a wide scale of offered descriptions.

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LOGOS OF THE INFORMATIONAL

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This paper is a preliminary study and presents a possibility how to begin the axiomatizing of the phenomenon that we call the informational and how to deduce still other axioms from the basic axiomatic viewpoint. If we solve the problem of an adequate formalization—introducing a symbolic and symbolically open language—the question of the logical consistency may still remain open. This situation may or may not represent an inadmissible position within different sciences. For after all, sciences have to deal with questions that rise the level of the traditional logical views and scientific disciplinability to a higher position of scientific cognition. Informational logic can offer a new and more critical view as it is customary in sciences rooting in classical logic. The logic of informational sets new standards that consider the active, also creative capabilities of informational entities in question. Decomposition and composition of entities in a parallel, spontaneous, circular, and intentional way can be the path on which parallelism, spontaneity, circularity, and intentionality become constructive capabilities of the informing of entities.

> Das Entwerfen des Verstehens hat die eigene Möglichkeit, sich abzubilden. Die Ausbildung des Verstehens nennen wir *Auslegung*. In ihr eignet sich das Verstehen sein Verstandenes verstehend zu.
>
> —Martin Heidegger [Heidegger 86] 148

1 Introduction

This essay deals with the logic of language concerning a theory of the informational, having its roots in the realm of the extended notion of informing of information [Železnikar 92b, Železnikar 93]. The informational might enter into a logician's language as something that is not consistently structured yet; thus, an additional effort is necessary to construct logical foundations, from which scientifically rigorous informational theories could be deduced. As we shall show indirectly by the presented discussion, the general foundations of a traditional mathematical logic may not suffice such undertaking. Right at the beginning of our discussion, we must reconcile of going our own logical way, which requires informational self–discipline in the realm, where entities inform and are informed in an arising, that is, spontaneous, circular, parallel, and interactive way. The main difference to traditional mathematical theories lies in the phenomena of informational arising, where entities (mathematical objects) perform and are performed in an active, that is, functionally arising way, which, in principle, is non–algorithmic, but only exceptionally algorithmic in a mathematical way.

How to deduce logically (naturally, realistically, linguistically) the concept of an informational entity that develops (emerges, arises, exists) in a spontaneous, cyclic, parallel, and intentional way? This is the question that will be in the focus of this paper[1] among other questions, which all concern a strict deductive (axiomatic) logical

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approach.

Our point of view will be to discuss the informational in terms of interacting (mutually impacting) informational entities (e.g. processes acting informationally upon informational entities), however, not to determine explicitly what by itself the informational might be. We shall axiomatize some basic phenomenal forms of things that we call informational entities. It is to understand that the following discussion is only a beginning on the way to a redefined, rethought, and broadened idea of the informational and its phenomenalism. This broadening view seems righteous if we consider the possibilities of the coming informational technology, for instance: parallel structured, networked and diversely performed processors; multimedia oriented memorizing and displaying devices; enormously information-supported designing and programming tools; and new philosophies of information use and development.

Nothing very new or uncommon will be said about the informational phenomenalism if we distinguish the dualistic character of information in a computer: both the information processing form and the information processed form of data, programs, and systems. Yet, the boundaries between regular data (passive information) and working programs (active information) are clear, strict, and indispensable within the prevailing (ruling) philosophy of sciences. The new informational philosophy grasps these boundaries and already comprehends how they are hindering the shifting into the realm of dynamically performing informational processes—natural and also artificial ones. The formal discussion of informational phenomena in this paper will smartingly reopen this question.

2 The First Informational Axiom

> Alle theoretische Forschung, obschon sie sich keineswegs bloß in ausdrücklichen Akten oder gar in kompleten Aussagen bewegt, terminiert doch zuletzt in Aussagen. Nur in dieser Form wird die Wahrheit und speziell die Theorie zum bleibenden Besitztum der Wissenschaft, sie wird zum urkundlich verzeichneten und allzeit verfügbaren Schatz des Wissens und des weiterstrebenden Forschens.
>
> —Edmund Husserl [Husserl 80] II/1 3

The operand and operator view (concept) is a common approach in formal theories of sciences. This view separates two categories of entities: the passive and the active ones. To apply this view in an informational theory is not so simple since a strict distinction of both categories may be possible only in a time, matter, or phenomenon slice, that is, on an abstract and ideal level of recognition. In the real nature, situation is similar. For instance, actors can be permuted, destroyed, enforced, etc. traversing from active state into a passive position where they can be modified, developed, changed, etc. Similarly, passive items of something can become actors with the force to impact passive and also acting entities. This is the well-known phenomenon in the living world.

As any other culturally based (abstract, idealized) cognition, the following one has its roots in human language. We search for a dynamic language category (e.g., verb, noun) that, on the general level, would be capable to cover a sufficiently broad realm of simultaneously (parallel) active and passive informational possibilities. On the route of our experience with the most sophisticated human tool, e.g., computer, we arrive to the verb *to inform* and to the noun *information*. In this respect, informing and information are candidates that may assure our needs, at least on the linguistic level, where we can say, for instance, information informs (something) [an *active* position], but also information is informed or is being informed (by something) [a *passive* position]. Thus, the active property of an informational entity may be called the *informingness* and the passive one the *informedness*. This view is in accord with even more general one, which is, for instance, any impacting(ness) and impactedness of something.

After this introduction we are ready to set the most basic informational axiom, a sort of *informatio prima* that, from the linguistic point of view, will suffice our further intention of a broadened informational theory development.

Definition 1 [Some Basic Operands and Operators] *We mark informational entities,*

which are operands of an emerging (informational) theory, by small and some distinguished capital Greek letters, that is,

$$\alpha, \beta, \gamma, \cdots, \omega, \Gamma, \cdots, \Omega \quad \textit{(informing entities)}$$

The corresponding informings of these entities we mark by capital calligraphic letters, that is,

$$\mathcal{A}, \mathcal{B}, \mathcal{C}, \cdots, \mathcal{Z}$$

or, explicitly, by

$$\mathcal{I}_\alpha, \mathcal{I}_\beta, \mathcal{I}_\gamma, \cdots, \mathcal{I}_\omega$$

Further, we define the informational operators with the following meaning:

$\models$ *'informs' or 'is informed (by)'*
$\Longrightarrow$ *'implies' or 'is implied (by)'*

We shall define other[2] *informational operands and operators simultaneously.* □

An informational entity α informs in its own way. We can express this property of informing by the most general informational operator of informing, marked by $\models$.

Axiom 1 (Informatio prima) [INFORMATIONAL EXTERNALISM; INFORMINGNESS; INFORMING FOR OTHERS] *An informational entity, marked by operand α, informs (informational operator $\models$); formally, $\alpha \models$. An informational entity α implies (informational operator $\Longrightarrow$) that it informs. Formally,*

$$\alpha \Longrightarrow (\alpha \models)$$

From this axiom other axioms can be deduced informationally by a common logical procedure. □

In the last axiom, we can distinguish three informational formulas: α as a simple operand of formula marker, $\alpha \models$ as the entity α externalism, and $\alpha \Longrightarrow (\alpha \models)$ as the basic implication pertaining to the entity α externalism. Expression $\alpha \models$ is an open informational formula. This formula (as any other informational formula), by itself, is an informational entity (operand). Thus, for instance, formula $(\alpha \models) \models$ is not only regular, but senseful. It says that *entity informs, informs.* The other view of the openness of Axiom 1 is operational (operator-like). On the empty right side of operator $\models$ in formula $\alpha \models$ there could stay another operand, for instance, $\alpha \models \beta$. As we can see, the openness of an informational formula is recursive. Denotation (also marker of something) α is the most primitive formula, that is, a single operand itself. This mean that any formula α can be developed in an informational way as $\alpha \models$ and recursively, beyond this formula.

3 Axioms that Extend Beyond the First Axiom

> Die Auslegung von Etwas als Etwas wird wesenhaft durch Vorhabe, Vorsicht und Vorgriff fundiert. Auslegung ist nie ein voraussetzungsloses Erfassen eines vorgegebenen.
>
> —Martin Heidegger [Heidegger 86] 150

In human language, the statement *something informs* presupposes that *something is being informed.* If the first form is an *active* informing (for the sake of clarity, we introduce the term *informingness*), the second one represents a *passive* informedness. Thus, the informedness of an entity (informational operand) is a consequence of an entity's informingness.

Axiom 2 (Informatio secunda) [INFORMATIONAL INTERNALISM; INFORMEDNESS; INFORMING FOR ITSELF] *An informational entity (operand), α, is informed or is being informed (informational operator $\models$); formally, $\models \alpha$. Informational entity (operand α) implies (informational operator $\Longrightarrow$) that entity is informed (or is being informed). Formally,*

$$\alpha \Longrightarrow (\models \alpha)$$

This axiom is a logical (axiomatic) consequence of the previous one (in the sense that if something informs, something will be informed). □

In fact, informatio secunda is an axiomatic consequence of informatio prima. To be consequent,

[2] Other markers for informational and informing operands can be the small and capital Fraktur letters, respectively, that is, $\mathfrak{a}, \mathfrak{b}, \cdots, \mathfrak{z}$ and $\mathfrak{A}, \mathfrak{B}, \cdots, \mathfrak{Z}$. Such markers are characteristically distinguishable, especially the capital ones.

we can "prove" the last axiom in the following formal way:

$$(\alpha \Longrightarrow (\alpha \models)) \Longrightarrow (\alpha \Longrightarrow (\models \alpha))$$

or, in short, $(\alpha \models) \Longrightarrow (\models \alpha)$. Formula $\models \alpha$ is informationally open in several respects. For instance: formula $(\models \alpha) \models$ says that *entity is being informed, informs*; formula $\models (\models \alpha)$ says that *entity is being informed, is being informed*; and formula $\beta \models \alpha$ says that *entity is being informed by another entity.* We see how the openness of an entity can be closed in different ways and how the results of certain closing remain recursively open for further possibilities of closing.

Both basic axioms generate consequences (lemmas, rules), which can still be comprehended as axiomatic since an ad hoc terminology concerning them is being introduced.

In fact, Axiom 1 hides another axiom, which concerns a basic consequence, that is, a rule of deduction. Informing of something has its sense only in case if something is being informed through informing of something.

Rule 1 (A consequence of informingness) [A BASIC DEDUCTION CONCERNING INFORMING] *If entities inform then there exist entities, which are informed. In general, the following implication holds:*

$$(\alpha \models) \Longrightarrow (\models \alpha)$$

This is an axiomatic consequence of informingness, which is logically evident in an informational way. □

Rule 2 (A consequence of informedness) [A BASIC DEDUCTION CONCERNING INFORMEDNESS] *If entities are informed then there exist entities, which inform. Generally,*

$$(\models \alpha) \Longrightarrow (\alpha \models)$$

This is an axiomatic consequence of informedness, which is logically evident in an informational way. □

The last two rules are basic deduction rules for formulas development. They are essential development procedures in formulas decomposition and composition approaches, treated later on in this paper. Many other rules follow from axioms, consequences, and theorems and can be applied in cases of formula development.

Axiom 3 (Informatio tertia) [INFORMATIONAL METAPHYSICALISM; INTERIOR CYCLICITY; INFORMING IN ITSELF] *An informational entity (operand), α, informs and is being informed simultaneously (in parallel) in itself and by itself; formally, $\alpha \models \alpha$. Informational entity (operand α) implies that entity informs and is informed (being informed) in itself. Formally,*

$$\alpha \Longrightarrow (\alpha \models \alpha)$$

This axiom logically follows from the previous ones. □

The last axiom follows from the previous ones. In its open informingness $(\alpha \models)$ and open informedness $(\models \alpha)$, entity α is a particular system per se, that is,

$$(\alpha \models; \models \alpha) \Longrightarrow (\alpha \models \alpha)$$

being informationally closed into itself (e.g., into its own existing, changing, emerging, vanishing). Thus, an informing entity implies its metaphysicalism where it informs itself and is being informed by itself (that is, exists, changes, emerges, vanishes in itself). In a particular way, concerning the entity, the described metaphysical situation seems normal (physical, philosophically acceptable).

An entity's internalism and metaphysicalism constitute together the attitude of the entity as observer. Internalism $\models \alpha$ is also an observing position of entity α. Internalism means that α might be capable of observing it concerning exterior and interior world, not only through $\models \alpha$, but $\models (\alpha \models \alpha)$, which considers α's metaphysicalism $\alpha \models \alpha$. Thus, internalism, $\models \alpha$, is a kind of α's observing metaphysicalism $\models (\alpha \models \alpha)$.

How objectively does α observe its exterior and interior world depends solely on the instantaneous state of α's metaphysical perception, that is on $(\models (\alpha \models \alpha))$'s structure and organization. The recognition of α's true world remains in the framework of $(\models (\alpha \models \alpha))$'s capabilities, which consider the intricate internalism $\models \alpha$ as well as the intricate metaphysicalism $\alpha \models \alpha$. For example, irrespective of the superb theories (gravitation, electromagnetism, relativity, quantum theory), contradictions in the form of incompleteness, insufficiency, paradoxicalness, etc. arise and show how the inner models and simulations fail to cover the outer world in its entirety.

Phenomena of informingness and informedness constitute the so-called phenomenalism of an informational entity.

Axiom 4 (Informatio quarta) [INFORMATIONAL PHENOMENALISM; INFORMATIONAL OPENNESS; INFORMING AS SUCH] *An informational entity (operand), α, informs and is being informed openly (in parallel) in respect to itself and to its environment; formally, $\alpha \models; \models \alpha$ is a formula system describing the phenomenalism of entity α. Informational entity (operand α) implies that entity informs and is informed (being informed) openly in any respect. Formally,*

$$\alpha \Longrightarrow (\alpha \models; \models \alpha)$$

This is a system axiom that follows from the previous axioms. □

Phenomenalism is the most general property of informing of an entity. It includes (informational operator $\subset$) the phenomena of externalism, internalism, and metaphysicalism. Thus,

$$\alpha \models, \models \alpha, \alpha \models \alpha \subset (\alpha \models; \models \alpha)$$

Informational entity behaves phenomenally, however, its phenomenalism is a particular form of informing characterizing the informational nature (Being, essence) of the entity in question. *Informatio quarta* unites all possible cases (externalism, internalism, metaphysicalism, and phenomenalism) of an entity appearance, occurrence, arising, coming into existence, etc. Thus, an adequate definition of entity α can be expressed considering the previous axiomatic origins.

Definition 2 (Informational entity) [PHENOMENAL DETERMINATION OF INFORMATIONAL ENTITY] *An informational entity, marked by α, is informationally determined by formulas of its externalism, internalism, metaphysicalism, and phenomenalism. There is,*

$$\alpha \rightleftharpoons_{\mathrm{Def}} \begin{cases} \alpha \models; & \text{externalism} \\ \models \alpha; & \text{internalism} \\ \alpha \models \alpha; & \text{metaphysicalism} \\ (\alpha \models; \models \alpha) & \text{phenomenalism} \end{cases}$$

where informational operator $\rightleftharpoons_{\mathrm{Def}}$ has the meaning "informs (means) in the sense of a definition" or, simply, "means by definition". □

Several facts have to be mentioned concerning the last definition. Firstly, the definition is a consequence (theorem) of four axioms. It would be necessary to prove that the definition pertaining to informational entity satisfies the concept of all entity-concerning informational phenomena. This seems to be true at least intuitively, that is, hypothetically. Secondly, the preceding definition is implicit in respect to α. The so-called definiendum (the defined–left side) means (informational operator $\rightleftharpoons_{\mathrm{Def}}$) definiens (the defining–right side), in which genus proximum is informational operand α and differentia specifica is informational operator $\models$ at the right and at the left position to operand α. The right side (definiens) is completely axiomatically determined. Operator $\rightleftharpoons_{\mathrm{Def}}$ may be understood as a particularization of the general informational operator $\models$, for instance, $\models_{\mathrm{definitional}}$, with the meaning *informs in a definitional way.* As we see, informational definitions will always inform implicitly, that is, in an informationally closed way within the realm of informational phenomenalism. Thirdly, the last definition possesses a parallel and an embedded parallel structure in the definiens part. Thus, we have to define the permissive parallel notations of informational formulas.

Definition 3 (Parallel notations) *Parallel informational entities (operands, formulas, and formula systems) can be formally expressed in different ways. The horizontal notation of parallel performing entities $\alpha, \beta, \cdots, \omega$ is*

$$(\alpha; \beta; \cdots; \omega) \quad \textit{or, simply,} \quad \alpha; \beta; \cdots; \omega$$

Vertical notations of parallelism explicate the parallel informing of entities in an formally evident manner. The following vertical parallel informational expressions are permissible:

$$\left\{ \begin{matrix} \alpha; \\ \beta; \\ \vdots \\ \omega \end{matrix} \quad \textit{or} \quad \begin{matrix} \alpha; \\ \beta; \\ \vdots \\ \omega \end{matrix} \right\} \textit{ or } \begin{pmatrix} \alpha; \\ \beta; \\ \vdots \\ \omega \end{pmatrix}$$

The semicolon simultaneously denotes the parallelism and the end of a particular entity in a parallel array. It is necessary when entities are presented by formulas, which exceed a single line. □

Definition 4 (Informational sets) *Informational sets are collections of entities (operands,*

formulas, and formula systems), which may be comprehended as informationally isolated items, where the question of their mutual informational interaction is not relevant. An informational set of elements $\alpha, \beta, \cdots, \omega$ is denoted by

$$\alpha, \beta, \cdots, \omega \quad or \quad \{\alpha, \beta, \cdots, \omega\}$$

A comma is the separator between isolated elements. Parallel notations of informational sets are permissible, that is,

$$\left\{\begin{matrix}\alpha, \\ \beta, \\ \vdots \\ \omega\end{matrix}\right\} \quad or \quad \left\{\begin{matrix}\alpha, \\ \beta, \\ \vdots \\ \omega\end{matrix}\right\} \quad or \quad \left\{\begin{matrix}\alpha, \\ \beta, \\ \vdots \\ \omega\end{matrix}\right\}$$

The comma has a similar function as the semicolon in the previous definition. □

4 Axioms of Informing

In this section we have to bring the duality of the presence (existing, arising) of an informational entity to the axiomatic surface. As a whole, in its entirety, or as an informational unit, informational entity α includes its own component of informing, marked by $\mathcal{I}_\alpha$ or, in the functional (predicative) notation, by $\mathcal{I}(\alpha)$. The informational duality of α lies in its nature to be a form and process simultaneously, that is in the parallel nature of its operational activism and passivism within the same unity, on one side (expressions $\alpha \models$ and $\models \alpha$), and the explicit expression of entity informing $\mathcal{I}_\alpha$, on the other side. That what we have to bring face to face are verbal phrases *to inform* and *to be informed*, on one side, and the integral property of *informing* of entity, on the other side. In fact, we have to decide between different kinds of expression of the phenomenon of informing.

If $\alpha \models$ and $\models \alpha$ say that α *informs* and that α *is being informed*, respectively, than $\mathcal{I}_\alpha$ represents the possibility of informing of α in α's entirety. In this respect, informing $\mathcal{I}_\alpha$ includes the expressive power of both $\alpha \models$ and $\models \alpha$ and introduces the informing of α as a distinguished operand within α, that is, informational entity.

Axiom 5 (Informing of an entity) [Existentialism of Informing] *We have the following senseful axiomatic implicational consequence:*

$$(\alpha \Longrightarrow (\alpha \models; \models \alpha)) \Longrightarrow \mathcal{I}_\alpha$$

Entity α implies that it informs and that it is informed (informational phenomenalism); informingness and informedness imply that entity has the entity, called informing $\mathcal{I}_\alpha$ as an informationally active part of the entity. □

In mathematical terms, $\mathcal{I}_\alpha$ seems legal as a predicative function of α, that is, $\mathcal{I}(\alpha)$. It represents the systemic (phenomenal) informing of α, expressed implicitly as $(\alpha \models; \models \alpha)$. On the other hand, operand-operator expressions $\alpha \models$ and $\models \alpha$ as operator open entities may not fit the traditional mathematical agreement and function (mean) as a non-consistent novum. This situation becomes even more inconvenient in case of expressions of the form

$$(\cdots((\alpha \models) \models) \cdots \models) \models$$

Imagine, for instance, the following: both $+a$ and $a+$ may still represent a reasonable expression of a's additivity. But, what could be said in cases of $+(+a)$, $(a+)+$, $+(a+)$, etc. New terminology (meaning) of such algebraic open cases has to be introduced. Operator $+$ always characterizes the operand, to which it belongs. Thus, in formula $+(+a)$, operator $+$ characterizes the operand $+a$.

Axiom 6 (Partitionism of informing) [Inclusiveness of an Entity Informing] *Axiom*

$$\mathcal{I}_\alpha \Longrightarrow (\mathcal{I}_\alpha \subset \alpha)$$

says that informing of an entity implies that the informing is a part (i.e., an active part) of the entity. □

The last axiom sounds natural, so, no further discussion is necessary.

Axiom 7 (Externalism of informing) [Entity Bounded Externalism of Informing] *Externalism of an entity informing (informing's informingness) is closed to the entity. That is,*

$$\mathcal{I}_\alpha \Longrightarrow (\mathcal{I}_\alpha \models \alpha)$$

says that informing $\mathcal{I}_\alpha$ informs its entity α in a closed way. □

Informing $\mathcal{I}_\alpha$ informs entity α.

Axiom 8 (Internalism of informing) [ENTITY BOUNDED INTERNALISM OF INFORMING] *Internalism of an entity informing (informing's informedness) is closed to the entity. That is,*

$$\mathcal{I}_\alpha \Longrightarrow (\alpha \models \mathcal{I}_\alpha)$$

says that the informedness of an entity informing is caused in an entity-closed way. □

Informing $\mathcal{I}_\alpha$ is informed by entity α.

Axiom 9 (Metaphysicalism of informing) [INFORMATIONAL REGULARITY OF METAPHYSICALISM OF INFORMING] *As usually,*

$$\mathcal{I}_\alpha \Longrightarrow (\mathcal{I}_\alpha \models \mathcal{I}_\alpha)$$

Informing of an entity informs metaphysically (basic-cyclically) as any other informational entity. □

The last axiom assures that informing $\mathcal{I}_\alpha$ can be metaphysically decomposed as a regular informational entity.

Axiom 10 (Phenomenalism of informing) [CIRCULAR BOUNDING OF INFORMING] *Let us introduce four implications for the specific phenomenalism of an entity informing:*

Informing's first mode of phenomenal circularity:

$$\mathcal{I}_\alpha \Longrightarrow ((\alpha \models \mathcal{I}_\alpha) \models \alpha)$$

Informing's second mode of phenomenal circularity:

$$\mathcal{I}_\alpha \Longrightarrow (\alpha \models (\mathcal{I}_\alpha \models \alpha))$$

Informing's third mode of phenomenal circularity:

$$\mathcal{I}_\alpha \Longrightarrow ((\mathcal{I}_\alpha \models \alpha) \models \mathcal{I}_\alpha)$$

Informing's fourth mode of phenomenal circularity:

$$\mathcal{I}_\alpha \Longrightarrow (\mathcal{I}_\alpha \models (\alpha \models \mathcal{I}_\alpha))$$

The phenomenalism of an entity informing is closed to the entity itself. □

Let us interpret the last four modes of informing of an entity, which are characterized by specific cyclical ways. In the first mode, α informs $\mathcal{I}_\alpha$ and, then, this process (subformula) as an entity informs α. While informing $\mathcal{I}_\alpha$ is directly informed by α (subformula $\alpha \models \mathcal{I}_\alpha$), it informs α indirectly through the entity $\alpha \models \mathcal{I}_\alpha$ [formula $(\alpha \models \mathcal{I}_\alpha) \models \alpha$]. In this mode, the α-cycle is evident.

In the second mode, α informs the process $\mathcal{I}_\alpha \models \alpha$, in which informing $\mathcal{I}_\alpha$ directly informs entity α. On the other hand, informing $\mathcal{I}_\alpha$ is informed indirectly by α through the entity $\mathcal{I}_\alpha \models \alpha$ [formula $(\alpha \models (\mathcal{I}_\alpha \models \alpha)$]. In this mode, the α-cycle is evident too.

In the third mode, entity $\mathcal{I}_\alpha \models \alpha$ informs $\mathcal{I}_\alpha$. In this mode, the metaphysical cycle of the form $\mathcal{I}_\alpha \models \mathcal{I}_\alpha$ is coming to the surface. In this cycle, $\mathcal{I}_\alpha$ directly informs α, but entity α informs entity $\mathcal{I}_\alpha$ indirectly, through the composed entity $\mathcal{I}_\alpha \models \alpha$. In this mode, the so-called $\mathcal{I}_\alpha$-cycle is evident.

In the fourth mode, entity $\mathcal{I}_\alpha$ informs the composed entity $\alpha \models \mathcal{I}_\alpha$. In this mode, informing $\mathcal{I}_\alpha$ informs entity α indirectly, but entity α directly informs its informing $\mathcal{I}_\alpha$. In this mode, the $\mathcal{I}_\alpha$-cycle is evident too.

Definition 5 (Informing of an entity) [PHENOMENAL INFORMING OF AN ENTITY] *Informing $\mathcal{I}_\alpha$ of an entity α is an α's phenomenalism, that is, an interweavement of different informational phenomena determined in the previous axioms. Formally,*

$$\mathcal{I}_\alpha \rightleftharpoons_{Def} \begin{cases} \mathcal{I}_\alpha \subset \alpha; & \textit{partitionism} \\ \mathcal{I}_\alpha \models \alpha; & \textit{externalism} \\ \alpha \models \mathcal{I}_\alpha; & \textit{internalism} \\ \mathcal{I}_\alpha \models \mathcal{I}_\alpha; & \textit{metaphysicalism} \\ (\alpha \models \mathcal{I}_\alpha) \models \alpha; & \textit{phenomenalism 1} \\ \alpha \models (\mathcal{I}_\alpha \models \alpha); & \textit{phenomenalism 2} \\ (\mathcal{I}_\alpha \models \alpha) \models \mathcal{I}_\alpha; & \textit{phenomenalism 3} \\ \mathcal{I}_\alpha \models (\alpha \models \mathcal{I}_\alpha) & \textit{phenomenalism 4} \end{cases}$$

This system of informing-$(\mathcal{I}_\alpha)$-definitional formulas can be understood to be a set of independent single formulas or a system of arbitrarily informationally connected formulas. □

5 Implicational Nature of Axioms

Implication belongs to the informationally most common forms of expression. Implication means nothing else than a logical connection of informational entities, their implicitness in an informational context that always exists and informs

in a spontaneously (intentionally, orientationally, worldly) interconnecting, interwoven, and cyclic way. Implication in informational axioms points to an artificial origin, which has its roots anywhere in the existing informational context and is posed by the observer or observer's intention, aim, truth, or belief. That is nothing else than a phenomenological reasoning or attitude, which pervades the today logic, sciences, and technological undertakings.

By logical convention, informational implication $\alpha \Longrightarrow \beta$ is read in the following sense: α as an informational operand (entity, formula) *implies* β as an informational operand (entity, formula). In this context, "α as an informational operand" has the meaning of the statement "it is true that α is an informational operand", which is in accordance with the implicational convention in ordinary (mathematical) logic.

6 How to Deduce Informational Consequences

The informational is the most general term, which is not informationally particularized yet. The question is how to deduce the general and how the particular consequences (theorems) in the framework of a general and a particular informational theory. Some decomposition and composition philosophy, which concerns informational deduction, will be found in section 7.

After that we have axiomatized and defined, the deduction of a general informational theory is a pure syntactic procedure, which never ends. There are infinitely many general informational consequences, which can be deduced by pure syntactic means from the previous axioms and definitions. But, that does not hold for particular informational theories, which are axiomatically bounded and correspond (model) particular informational cases. Thus, for instance, informational theories of discourse, time, understanding, a certain intelligence, etc. become senseful in an informational manner. Such particularized and complex informational entities are described by some initial informational formula systems, which develop and behave informationally.

Consequence 1 (Informational Syntax) *A general syntax of informational formulas follows from the previous axioms and definitions and is the following:*

φ	informational entity: *operand, formula, or formula system;* any operand symbol: $\alpha, \beta, \cdots, \omega$ *or* $\mathcal{A}, \mathcal{B}, \cdots, \mathcal{Z}$*;*
(φ)	*parenthesized entity;*
$\varphi \models$	*entity externalism;*
$\models \varphi$	*entity internalism;*
$\varphi \models \varphi$	entity metaphysicalism: *informational serialism,* informing among different entities: *for instance,* $\varphi \models \psi$;
$\varphi \models; \models \varphi$	*entity phenomenalism: entity system informing;*
$\mathcal{I}_\varphi$, $\mathcal{I}(\varphi)$	*informing of entity* φ;
$\varphi, \varphi, \cdots, \varphi$	*informational set;*
$\varphi; \varphi; \cdots; \varphi$	*informational parallelism*

The general syntax of informational formulas is recursive. □

The consequence of informational syntax assures that by decomposition and composition of entities any possible formula or formula system can arise, irrespective of the nature of particular decomposition and composition rules (that is, formula constructing impulses, situations, attitudes, etc.). Within processes of decomposition and composition of informational formulas, operands and operators are particularized and universalized according to given situations, following the principles, by which various forms of informational semantics and pragmatics arise. Thus, the following consequence becomes senseful.

Consequence 2 (Informational Semantics and Pragmatics) *The arising and constitution of general semantics and pragmatics concerning syntactically structured informational formulas are a consequence of various semantic and pragmatic, spontaneous and circular, serial and parallel informational decomposition, composition, particularization, and universalization processes, which arise during intentional, interpretational, conscious, and other processes of formula systems development.* □

Consequence 1 and Consequence 2 are general informational paragons of any informational theory

development. We shall treat the most relevant decomposition and composition approaches in the next section.

Consequence 1 and Consequence 2 are general informational paragons of an informational theory development. Concrete theories are always concretely particularized and universalized in respect to the occurring informational operands and operators. These consequences are general schemes for the arising (deduction, induction, appearance, occurrence) of particular theorems. Proofs of such theorems are always in accordance with the previous two consequences.

7 Informational Decomposition and Composition

Informational consequences can be deduced and induced by various rules for decomposition and composition of formulas. The nature of decomposition and composition is parallel, serial, and circular. According to the discussed axioms, these rules can be very pragmatic following only the formula syntax convention and the characteristics (meaning, semantics) of particular or universal cases.

7.1 Some Basic Parallel Decomposition Principles, Rules, and Notations

Parallelism of informational phenomena belongs to the cognitively and technologically most obvious cases of informing of informational entities. For instance, one and the same phenomenon can be understood (interpreted) in different, that is, parallel ways at different (parallel) situations and attitudes of observation. Parallel decomposition means a splitting of entities (operands, formulas, formula systems) into greater interpretational details. Processes of parallel decomposition are both deductive (a theory-intentional) as well as inductive (spontaneous within theoretical boundaries).

Rule 3 (Informational Parallelism) *Informational entities inform in different, that is,* parallel *ways. Thus, by definition,* $\alpha \models$ *means different parallel occurrences of the form* $\alpha \models$. *There is, formally,*

$$(\alpha \models) \rightleftharpoons_{\text{mean}} \begin{cases} \alpha \models; & \textit{Parallel Externalism} \\ \alpha \models; & \\ \vdots & \\ \alpha \models & \end{cases}$$

Informational entities are informed in different, that is, parallel *ways. Thus, by definition,* $\models \alpha$ *means different parallel occurrences of the form* $\models \alpha$. *There is, formally,*

$$(\models \alpha) \rightleftharpoons_{\text{mean}} \begin{cases} \models \alpha; & \textit{Parallel Internalism} \\ \models \alpha; & \\ \vdots & \\ \models \alpha & \end{cases}$$

Informational entities inform metaphysically in different, that is, parallel *ways. Thus, by definition,* $\alpha \models \alpha$ *means different parallel occurrences of the form* $\alpha \models \alpha$. *There is, formally,*

$$(\alpha \models \alpha) \rightleftharpoons_{\text{mean}} \begin{cases} \alpha \models \alpha; & \textit{Parallel} \\ \alpha \models \alpha; & \textit{Metaphysicalism} \\ \vdots & \\ \alpha \models \alpha & \end{cases}$$

Informational entities inform phenomenally in different, that is, parallel *ways. Thus, by definition, system* $\alpha \models; \models \alpha$ *means different parallel occurrences of the system form* $\alpha \models; \models \alpha$. *There is, formally,*

$$(\alpha \models; \models \alpha) \rightleftharpoons_{\text{mean}} \begin{cases} (\alpha \models; \models \alpha); & \textit{Parallel} \\ (\alpha \models; \models \alpha); & \textit{Phenome-} \\ \vdots & \textit{nalism} \\ (\alpha \models; \models \alpha) & \end{cases}$$

To explicate the parallel informing of entity α *in the previous four cases, one can introduce notations* $\alpha \Vdash$, $\Vdash \alpha$, $\alpha \Vdash \alpha$, *and* $\alpha \Vdash; \Vdash \alpha$ *for parallel externalism, internalism, metaphysicalism, and phenomenalism, respectively. This completes the basic rules of parallel decomposition concerning informing of an informational entity* α. □

Decomposition rules concerning parallel externalism, internalism, metaphysicalism, and phenomenalism are not understood to be tautological or simply identical cases. Each occurrence of a parallel component, for example within $\alpha \models; \alpha \models; \cdots$,

represents a split case of $\alpha \models$ and it is to understand that at an end of decomposition the initial 'simple' meaning of $\alpha \models$ is in a way integrated meaning of parallel components $\alpha \models$. That means that after a parallel decomposition of an entity's externalism $\alpha \models$ an integrative (composed) meaning arises, described by a kind of the reverse formula, that is,

$$\left.\begin{array}{l}\alpha \models; \\ \alpha \models; \\ \vdots \\ \alpha \models\end{array}\right\} \rightleftharpoons_{\text{mean}} (\alpha \models)$$

The listed example is in no way a non-scientific case. For instance, in quantum theory, parallel occurrences of one and the same particle (photon) can appear in different places (two places at once), traveling different routes and being detected when they interfere with one another (Quantum Magic and Quantum Mystery in [Penrose 90]). On the other hand, arising of information in mind as described by parallel-decomposing processes lies outside of the conventional doubt and is consciously evident.

Similar explanation schemes can hold for the remaining cases of Rule 3 (internalism, metaphysicalism, and phenomenalism).

Consequence 3 (Parallelism of Informing) *A consequence of Axiom 10 and Rule 3 is the parallelism of informing $\mathcal{I}_\alpha$. Thus,*

$$(\alpha \models; \models \alpha) \rightleftharpoons_{\text{Def}} \begin{cases} (\alpha \models; \models \alpha) \Longrightarrow \mathcal{I}_\alpha; \\ (\alpha \models; \models \alpha) \Longrightarrow \mathcal{I}_\alpha; \\ \vdots \\ (\alpha \models; \models \alpha) \Longrightarrow \mathcal{I}_\alpha \end{cases}$$

By this consequence, parallel (different, alternative) entities of informing, that is, $\mathcal{I}_\alpha; \mathcal{I}_\alpha; \cdots; \mathcal{I}_\alpha$, are introduced. □

The last consequence, introducing parallel occurrences of informing, which can be marked as $\mathcal{I}^1_\alpha, \mathcal{I}^2_\alpha, \cdots, \mathcal{I}^n_\alpha$, has to be understood as a particular (particularized) parallel phenomenalism of the form

$$(\alpha \models; \models \alpha) \rightleftharpoons_{\text{Def}}$$

$$\begin{pmatrix} (\alpha \models^1_{\text{particularly}}; \models^1_{\text{particularly}} \alpha) \Longrightarrow \mathcal{I}^1_\alpha; \\ (\alpha \models^2_{\text{particularly}}; \models^2_{\text{particularly}} \alpha) \Longrightarrow \mathcal{I}^2_\alpha; \\ \vdots \\ (\alpha \models^n_{\text{particularly}}; \models^n_{\text{particularly}} \alpha) \Longrightarrow \mathcal{I}^n_\alpha \end{pmatrix}$$

where α maintains its identity, but can inform in different (parallel) ways. Informational operators $\models^1_{\text{particularly}}, \models^2_{\text{particularly}}, \cdots, \models^n_{\text{particularly}}$ are differently particularized forms of the general operator $\models$ and read as 'inform(s) particularly'. This case is nothing other than an example of parallel decomposition of α's informing.

Definition 6 (A list of operands) *Instead of a sequence of parallel formulas of the form*

$$\alpha_1 \models \beta; \alpha_2 \models \beta; \cdots; \alpha_n \models \beta$$

the shortcut form

$$\alpha_1, \alpha_2, \cdots, \alpha_n \models \beta$$

can be used, where $\alpha_1, \alpha_2, \cdots, \alpha_n$ is a list of operands separated by commas. □

Definition 7 (A list of parallel formulas) *A formula system*

$$\alpha_1 \models \beta_1; \alpha_2 \models \beta_2; \cdots; \alpha_n \models \beta_n$$

means that formulas of the system, separated by semicolons, inform in parallel. This system of formulas can be marked, for instance, by φ and written as

$$\varphi \models_{\text{mark}} (\alpha_1 \models \beta_1; \alpha_2 \models \beta_2; \cdots; \alpha_n \models \beta_n)$$

or also, in a parallel clear form, as

$$\varphi \models_{\text{mark}} \begin{cases} \alpha_1 \models \beta_1; \\ \alpha_2 \models \beta_2; \\ \vdots \\ \alpha_n \models \beta_n \end{cases}$$

The last form was already used in some previous cases. Certainly, operator $\models_{\text{mark}}$ can be replaced (particularized) by (in) any meaningly adequate form. □

7.2 Spontaneity, Circularity, Intentionality, and Alternativity as Entity-parallel and Entity-circular Phenomenalism

The title of this subsection stresses that spontaneity, circularity, alternativity, and intentionality as informational phenomena is an entity-parallel and entity-circular phenomenalism. It means that these entities are interconnected, interdependent, and mutually supported in an informational (physical, biological, social, etc.) way. As observers of informational entities, we obviously consciously perceive this kind of interrelatedness. On the other side, spontaneity, circularity, alternativity, and intentionality seems to cover the most important aspects of human experience in philosophy, technology, and everyday life. Further, the four distinguished entities can spontaneously, circularly, alternatively, and intentionally resemble other significant informational entities which may appear in an intricate way.

One of the basic axioms concerning informational entity says that an informational entity informs in a spontaneous–circular or circular–spontaneous way. A special operator for this faculty of an informing entity can be introduced.

Definition 8 (Operator of a circular–spontaneous informing) *Let us introduce the following basic informational operator:*

$\alpha \looparrowright$ means α *informs circularly and spontaneously*

The particularized general operator would look cumbersome,

$$\alpha \models_{\text{circular–spontaneously}}$$

for example. □

The four special operators are as follows by the next definition.

Definition 9 (Operators of spontaneity, circularity, intentionality, and alternativity) *We introduce the following four basic informational operators:*

$\alpha \rightsquigarrow$	means	α *informs spontaneously*
$\alpha \circlearrowright$	means	α *informs circularly*
$\alpha \rightarrowtail$	means	α *informs intentionally*
$\alpha \rightrightarrows$	means	α *informs alternatively*

We can use also particularized general operators of informing, that is,

$$\alpha \models_{\text{spontaneously}}, \alpha \models_{\text{circularly}},$$
$$\alpha \models_{\text{intentionally}}, \alpha \models_{\text{alternatively}}$$

respectively. □

Although in the previous two definitions, the informational externalism of entity α is shown, the reader can easily complete the cases of internalism, metaphysicalism, and phenomenalism by himself/herself.

Consequence 4 (An implication concerning the spontaneous–circular informing) *A consequence of definitions 8 and 9 concerning the spontaneous–circular informing of an entity in general and its intricate particular informings of spontaneity, circularity, intentionality, and alternativity is the following:*

$$(\alpha \looparrowright) \Longrightarrow$$

$$\left(\begin{pmatrix} \alpha \rightsquigarrow; \\ \alpha \circlearrowright; \\ \alpha \rightarrowtail; \\ \alpha \rightrightarrows \end{pmatrix} \Longrightarrow (\alpha \rightsquigarrow \circ(\circlearrowright \circ (\rightarrowtail \circ \rightrightarrows)))\right)$$

where $\rightsquigarrow\circ(\circlearrowright\circ(\rightarrowtail\circ\rightrightarrows))$ *is a notation of the so-called informational composition (operational unity or perplexity) of informational operators* $\rightsquigarrow, \circlearrowright, \rightarrowtail,$ *and* $\rightrightarrows$. *Token '*$\circ$*' marks the operator of operator composition.* □

7.2.1 A Structure of Spontaneity

Spontaneity as an informational entity is in no way a purely chaotic phenomenon without boundaries in the spontaneity itself. Spontaneity does not mean a chaotic informational arising, but physical, biologic, discursive, social, etc. persevering, directionality, or intentionality. Simultaneously (in parallel), spontaneity as an informational entity is cyclically and alternatively structured, where alternativity can be understood as a specific form of spontaneity.

Our task is to capture spontaneity of informational entities as a regular informational faculty, to give the phenomenon an explicit formal character. For this purpose, a special informational operator ($\rightsquigarrow$) was introduced.

Consequence 5 (An implication of spontaneity) *Informational spontaneity means a certain circularity, intentionality, and alternativity of an informational entity. Thus,*

$$(\alpha \rightsquigarrow) \Longrightarrow \left(\begin{pmatrix} \alpha \circlearrowleft; \\ \alpha \mapsto; \\ \alpha \rightrightarrows \end{pmatrix} \Longrightarrow (\alpha \circlearrowleft \circ(\mapsto \circ \rightrightarrows))\right)$$

or also,

$$\left((\alpha \rightsquigarrow) \Longrightarrow \begin{pmatrix} \alpha \circlearrowleft; \\ \alpha \mapsto; \\ \alpha \rightrightarrows \end{pmatrix}\right) \Longrightarrow (\alpha \circlearrowleft \circ(\mapsto \circ \rightrightarrows))$$

where $\circlearrowleft \circ (\mapsto \circ \rightrightarrows)$ *is a notation of informational composition of informational operators* $\circlearrowleft, \mapsto$, *and* $\rightrightarrows$. *The duality of the first and the second expression is characteristic and can be observed elsewhere in the realm of the informational.* □

Alternativity may be recognized as an explicit spontaneous faculty of choice among different possibilities of informing. However, circularity and intentionality may have their own characters of spontaneity in their circular and intentional possibilities. Thus, spontaneity stays in the background of any informational activity.

7.2.2 A Structure of Circularity

Circularity (cyclicity) is one of the basic faculties of an informing entity. Circularity means recursiveness, metaphysical and other kinds of cycling, memorizing, maintaining of informational components, informational persevering which keeps a course of spontaneity, intentionality, alternativity, etc. Metaphysicalism is a basic interior mechanism of circularity. Cyclic processes can include parallel structures, representing circular–parallel forms of informing.

Consequence 6 (Implications and a meaning concerning metaphysical circularity) *Pertaining to metaphysicalism* $\alpha \models \alpha$, *there is,*

$$(\alpha \circlearrowleft) \Longrightarrow (\alpha \models \alpha);$$
$$(\circlearrowleft \alpha) \Longrightarrow (\alpha \models \alpha);$$
$$(\alpha \models \alpha) \rightleftharpoons (\alpha \circlearrowleft; \circlearrowleft \alpha)$$

where informational operator $\rightleftharpoons$ *means 'means'. Obviously,*

$$(\alpha \circlearrowleft) \Longrightarrow (\circlearrowleft \alpha);\ (\circlearrowleft \alpha) \Longrightarrow (\alpha \circlearrowleft)$$

Metaphysicalism is a specific circular form of informing. □

Consequence 7 (An implication concerning general circularity) *Informational circularity means a certain spontaneity, intentionality, alternativity, metaphysicalism, cyclic parallelism of an informational entity. This property of informational circularity means*

$$(\alpha \circlearrowleft, \circlearrowleft \alpha) \Longrightarrow$$

$$\left(\begin{pmatrix} \alpha \rightsquigarrow \alpha; \\ \alpha \mapsto \alpha; \\ \alpha \rightrightarrows \alpha \end{pmatrix} \Longrightarrow (\alpha \rightsquigarrow \circ(\mapsto \circ \rightrightarrows))\right)$$

or also,

$$\left((\alpha \circlearrowleft, \circlearrowleft \alpha) \Longrightarrow \begin{pmatrix} \alpha \rightsquigarrow \alpha; \\ \alpha \mapsto \alpha; \\ \alpha \rightrightarrows \alpha \end{pmatrix}\right) \Longrightarrow$$

$$(\alpha \rightsquigarrow \circ(\mapsto \circ \rightrightarrows))$$

□

Spontaneous, intentional, and alternative circularity is either metaphysical (that is, entity–interior) or entity–exterior (concerning entities outside the entity in question).

7.2.3 A Structure of Intentionality

Intentionality of something belongs to the most basic virtues of physical things, informational entities, social processes, and other informationally structured phenomena. In intention, there is besides linguistically known meanings always something spontaneous, cyclic, and alternative. Intentionality proceeds in the direction of, for example, a goal, belief, physical structure, organization, and process, keeping as it seems, the validity of the so-called physical laws as the most general images of minds. Thus, let us set the following frame consequence.

Consequence 8 (An implication concerning intentionality) *Intentionality of something implies its spontaneity, circularity, and alternativity in its fragmental and composite form. Evidently, one can set*

$$(\alpha \mapsto) \Longrightarrow \left(\begin{pmatrix} \alpha \rightsquigarrow; \\ \alpha \circlearrowleft; \\ \alpha \rightrightarrows \end{pmatrix} \Longrightarrow (\alpha \rightsquigarrow \circ(\circlearrowleft \circ \rightrightarrows))\right)$$

or also,

$$\left((\alpha \rightarrowtail) \Longrightarrow \begin{pmatrix} \alpha \rightsquigarrow; \\ \alpha \circlearrowleft; \\ \alpha \rightrightarrows \end{pmatrix}\right) \Longrightarrow (\alpha \rightsquigarrow \circ(\circlearrowleft \circ \rightrightarrows))$$

□

7.2.4 A Structure of Alternativity

When an informational entity informs, it informs alternatively to some extent. Within a kind of informing there is possible to observe the so-called counterinforming. Alternativity (alternative choice of possibilities) belongs to the phenomenalism of counterinforming. So, to a kind of informing there may exist an alternative informing. Alternativity means alternativeness, alternation, opposition, otherness, pluralism, parallelism, severalty, succession, etc. as a unity. To each informational operator there is possible to determine its alternative type. One of the most general informational alternativity is that which concerns an entity informing.

Definition 10 (Alternative informing) *Let us mark by $\Dashv$ the alternative operator to the general operator $\models$. We have the following reading convention:*

$$\begin{array}{lll} \alpha \models \beta & \text{reads} & \alpha \textit{ informs } \beta \\ \beta \Dashv \alpha & \text{reads} & \beta \textit{ is informed by } \alpha \end{array}$$

□

The alternativity of the case is in the difference between 'to inform' and 'to be informed', where objects which inform and which are informed may have different functions. This difference lies in an entity's externalism and internalism. In the first case, a first entity informs something. In the second case, a second entity is informed by something. We can agree that, e.g. intention of the first entity might be different of the intention of the second entity. In this sense, to each informational operator its informational alternate can be introduced. The following convention seems to be appropriate.

Definition 11 (Alternative operators) *We can define a set of alternative operators corresponding to the original ones. The following pairs of operator–alternative_operator conventions are introduced:*

$\models$,	$\Dashv$	*informs [alternatively]*
$\not\models$,	$\not\Dashv$	*does not [alternatively] inform*
$\Vert\!\models$,	$\Dashv\!\Vert$	*informs [alternatively] in parallel*
$\Vert\!\not\models$,	$\not\Dashv\!\Vert$	*does not [alternatively] inform in parallel*
$\vdash$,	$\dashv$	*informs cyclically [alternatively]*
$\nvdash$,	$\not\dashv$	*does not cyclically inform [alternatively]*
$\Vert\!\vdash$,	$\dashv\!\Vert$	*informs [alternatively] parallel-cyclically*
$\Vert\!\nvdash$,	$\not\dashv\!\Vert$	*does not parallel-cyclically inform [alternatively]*
$\multimap\!\!\!\to$,	$\leftarrow\!\!\!\multimap$	*informs spontaneous–circularly [alternatively]*
$\rightsquigarrow$,	$\leftsquigarrow$	*informs spontaneously [alternatively]*
$\circlearrowleft$,	$\circlearrowright$	*informs circularly [alternatively]*
$\rightarrowtail$,	$\leftarrowtail$	*informs intentionally [alternatively]*
$\rightrightarrows$,	$\leftleftarrows$	*informs alternatively [alternatively]*

□

Several other alternative operators can be introduced. Any particularized operator has its alternate. For example,

$$\models_{\text{particularized}} \quad \text{and} \quad \Dashv_{\text{particularized}}$$

are cases alternative to each other. The directionality of the original and alternative operators is evident. The original operators point from the left to the right, and the alternative from the right to the left. But, there is not only the directionality, because by alternative operators their semantics in comparison to the original ones is essentially changed. The original operators express the informingness of their left operand, while the alternative ones express the informedness of their left operands. The difference between the informing and informedness, that is, between an entity's externalism and internalism is substantial. Alternativity means the distinction which arises in an expressing and impressing process, when something emits information and something accepts it.

Within the scope of the discussed circumstances concerning informational alternativity we can consider the next consequence.

Consequence 9 (Implications concerning alternativity) *Informational alternativity of an*

entity is alternatively recursive entity, is an alternativeness of alternativeness, which causes the alternative operator of informing. There is,

$$(\alpha \rightleftarrows) \Longrightarrow (\leftleftarrows \alpha);$$
$$(\leftleftarrows \alpha) \Longrightarrow (\alpha \rightleftarrows)$$

By this consequence, the alternative informational operators are introduced, according to Definition 11. □

According to the previous discussion, there is possible to agree with a general consequence pertaining to alternativity in the following way.

Consequence 10 (General implications concerning alternativity) *For the alternativity and alternative alternativity there is*

$$(\alpha \rightleftarrows) \Longrightarrow$$

$$\left(\begin{pmatrix} \leftleftarrows \alpha; \\ \alpha \Vdash; \\ \alpha \rightsquigarrow; \\ \alpha \circlearrowleft; \\ \alpha \rightarrowtail \end{pmatrix} \Longrightarrow (\leftleftarrows \alpha; \alpha \Vdash \circ (\rightsquigarrow \circ (\circlearrowleft \circ \rightarrowtail)))\right);$$

$$(\leftleftarrows \alpha) \Longrightarrow$$

$$\left(\begin{pmatrix} \alpha \rightleftarrows; \\ \rightleftarrows \alpha; \\ \rightsquigarrow \alpha; \\ \circlearrowleft \alpha; \\ \rightarrowtail \alpha \end{pmatrix} \Longrightarrow (\alpha \rightleftarrows; ((\rightleftarrows \circ \rightsquigarrow) \circ \circlearrowleft) \circ \rightarrowtail \alpha)\right)$$

There exist various other alternative consequences. □

7.3 Serial, Parallel, Circular, and Metaphysical Modes of Informational Decomposition

We shall now develop a systematic approach to the topical modes of informational decomposition which concern the informationally serial, parallel, circular, and metaphysical. For this purpose we introduce a standardized symbol Δ which is a mark for the formula of informational decomposition in general. Different superscripts and subscripts then determine the specific cases of the mentioned decompositions of an informational entity. As we shall recognize, informational decomposition concerns an entity, formula, or formula system as an entity (informational unity) in question.

7.3.1 Marking Decomposition Formulas

In principle, decomposition proceeds from a topical theme, e.g., a marker, basic formula, or even formula system into greater details. On contrary, composition proceeds from particular detail themes and builds up a topical theme.

Definition 12 (Markers of informational decomposition) *For informational decomposition Δ of informational entity α, that is $\Delta(\alpha)$ in general, we introduce the following particularized decompositional cases:*

$\Delta(\alpha)$	*informational decomposition Δ of entity α;*
$\Delta_{\text{serial}}(\alpha)$	*serial decomposition;*
$\Delta_{\text{parallel}}(\alpha)$	*parallel decomposition;*
$\Delta_{\text{serial-parallel}}(\alpha)$	*serial–parallel decomposition;*
$\Delta_{\text{parallel-serial}}(\alpha)$	*parallel–serial decomposition;*
$\Delta^{\text{circular}}_{\text{serial}}(\alpha)$	*circular serial decomposition;*
$\Delta^{\text{circular}}_{\text{parallel}}(\alpha)$	*circular parallel decomposition;*
$\Delta^{\text{circular}}_{\text{serial-parallel}}(\alpha)$	*circular serial–parallel decomposition;*
$\Delta^{\text{circular}}_{\text{parallel-serial}}(\alpha)$	*circular serial–parallel decomposition;*
$\Delta^{\text{metaphysical}}_{\text{serial}}(\alpha)$	*metaphysical serial decomposition;*
$\Delta^{\text{metaphysical}}_{\text{parallel}}(\alpha)$	*metaphysical parallel decomposition;*
$\Delta^{\text{metaphysical}}_{\text{serial-parallel}}(\alpha)$	*metaphysical serial–parallel decomposition;*
$\Delta^{\text{metaphysical}}_{\text{parallel-serial}}(\alpha)$	*metaphysical parallel–serial decomposition*

□

7.3.2 Serial Decomposition

Serial decomposition of an entity α has to proceed in consequent steps from one decomposed state to another. The serial has the meaning of the consecutive. In this way, there exists an ordered sequence of possibilities in which something can be decomposed in a serial way. By serial decomposition of an informational entity, the process of informing enters into informational details, that is, subentities concerning the entity in question. By decomposition, informational components of

something come to the surface and the entity is being analyzed to the possible constitutional details. Thus, a decomposition procedure always concerns the chosen entity and its own components, which within the informational framework of the entity, arise to the informational existence.

Consequence 11 (Serial decomposition of an entity) *For a serial decomposition situation of entity α, marked by $\Delta_{\text{serial}}(\alpha)$, where entities $\beta, \gamma, \cdots, \omega$ are α's components, there is,*

$$\Delta_{\text{serial}}(\alpha) \rightleftharpoons$$

$$\left(\begin{array}{l} (\beta, \gamma, \cdots, \omega \subset \alpha) \Longrightarrow \\ \\ \left(\begin{array}{l} \alpha \models (\beta \models (\gamma \models (\cdots (\psi \models \omega) \cdots))); \\ (\alpha \models \beta) \models (\gamma \models (\cdots (\psi \models \omega) \cdots)); \\ \vdots \\ (((\cdots (\alpha \models \beta) \cdots) \models \chi) \models \psi) \models \omega \end{array} \right) \end{array} \right)$$

etc. Also other patterns (decompositional alternatives) of serial decomposition are possible. □

7.3.3 Parallel Decomposition

A parallel decomposition of something anticipates a parallel set of autonomous and also informationally (sequentially) connected formulas concerning the entity in question and its components.

The needs for a parallel decomposition appear, for instance, in semantic and pragmatic analysis of an entity (e.g., headword, sentence, paragraph, text, etc.), where by parallel formulas an entity is additionally (in a detailed way) *interpreted* in various possible (also unforeseeable, counterinformational) ways, according to the semantic and pragmatic linguistic conventions and innovations. Understanding of something represents a characteristic process of interpreting not only in parallel, but also in various serial, circular (tautological), and metaphysical ways. Parallelism is one of the semantically most powerful approaches of decomposition.

Consequence 12 (Parallel decomposition of an entity) *Let us have the following of one possible general structures (meanings) of the parallel decomposition of entity α:*

$$\Delta_{\text{parallel}}(\alpha) \rightleftharpoons$$

$$\left(\begin{array}{l} \left(\left(\begin{pmatrix} \alpha_1, \alpha_2, \cdots, \alpha_{n_\alpha}, \\ \beta_1, \beta_2, \cdots, \beta_{n_\beta}, \\ \vdots \\ \omega_1, \omega_2, \cdots, \omega_{n_\omega} \end{pmatrix} \subset \alpha \right) \Longrightarrow \right. \\ \\ \left(\begin{pmatrix} \alpha \models \alpha_1; \\ \alpha_1 \models \alpha_2; \\ \vdots \\ \alpha_{n_\alpha - 1} \models \alpha_{n_\alpha} \end{pmatrix}; \begin{pmatrix} \alpha \models \beta_1; \\ \beta_1 \models \beta_2; \\ \vdots \\ \beta_{n_\beta - 1} \models \beta_{n_\beta} \end{pmatrix}; \right. \\ \\ \left. \left. \cdots; \begin{pmatrix} \alpha \models \omega_1; \\ \omega_1 \models \omega_2; \\ \vdots \\ \omega_{n_\omega - 1} \models \omega_{n_\omega} \end{pmatrix} \right) \right) \end{array} \right)$$

□

7.3.4 Serial–parallel Decomposition

Another logical situation is the so–called serial–parallel decomposition of something. In this case, within a serial decomposition some parallel blocks appear. One can express this possibility by the following consequence.

Consequence 13 (Serial–parallel decomposition of an entity) *For a serial–parallel decomposition situation of entity α, marked by $\Delta_{\text{serial-parallel}}(\alpha)$, where entities β_{par}, γ_{par}, $\cdots$, χ_{par}, ψ_{par}, ω_{par} mark α's parallel structured components, that is,*

$$\beta_{\text{par}} \rightleftharpoons \begin{pmatrix} \beta_1; \\ \beta_2; \\ \vdots \\ \beta_{i_\beta} \end{pmatrix}; \gamma_{\text{par}} \rightleftharpoons \begin{pmatrix} \gamma_1; \\ \gamma_2; \\ \vdots \\ \gamma_{i_\gamma} \end{pmatrix}; \cdots;$$

$$\chi_{\text{par}} \rightleftharpoons \begin{pmatrix} \chi_1; \\ \chi_2; \\ \vdots \\ \chi_{i_\chi} \end{pmatrix}; \psi_{\text{par}} \rightleftharpoons \begin{pmatrix} \psi_1; \\ \psi_2; \\ \vdots \\ \psi_{i_\psi} \end{pmatrix};$$

$$\omega_{\text{par}} \rightleftharpoons \begin{pmatrix} \omega_1; \\ \omega_2; \\ \vdots \\ \omega_{i_\omega} \end{pmatrix}$$

respectively, one of the serial-parallel decomposition schemes, marked by $\Delta_{\text{serial-parallel}}(\alpha)$, *may have the following form:*

$$\Delta_{\text{serial-parallel}}(\alpha) \rightleftharpoons$$

$$\left(\begin{array}{l}(\beta_{\text{par}}, \gamma_{\text{par}}, \cdots, \omega_{\text{par}} \subset \alpha) \Longrightarrow \\ \left(\begin{array}{l}\alpha \models (\beta_{\text{par}} \models (\gamma_{\text{par}} \models (\cdots(\psi_{\text{par}} \models \\ \quad \omega_{\text{par}})\cdots))); \\ (\alpha \models \beta_{\text{par}}) \models (\gamma_{\text{par}} \models (\cdots(\psi_{\text{par}} \models \\ \quad \omega_{\text{par}})\cdots)); \\ \vdots \\ (((\cdots(\alpha \models \beta_{\text{par}})\cdots) \models \chi_{\text{par}}) \models \psi_{\text{par}}) \models \\ \quad \omega_{\text{par}}\end{array}\right)\end{array}\right)$$

□

Another scheme, demonstrating the dominance of the parallel principle, the so–called parallel–serial decomposition, belongs to the category of the parallel type of decomposition.

7.3.5 Parallel–serial Decomposition

As mentioned in the preceding subsection, another possible logical situation is the so–called parallel–serial decomposition of something. In this case, within a parallel decomposition various serial decompositions appear. One can express such a possibility by the following consequence.

Consequence 14 (Parallel–serial decomposition of an entity) *For a parallel–serial decomposition situation of entity* α, *marked by* $\Delta_{\text{parallel-serial}}(\alpha)$, *there is,*

$$\Delta_{\text{parallel-serial}}(\alpha) \rightleftharpoons$$

$$\left(\begin{array}{l}\left(\left(\left(\begin{array}{l}\alpha_1, \alpha_2, \cdots, \alpha_{n_\alpha - 1}, \alpha_{n_\alpha}, \\ \beta_1, \beta_2, \cdots, \beta_{n_\beta - 1}, \beta_{n_\beta}, \\ \vdots \\ \omega_1, \omega_2, \cdots, \omega_{n_\omega - 1}, \omega_{n_\omega}\end{array}\right) \subset \alpha\right) \Longrightarrow\right) \\ \left(\begin{array}{l}\alpha \models (\alpha_1 \models (\cdots(\alpha_{n_\alpha - 1} \models \alpha_{n_\alpha})\cdots)); \\ \alpha \models (\beta_1 \models (\cdots(\beta_{n_\beta - 1} \models \beta_{n_\beta})\cdots)); \\ \cdots \\ \alpha \models (\omega_1 \models (\cdots(\omega_{n_\omega - 1} \models \omega_{n_\omega})\cdots)); \\ \\ (\alpha \models \alpha_1) \models (\cdots(\alpha_{n_\alpha - 1} \models \alpha_{n_\alpha})\cdots); \\ (\alpha \models \beta_1) \models (\cdots(\beta_{n_\beta - 1} \models \beta_{n_\beta})\cdots); \\ \cdots \\ (\alpha \models \omega_1) \models (\cdots(\omega_{n_\omega - 1} \models \omega_{n_\omega})\cdots); \\ \vdots \; \vdots \\ (((\cdots(\alpha \models \alpha_1)\cdots) \models \alpha_{n_\alpha - 1}) \models \alpha_{n_\alpha}; \\ (((\cdots(\alpha \models \beta_1)\cdots) \models \beta_{n_\beta - 1}) \models \beta_{n_\beta}; \\ \cdots \\ (((\cdots(\alpha \models \omega_1)\cdots) \models \omega_{n_\omega - 1}) \models \omega_{n_\omega}\end{array}\right)\end{array}\right)$$

This is only one of the possible cases of parallel–serial decomposition of entity α. □

7.3.6 Circular Serial Decomposition

Besides of the circular serial decomposition in this subsection, we shall discuss circular parallel, circular serial–parallel, and circular parallel–serial decompositions in the next subsections. Circular decomposition of something closes its decomposition circularly into something itself. From the view of the decomposed entity, circular decomposition is a kind of the self-reflexive analysis or also the top–down design, by which the informational components of the entity in question come to the formal surface, for instance, in the form of extended and new informational formulas and formula systems.

Consequence 15 (Serial circular decomposition of an entity) *Serial circular decomposition of entity* α *follows the principle of serial decomposition with the condition that the system must be circularly (cyclically) closed in regard to* α. *According to serial decomposition in Consequence 11, the right–most operand in any serial*

formula, where the left–most operand is α, must be α too. Thus,

$$\Delta^{\text{circular}}_{\text{serial}}(\alpha) \rightleftharpoons$$

$$\left(\begin{array}{l}(\beta,\gamma,\cdots,\omega \subset \alpha) \Longrightarrow \\ \left(\begin{array}{l}(\alpha \models (\beta \models (\gamma \models (\cdots(\psi \models (\omega \models \alpha)\cdots); \\ (\alpha \models \beta) \models (\gamma \models (\cdots(\psi \models (\omega \models \alpha)\cdots); \\ \vdots \\ (\cdots(\alpha \models \beta)\cdots) \models \chi) \models \psi) \models \omega) \models \alpha\end{array}\right)\end{array}\right)$$

etc. where $\Delta^{\text{circular}}_{\text{serial}}(\alpha)$ marks a serial circular scheme of α's decomposition. □

From the technical point of view, circular serial decomposition has the meaning of an internal insight into the successive functional structure of entity α.

7.3.7 Circular Parallel Decomposition

Consequence 16 (Parallel circular decomposition of an entity) *Parallel circular decomposition concerning entity α may perform indirectly (in an indirectly visible, 'subconscious', hidden, or unrevealed way). So, instead of a serial structured formula system in Consequence 12, there can be an arbitrarily mixed structure of parallel formulas such that*

$$\Delta^{\text{circular}}_{\text{parallel}}(\alpha) \rightleftharpoons$$

$$\left((\beta,\gamma,\cdots,\omega \subset \alpha) \Longrightarrow \left(\begin{array}{l}\alpha \models \beta; \\ \beta \models \gamma; \\ \vdots \\ \psi \models \omega; \\ \omega \models \alpha\end{array}\right)\right)$$

where $\Delta^{\text{circular}}_{\text{parallel}}(\alpha)$ marks a circular parallel scheme of α's decomposition. □

Circular parallel decomposition of an entity has its evident paragons in different physical and artificial systems, and in social informational systems.

7.3.8 Circular Serial–parallel Decomposition

A circular serial–parallel decompositional scheme (concept) of a phenomenon seems to be close to a natural picture of a thing's structure and organization. Pure serial and pure parallel situations and attitudes are a matter of an abstract or technological approaches within artificial and theoretical systems. Circular serial–parallel decomposition of an entity is a decomposition or a set of decompositions closed circularly into the entity itself. In this way, circular serial–parallel decomposition can be obtained from Consequence 13 by setting the last operands in serial sequences by α.

Consequence 17 (Circular serial–parallel decomposition of an entity) *For a circular serial–parallel decomposition situation of entity α, marked by $\Delta^{\text{circular}}_{\text{serial–parallel}}(\alpha)$, where entities $\beta_{\text{par}},\gamma_{\text{par}},\cdots,\omega_{\text{par}}$ mark parallel α's components in Consequence 13, there is,*

$$\Delta^{\text{circular}}_{\text{serial–parallel}}(\alpha) \rightleftharpoons$$

$$\left(\begin{array}{l}(\beta_{\text{par}},\gamma_{\text{par}},\cdots,\omega_{\text{par}} \subset \alpha) \Longrightarrow \\ \left(\begin{array}{l}(\alpha \models (\beta_{\text{par}} \models (\gamma_{\text{par}} \models (\cdots(\psi_{\text{par}} \models \\ \qquad \omega_{\text{par}}) \models \alpha)\cdots); \\ (\alpha \models \beta_{\text{par}}) \models (\gamma_{\text{par}} \models (\cdots(\psi_{\text{par}} \models \\ \qquad \omega_{\text{par}}) \models \alpha)\cdots); \\ \vdots \\ (\cdots(\alpha \models \beta_{\text{par}})\cdots) \models \chi_{\text{par}}) \models \psi_{\text{par}}) \models \\ \qquad \omega_{\text{par}}) \models \alpha\end{array}\right)\end{array}\right)$$

The circular serial–parallel decomposition can be characterized also as a parallel type of circular-serial decomposition when considering various informing possibilities of α. □

7.3.9 Circular Parallel–serial Decomposition

Another possible logical situation is the so–called circular parallel–serial decomposition of something. In this case, within a parallel decomposition circular serial decompositions appear. One can express this possibility by the following consequence.

Consequence 18 (A Circular parallel–serial decomposition of an entity) *For a circular parallel–serial decomposition situation of entity α, marked by $\Delta^{\text{circular}}_{\text{parallel–serial}}(\alpha)$, there is,*

$$\Delta^{\text{circular}}_{\text{parallel–serial}}(\alpha) \rightleftharpoons$$

$$\left(\left(\begin{pmatrix}\alpha_1,\alpha_2,\cdots,\alpha_{n_\alpha},\\ \beta_1,\beta_2,\cdots,\beta_{n_\beta},\\ \vdots\\ \omega_1,\omega_2,\cdots,\omega_{n_\omega}\end{pmatrix} \subset \alpha\right) \Longrightarrow \right.$$

$$\left.\begin{pmatrix}\alpha \models (\alpha_1 \models (\cdots(\alpha_{n_\alpha} \models \alpha)\cdots));\\ \alpha \models (\beta_1 \models (\cdots(\beta_{n_\beta} \models \alpha)\cdots));\\ \cdots\\ \alpha \models (\omega_1 \models (\cdots(\omega_{n_\omega} \models \alpha)\cdots));\\ \\ (\alpha \models \alpha_1) \models (\cdots(\alpha_{n_\alpha} \models \alpha)\cdots);\\ (\alpha \models \beta_1) \models (\cdots(\beta_{n_\beta} \models \alpha)\cdots);\\ \cdots\\ (\alpha \models \omega_1) \models (\cdots(\omega_{n_\omega} \models \alpha)\cdots);\\ \vdots\ \vdots\\ ((\cdots(\alpha \models \alpha_1)\cdots) \models \alpha_{n_\alpha}) \models \alpha;\\ ((\cdots(\alpha \models \beta_1)\cdots) \models \beta_{n_\beta}) \models \alpha;\\ \cdots\\ ((\cdots(\alpha \models \omega_1)\cdots) \models \omega_{n_\omega}) \models \alpha\end{pmatrix}\right)$$

This is only one of the possible cases of the circular parallel–serial decomposition of entity α. □

7.3.10 Metaphysical Decomposition

We can standardize a certain form of metaphysical decomposition of an informing entity α, saying that the informing process is a structure and organization of entity's informing, counterinforming, and informational embedding. This decomposition standard carries a logical background—which considers the entity's intentional spontaneous-circular informing—by the informing of which information arrives and arises spontaneously, is accepted (embedded, interpreted, connected) in a certain amount and way, and all this processing runs in one or another circular way regarding the entity in question.

A standardized and pragmatical metaphysical scheme was already discussed in [Železnikar 93]. For entity α, its standardized (metaphysically universalized or generalized) components are informing $\mathcal{I}_\alpha$, counterinforming $\mathcal{C}_\alpha$, counterinformation γ_α, informational embedding $\mathcal{E}_alpha$, and embedding information ε_α. For these components, including α, metaphysical serial, parallel, serial–parallel, and parallel–serial decomposition can be determined in various possible ways. These standardized components can be pragmatized (metaphysically particularized) according to the entity inner structure and organization, and according to the outer informational impacts. In this way, metaphysical decomposition is meant to be the α's own way of inner informational arising, its autonomous informing in the realm of α–influencing environment.

Consequence 19 (Metaphysical decompositions by an entity's standardized components) *Let us have to an entity belonging metaphysical entities marked in the following way:*

α	for	*an informing entity,*
$\mathcal{I}_\alpha$	for	*informing of entity* α,
$\mathcal{C}_\alpha$	for	*counterinforming of entity* α,
γ_α	for	*a counterinforming entity within entity* α,
$\mathcal{E}_\alpha$	for	*informational embedding of entity* α,
ε_α	for	*an embeddingly informing entity of entity* α

Then some of possible metaphysical decomposition schemes are, systematically, the following:

$$\Delta^{\text{metaphysical}}_{\text{serial}}(\alpha) \rightleftharpoons$$

$$\left((\mathcal{I}_\alpha,\mathcal{C}_\alpha,\gamma_\alpha,\mathcal{E}_\alpha,\varepsilon_\alpha \subset \alpha) \Longrightarrow \right.$$

$$\left.\begin{pmatrix}(\alpha \models (\mathcal{I}_\alpha \models (\mathcal{C}_\alpha \models (\gamma_\alpha \models (\mathcal{E}_\alpha \models\\ \quad (\varepsilon_\alpha \models \alpha)))));\\ (\alpha \models \mathcal{I}_\alpha) \models (\mathcal{C}_\alpha \models (\gamma_\alpha \models (\mathcal{E}_\alpha \models\\ \quad (\varepsilon_\alpha \models \alpha)))));\\ \vdots\\ ((((\alpha \models \mathcal{I}_\alpha) \models \mathcal{C}_\alpha) \models \gamma_\alpha) \models \mathcal{E}_\alpha) \models\\ \quad \varepsilon_\alpha) \models \alpha\end{pmatrix}\right)$$

for the long-cycle metaphysical serial informing;

$$\Delta^{\text{metaphysical}}_{\text{parallel}}(\alpha) \rightleftharpoons$$

$$\left((\mathcal{I}_\alpha,\mathcal{C}_\alpha,\gamma_\alpha,\mathcal{E}_\alpha,\varepsilon_\alpha \subset \alpha) \Longrightarrow \right.$$

$$\left.\begin{pmatrix}\alpha \models \mathcal{I}_\alpha;\\ \mathcal{I}_\alpha \models \mathcal{C}_\alpha;\\ \mathcal{C}_\alpha \models \gamma_\alpha;\\ \gamma_\alpha \models \mathcal{E}_\alpha;\\ \mathcal{E}_\alpha \models \varepsilon_\alpha;\\ \varepsilon_\alpha \models \alpha\end{pmatrix}\right)$$

for a metaphysical parallel informing of entity α;

$$\Delta^{\text{metaphysical}}_{\text{serial–parallel}}(\alpha) \rightleftharpoons$$

$$\left((\mathcal{I}^{\text{par}}_{\alpha}, \mathcal{C}^{\text{par}}_{\alpha}, \gamma^{\text{par}}_{\alpha}, \mathcal{E}^{\text{par}}_{\alpha}, \varepsilon^{\text{par}}_{\alpha} \subset \alpha) \Longrightarrow \left(\begin{array}{l} (\alpha \models (\mathcal{I}^{\text{par}}_{\alpha} \models (\mathcal{C}^{\text{par}}_{\alpha} \models (\gamma^{\text{par}}_{\alpha} \models \\ \quad (\mathcal{E}^{\text{par}}_{\alpha} \models (\varepsilon^{\text{par}}_{\alpha} \models \alpha))))); \\ (\alpha \models \mathcal{I}^{\text{par}}_{\alpha}) \models (\mathcal{C}^{\text{par}}_{\alpha} \models (\gamma^{\text{par}}_{\alpha} \models \\ \quad (\mathcal{E}^{\text{par}}_{\alpha} \models (\varepsilon^{\text{par}}_{\alpha} \models \alpha))))); \\ \vdots \\ (((((\alpha \models \mathcal{I}^{\text{par}}_{\alpha}) \models \mathcal{C}^{\text{par}}_{\alpha}) \models \gamma^{\text{par}}_{\alpha}) \models \\ \quad \mathcal{E}^{\text{par}}_{\alpha}) \models \varepsilon^{\text{par}}_{\alpha}) \models \alpha \end{array} \right) \right)$$

for the long-cycle metaphysical serial–parallel informing where, for example,

$$\mathcal{I}^{\text{par}}_{\alpha} \rightleftharpoons \begin{pmatrix} \mathcal{I}^{\text{spont}}_{\alpha} \\ \mathcal{I}^{\text{circu}}_{\alpha} \\ \mathcal{I}^{\text{inten}}_{\alpha} \\ \mathcal{I}^{\text{alter}}_{\alpha} \\ \vdots \end{pmatrix}; \quad \mathcal{C}^{\text{par}}_{\alpha} \rightleftharpoons \begin{pmatrix} \mathcal{C}^{\text{spont}}_{\alpha} \\ \mathcal{C}^{\text{circu}}_{\alpha} \\ \mathcal{C}^{\text{inten}}_{\alpha} \\ \mathcal{C}^{\text{alter}}_{\alpha} \\ \vdots \end{pmatrix};$$

$$\gamma^{\text{par}}_{\alpha} \rightleftharpoons \begin{pmatrix} \gamma^{\text{spont}}_{\alpha} \\ \gamma^{\text{circu}}_{\alpha} \\ \gamma^{\text{inten}}_{\alpha} \\ \gamma^{\text{alter}}_{\alpha} \\ \vdots \end{pmatrix}; \quad \mathcal{E}^{\text{par}}_{\alpha} \rightleftharpoons \begin{pmatrix} \mathcal{E}^{\text{spont}}_{\alpha} \\ \mathcal{E}^{\text{circu}}_{\alpha} \\ \mathcal{E}^{\text{inten}}_{\alpha} \\ \mathcal{E}^{\text{alter}}_{\alpha} \\ \vdots \end{pmatrix};$$

$$\varepsilon^{\text{par}}_{\alpha} \rightleftharpoons \begin{pmatrix} \varepsilon^{\text{spont}}_{\alpha} \\ \varepsilon^{\text{circu}}_{\alpha} \\ \varepsilon^{\text{inten}}_{\alpha} \\ \varepsilon^{\text{alter}}_{\alpha} \\ \vdots \end{pmatrix}$$

In this system of parallel structured metaphysical components, spont, circu, inten, alter, etc. *mark spontaneous, circular, intentional, alternative, etc. parts, respectively which can be shaped pragmatically according to the situation and attitude of entity α. The pragmatical means sufficiently concretized, for instance, intelligent in a certain (intentional, understanding) way (informational–associative, counterinformational–creative, embedding–interpretative) (look at [Železnikar 93] where intelligence as an informational entity's metaphysicalism is discussed). Thus, lastly,*

$$\Delta^{\text{metaphysical}}_{\text{parallel–serial}}(\alpha) \rightleftharpoons$$

$$\left(\left(\begin{pmatrix} \mathcal{I}^{1}_{\alpha}, \cdots, \mathcal{I}^{n_{\mathcal{I}}}_{\alpha}, \mathcal{C}^{1}_{\alpha}, \cdots, \mathcal{C}^{n_{\mathcal{C}}}_{\alpha}, \\ \gamma^{1}_{\alpha}, \cdots, \gamma^{n_{\gamma}}_{\alpha}, \mathcal{E}^{1}_{\alpha}, \cdots, \mathcal{E}^{n_{\varepsilon}}_{\alpha}, \\ \varepsilon^{1}_{\alpha}, \cdots, \varepsilon^{n_{\varepsilon}}_{\alpha} \end{pmatrix} \subset \alpha \right) \Longrightarrow \left(\begin{array}{l} (\cdots((\alpha \models \mathcal{I}^{1}_{\alpha}) \models \mathcal{I}^{2}_{\alpha}) \cdots) \models \mathcal{I}^{n_{\mathcal{I}}}_{\alpha}; \\ (\cdots((\mathcal{I}^{n_{\mathcal{I}}}_{\alpha} \models \mathcal{C}^{1}_{\alpha}) \models \mathcal{C}^{2}_{\alpha}) \cdots) \models \mathcal{C}^{n_{\mathcal{C}}}_{\alpha}; \\ (\cdots((\mathcal{C}^{n_{\mathcal{C}}}_{\alpha} \models \gamma^{1}_{\alpha}) \models \gamma^{2}_{\alpha}) \cdots) \models \gamma^{n_{\gamma}}_{\alpha}; \\ (\cdots((\gamma^{n_{\gamma}}_{\alpha} \models \mathcal{E}^{1}_{\alpha}) \models \mathcal{E}^{2}_{\alpha}) \cdots) \models \mathcal{E}^{n_{\varepsilon}}_{\alpha}; \\ (\cdots((\mathcal{E}^{n_{\varepsilon}}_{\alpha} \models \varepsilon^{1}_{\alpha}) \models \varepsilon^{2}_{\alpha}) \cdots) \models \varepsilon^{n_{\varepsilon}}_{\alpha}; \\ \varepsilon^{n_{\varepsilon}}_{\alpha} \models \alpha \end{array} \right) \right)$$

for a metaphysical parallel–serial informing of entity α. □

7.3.11 Marking Composition Formulas

In principle, composition proceeds from given, also to the greatest detail particularized entities and builds up a topical entity, which represents a new operand Γ, coming into existence by a procedure of composition of sequentially informing components.

Definition 13 (Markers of informational composition) *For informational composition Γ of a set ψ of informational entities α_1, α_2, $\cdots$, α_n, that is $\Gamma(\alpha_1, \alpha_2, \cdots, \alpha_n)$, we introduce the following particularized compositional cases:*

$\Gamma(\psi)$	*informational composition Γ of entity set ψ;*
$\Gamma_{\text{serial}}(\psi)$	*serial composition;*
$\Gamma_{\text{parallel}}(\psi)$	*parallel composition;*
$\Gamma_{\text{serial–parallel}}(\psi)$	*serial–parallel composition;*
$\Gamma_{\text{parallel–serial}}(\psi)$	*parallel–serial composition;*
$\Gamma^{\text{circular}}_{\text{serial}}(\psi)$	*circular serial composition;*
$\Gamma^{\text{circular}}_{\text{parallel}}(\psi)$	*circular parallel composition;*
$\Gamma^{\text{circular}}_{\text{serial–parallel}}(\psi)$	*circular serial–parallel composition;*
$\Gamma^{\text{circular}}_{\text{parallel–serial}}(\psi)$	*circular serial–parallel composition;*
$\Gamma^{\text{metaphysical}}_{\text{serial}}(\psi)$	*metaphysical serial composition;*
$\Gamma^{\text{metaphysical}}_{\text{parallel}}(\psi)$	*metaphysical parallel composition;*

$\Gamma^{\text{metaphysical}}_{\text{serial-parallel}}(\psi)$ *metaphysical serial–parallel composition;*

$\Gamma^{\text{metaphysical}}_{\text{parallel-serial}}(\psi)$ *metaphysical parallel–serial composition*

□

7.3.12 Serial Composition

In a serial composition Γ_{serial} of sequentially acting entities (components) $\alpha_1, \alpha_2, \cdots, \alpha_n$, the procedure of composition runs from the left to the right by the informing insertion of operands, operators, and parentheses or, in the reverse direction, when alternative cases are composed.

A serial composition may consider both the interior and exterior components in respect to a given informational components $\alpha_1, \alpha_2, \cdots, \alpha_n$. If only some interior components are considered, the composition may follow a (partial) metaphysical concept, in which some components become cyclically informed. If exterior components are considered, the composed formula models a new exterior, that is, a non–metaphysical phenomenon in which component entities are involved. A serial composition has to proceed in consequent steps from one composed state to another. In this way, there exists an ordered sequence of possibilities in which something can be composed in a serial manner.

Consequence 20 (Serial composition of an informational entity) *For a serial composition, marked by* $\Gamma_{\text{serial}}(\alpha_1, \alpha_2, \cdots, \alpha_n)$*, where entities* $\alpha_1, \alpha_2, \cdots, \alpha_n$ *are components, there is,*

$$\Gamma_{\text{serial}}(\alpha_1, \alpha_2, \alpha_3, \cdots, \alpha_{n-2}, \alpha_{n-1}, \alpha_n) \rightleftharpoons$$

$$\begin{pmatrix} (\alpha_1 \models (\alpha_2 \models (\alpha_3 \models (\cdots(\alpha_{n-1} \models \alpha_n)\cdots); \\ (\alpha_1 \models \alpha_2) \models (\alpha_3 \models (\cdots(\alpha_{n-1} \models \alpha_n)\cdots); \\ \vdots \\ (\cdots(\alpha_1 \models \alpha_2)\cdots) \models \alpha_{n-2}) \models \alpha_{n-1}) \models \alpha_n \end{pmatrix}$$

etc. Also other patterns (compositional alternatives) of serial composition are possible. □

7.3.13 Parallel Composition

We have to make a clear distinction between the processes of formula or formula system decomposition and composition. A decomposition is a top-down development (project, design) proceeding from a top idea (concept, basic structure) into more specific details in parallel, serial, and circular ways following some informational intention in such or another way. A composition means a combining of already existing entities (a kind of bottom-up development) into new entities, where, for instance, new relations, combinations, operations between entities are introduced. The introducing of new operand and operator entities is characteristic for both decomposition and composition, because it follows the so-called principle of informational spontaneity.

Consequence 21 (Parallel composition of an informational entity) *For a parallel composition, marked by* $\Gamma_{\text{parallel}}(\alpha_1, \alpha_2, \cdots, \alpha_n)$*, where entities* $\alpha_1, \alpha_2, \cdots, \alpha_n$ *are components, there is,*

$$\Gamma_{\text{parallel}}(\alpha_1, \alpha_2, \cdots, \alpha_n) \rightleftharpoons$$

$$\left(\begin{pmatrix} \alpha_i \models \alpha_j; \\ i, j \in \{1, 2, \cdots, n\} \end{pmatrix} \Longrightarrow \begin{pmatrix} \alpha_1; \\ \alpha_2; \\ \vdots \\ \alpha_n \end{pmatrix} \right)$$

In this consequence only some $\alpha_i \models \alpha_j$ *may exist, so the composed system in not necessarily completely informationally connected.* □

Other compositional (e.g. serial–parallel and parallel–serial) cases, analogous to the previously discussed decomposition cases, can easily be constructed by the reader according to the scheme of compositional markers in Definition 13.

7.3.14 Circular versus Metaphysical Composition

While a common circular composition is a free case of circularly structured components, a metaphysical composition is actually a case of metaphysical decomposition. Certainly, the metaphysical composition can also consider the so–called internalization of exterior phenomena which impact the entity in question. But, this means nothing else than an internally occurring informational affair within the entity's metaphysicalism.

Consequence 22 (Circular serial composition of an informational entity) *For a circular serial composition,*

marked by $\Gamma^{\text{circular}}_{\text{serial}}(\alpha, \alpha_1, \alpha_2, \cdots, \alpha_n)$, *where entities* $\alpha, \alpha_1, \alpha_2, \cdots, \alpha_n$ *are components, and entity* α *is the cycling operand, there is,*

$$\Gamma^{\text{circular}}_{\text{serial}}(\alpha, \alpha_1, \alpha_2, \cdots, \alpha_{n-1}, \alpha_n, \alpha_n) \rightleftharpoons$$

$$\begin{pmatrix} (\alpha \models (\alpha_1 \models (\alpha_2 \models (\cdots(\alpha_n \models \alpha)\cdots); \\ (\alpha \models \alpha_1) \models (\alpha_1 \models (\cdots(\alpha_n \models \alpha)\cdots); \\ \vdots \\ (\cdots(\alpha \models \alpha_1)\cdots) \models \alpha_{n-1}) \models \alpha_n) \models \alpha \end{pmatrix}$$

etc. Also other patterns (compositional alternatives) of circular serial composition are possible. □

Consequence 23 (Circular parallel composition of an informational entity) *For a circular parallel composition, marked by* $\Gamma^{\text{circular}}_{\text{parallel}}(\alpha, \alpha_1, \alpha_2, \cdots, \alpha_n)$, *where entities* $\alpha, \alpha_1, \alpha_2, \cdots, \alpha_n$ *are components and entity* α *is the cycling operand, there is,*

$$\Gamma^{\text{circular}}_{\text{parallel}}(\alpha, \alpha_1, \alpha_2, \cdots, \alpha_n) \rightleftharpoons$$

$$\left(\begin{pmatrix} \alpha \models \alpha_i; \\ \alpha_i \models \alpha_j; \\ \alpha_j \models \alpha; \\ i, j \in \{1, 2, \cdots, n\} \end{pmatrix} \Longrightarrow \begin{pmatrix} \alpha; \\ \alpha_1; \\ \alpha_2; \\ \vdots \\ \alpha_n \end{pmatrix} \right)$$

In this consequence only some sequences $\alpha \models \alpha_i$; $\alpha_i \models \alpha_j$; $\alpha_j \models \alpha$ *may exist, so the composed system in not necessarily uniquely circularly closed.* □

The reader can easily construct the consequences which pertain to other circular and metaphysical compositions, following the ideas of the adequate (discussed) cases of decomposition (symbol Δ). In this way, the study of possible decomposition and composition cases is coming to a reasonable end.

8 Conclusion

> A very large–scale information processing technology has two aspects: one is to enlarge the amount of knowledge and the other to enlarge the capacity to process knowledge. (...) Very large–scale knowledge does not simply mean collecting knowledge in substantial amounts. Totally new technologies are required to automatically acquire and store massive knowledge as efficiently as possible. (...) Knowledge is varied, diversified, and comes in many forms.
>
> —[Knowledge 92] 3–5

The problem of a new informational theory is how to organize its structure and symbolism in a way (e.g. counterinformationally), that formal, discursive (mathematical, scientific), and semantic conventions remain preserved and that communication (informational embedding, interpreting) to existing theories is possible. The problem is how to keep the individual of the new theory and put it into the discourse of a new reality, for which it is believed that it will find a philosophical, scientific, and technological background (understanding). The question of a general informational theory is how to set the boundaries sufficiently wide, apart from conventional possibilities, enabling the informational fragmentation (decomposition) and, simultaneously, the synthesization (composition). In this view, a general informational theory is possibility–trivial, possessing an infinite set of consequences (theorems, lemmas, rules) which follow from basic axioms. For instance, we learned that symbol $\models$ represents an extremely general (powerful) informational operator, which can replace any particular or universal operational concept and acts in an informational formula game (scenario) as an operator joker (trump–operator).

Such a trivial situation of a general informational theory changes in case of a theory particularization where informational operands and operators become informationally closed (e.g. tautologically determined) entities. But, formal expressions (formulas, formula systems) carry their own stories, inform and counterinform surprisingly in regard to the traditional, that is, logical, mathematical, and linguistically abstract forms. There is much more informational background in that what is called informationally arising, coming to informational surface and much less of that what in traditional theories is reduced, neglected, unconscious, and simply eliminated as insignificant. The realm of the informational is meaningly broader, parallel, interconnected; in short, it is more complex, perplexed, interwoven, circular, and spontaneous; it corresponds better than

the traditional philosophies do to that that approaches as evolution of man's abstract, circular, and spontaneous mind and what has to a reasonable extent been impacted by human informational tools where, for example, information processing of information processing became an evident and logically possible, manageable task.

The concept of an informational machine implementation [Železnikar 92c] remains one of the most challenging projects for the coming decades. It has to follow some essential changes in the design of both machine's hardware and software, where the informationally arising machine components are regularly supported by the machine system. It was shown, how understanding of text can become informationally arising in the framework of an informational environment [Železnikar 92d] (e.g., at the analysis and interpretation of the most lucid, comprehensive, and circularly perplexed philosophical texts and their translation from one natural language into another [Heidegger 86]).

At the end, it seems evident that informational concepts in the form of machines and programs need an informational formalism which can guarantee sufficiently safe, error–free and efficient design. This experience is nothing new in the realm of computer design and use where mathematically rigorous techniques have been applied at the design of computer architecture, operating systems, structured programming and the like. In this view, mathematics seems to be only a specific mental technique which can assure the repeatability, efficiency, and safety (security) of computational processes (algorithms). So let us close with the following remarkable citation ([Husserl 80] I, p. 253) concerning also the phenomenon of construction of future informational machines and programs (written down at the very beginning of this century, in the year 1900): *Hier ist zu beachten, daß der Mathematiker in Wahrheit nicht der reine Theoretiker ist, sondern nur der ingeniöse Techniker, gleichsam der Konstrukteur, welcher, in bloßem Hinblick auf die formalen Zusammenhänge, die Theorie wie ein technisches Kunstwerk aufbaut. So wie der praktische Mechaniker Maschinen konstruiert, ohne dazu letzte Einsicht in das Wesen der Natur überhaupt und in das Wesen ihrer sie bedingenden Begriffe und Gesetze besitzen zu müssen. Ähnlich verhält es sich ja bei allen „Spezialwissenschaften".*

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THE INFORMATION TECHNOLOGY (IT) FOR ENABLING DISABLED PEOPLE – A STRATEGIC AGENDA –

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The agenda and strategy building for enabling the disabled and needy people via Information Technology (IT) will be the major health and welfare issue in both developing and developed countries in the coming century. This paper, based upon some comparative findings and projected scenarios in East Asian countries, tries to examine the feasibility of and argue for the IT enhanced enabling (disabled people) approach in health and welfare promotion. Part One of the paper examines, analytically and historically, the case of Asian experience in: (1) traditional forms of social response towards the disabled people, (2) modern organized form of social services for the disabled, and (3) the futuristic individually tailor-made services for the disabled via IT provision in different communities.

In Part Two, findings and observations in the Asian context are outlined and discussed. Three major arena of possible integration between IT and disabled people are identified: within family system, in the functional (e.g. disabled) groups, and in the new form of community. Coupled with a discussion on the gender issues of the IT in health and welfare promotion, the respective specificity of the arena will be articulated. Also, the differential albeit inter-related rate and intensity of IT utilization in different arena will be examined. The related analyses, as argued in Part Three, indicate the feasibility of the informational based disabled community networking, in and through which the disabled can be integrated into normal life. But, the effectiveness of this approach is, articulated in the later part, contingent upon the variables embedded in the technology -namely, risks- and social structure. The paper ends with a set of agenda and policy-related strategies for enabling the disabled in the 1990s and beyond within the global context.

1 Introduction

The Newly Industrialized Economies (NIEs) in East Asia have been taking up a more important position in the global economy and hence, economic development of these countries is highly and structurally associated with the globalization of capital in general, IT in particular [21, 38]. But the rapid economic development in this region is not necessary implying that socio- economic conditions and welfare of the underprivileged and disabled could be enhanced if not fully supported by these (non welfare) states. How this region responds to health and welfare issues, as ageing of

population and increasing disabled people in public sphere, will become a global issue.

The global development of IT – one of the three major futuristic technologies: bio-technology, and material-cum-energy technology – and its application in non-productive sector, namely in social arena in general, and welfare and health sector in particular will be the crucial factors in shaping future societal development in these NIEs. In other words, how to utilize IT in these arena will determine welfare benefits of the people.

Hence, the agenda and strategy building for enabling the disabled and needy people via IT will be the major health and welfare issue in both developing and developed countries in the coming century. This paper, based upon some comparative findings and projected scenarios in East Asian countries, tries to examine the feasibility of and argue for the IT enhanced enabling (disabled people) approach in health and welfare promotion [40].

This paper starts with an introduction of the contextual specificity of the Asian (yet highly differentiated) experience in state's welfare and health provisions, then some major observations will be discussed. In later parts, strategies of the IT based disabled community networking will be discussed. The paper ends with some remarks on the IT based promotion strategy for welfare and health in the coming decade.

2 Coping with Health and Welfare in Asian Context

Despite socio-cultural differences in the East Asian countries, family system and the spatially bound socio-cultural units -village or community- have historical contribution towards the (yet non-)promotion of health and welfare for disabled people or those-in-need [13]. The functional units (family in general and women in particular) in these economies are in fact the only agency that supported the disabled in traditional societies.

Those needy in these societies were treated socially (with or without welfare services) at the interface between the traditional and modern structures, and adjacent to the Eastern and Western cultural heritage of welfare ideas [9]. Most of them were regrettably treated as "spiritual deviance" or symbols of immoral acts of their ancestors. In short, they were treated, in our present societal standards, less humane than it could. The actual effects were the marginalization of these disabled in community and they became the burden of the less well functioned family system on the way to modernization.

The modern and organized form of social services for the disabled was developed alongside (in many cases) with (Western) charitable and religious institutional welfare services set up. With the exception of some socialist states in the region (e.g. PR China), the degree of openness of respective countries indirectly reflects the level of organized welfare provision and to a certain extent determines the ways and forms of welfare every citizen entitled. In short, economic-political development within the global networking, in most cases, shapes how and when the state provided welfare in these economies [12, 41].

With structural change within the networking of the New International Divisions of Labour, the futuristic IT service for the disabled has opened up a new arena of health and welfare promotion. The new development in IT, particularly in medical and health sector, and its application in rehabilitation will likely have a paradigmatic impact on societal views on those welfare-needy or disabled people. This is because of the fact that, despite its complex system, the very nature of (people's immediate contacts with) IT: its simplicity, flexibility, mobility and multi-modal accessibility and user-friendliness, could enable if not inflate the expectation of people on the possible performance of those needy groups and also fulfilling the notion of excellence of helping professionals.

3 The Differential Impact of IT on Asian Societies

The impact of IT is global and substantial, yet unequal and differential [8]! In the coming sections, we shall outline the major arena of possible integration between IT and disabled people:- within family system, in functional (e.g. disabled) groups, and in the (new form of) community, coupled with a discussion on the gender issue of IT in health and welfare promotion.

The differential development course in Asian developing economies within the globally organized divisions of labour has uneven impact on

the form of state and society relationship [33]. This differential albeit strong development of IT in production sector is quite obvious, particularly in shaping the positive strategic position of state policy on IT [11, 23]. But the applications of technology have done so on a very narrow base [6], particularly, IT utilization in health and welfare related sector is quite limited if not total neglected. Yet, studies and advocacy on this issue are seldom attempted.

One of the major observations in these economies is the fact that many (both software and hardware) piracies happened at the beginning phase of integrating computer technology and IT in their production systems. But this piracy issue is not the major one as IT industry matures, particularly when the industry realizes and provides certain samples of both hard- and software gratis to non- profit making public bodies [34]. The related industry's (counter-)reactions on the piracy issue thus have a strong implication for and in shaping the filtering or diffusion rate of IT in family, group, and community, upon which no existing state policy has acted.

Beyond most of the academic discourses on them, most of the Asian NIEs have a very strong state intervention in the economies and hence, a crucial role played by the developing states in high technology related production, vis-a-vis social welfare provision that is considered negatively as collective consumption burden of the states [1, 17].

Within the hegemonic paradigm for (solely economic) development, the underprivileged groups (women and disabled in particular) have to depend much upon the existing support from their families or (to a less extent) social groups. In other words, they are less visible to be seen nor playing any significant role on the political platform of the "economic miracle" of these NIEs. In short, these groups of people in different (in home and factory) settings have continuously and historically absorbed the burden of economic growth [26,32]. For them, IT is only the mechanism for production rather than consumption, economic growth rather than social development.

4 IT for the Promotion of Health and Welfare

In this Part, IT and more important, the related information (necessarily, the value and moral-laden discourse) on health and welfare are considered as crucial elements in determining the level of socio-cultural development in these economies [7], and the feasibility of the informational based disabled community networking, in and through which the disabled can be integrated into normal life will be examined.

The outlined scenario that the NIEs' selective development in economic and technology, juxtaposing their underdevelopment in technology-for-needy, prompts us to consider the development strategy in and through which a truly equitable welfare can be enhanced via the Pro-Active involvement of IT. This development should be viewed within a wider context that more (even some poor) economies are developing their IT and the possible involvement of technology aids in some Asian countries [14]. The following delineation is the core of our thesis.

First, the disabled and underprivileged are in most cases less mobile than their counterparts thus they merely have to anchor in the community they live or work. The community based nature (and constraint) of these groups also limits their access to information and contacts with outside world. At this juncture, IT can enable them to live and work in their limited place (domestic setting) yet can have similar if not equal and equitable life chance, as the opportunity structure available is dependent upon information one does have.

Second, gifted by the TOUCH (-screen, -plate, or -tablet) and (remote) SENSING technological set up, IT can and will enable the maximum level of communication of the disabled on the FLOW of information – networking, yet this might produce their omnipotent impacts on others, society at large! In other words, IT and its products, if effectively used by and accessible to the disabled people will likely shift our World-View on their (strong and potential) performance and thus considered them as beneficial to the community at large! For instance, the Handicapped Digest, a moderated bulletin board for and with the disabled accessible internationally

via: "l-hcap@ndsuvm1.Bitnet", Internet, Fidonet and Compuserv has been serving multi-functional and multi-dimensional activities, say, policy advocacy, informational exchanges, and consultation.

Last yet the most important one, the very nature of IT is a form of public good because once its hard and software are developed, if they are accessible, there is no cost to "make" more copy or duplication [2]. The implication of this nature of IT is very obvious that people in general and those-in-needs in particular can (and should be encouraged to) have equal access to this omnipotent means in enhancing their individual as well as collective welfare. At this juncture, the state has an important role to play in this process.

Given these conditional observations, we outline the consideration for developing a futuristic brief for the IT based strategic plan for the promotion of health and welfare, particularly, for the disabled in the coming decade in Asian context.

Considering the fact that state policies on computer technology might not be the most important variable in facilitating the diffusion of IT and its utilization for the benefits of society at large [23]: "such policies are more effective in promoting production than use of computers", we should consider the development of IT within the context of social development, namely how best IT can promote welfare of the people.

Hence, the major consideration is that the diffusion of IT and its beneficial effects on society at large should be measured at qualitative terms. For instance, state intervention will provide the likely involvement of IT for those in normal schooling and perhaps, this provision is "necessarily" allocated and is extended to those underprivileged vocational training and rehabilitation programs.

However, no single policy can cope with the diversified and complex society we have today. Therefore, it should be pointed out that, for both the disabled and underprivileged groups, the internal differentiation (i.e. individual differences) among themselves, and distinction between them and the normal population are very significant; and this particular condition might lessen the extent of a single, standardized, communicable and compatible network for them. In other words, rehabilitation or intervention programs should be tailor- made within a comprehensive state-wide framework and planning yet kept them compatible and communicable with each others [27].

The basic principle in developing IT in health and welfare promotion of these countries is soliciting the necessary socio-political supports, namely, any positive policy change in IT should be in accordance with Social Justice principle [36] through which the disabled or underprivileged groups can be directed towards a sustainable mechanism for further empowerment of themselves [28].

For further development of IT infrastructure and utilization in social sphere, efforts should be focused on developing IT beyond production and profit principle, particulary for family and social groups, in terms of technology and professional aids, and the building up of IT network in and through which the underprivileged groups can have equal and equitable access to new information and technology.

More specific, the following arena upon which IT based health and welfare promotion strategies could be focused.

Macro Level:

Legal and political infrastructure should be established in such way that disabled people can participate and have empowerment in the process of rehabilitation back to society and enjoy similar (if not the same) level of rights to access and the utilization of IT. In short, the rights to have (or access to) IT should be incorporated into the social rights of citizens. Supportive aids following justice and equity principle should be provided when and where appropriate. Here, it should be pointed out that some yet different forms of social security for the disabled have been provided in all Asian NIEs, therefore, the IT rights should be considered as an extension of the existing provision in social rights.

By this basic and necessary provision in legal and political infrastructure, the governmental intervention –in school system, medical and health services, rehabilitation and positive discriminatory programs– would be influential in empowering the disabled and underprivileged groups beyond welfare and health arena. In short, the IT based empowerment is for all citizens in general and those needy in particular. Only by enacting legislations that promote health and welfare of people via the IT rights, it is possible to develop

a sustainable society.

Meso Level:

The basic principle for IT aids should go with citizens participation. For the first step, promotion of disabled people's health and welfare is to let them gain access to technology (and IT) with the support of facilitators, namely significant others in their daily milieu. The state's enabling, via cash payment, the provision of facilitators or IT hard and software, could be developed here.

The involvement of IT in health and welfare arena should, firstly, take the gender-specificity into account as more and more women involving in the production and consumption processing of these services, this specificity is very much due to the biological (say, longer life expectancy of female) and soci- cultural (e.g. male tend to have a higher non-response toward welfare provision) structuration of WOMEN within the health and welfare market [5]. Hence, women are the main producers and consumers in the health and welfare market.

Home and other social institutions, say, school or work unit, and their cultural context will shape the possible forms of promoting welfare for disabled people in future, and in fact, the related socio-cultural structure will enhance (or limit) the extent of technological diffusion in these arenas [17]. More important, for strategic development, we should build up a supportive socio-cultural environment with IT for this change in future.

For illustration, three major social arenas that are significant for the strategic promotion of health and welfare will be briefly discussed here:- (1) Family, (2) School, and (3) Work Unit.

Family System:

Diffusion of IT is, as other innovations do, at the least in home or family setting, therefore much work has to be done in future. As most of the Asian societies have a comparatively strong family network or at least the family system did, do and will play a significant role in socialization, it is logically to suggest that more IT (supported by the states) should be available for families. The basic condition of enabling families having access to IT regardless of class and race should be cultivated in social policy, bearing in mind that IT industry has experience in providing hard-and-software gratis to non-profit making bodies.

The extension of IT beyond production sector (and interestingly back) to family and household domain seemingly is the coming major phenomenal trend juxtaposing the history of telecommunication. The strategy to increase the utilization of IT in household domain and at the community level via state intervention (by financing or other state policies), will enhance not just the living quality of people, but also strengthening IT consumption and (re)production in the Asia-Pacific Rim. This will eventually enhance the sustainability of the region.

The global trend in socialization process of the next generation is quite clear that this process in future will be developed within a set of technological variables, mass media (as news and information provider) and the new consumption patterns via IT (e.g., music TV, video-text and games) within home setting. Different messages, life portraits and virtual realities via IT might challenge the very ascriptive nature of family system. Enabling families or households to have a positive and developmental access to and acquisition of IT within an appropriate socio-cultural framework therefore is becoming one of the major tasks of the state for social development.

One precaution must be noted here that, with the increasingly important role of IT in family system, more of the traditional assigned tasks and control of, the family on younger generation and the gender specificity between male and female, might become a dynamic and flowing rather than static condition. For instance, the logic of control via flow, vis-a-vis hierarchial form – say, the quest for women power, of family governance might be the paradoxical phenomenon of, the increase of IT led knowledge base of family cycling process, on the one hand, and the loosening of parental (vs. childhood) control, on the other.

4.1 School System

For schooling, "IT can make education information dissemination less costly and more extensive and efficient so that the opportunity for self-enlightenment is easily accessible to a much larger population than otherwise" [3]. More importantly, given the new development in IT in Asian context, particularly the radio and (satellite) television-led education can be less dependent on English- dominated cultural influence and, thus it is very crucial for the national and

cultural integration of different communities on the way to and for their development in the global system.

One of the related development in school via IT is the vocational training that is positioned between the production and schooling. Vocational training in these developing economies will likely be the domain where more disabled and needy to be involved in the process of empowerment of themselves on the one hand, and the further advancement of quality of health and welfare, on the other.

Paradoxically, the existing IT involved education has a strong bias towards the creation of knowledge infrastructure for the reproduction of profit or monetary value but not the welfare of people in general and those-in-need in particular [15, 35]. To reverse this imbalance development, the state or supra-national organization, say, UNDP, UNICEF, has the obligation to counter-act this developmental trend for people's welfare (to have equitable distribution of collective resources) and the prevention of socio-spatial segregation.

One of the major challenge for school system in the process of enhancing the ability of students (including socially, physically and mentally deprived groups) is the dissemination of "expert" knowledge among laymen. That might increase the vulnerability of schooling in exposing itself towards a wider global community which engenders different sets of value and moral basis of knowledge, and the direct consequence would be loosening of schooling control on people. With this respect, a value-laden and morally charged guideline for utilizing IT in schooling is envisaged.

4.2 Work Unit:

Since "Work" has a significant role to play in the empowerment process of the disabled, different albeit inter-related strategies in re-integrating them back to work environment with successful experience should be advocated [20]. This is particularly the case when IT-led labour empowerment can also reinforce and strengthen the development of an IT community. Hence, the increase productivity of the disabled within (a competitive) working environment via IT in general and the empowerment of workers' bargaining power in particular can be achieved quite readily [31].

Assistive Technology (defined as devise or know-how that directly assists an individual with a disability to have the highest performance as s/he can) for the increase of productivity of disabled people is the basic step for possible involvement or rehabilitation of them in daily living [19]. It should be note that not just the targeted IT but also the ACCESS (system) to IT should be provided in the process of integrating the disabled in normal daily working environment.

For the integration of disabled and special needs people in work environment, the notion of individuals difference in the Sense of Control should be noted [22]. The related practical implication is that the extent of having the Sense of Control with similar assistive devices technology in work may vary among individuals. To cope with individual's (dis)Ability and strength is becoming one of the challenge for producers and coworkers.

4.3 Social Groups:

Interaction in groups will be the major arena in which disabled people experience (both positive and negative) societal encounters. The end-products of IT have been useful in providing (perhaps, more than) the necessary interaction between technology-simulated environment and the disabled, say video games and the simulated virtual reality! Further stimulation for their integration into community, on the one hand, and the experiencing of other people's feeling, on the other, will enable the disabled to have further and more access to external environment to the fullest extent. Nevertheless, the actual link-up between the simulated environment and reality is yet to be worked out.

4.4 In the Community:

It is half rightly pointed out that, among others, the informational support provided in social environment is very crucial in helping disabled people to make the right and appropriate decision when facing with problems [10]. Hence, the further networking of and for the disabled locally and globally enabled by the ever increasing new IT can be envisaged [16].

Networking via IT for subsequent direct personal contacts in community can enhance the

sense of belonging and neighbourhood. One of the major networking effects will be the enlargement of personal knowledge basis and the diversification (vis-a-vis traditional form) of people's outlook, attitude, and lifestyle within the global culture(s) – the world becomes smaller! However, this might be paradoxical when further networking, in some instance, prevents normal face-to-face encounters in (traditional) community setting.

To what extent should state and society assume a control or guidance (private vs. public ownership, centralized vs. decentralized control) on the development of media networks is and will be a major socio-political issue [37].

4.5 Micro Level:

The advantage of IT in welfare and health promotion is its possibility of developing an "individually adaptive and tailor-made IT set up". Helping professional aid to provide a tailor-made, flexible and adaptive IT for the disabled and underprivileged should be the goal of rehabilitation in the coming decade. In other words, the rehabilitation contribution of IT should be developed along with the psycho-social aspects of the clienteles in terms of task and situation specificity.

The development of IT in health and welfare sector should thus have to consider (seemingly contradictory requirement for) not just cognitive but also emotional aspects of the involving parties. Hence, a balance and comprehensive approach in developing IT in the related sector should have the domains in cognitive and behavioral development as well as emotional involvement. In other words, the basic issue (or debate) in the IT based empowerment strategies for people's welfare is: how to develop People's (vis-a-vis machine) potential? The problematique is that the reinforcement on and its related positive effects on individuals via IT application are very crucial in determining long-term and sustainable (health and welfare) development of a community.

5 IT in a Risk Society!

It should be reminded that IT and its applications are not fault-proof! That is, social benefits derived from IT's effectiveness are contingent upon the variables embedded in the technology -namely, risks- and social structure.

The diffusion of IT in production is more readily in Asia which is paralleling the development of the informal sector (in both economic and IT piracy sense). As a result of the hypermobility of technology, the form of informal economy and the development of underclass in the process of informatization of technology reproduction is obvious. For instance, the formation of 'Dual City' in which development juxtaposed under-development is possible [8].

Deep anxiety and perplexity with technology are becoming the fact of life as more technological disasters (accidents) happened in the last decade, Chernobyl and Bhopal are some of them. At this juncture, it is appropriate to describe our present form of civilization as technology-cum-risks society [4, 25]. The characteristics of this Technology-Risk-Environment Syndrome are the invisibility and global nature of risks, and the techno-risks multiply themselves at a geometrical rate and exponential scale:- the synergetic effects of technological development, associated risks and others, as calculated, reacted, mediated and felt by the shocked public via IT based mass media.

Hence, the IT based media has been and will continue facilitating the bombarding process of the techno-related accidents in front of global audience. One implicit meaning of this process is:- the poverty of science regarding the failure and subjectivity of the assumed scientific professional risk assessment. The societal effect enabled by IT and mass media is the De-coupling of assumed scientific rationality and societal mass yet differentiated subjectivity on development issues, green and environmental protests are part of the manifested De-coupling process.

The further development of IT for promoting health and welfare, in the Risk Society, needs to be considered within the framework of the IT associated risks and ramification, as the target groups of having IT are normally quite vulnerable and fragile, in the accidental occurrences. How individuals, groups and organizations respond to and contribute towards the potential risks incurred in IT application should be re-examined. Furthermore, users (broadly defined) participation in IT development, particularly its application in health and welfare sector, is thus to be

strengthened in future. The formation of Users - cum- Producers Groups for sustainable development should therefore be encouraged.

6 IT led-Welfare Development in Next Modernity?

The syndrome of "IT illiteracy" (lack of know-how and personnel, coupled with the sceptical views on "foreign technology") is the major obstacle in applying IT for health and welfare promotion, particularly when people consider the non-profit making nature of the development in this sector. This syndrome can only be dealt with when IT is being at least recognized by the state or supra-national development bodies (say, World Bank or United Nations) in national development strategy for the enlightenment of the entire population regardless of race and class. In other words, governmental Pro-Active policy of utilizing IT in all sectors is the only possible way to develop its sustainability. Hence, IT rights within the framework of soci-political rights of citizens should be recognized.

But the endorsement of the rights on (accessing) IT would not be fault-proof in the development course, as the utilization of IT is only effective and functional if and when this praxis is sustained by a new conceptualization of natural and social events [30, 38] and more important, a set of critical thinking constructs (regarding the self-reflectivity on risks, technology, and environment) developed in public sphere. In short, the new conceptualization on IT-led development should be based upon socio-ecological sustainability.

The IT mediated global exposure, say, the virtual reality, will be part of social life in future, and this conditional structure of (post-)modernity will shape – opinions, views and attitudes– the World-View of people regarding resources distribution on health and welfare provision, sustainability at large. In futuristic terms, how people articulate the health and welfare interests, vis-a-vis ecology, in public sphere and its results will form the basic living conditions of those needy or (under-)privileged in future. "Prevention rather than Cure " is the slogan that symbolizes the modernization process of health and welfare related technology. Confronting the coming (post-)modernity, issue on risks in particular, the empowerment of everyone seemingly is the principle target or course of actions that we should take! Unless precautionary actions and re- thinking are considered at this critical juncture, social uncertainties, risks and IT related accidents might be the message in the media!

On the way to another (post-)modernity, seemingly, the logic of (non)development take many yet fragmented forms that are in line with the accumulation process of the undesirable but hegemonic course of technological advancement, and this "underside" is not the logistical or the outcome of purely technical errors [29]. For the sustainable development of nature and people, some sort of "technological-ecological ethics" should thus be developed to guide the IT development and application in future!

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A COMBINED ALGORITHM FOR TESTING IMPLICATIONS OF FUNCTIONAL AND MULTIVALUED DEPENDENCIES

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In this paper a combined algorithm for testing implication problem, $F \models f$, where F is a set of functional or multivalued dependencies, and f is a functional or multivalued dependency, is presented. The algorithm combines two well known algorithms. The first algorithm solves the implication problem $F \models f$, where F is a set of functional dependencies and f is a functional dependency (the algorithm is based on the closure of a set of attributes [Maier 83]). The other algorithm solves the problem $F \models f$, where F is a set of functional or multivalued dependencies and f is a functional or multivalued dependency (the algorithm is based on the dependency basis [Beeri 80]). The time complexity of the new algorithm is the same as one of the algorithm in [Beeri 80]. In addition, the new algorithm is more informative than the algorithms in [Maier 83] and [Beeri 80] in so far as the new algorithm includes the result explanations RE1 and RE2 that indicate how the imlication problem $F \models f$ is solved; the algorithms in [Maier 83] and [Beeri 80] produce only the answer 'Yes' or the answer 'No'. Also, RE1 and RE2 contain the proof of the correctness of the new algorithm.

1 Introduction

One of the important issues in the design of relational database schemas is the specification of the constraints that the data must satisfy to model corretly the part of the world under consideration[1]. Of particular importance are the constraints, called functional and multivalued dependencies ([Gallaire et al. 81], [Maier 83], [Ullman 88], and [Vardi 88]).

The specification of dependencies is based on implication problem solving ([Beeri and Vardi 81], [Beeri and Vardi 84], [Fagin 82], [Honeyman 82], [Maier et al. 81], and [Vardi 83]). In this work, we give the combined algorithm for testing the implications of functional and multivalued dependencies.

The algorithm combines two well known algorithms (the algorithms in [Maier 83] and [Beeri 80]).

This paper consists of 5 sections. Section 2 contains the basic concepts of the dependency theory. In Section 3, we describe two well known algorithms for solving the implication problem $F \models f$. In Section 4, we give the combined algorithm for solving the implication on problem $F \models f$, where F is a set of functional or multivalued dependencies and f is a functional or multivalued dependency. First we present the basic propositions and describe the general idea of our algorithm. Upon that we present the algorithm and consider its correctness and time complexity. Conclusions are discussed in Section 5.

2 Basic Concepts

Attributes are symbols taken from a given finite (nonempty) set $R = \{A_1, .., A_n\}$.

The set R is called the relation scheme. In what follows we use the letters A, B, C, D, E, F, G, H

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(possibly with subscripts) to indicate single attributes, and U, V, W, X, Y, Z (possibly with subscripts) to indicate sets of attributes. The union of X and Y is denoted by XY. We usually do not distinguish between the attribute A and the set $\{A\}$. Thus, $A_1...A_k$ denotes the set $\{A_1, .., A_k\}$. We assume that with each attribute A_i there is associated a (nonempty) set, called its domain, denoted by dom (A_i).

Let $R = \{A_1, .., A_n\}$ be a relational scheme, and $D = \bigcup_{A_i \in R} \text{dom}(A_i)$ be a domain of R. A tuple on scheme R is a mapping $t : R \to D$, such that $t(A_i) \in \text{dom}(A_i)$ for all $A_i \in R$. $t[Z]$ is a projection of a tuple t on a set of attributes Z, where $Z \subseteq R$.

A relation on relational scheme R is an ordered pair (R, r), where r is a finite set of tuples on R.

We denote tuples by the letters t, u, v (possibly with subscripts). Also, $|S|$ is the number of elements in a set S.

2.1 Functional Dependencies

Let $X, Y \subseteq R$ be subsets of a relational scheme R. A functional dependency is an expression of the form $X \to Y$.

$X \to Y$ holds in (R, r), denoted

$$(R, r) \Vdash X \to Y,$$

if

$$(\forall t_1, t_2 \in r)[t_1[X] = t_2[X] \Rightarrow t_1[Y] = t_2[Y]]$$

Let $FD(R) = \{X \to Y \mid X, Y \subseteq R\}$ be a set of all functional dependencies on R.

2.2 Multivalued Dependencies

Let $X, Y \subseteq R$ be subsets of a relational scheme R. A multivalued dependency is an expression of the form $X \twoheadrightarrow Y$.

$X \twoheadrightarrow Y$ holds in (R, r), denoted

$$(R, r) \Vdash X \twoheadrightarrow Y,$$

if

$$\begin{aligned}(\forall t_1, t_2 \in r)[t_1[X] = t_2[X] \to \\ (\exists t_3 \in r)[t_3[XY] = t_1[XY] \wedge \\ t_3[R \backslash XY] = t_2[R \backslash XY]]\end{aligned}$$

A set of all multivalued dependencies on R is denoted by $MVD(R)$, that is,

$$MVD(R) = \{X \twoheadrightarrow Y \mid X, Y \subseteq R\}$$

Moreover,

$$FMVD(R) = FD(R) \cup MVD(R)$$

is a set of all functional or multivalued dependencies on R.

2.3 Logical Consequence

Let R be a relation scheme, $F \subseteq FMVD(R)$, and $f \in FMVD(R)$. We say that f is a logical consequence of F, or F logically implies f, written as $F \models f$, if

$$(\forall (R, r))[(R, r) \Vdash F \Rightarrow (R, r) \Vdash f],$$

where

$$(R, r) \Vdash F \quad \text{if} \quad (\forall g \in F)[(R, r) \Vdash g]$$

Let $F, G \subseteq FMVD(R)$. We say that G is a logical consequence of F, denoted $F \models G$, if $(\forall g \in G)[F \models g]$. $\not\models$ is the complement of $\models$.

2.4 Closure of an Attribute Set

Let $F \subseteq FD(R), X \subseteq R$. The closure of X with respect to F, denoted X_F^+, is defined by

$$X_F^+ = \{A \in R \mid F \models X \to A\}$$

Then, the following equivalence holds [Ullman 88]:

$$F \models X \to Y \Leftrightarrow Y \subseteq X_F^+$$

2.5 The Dependency Basis

Let $F \subseteq FMVD(R), X \subseteq R$. Next, let M be a set of multivalued dependencies, defined as follows:

M consists of

(a) all multivalued dependencies in F, and

(b) for each functional dependency $X \to Y$ in F, the set of multivalued dependencies

$$X_i \twoheadrightarrow A_1, .., X_i \twoheadrightarrow A_k$$

where $Y_i = A_1..A_k$.

The dependency basis of X with respect to M, denoted $DB(X, M)$, is defined by

$$DB(X,M) = \{Z \subseteq R\backslash X \mid Z \neq \emptyset \wedge M \models X \twoheadrightarrow Z \wedge [(M \models X \twoheadrightarrow U \wedge U \subseteq Z \wedge U \neq \emptyset) \Rightarrow U = Z]\}$$

The following properties of the dependency basis hold:

(1) $DB(X, M)$ is a partition of $R\backslash X$.

(2) If $Y \subseteq R$ and $X \cap Y = \emptyset$, then

$$F \models X \twoheadrightarrow Y \Leftrightarrow Y$$

is a union of sets in $DB(X, M)$.

(3) If $A \in R$ and $A \notin X$, then

$$F \models X \rightarrow A \Leftrightarrow [A \in DB(X,M)] \wedge [(\exists X_i \rightarrow Y_i \in F)[A \cap X_i = \emptyset \wedge A \in Y_i]]$$

For details, see [Ullman 88] and [Beeri 80].

3 Algorithms for Implication Problem Solving

In this section, we describe two well known algorithms for implication problem solving.

3.1 Algorithm (A)

The Algorithm (A) tests $F \models f$, where $F \subseteq FD(R)$ and $f \in FD(R)$, and is based on the closure of an attribute set (the algorithm for the closure computing is in [Maier 83]; its time complexity is $O(|F| \cdot |R|)$

Algorithm (A)

Input: $F \subseteq FD(R)$, $f : X \rightarrow Y \in FD(R)$.

Output: Yes if $F \models f$. No if $F \not\models f$.

Method:

(1) Compute X_F^+.
(2) $F \models X \rightarrow Y$ if $Y \subseteq X_F^+$; $F \not\models X \rightarrow Y$ if $Y \not\subseteq X_F^+$.

Obviously, the time complexity of the Algorithm (A) is also $O(|F| \cdot |R|)$ (note that item (1) makes up the body of the Algorithm (A)).

3.2 Algorithm (B)

The algorithm (B) tests $F \models f$, where $F \subseteq FMVD(R)$ and $f \in FMVD(R)$. The algorithm is based on the algorithm for the dependency basis computing, [Beeri 80].

Algorithm (B)

Input: $F \subseteq FMVD(R)$, $f : X \rightarrow Y$ or $f : X \twoheadrightarrow Y$, where $X, Y \subseteq R$ and $X \cap Y = \emptyset$.

Output: Yes if $F \models f$. No if $F \not\models f$.

Method:

(1) Compute the dependency basic $DB(X, M)$.

(2) If $f : X \rightarrow Y$, then apply the module FUNDEP.

(3) If $f : X \twoheadrightarrow Y$, then apply the module MULDEP.

FUNDEP

Let $Y = B_1..B_n$. Because $F \models X \rightarrow B_1..B_n \Leftrightarrow F \models X \rightarrow B_i$, for all B_i, (the union rule and the decomposition rule for functional dependencies, [Ullman 88]), we have to test $F \models X \rightarrow B_i$ for all B_i.

Method:

FUNDEP:

$F \models X \rightarrow B_i$ if and only if

1) $B_i \in DB(X, M)$, and

2) $(\exists X_j \rightarrow Y_j \in F)[\{B_i\} \cap X_j = \emptyset$ and $B_i \in Y_j]$.

MULDEP:

$F \models X \twoheadrightarrow Y$ if and only if

1) $(\exists D_1,..,D_s \in DB(X,M))[Y = \bigcup_{i=1}^{s} D_i]$.

The time complexity for the algorithm (B) is $O(|M| \cdot |R|^3)$ [Beeri 80].

4 The Combined Algorithm for Implication Problem Solving

In this section, we present the combined algorithm for implication problem solving. The algorithm tests $F \models f$, where $F \subseteq FMVD(R)$ and $f \in FMVD(R)$, by a combination of the algorithms (A) and (B). It is based on the following facts.

4.1 Proposition 1

Let $X, Y, Z \subseteq R$, and $F \subseteq FMVD(R)$. Then

(1) $F \models X \to Y \Rightarrow F \models X \to Z$ if $Z \subseteq Y$ (fd-decomposition);

(2) $F \models X \to Y \wedge F \models X \to Z \Rightarrow F \models X \to YZ$ (fd-union);

(3) $F \models X \to Y \Leftrightarrow F \models X \to (Y \backslash X)$ (fd-simplification);

(4) $F \models X \to\to Y \Leftrightarrow F \models X \to\to (Y \backslash X)$ (mvd-simplification); and

(5) $X \to Y \models X \to\to Y$ (translation).

Proof

The proof is straightforward.

4.2 Proposition 2

The relation $\models$ between sets of dependencies has the following properties:

(1) $(\forall F, G \subseteq FMVD(R))[F \subseteq G \Rightarrow G \models F]$ (reflexivity);

(2) $(\forall F, G, H \subseteq FMVD(R))[F \models G \wedge G \models H \Rightarrow F \models H]$ (transitivity); and

(3) $(\forall F, G, H \subseteq FMVD(R))[F \subseteq G \wedge F \models H \Rightarrow G \models H]$ (monotony).

Proof

The proofs of (1) and (2) are direct consequences of the definition of $\models$, and (3) easily follows from (1) and (2).

4.3 Proposition 3

Let $F \subseteq FMVD(R)$ and $f : X \to A \in FMVD(R)$. Then

$(\forall X_i \to Y_i \in F)[A \notin Y_i] \Rightarrow F \not\models X \to A$ (right-side).

Proof

Because $(\forall X_i \to Y_i \in F)[A \notin Y_i]]$, we see that the condition 2) in the module FUNDEP is not satisfied. Hence we have $F \not\models X \to A$.

Now we describe the general idea of our algorithm. In solving the implication problem $F \models f$, where $F \subseteq FMVD(R)$ and $f : X \to Y$, we first build the set $G = \{X_i \to Y_i | X_i \to Y_i \in F\}$. Upon that, we test $G \models f$ by the Algorithm (A). If we obtain that $G \models f$ holds, then we have, by the Proposition 2 (monotony), $F \models f$.

In the opposite case, that is, if $G \not\models f$, we examine the condition

(C) $(\forall B_i \in (Y \backslash X)(\exists X_i \to Y_i \in G)[B_i \in Y_i]$

If (C) does not hold, then, by the Proposition 3 (right-side), we obtain $F \not\models X \to B_j$, for some B_j in $(Y \backslash X)$. Hence, by the Proposition 1 (fd-decomposition), we have $F \not\models X \to (Y \backslash X)$. Therefore, by the Proposition 1 (fd-simplification), $F \not\models X \to Y$.

If (C) holds, we apply the Algorithm (B), without the item 2) in the modul FUNDEP as the item 2) is already tested in (C), in solving $F \models X \to B_j$, for all B_j in $(Y \backslash X)$. For solving the implication problem $F \models f$, where $F \subseteq FMVD(R)$ and $f : X \to\to Y$, we make use of the next strategy. In the first place, we test $G \models X \to Y$ (by the Algorithm (A)), where $G = \{X_i \to Y_i | X_i \to Y_i \in F\}$. If $G \models X \to Y$, then, by the Proposition 1 (translation) and the Proposition 2 (transitivity), we obtain $G \models X \to\to Y$. Therefore, by the Proposition 2 (monotony), we have $F \models f$.

In the case $G \not\models X \to Y$, we proceed with testing $F \models X \to\to Y$ by Algorithm (B).

Well, the modus operandi of our algorithm is simple: We always make an attempt at solving $F \models f$ by the Algorithm (A). The Algorithm (B) will be used only if the Algorithm (A) fails. In addition, the new algorithm will include the result explanations RE1 and RE2 that have threefold role:

(R1) RE1 and RE2 contain a proof of the correctness of the algorithm. We suppose merely that the algorithms (A) and (B) are correct.

(R2) RE1 and RE2 go to show how the implication problem $F \models f$ is solved. From this we can see not only if $F \models f$ or $F \not\models f$ holds but also if $G \models f$ or $G \not\models f$ holds, where G is the set of all functional dependencies in F.

(R3) RE1 and RE2 make possible the implementation of the algorithm in such a manner that the users of the algorithm can learn about the properties of the relation $\models$. This is a consequence of (R1) and (R2).

For the new algorithm will have the properties (R1) and (R2), and because the Algorithm (B) produces only the answer Yes or the answer No, we shall say that the new algorithm is more informative than the Algorithm (B).

Now we present the algorithm that we sketched a little while ago.

Algorithm (C)

Input: $F \subseteq FMVD(R)$, $f \in FMVD(R)$
Output: $F \models f$ with a result explanation RE1, or
$F \not\models f$ with a result explanation RE2.

Method:

(1) If $f : X \rightarrow Y$, then apply module FUN1.

(2) If $f : X \rightarrow\!\!\!\rightarrow Y$, then apply module MUL1.

FUN1

The module FUN1 tests $F \models X \rightarrow Y$.

1) Let $G = \{X_i \rightarrow Y_i | X_i \rightarrow Y_i \in F\}$ be a set of all functional dependencies in F.

2) Test $G \models f$ (by the Algorithm (A)).

3) If $G \models f$, then $F \models f$.

RE1: The functional dependency $f : X \rightarrow Y$ follows from the set of functional dependencies G, $G \subseteq F$, by the Algorithm (A). Therefore, we have, by the Proposition 2 (monotony), $F \models f$.

If $G \not\models f$, then [if $G = F$, then $F \not\models f$].

RE2: Because $G \not\models f$ and $G = F$, we obtain $F \not\models f$.

If $G \not\models f$ and $G \neq F$, then the algorithm proceeds with testing.

4) Apply module FUN2.

FUN2

The module FUN2 proceeds with testing $F \models X \rightarrow Y$.

1) Check the condition (C):

$(\forall B_i \in (Y \backslash X)(\exists X_i \rightarrow Y_i \in G)[B_i \in Y_i]$.

2) If (C) does not hold, then $F \not\models f$.

RE2: Because the condition (C) does not hold, we have, by the Proposition 3 (right-side), $F \not\models X \rightarrow B_j$, for some B_j in $(Y \backslash X)$. Hence, by the Proposition 1 (fd-decomposition), we obtain $F \not\models X \rightarrow (Y \backslash X)$. Therefore, by the Proposition 1 (fd-simplification), we have $F \not\models X \rightarrow Y$.

If (C) holds, then apply the Algorithm (B) (the modul FUNDEP without the item 2)) in solving $F \models X \rightarrow B_j$, for all B_j in $(Y \backslash X)$.

The Explanation: As the item 2) in the modul FUDEP is already tested in (C), we only have to test the item 1) in the modul FUNDEP.

3) If $F \models X \rightarrow B_j$, for all B_j in $(Y \backslash X)$, then $F \models f$.

RE1: Because $F \models X \rightarrow B_j$, for all B_j in $(Y \backslash X)$, we have, by the Proposition 1 (fd-union), $F \models X \rightarrow (Y \backslash X)$. Hence, by the Proposition 1 (fd-simplification), we obtain $F \models X \rightarrow Y$.

If $F \not\models X \rightarrow B_k$, for some B_k in $(Y \backslash X)$, then $F \not\models f$.

RE2: Because $F \not\models X \rightarrow B_k$, for some B_k in $(Y \backslash X)$, we have, by the Proposition 1 (fd-decomposition), $F \not\models X \rightarrow (Y \backslash X)$. Therefore, by the Proposition 1 (fd-simplification), $F \not\models X \rightarrow Y$.

MUL1

The module MUL1 tests $F \models X \rightarrow\!\!\rightarrow Y$.

1) Test $F \models X \rightarrow Y$ (by the module FUN1 without the modul FUN2).

   If $F \models X \rightarrow Y$, then $F \models X \rightarrow\!\!\rightarrow Y$, that is, $F \models f$.

   RE1: Because $F \models X \rightarrow Y$, we have, by the Proposition 1 (translation) and the Proposition 2 (transitivity), $F \models X \rightarrow\!\!\rightarrow Y$, that is, $F \models f$.

   If $F \not\models X \rightarrow Y$ or $G \not\models X \rightarrow Y$, then apply the Algorithm (B) in solving $F \models X \rightarrow\!\!\rightarrow (Y \backslash X)$.

2) If $F \models X \rightarrow\!\!\rightarrow (Y \backslash X)$, then $F \models X \rightarrow\!\!\rightarrow Y$.

   RE1: Because $F \models X \rightarrow\!\!\rightarrow (Y \backslash X)$, we have, by the Proposition 1 (mvd-simplification), $F \models X \rightarrow\!\!\rightarrow Y$.

   If $F \not\models X \rightarrow\!\!\rightarrow (Y \backslash X)$, then $F \not\models X \rightarrow\!\!\rightarrow Y$.

   RE2: Because $F \not\models X \rightarrow\!\!\rightarrow (Y \backslash X)$, we have, by the Proposition 1 (mvd-simplification), $F \not\models X \rightarrow\!\!\rightarrow Y$.

Proposition (correctness + complexity)

The Algorithm (C) is correct and the time complexity for the Algorithm (C) is the same as the time complexity for the Algorithm (B).

Proof

The proof of the correctness of the Algorithm (C) is given in the result explanations RE1 and RE2 that are included in the Algorithm (C). Also, the proof of the correctness of the same algorithm is sketched in the description of the general idea of the algorithm.

To see how the time complexity of the Algorithm (C) is the same as the time complexity of the Algorithm (B), observe that, during the execution of the Algorithm (C), we are always using the Algorithm (A), that is, the module FUN1, previous to the Algorithm (B). The Algorithm (B) will be used only if the Algorithm (A) (the modul FUN1) fails. For the time complexities of the Algorithm (A) and result explanations RE1 and RE2 are less than the time complexity of the Algorithm (B), we can conclude that the time complexity of the Algorithm (C) is the same as one of the Algorithm (B), that is, the time complexity is $O(|M| \cdot |R|^3)$.

5 Conclusions

We presented a combined algorithm for implication problem solving. The algorithm tests the implication problem, $F \models f$, where F is a set of functional or multivalued dependencies and f is a functional or multivalued dependency. It combines two well known algorithms (A) and (B) that are based on the closure of the set of attributes and the dependency basis, respectively. The time complexity of the new algorithm is the same as the one of the Algorithm (B), (It is $O(|M| \cdot |R|^3)$. The Algorithm (B) produces only the answer Yes or the answer No. The new algorithm is more informative than the Algorithm (B) in so far as the new algorithm contains the result explanations RE1 and RE2 which indicate how the implication problem $F \models f$ is solved. Moreover, from RE1 and RE2 we can see not only if $F \models f$ or $F \not\models f$ holds but also if $G \models f$ or $G \not\models f$ holds, where G is the set of all functional dependencies in F.

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ELECTRONIC NETWORKING FOR PHILOSOPHICAL DEVELOPMENT IN THE PRINCIPIA CYBERNETICA PROJECT

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The Principia Cybernetica Project (PCP) is a collaborative attempt to develop a complete cybernetic and evolutionary philosophy. Such a philosophical system should arise from a transdisciplinary unification and foundation of the domain of Systems Theory and Cybernetics. PCP is meta-cybernetical in that we intend to use cybernetic tools and methods to analyze and develop cybernetic theory, which include the computer-based tools of hypertext, electronic mail, electronic publishing, and knowledge structuring software. They are meant to support the process of collaborative theory-building by a variety of contributors, with different backgrounds and living in different parts of the world.

1 Principia Cybernetica in a Nutshell

The Principia Cybernetica Project (PCP) is a collaborative attempt to develop a complete cybernetic and evolutionary philosophy. Such a philosophical system should arise from a transdisciplinary unification and foundation of the domain of Systems Theory and Cybernetics. Similar to the metamathematical character of Whitehead and Russell's *Principia Mathematica,* PCP is meta-cybernetical in that we intend to use cybernetic tools and methods to analyze and develop cybernetic theory.

These include the computer-based tools of hypertext, electronic mail, electronic publishing, and knowledge structuring software. They are meant to support the process of collaborative theory-building by a variety of contributors, with different backgrounds and living in different parts of the world. PCP will thus naturally develop in the *cyberspace* of interlinked electronic networks, as implemented for example in the World-Wide Web distributed hypertext software.

PCP is to be developed as a dynamic, multi-dimensional conceptual network. The basic architecture consists of nodes, containing expositions and definitions of concepts, connected by links, representing the associations that exist between the concepts. Both nodes and links can belong to different types, expressing different semantic and practical categories.

As its name implies, PCP will focus on the clarification of fundamental concepts and principles

of the broadly defined domain of cybernetics and systems, which includes related disciplines such as the *sciences of complexity,* AI, ALife, Cognitive Science, Evolutionary Systems, etc. Concepts include: Complexity, Information, Entropy, System, Freedom, Control, Self-organization, Emergence, etc. Principles are for example Natural Selection, *the whole is more than the sum of its parts,* and the Laws of Requisite Variety, of Requisite Hierarchy, and of Regulatory Models.

The PCP philosophical system is to be seen as a clearly thought out and well-formulated, global *world view,* integrating the different domains of knowledge and experience. It should provide an answer to the basic questions: *Who am I? Where do I come from? Where am I going to?*

The PCP philosophy is systemic and evolutionary, based on the spontaneous emergence of higher levels of organization or control (metasystem transitions) through blind variation and natural selection. It includes:

a) a metaphysics, based on processes or actions as ontological primitives,

b) an epistemology, which understands knowledge as constructed by the subject or group, but undergoing selection by the environment;

c) an ethics, with survival and the continuance of the process of evolution as supreme values.

Philosophy and implementation of PCP are united by their common framework based on cybernetic and evolutionary principles: the computer-support system is intended to amplify the spontaneous development of knowledge which forms the main theme of the philosophy.

PCP is managed by a board of editors (presently V. Turchin [CUNY, New York], C. Joslyn [NASA and SUNY Binghamton] and F. Heylighen [Free University of Brussels]). Contributors are kept informed through the PRNCYB-L electronic mailing list, and the Principia Cybernetica Newsletter, distributed in print and by e-mail. Further activities of PCP are publications in journals or books, and the organization of meetings or symposia. More information about PCP is available by anonymous FTP at

`is1.vub.ac.be`,

directory

`/pub/projects/Principia_Cybernetica`,

on World-Wide Web

(`http://pespmc1.vub.ac.be`)

or by an e-mail request to

`fheyligh@vnet3.vub.ac.be`.

2 Rationale

PCP is about Philosophy. But what is philosophy? Philosophy intends to answer the questions: Who am I? Where do I come from? Where am I going? What is knowledge? What is truth? What is good? What is evil? What should my supreme goals in life be, and what is the meaning of life? But there is a huge literature on philosophy. What is new here?

Every time has its own approach to these eternal philosophical questions, deriving from its knowledge and technology. We hold that in our time, the age of information, it is systems science and cybernetics, as the general sciences of organization and communication, that can provide the basis for contemporary philosophy. Therefore, this philosophical system is derived from, and further develops, the basic principles of cybernetics.

Moreover, we start from the thesis that systems at all levels have been constructed by evolution, which we see as a continuing process of variation and natural selection of the *fittest* configuration. Evolution continuously adds complexity and makes systems more adaptive by giving them better control over their environments. Control in cybernetics implies the existence of choice from a variety of actions (freedom), and the competence or knowledge to choose the action most likely to bring the system closer to its goals (constraint). The complementary creation of freedom and constraint is realized when a new level of control emerges. We call this a *metasystem transition,* and consider it as the quantum of evolution.

As cybernetic theory informs our philosophy, so cybernetic technology lets us do things that philosophers of other times could never do. Using computer technology, we develop a large philosophical text from many nodes which are linked together with different relationships. Readers can navigate among the many concepts, guided by their individual understanding and interests. Disparate material can be integrated together while being written and read by collaborators from all around the world.

We hold that PCP is more than an interesting experiment, and that there is an acute need for an approach similar to PCP. The ongoing explosion and fragmentation of knowledge demands a renewed effort at integration. This has always been the dream of the systems theorists; all they lacked was the appropriate technology to attack the complexity of the task. The remainder of this text sketches some of the electronic tools we are presently using to support the project.

The proposed philosophy, constituting the content of the project, and the conceived distributed hypermedia/e-mail implementation, constituting the form of the project, are in fact closely connected. Both are constructive, in the sense that they start from *primitive* systems from a variety of origins (nodes containing expositions written by diverse participants), which are brought into contact (e-mail conversations , and links to shared files), connected (semantic links), and selectively stabilized, so as to retain those combinations which define a new, more integrated system.

When constructing a cybernetic philosophy the fundamental building blocks that we need are ideas: concepts and systems of concepts. Ideas, similarly to genes, undergo a variation-and-selection type of evolution, characterized by mutations and recombinations of ideas, and by their spreading and selective reproduction or retention. The basic methodology for quickly developing a system as complex as a cybernetic philosophy would consist in supporting, directing and amplifying this natural development with the help of cybernetic technologies and methods.

It will require, first, a large variety of concepts or ideas, provided by a variety of sources: different contributors to the project with different scientific and cultural backgrounds. These people need a fast, flexible communication tool: electronic mail. Second, we need a practical way for storing the thus gathered information, and for making it available all over the world: fileservers. Third, we need a system that allows the representation of different types of combinations or associations of concepts: hypermedia. Fourth, we need selection criteria, for creating combinations of concepts, that are partly internal to the system (e.g. consistency, simplicity ...), partly defined by the requirements of the people that are developing the system (consensus, ...). Finally, we will need procedures for reformulating the system of concepts (knowledge structuring, closure, ...), building further on the newly selected recombinations, with the help of the concepts of emergence, and especially of metasystem transition.

3 The PRNCYB-L Electronic Mailing List

We are using the PRNCYB-L mailing list on the BINGVMB computer system at SUNY-Binghamton in New York. PRNCYB-L is a LISTSERV mailing list combining the functions of a message board and a file storage server.

3.1 Purpose

PRNCYB-L provides an open forum for all participants in the project, allowing interactive discussions about all issues related to PCP. It functions as the main medium for communication about the Project.

At present, over 50 people, representing the 5 continents, subscribe to PRNCYB-L. Topics that have been discussed include: entropy increase and self-organization, causality as covariation, thermodynamics and evolution of mortality, memetics and the evolution of cooperation, formal expression, criteria for reality. A selection of relevant information (e.g. congress announcements, publications; on hypertext, electronic publishing, evolution of the brain, ...) from other electronic forums is regularly cross-posted on PRNCYB-L.

A digest, or summary, of the discussions and node development on PRNCYB-L will be produced, and published in the Newsletter. It is sent to all people on our list of potential PCP contributors, including those who do not have access to electronic mail or who otherwise want only summary information about the project.

The mailing list is not meant for idle chattering or uninformative technicalities. It is also not meant as a general forum for discussion about cybernetics and systems science. Such a forum already exists in the mailing list CYBSYS-L (contact Joslyn for more information). Whereas CYBSYS-L is open to anyone with an interest in cybernetics and systems, PRNCYB-L is restricted to active participants and those who wish to be informed about the specifics of PCP.

3.2 How does it work?

The functioning of the list is very simple, and does not require any technical knowledge. If you are subscribed to PRNCYB-L, you will automatically and immediately receive all messages sent to the list on your e-mail address. In this way the mailing list functions as a *live* Newsletter about the project, keeping you abreast of conceptual developments, as well as practical opportunities, such as workshops or publications.

Once subscribed, if you wish to contribute yourself, you just send an electronic mail message to the list address, and it will be automatically broadcasted to all others who have subscribed. In that way you can mail out e.g. questions, proposals, or reactions.

The third function of PRNCYB-L is the file server. Files containing larger pieces of information (e.g. PCP nodes, publications, bibliographies, logbooks of past discussions) are stored in a central computer. They can be requested by any subscriber by sending a simple e-mail command message to the file server address.

3.3 Contributing to PRNCYB-L

Participants can best contribute to PCP by posting to PRNCYB-L. But for those who cannot use e-mail, we will accept contributions on a diskette file. MS-DOS diskettes (double density only) can be sent to Joslyn's address below; Macintosh, or MS-DOS (3.5", 720 Kb only) diskettes to Heylighen. The formats we can accept are straight ASCII or *text only* (preferred); TeX, LaTeX or Word Perfect (IBM only) [Joslyn]; Word, WordPerfect or other common word processors [Heylighen].

Those people who do not use e-mail as yet are encouraged to inquire about available facilities at their university or research center (these may not exist in Eastern Europe, or certain other regions). Although e-mail does require a (short) learning period, its use is in general quite simple once somebody has explained the conventions to you (these can be different for different computers and networks). It does not require any knowledge of computer science or programming.

If you wish to join PRNCYB-L, please send an e-mail note to the address:

`cjoslyn@bingsuns.cc.binghamton.edu`

containing the following information:

1) Name.
2) E-mail address.
3) Postal address.
4) Phone.
5) Affiliations.
6) How did you hear about PCP?
7) Do you wish to be a full subscriber to PRNCYB-L, or just receive the Digest?
8) Please take at least one page to describe your work and how it might relate to PCP.

You will then be added to the mailing list, and receive initial instructions on how to operate the LISTSERV software.

4 The Principia Cybernetica FTP-server

The Computing Center of the Free University of Brussels (VUB) has put up an anonymous FTP-file server for PCP. FTP allows a much more interactive, universal and user-friendly way of retrieving files than the PRNCYB-L file server. The server is freely available for everybody on the Internet. In a further stage we hope to complement this FTP server by a Gopher server.

To retrieve a PCP file by FTP from a Unix/Internet site, connect to the host by typing:

`ftp is1.vub.ac.be`.

When you are asked for your login, type:

`anonymous`.

Enter your e-mail address as password. Then change directories ('cd' command) by typing:

`cd /pub/projects/Principia_Cybernetica`

To show the available files and directories, type: `ls`.

You will get a list of subdirectories, including the following:

`/Misc.Info`: contains diverse information (reports, bibliography, ...) on tools that may be useful for PCP, such as WWW.

`/News`: contains the newsletters distributed about PCP, and reports on PCP activities.

`/Nodes`: contains preliminary concept definitions developed by the PCP-editors, to be organized as a hypertext, semantic network.

`/Papers_Heylighen`: contains papers on PCP themes by PCP-editor Francis Heylighen.

`/Papers_Joslyn`: contains papers on PCP themes by PCP-editor Cliff Joslyn.

`/Papers_Turchin`: contains papers on PCP themes by PCP-editor Valentin Turchin.

`/Papers_Others`: contains papers on or related to PCP by other contributors.

`/PCP-Web`: contains a mirror of our hypertext-files for World-Wide Web (see next section).

`/PRNCYB-L`: contains material (discussions, list of members) from the PRNCYB-L mailing list.

`/Software`: contains the *HyperVision* application, a simple hypertext viewer and editor for MS-DOS, and browsers for WWW (see further).

`/Texts_General`: contains introductory or overview papers by the editors collectively, and collected contributions of others, including the workbook of the PCP Workshop in Brussels, 1991.

`/WF-issue`: contains draft papers contributed by the editors and others for a special issue of *World Futures: the journal of general evolution* devoted to the theory of Metasystem Transitions, which forms the core of the PCP philosophy.

Most of the files available on this server are in ASCII format, and should be retrieved as text. The '.txt' file suffix denotes pure text files, that can be read as such. The '.tex' suffix denotes ASCII files formatted in LaTeXwhich should ideally be processed by a LaTeXeditor in order to reconstruct formats, formulas and figures, but where the text is mostly readable as such.

Again change to the directory you want and list the available files. You can then retrieve the file you want with 'get' followed by the filename, e.g.:

`get Workbook.txt`.

When you have the file(s) you want, type:

`quit`.

In case of doubt or difficulty, consult your system manager.

Where the above procedures are not available (e.g. from Bitnet or other networks), there are two gateway fileservers:

`ftpmail@decwrl.dec.com`

and

`bitftp@pucc.bitnet`

that will do the transfer for you. To one or the other of them, send the following one line message by e-mail:

`help`

for instructions (which will be similar to the above, but will be in the form of a series of lines in an e-mail message

`ftpmail` or `bitftp`

that will then execute for you).

5 Principia Cybernetica on World-Wide Web

We have recently started up a new PCP server for distributed hypertext, in the World-Wide Web (WWW) format. WWW is an extension to, and integration of, other Internet services, such as telnet, newsgroups, FTP, gopher and WAIS. WWW combines extreme power (it does everything the other systems do and more), with maximal simplicity and ease of use. WWW allows you to fetch files ('documents'), containing hypertext links to other, related files, which may reside in different parts of the world. By selecting one of the links, you automatically fetch the linked files. In that way you can navigate through a world-wide network of interconnected documents, without having to type in any commands. WWW also offers multimedia support on the appropriate platforms: hypertexts may contain color images, sounds and even animations.

WWW software is freely available for all major computer platforms, and only requires an Internet connection. More information about WWW can be found by anonymous FTP to `info.cern.ch`, (directory: `/pub/www/doc` for 'paper copies' of articles on WWW in PostScript and ASCII forms) or to the PCP FTP server (directory: `.../Misc.Info`). An even better introduction can be got by directly logging in to the Web, using telnet to one of the following hosts (in mainframe systems, the command is normally `telnet`

followed by one of the following addresses or IP numbers):

`info.cern.ch` (IP number 128.141.201.74): No password required.

`eies2.njit.edu` (IP number 128.235.1.43): Log in as `www`. A full-screen browser.

`vms.huji.ac.il` (IP number 128.139.4.3): Log in as `www`.

`kufacts.cc.ukans.edu`: Login as `www`.

`ukanaix.cc.ukans.edu`: Full screen browser, requires a VT100 terminal. Log in as `www`.

Free WWW-software ('browsers') can be found by anonymous FTP at the following places:

`ftp.ncsa.uiuc.edu`, in directory `/Mosaic` or

`/Mac/Mosaic`: Mosaic multimedia browser for X-Windows, Mac and Microsoft Windows.

`fatty.law.cornell.edu`, in directory `/pub/LII/cello`: Browser for Microsoft Windows.

`info.cern.ch`, in directory `/pub/www/bin`: Several browsers (Mac, NeXt, Dec...).

Once you are connected to WWW, the PCP Web can be found on the geographical list of all WWW-servers under 'Europe: Belgium', or on the following WWW-address ('URL'):

`http://pespmc1.vub.ac.be/`

In the near future, all material collected by PCP will be made available on the Web in the form of linked nodes. The Web is to function as the main medium for practical and theoretical development of PCP, containing all definitions of concepts and principles, linked together by semantic relationships. Later, the Web will also provide the capacity for people reading nodes to make annotations with comments or criticisms, thus providing a computer support system for truly worldwide collaboration.

5.1 Retrieving WWW-files by e-mail

People who are not directly connected to the Internet, yet can use e-mail (e.g. through Bitnet or CompuServe) can still get WWW-files by sending a message to the address:

`listserv@info.cern.ch`

The message should consist of one or more lines, each containing the command `SEND` followed by the WWW-address (URL) of a desired document. E.g. for the PCP default home page a command line would read:

`SEND http://pespmc1.vub.ac.be/`

General info about WWW can be found at the following addresses:

`http://www.vuw.ac.nz:`
`80/non-local/gnat/www-faq.html`;

`http://info.cern.ch`
`/hypertext/WWW/Summary.html`

`http://pulua.hcc.hawaii.edu`
`/guide/www.guide.html`

`http://info.cern.ch`
`/hypertext/WWW/TheProject.html`

The `SEND` command returns the hypertext document with the given W3 address, formatted to 72 character width (ASCII, text-only), with links numbered. A separate list at the end gives the document-addresses of the linked documents, which can then be requested by a subsequent message. In this way, you can navigate through the Web, albeit only at mail speed. As WWW links to FTP, this mail service can also be used to retrieve FTP-files but it is better to use the previously mentioned gateways for FTP, in order not to overburden the system.

6 PCP Publications

Several texts on the PCP are now available, and more are being planned.

6.1 Workbook

Heylighen F. (ed.) (1991): *Workbook of the 1st Principia Cybernetica Workshop* (Principia Cybernetica, Brussels–New York).

This booklet (70 pages) contains short articles and abstracts presented at the Workshop in Brussels. Presently it provides the most complete overview of PCP related work. It is available on the FTP-server or in printed form from F. Heylighen for free.

6.2 Papers

In addition to the papers in the Workbook, the following papers directly address PCP, or its underlying philosophy. Most of these texts are available on the FTP-file server, where they can be automatically requested. Papers can also be requested from their respective authors. However, because of our limited facilities and the virtually unlimited number of people interested in PCP, we cannot send all papers to everybody. So we would appreciate if you would only ask hard copy reprints for papers that you really need and cannot get in any other way.

Heylighen F. (1991): *Cognitive Levels of Evolution: pre-rational to meta-rational,* in: The Cybernetics of Complex Systems, F. Geyer (ed.), (Intersystems, Salinas, California), pp. 75–92.

Heylighen F. (1992): *Principles of Systems and Cybernetics,* in: Cybernetics and Systems '92, R. Trappl (ed.), (World Science, Singapore), pp. 3–10.

Heylighen F., Joslyn C. & Turchin V. (1991): *A Short Introduction to the Principia Cybernetica Project,* Journal of Ideas 2, #1, pp. 26–29.

Heylighen F. (1993): *Selection Criteria for the Evolution of Knowledge,* in: Proc. 13^{th} Int. Congress on Cybernetics (Association Internat. de Cybernetique, Namur), p. 529.

Joslyn C., Heylighen F. & Turchin V. (1993): *Synopsys of the Principia Cybernetica Project,* in: Proc. 13^{th} Int. Congress on Cybernetics (Association Internationale de Cybernetique, Namur), p. 509.

Joslyn C. (1991): *Tools for the Development of Consensually-Based Philosophical Systems: a feasibility study for the Principia Cybernetica Project* (Principia Cybernetica Technical Report).

Joslyn, C. (1991): *Control Theory and Cybernetic Ontology,* (Principia Cybernetica Technical Report, long version of the paper on p. 24 of the Workbook).

Lichtenstein B. (1991): *A difference that makes a differance: cybernetic inquiry and postmodern philosophy,* in: The Cybernetics of Complex Systems, F. Geyer (ed.), (Intersystems, Salinas, California), pp. 11–20.

Moritz E. (1991): *On the Road to Cybernetic Immortality: A Report on the First Principia Cybernetica Workshop,* Journal of Ideas, 2, # 2/3.

Turchin V. (1990): *Cybernetics and Philosophy,* in: The Cybernetics of Complex Systems, F. Geyer (ed.), (Intersystems, Salinas, California), pp. 61–74.

Turchin V. (1993): *On Cybernetic Epistemology,* Systems Research 10:1, pp. 3–28.

Turchin V. (1993): *The Cybernetic Ontology of Actions,* Kybernetes 22:2, pp. 10–30.

Turchin V. and Joslyn C. (1990): *The Cybernetic Manifesto,* Kybernetes 19:2–3, pp. 63–65.

In addition to those, the following papers, presented at a Symposium on the Principia Cybernetica Project, have been published in the Proceedings of the 13th Int. Congress of Cybernetics (Int. Association of Cybernetics, Namur, 1993).

Introduction (Heylighen F.), p. 507.

Jdanko A.V.: *On Fundamental Problems of the Principia Cybernetica Project*, p.514.

Umerez J., Etxeberria A. & Moreno A.: *Emergence and Functionality,* p. 519.

Glück R.: *The Requirement of Identical Variety,* p. 524.

Elohim J.L.: *Automation: a conscious human tool to rationally accomplish human aims in order to purposefully push ahead human evolution,* p. 534.

Carvallo M.E.: *Some Alternatives to the Representational Mind,* p. 539.

Maddock J. W.: *Modeling Human Relationships via Dialectical Ecology,* p. 544.

Conclusion (Heylighen F.), p.549.

6.3 Books

A first volume, to be completed in 1993, will be an edited collection of papers by invited authors, including the PCP editors, William T. Powers, Elan Moritz, Robert Glück & Andrei Klimov, Jon Umerez & Alvaro Moreno, Charles Francois, Len Troncale and Donald T. Campbell. This volume will appear as a special issue of *World Futures: the Journal of General Evolution,* published by Gordon and Breach, New York. Its theme is the Theory of Metasystem Transitions. A number of these ideas can already be found in a pre-PCP book:

Turchin V. (1977): *The Phenomenon of Science,* Columbia University Press, New York.

A second, more long-term project is to synthesize the different ideas that were developed separately, in the form of a real *Principia Cybernetica* monograph, authored by the PCP editorial board, and similar to the set of linked nodes existing on the PCP-Web. A provisional outline includes the topics below. It is similar to the structure of the hypertext network on our World-Wide Web server.

INTRODUCTION

PCP in context of intellectual history;

PCP in systems and cybernetics.

WHAT ARE CYBERNETICS AND SYSTEMS SCIENCE?

Systems concepts;

Cybernetic principles (including semantic and anticipatory control, and metasystem transitions).

WHAT IS PHILOSOPHY?

Metaphysics;

Epistemology;

Ethics.

EVOLUTION

History of evolution: life, multicellular organisms, movement, irritability, complex reflexes, associating, human intelligence;

Future of evolution: immortality, superbeings, social integration.

THE PRINCIPIA CYBERNETICA PHILOSOPHY

Meta-foundationalism;

PCP metaphysics;

PCP epistemology;

PCP ethics: ultimate human values, continuance of evolution, four types of immortality.

SYSTEM ARCHITECTURE

Syntactic: hypermedia, markup standards;

Semantic: link and node types.

7 Other PCP activities

PCP regularly organizes conferences or meetings. Until now there have been:

1. A Symposium on *Cybernetics and Human Values* at the 8^{th} World Congress of Systems and Cybernetics (New York, June 1990).

2. *The 1^{st} Workshop of the Principia Cybernetica Project* (Free University of Brussels, July 1991).

3. A Symposium on *The Principia Cybernetica Project* at the 13^{th} Int. Congress on Cybernetics (Namur, August 1992).

4. A Symposium on *Cybernetic Principles of Knowledge Development* (in collaboration with Stuart Umpleby) is planned for the 12^{th} European Meeting on Cybernetics and Systems Research (Vienna, April 1994).

The meetings allow researchers potentially interested in contributing the Project to meet in a relaxed atmosphere. The emphasis is on discussion, rather than on formal presentation. Contributors are encouraged to read some of the available texts on the PCP in order to get acquainted with the main issues.

PCP also publishes a *Principia Cybernetica Newsletter,* which is freely sent by postal or electronic mail to all people who ask to be on our mailing list. There have been two issues to date (0 and 1). The Newsletter appears irregularly, and summarizes the main developments (meetings, publications, theoretical developments, practical issues). It is edited by Francis Heylighen.

8 Collaborators Needed

We are still looking for people to work with us in a variety of capacities, including contributors, reviewers, readers, and general source-people.

We would also appreciate help with the administration: sending out mail, editing and printing newsletters and documents, connecting different communication channels (e.g. translating printed or faxed text to electronic texts). If you would dispose of secretarial or technical facilities, or have the time to help, please contact us. We are in particular looking for people with experience in hypermedia and computer-supported collaborative work environments, who might help us in choosing or developing the right tools. If you feel a strong resonance with Principia Cybernetica and the views we are expressing, we would also be very interested in talking about involvement at deeper levels.

If you wish to contribute in any way, please contact one of the editors below. We would appreciate that in your note you would give a short overview of your current interests and how they relate to Principia Cybernetica. More specific proposals about how you might contribute would be helpful.

9 Editorial Board

The Principia Cybernetica project is managed by a Board of Editors. The Board is responsible for the collection and development of the material, and for the implementation of the computer system. All inquiries or proposals about PCP should be directed to one of the editors below:

Francis Heylighen, PO, Free University of Brussels, Pleinlaan 2, B-1050 Brussels, Belgium.

Fax: +32-2-641 24 89.

E-mail: fheyligh@vnet3.vub.ac.be.

Cliff Joslyn, Systems Science, SUNY Binghamton, 327 Spring St. # 2, Portland ME 04102, USA.

Phone/Fax: 207/774-0029

(Fax after notice by phone).

E-mail: cjoslyn@bingsuns.cc.binghamton.edu or joslyn@kong.gsfc.nasa.gov.

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E-mail: turcc@cunyvm.bitnet.

TO THE INTERNAL REPRESENTATION DEBATE

On Internal Representation (F. Heylighen)

Paul Pangaro made the following comment on internal representation (CYBSYS-L electronic mailing list):

Much of Maturana and Varela's work (and by association, recent writings by Winograd, Flores) (most of which is supported by previous work by von Foerster) is about the differences of approach of modelling from the perspective of internal representation *versus not. I know of nothing that prevents a system without* internal representation *of the environment from being a priori* not intelligent, *and rather like the implications that arise from not being dependent on such a thing to create intelligence. (My term for the relationship between organism and environment where this is the case is* through looping; *the mapping made by the organism is not* external to internal *but rather* through; *looping is required for recursion and stabilization.*

As much as I hate to once again open the debate on representation, I would like to attract people's attention to Conant and Ashby's famous result that *every good regulator of a system must be a model of that system.* They have proven that for the most general definition of control (including feedback as well as feedforward), control of a system requires that there must be a homomorphism (one-to-one or many-to-one mapping) of the events in that system to the actions used to control it.

As the most general meaning of model or representation is just that of a homomorphic mapping, the only possible conclusion is that any agent, who has any form of control over its environment, must in some way have a representation of that environment. The debate remains open over whether that representation is *internal* or not.

Pangaro's view of a mapping *through* rather than *into* would be compatible with Conant and Ashby's result, as they only require a mapping from environmental events to actions performed by the agent, not necessarily to cognitive structures inside the agent. But it seems difficult to imagine how such a mapping could be implemented in a stable way without some form of stable, intermediate structures (neural pathways, or whatever) connecting the agent's sensors to its effectors. And why wouldn't we want to call such internal connections a *representation*, as they map specific classes of perceived events onto specific patterns of activation in the cognitive system?

Of course, if *representation* is understood in the most restricted sense as a mapping of static entities (objects in the environment) to static symbols (cognitive elements) then the Conant and Ashby result does not in any way entail a representation. The only correspondence required is one between processes (events and actions), not entities. What Brooks, Maturana, Varela and others seem to have discovered is that you can have control without such *static* representations. However, they seem a little bit too eager in their fight with the old symbolic or representationalist school of AI, and tend to *throw away the child with the bath-water*, rejecting any use of the concept of representation even though their own models do require representation in the *dynamic* sense.

REFERENCE:

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ADDRESS:

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On Informing between Entities (A.P. Železnikar)

Informing between entities α (environment) and β (observer) can also be understood as a problem of β's *internal representation* of α. In informational language, the phenomenon of transition, marked by $\alpha \models \beta$, has to be informationally interpreted. An entity (das Seiende) is an informationally arising phenomenon for which the so-called homomorphic mapping (ono-to-one or many-to-

one, even in the most free manner) is in no way a sufficient interpretation. The question is: *How is the image ι_β of environment α made (informed, constructed, phenomenalized) by the environment observer β?*

Let us *present* (interpret) the process (entity, transition, operand) $\alpha \models \beta$ through several formal situations. The observing of α by β should be without any (informational or physical) impact on α. This is an idealistic (reductionistic) situation being quite convenient for our informational investigation. So, let

$$\begin{pmatrix} \alpha \models \beta; \\ \alpha \not\subset \beta \end{pmatrix} \Longrightarrow (\iota_\beta(\alpha) \subset \beta)$$

In this expression, $\iota_\beta(\alpha)$ marks an informational function (ι_β), a formula system, which depends on (considers) α, and this function is being in (operator $\subset$) β. Operator $\subset$ denotes the so-called Informational Being-in (in-volvement) of something in something.

Through function $\iota_\beta(\alpha)$, entity α becomes involved in entity β, however, as an entity belonging to β. The question is what is reflected in $\iota_\beta(\alpha)$ in concern to α, since this reflection belongs to observer β observing environment α. Thus, $\alpha \not\subset \beta$ (in fact, $\beta \not\models \alpha$) in the upper formula seems not to be completely reliable supposition! But on the other side, if β does not impact α, this supposition is righteous.

Informational Being-in (inclusiveness, includedness) of operands (entities) ξ and η, as an autonomous informational entity, can be defined (axiomatized) recursively, for instance, as

$$(\xi \subset \eta) \rightleftharpoons_{\text{Def}} \begin{pmatrix} \eta \models \xi; \\ \xi \models \eta; \\ ((\eta \models \xi) \subset \eta) \models_{\text{possible}}; \\ ((\xi \models \eta) \subset \eta) \models_{\text{possible}}; \\ ((\eta \models \xi) \subset \xi) \models_{\text{possible}}; \\ ((\xi \models \eta) \subset \xi) \models_{\text{possible}} \end{pmatrix}$$

The particularized informational operator $\models_{\text{possible}}$ says that the formula informs to be possible, according to the choice of an agent (e.g., entity marked by η, ξ, both of them, or an exterior setter of the formula system).

Informational Being-in concerning an informational entity (informational operand) is a conditio sine qua non for the so-called circular serialism, which can—under certain metaphysical conditions—outgrow to an intelligent entity. Let us demonstrate this phenomenon informationally to our initial example.

According to the second formula, if we choose the first and the second possibility, that is, $(\beta \models \iota_\beta(\alpha)) \subset \beta$ and $(\iota_\beta(\alpha) \models \beta) \subset \beta$, two serial loops come into existence, that is,

$$\begin{gathered} (\beta \models \iota_\beta(\alpha)) \models \beta; \\ \beta \models (\iota_\beta(\alpha) \models \beta) \end{gathered}$$

as a consequence of

$$(\iota_\beta(\alpha) \subset \beta) \rightleftharpoons \begin{pmatrix} \beta \models \iota_\beta(\alpha); \\ \iota_\beta(\alpha) \models \beta; \\ (\beta \models \iota_\beta(\alpha)) \subset \beta; \\ (\iota_\beta(\alpha) \models \beta) \subset \beta \end{pmatrix}$$

In the first circular formula, β is the observer of the transition $\beta \models \iota_\beta(\alpha)$, while in the second circular formula the role of the observer of β belongs to the transition $\iota_\beta(\alpha) \models \beta$. Similarly, one can say that in the first formula, transition $\beta \models \iota_\beta(\alpha)$ is the informer of β, while in the second circular formula β is the main informer. In both cases, formulas are circular in respect to β.

Informational entities (agents) are dynamic phenomena (also systems, processes, events, actions) and their *intelligence* depends on their own and environmental spontaneity and circularity (e.g., on the spontaneous *through*—operator $\models$ between entities α and β—instead of the spontaneous *into* together with informational looping). If function $\iota_\beta(\alpha)$ does include a kind of understanding as a property within β, marked by understanding $\mathcal{U}_\beta(\alpha)$, then this understanding cyclically produces the so-called meaning $\mu_{\mathcal{U}_\beta}(\alpha)$, concerning environment (or, more precisely, an environmental phenomenon) α. We say that $\iota_\beta(\alpha)$ within itself is decomposed (identified, interpreted) as an understanding entity in regard to α by

$$(\mu_{\mathcal{U}_\beta}(\alpha) \subset \mathcal{U}_\beta(\alpha)) \subset \iota_\beta(\alpha)$$

The whole story of spontaneous cyclicity concerning the observer β and the observed environmental entity α now proceeds into the complex circular scheme, expressed by the formula

$$\alpha \models \Big(((\mu_{\mathcal{U}_\beta}(\alpha) \subset \mathcal{U}_\beta(\alpha)) \subset \iota_\beta(\alpha)) \subset \beta\Big) \qquad (1)$$

The reader can imagine how this formula could be decomposed according to the definition of $\xi \subset \eta$ recursively and, for instance, pragmatically interpreted (additionally decomposed) into further informational detail. The difference between the object α and its *internal representations* in the form of spontaneous-cyclically connected entities $\iota_\beta(\alpha)$, $\mathcal{U}_\beta(\alpha)$, and $\mu_{\mathcal{U}_\beta}(\alpha)$ depends on the internal cyclic informing of β or, precisely, on its *metaphysicalism.*

That what informs within β as a consequence of α's impact, and informationally concerns α, is certainly not the environmental entity α itself, but β's imagery (physical, informational phenomenality) of α in the form of, for example, $\iota_\beta(\alpha)$, $\mathcal{U}_\beta(\alpha)$, and $\mu_{\mathcal{U}_\beta}(\alpha)$ within an intelligently structured entity β.

One of metaphysical shells of the observing entity β consists of three standard parts called informing, counterinforming, and (informational) embedding. We have the following basic metaphysical (circular) serial scheme concerning an informational entity in general, and entity β in particular:

$$\overbrace{\Big(\Big(\big(\big(\beta \models \underbrace{\mathcal{I}_\beta) \models \mathcal{C}_\beta}_{\text{informing}}\big) \models \underbrace{\gamma_\beta\big) \models \mathcal{E}_\beta}_{\text{counterinforming}}\big) \models \underbrace{\varepsilon_\beta\Big) \models \beta}_{\text{embedding}}}^{\text{metaphysical informing of } \beta \text{ as a whole}}$$

Other schemes can be constructed by all possible permutations of parenthesis pairs. In short, in this scheme, $\mathcal{I}_\beta$, $\mathcal{C}_\beta$, γ_β, $\mathcal{E}_\beta$, and ε_β are called informing, counterinforming, counterinformation, embedding, and embedding information, respectively.

This particular scheme of serial metaphysical shell is a consequence of a scenario of informational includedness being informed by an exterior entity α so, according to Formula (1),

$$\alpha \models \Big(\Big(\big(\big(\varepsilon_\beta(\alpha) \subset \mathcal{E}_\beta(\alpha)\big) \subset \gamma_\beta(\alpha)\big) \subset \mathcal{C}_\beta(\alpha)\Big) \subset \mathcal{I}_\beta(\alpha)\Big) \subset \beta\Big)$$

This metaphysical shell of β recognizing α can now be filled intelligently, that is, the informing part of β by specific components characterizing β in a narrower sense; the counterinforming part by understanding and by it produced concept of meaning; and the embedding part by further interpretation of meaning in informational connection with β. This formal philosophy (theory) reveals the problem of internal representation in a complex, dynamic, and never definite way. Informational formulas are arising informational entities by themselves and in this manner essentially deviate from abstract mathematical notions (theories, systems, formulas).

The other approach of internal representation of α by entity β is metaphysically parallel and much more straightforward in respect to the traditional understanding of informational includedness. It proceeds from the basic parallel metaphysical shell of entity β which is

$$\text{entity } \beta \begin{cases} \left.\begin{matrix} \beta \subset \varepsilon_\beta; \\ \varepsilon_\beta \subset \mathcal{E}_\beta; \end{matrix}\right\} \beta\text{'s embedding} \\ \left.\begin{matrix} \mathcal{E}_\beta \subset \gamma_\beta; \\ \gamma_\beta \subset \mathcal{C}_\beta \end{matrix}\right\} \beta\text{'s counterinforming} \\ \left.\begin{matrix} \mathcal{C}_\beta \subset \mathcal{I}_\beta; \\ \mathcal{I}_\beta \subset \beta \end{matrix}\right\} \beta\text{'s informing} \end{cases}$$

Decomposing this shell in respect to operator $\models$, the internal representation of entity α by (within) entity β is a consequence of the metaphysical system

$$\alpha \models \begin{pmatrix} \beta \models \varepsilon_\beta(\alpha); & \beta \models \mathcal{I}_\beta(\alpha); \\ \varepsilon_\beta(\alpha) \models \mathcal{E}_\beta(\alpha); & \mathcal{I}_\beta(\alpha) \models \mathcal{C}_\beta(\alpha); \\ \mathcal{E}_\beta(\alpha) \models \gamma_\beta(\alpha); & \mathcal{C}_\beta(\alpha) \models \gamma_\beta(\alpha); \\ \gamma_\beta(\alpha) \models \mathcal{C}_\beta(\alpha); & \gamma_\beta(\alpha) \models \mathcal{E}_\beta(\alpha); \\ \mathcal{C}_\beta(\alpha) \models \mathcal{I}_\beta(\alpha); & \mathcal{E}_\beta(\alpha) \models \varepsilon_\beta(\alpha); \\ \mathcal{I}_\beta(\alpha) \models \beta; & \varepsilon_\beta(\alpha) \models \beta \end{pmatrix}$$

The reader can now imagine how the results of the internal representation of α within β can arise when the metaphysical shell is being filled by some concrete components of reasoning (e.g., understanding, meaning, interpretation, etc.)

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Global Modernization Plan of Telecommunications Infrastructure and Services in Slovenia (MTIS)

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Outline of the global modernization plan of information technology and telecommunications infrastructure in Slovenia (MTIS) is presented in the paper. The preparation of this plan has been based on reference documents, supplied by major actors, represented in the Commission for Policy and Strategy of further Telecommunications Development. Its objective is to activate the modernization process, that consists of principles, methodologies and development scenarios of all topics covered by MTIS. The operational plan with detailed analysis of investments, timing and responsibilities will be object of the further document, the Master Plan, which will be produced immediately after the approval of MTIS. MTIS has been primarily focused on the existing status of telecommunications infrastructure and services and on the innovation aspects of the unification of the telecommunications and information technology based on the convergency of needs of different sectors. With the respect to the development three fundamental scenarios, namely natural, accelerated and survival scenario have been presented. The accelerated scenario has been proposed to be brought into effect as soon as possible.

1 Introduction

Telecommunications are, and will increasingly be of critical importance to economic, social and cultural development. They are the nervous system of modern society.

Efficient telecommunication network infrastructures and telecommunications services will be essential for the development, growth and flexibility of Slovenian economy as a whole. Telecommunications have a great influence not only on services in general, such as financial services, transport and tourism, but also on trade in goods and on European industrial co-operation.

Demand for data communications capacity is growing among the big European industrial companies at a rate of 40% a year. Companies are using these services to find out more rapidly what their customers need; others are using communications to reduce stocks of parts, to manage cash, to monitor remote installations, etc. In many trading and financial service activities, the availability of the most advanced communications is already essential to the commercial success. The same is becoming increasingly true for industry. This applies not only to large companies, which need to move large amounts of data among installations, but also to smaller firms for which ad-

vanced communications open up markets, which were previously out of range. Finally, the ability to send and receive information is important for individuals if they are to play their full part in society.

The overriding aim of the MTIS is the development of a strong telecommunications infrastructure enabling Slovenian user a broad variety of world-wide, good quality and low cost telecommunications services.

Outline of the global modernization plan of telecommunications infrastructure and services in Slovenia is given in the paper. At first, the objectives of the development policy are discussed and the basic development principles are introduced. The unification process of telecommunications and information technologies are based on the convergency of needs. After that, the state of Slovenian telecommunications infrastructure and information services is described. Individual needs of the sectors are identified as a basis for further consolidation and development towards digital transparent network, controlled by sophisticated computer software. The guidelines for future development of the unified modernization plan are given with the emphasis on the fibre optics technology and the parallel construction of more main networks must be avoided. After the approval of MTIS by the governmental institutions, the Master plan comprising detailed analysis and specifications, must be composed. With respect to the development policy, various possible scenarios for future development of telecommunications are evaluated. Finally, a single multi-functional transmission network predominantly based on optical fibre cables is proposed in the implementation plan. The result of the harmonious development would be technologically unified, self healing and transparent network, enabling wide variety of new services.

2 Objectives and Principles

The **development of Republic of Slovenia**, keeping in mind both economic and social needs, represents a strategic governmental objective. In order to facilitate the achievement of this objective, telecommunications play an essential role through the interconnection and the services based on information that they can provide.

Telecommunications give a firm backbone for functioning and development of the whole society. Required achievement of higher level of general development includes request for higher level of telecommunications development. Therefore, accelerated investment into telecommunications infrastructure is necessary.

In consistency with the Slovenian governmental program ([2]) **MTIS (Global Modernization plan of Telecommunications Infrastructure and Services in Slovenia)** has been developed with the scope to unify the existing information technology together with the telecommunications facilities and services. Based on the present situation of telecommunications and information technology of Slovenia some various scenarios for the future development has been painted.

MTIS is based on a qualified collection of data and information, provided by the major service providers and major users of telecommunications network.

MTIS provides policy and strategy for further telecommunications infrastructure development, including information and telecommunications services in Slovenia in the form of technological neutral study.

During the last decade the evolution of telecommunications was focused on the digitalization, i.e. the transformation and transmission of information (voice, data and video) in a form suitable to be processed by computers. The introduction of computers into telephone exchanges enables:

- introduction of new information and telecommunications services, where data transmission, processing and storing capacities are of basic importance;
- control, management and monitoring of the telecommunications network using special purpose software.

Reduction of the threshold between the public and private networks gradually leads into integration of telecommunications and information technology. The integration will be consolidated in 3 to 5 years.

A full usage of digitalization may be achieved whenever the integration of applications is envisaged as key principle; the *Integrated Services*

Digital Network (ISDN) is the first step of this phase. The digitalization of telecommunications may in addition allow the national telecommunications providers to diversify services and offer Value Added Network Services (VANS).

The scope of services rendered in Slovenia by service providers is to satisfy the needs of users. The Slovenian market has today individual users (citizens), companies (private and public) and Administration. The satisfaction of users requirements forms the basis for the existence of services.

All users expect from service providers a range of services with the right quality, with the appropriate prices and all of them want to be treated as clients and not as passive actors. Companies are the primary users of the services because they represent the tool to develop their activities. Administrations are although users, but with the aim of intercommunication and monitoring of their activities. The evolution of the spirit of Administration from supervisory phase to productivity phase and effectiveness of activities is envisaged.

The different actors involved in the process of modernization of all the national sectors have the natural attitude to support with the highest priority the budgets of their own sector. In parallel, the permanent economic constraints of any administration make frequently difficult the acceptance of the sectorial budgets. Finally, the wish from the social and economic viewpoint to speed up the modernization process may produce an unbalanced effect of acceleration for some sectors. All the previous elements, together with the human behaviour, may generate the wish to develop anyhow the modernization in some sector without the appropriate coordination. The effect of this behaviour is a plan that is much more near the survival scenario than the natural one; definitively it is far from the accelerated one. This must not happen.

3 Development Policy

The rationales of the **development policy** of telecommunications infrastructure and services are the following:

- better telecommunications and information services in the near future based on better telecommunications infrastructure;
- definition of telecommunications infrastructure that enables the set of services comparable to those in western Europe and the entrance into the open European market of information;
- recognition of Slovenia as a state with appropriate modernization plans and investment possibilities providing the approach and later the integration into European community;
- establishment of basic prerequisites needed for setting up those state functions that are preconditions for approach to EC (e.g. creation of the system for EDI (Electronic Data Interchange) for daily added value taxation);
- prevention of development of parallel networks for different monopolistic organizations (Electricity, Railways);
- cutting down the expenses for state and local administrations;
- quicker turn-over of the capital;
- exceeding of lagging;
- coordinated regional development;
- diminishing of daily migrations, etc.

Appropriate **legislative** in the field of telecommunications and information services and infrastructure should be adopted in 1993. It should be done similar to the EC legislative and should consist of at least following items:

- the law of telecommunications and services:
  - disjunction of post and telecommunications;
  - deregulation and liberalization of services and equipment market;
  - de-monopolization and licensing;
  - prevention of capital flow from the monopolistic services into the marketed services (i.e. prevention of unfair competition);
  - restoration of ownership of telecommunications organizations, infrastructure, ...
- the law of radio-diffusion (frequency space),

- the law of cable distribution systems,
- appropriate technical regulations and standards and
- appropriate tariff system and price policy.

The process of unification of telecommunications with the information technology together with the process of modernisation should be a part of the **permanent program of informatization**. This program could be developed with the modern technologies themselves and spread at the appropriate levels.

The offer of services made available to citizens as the result of MTIS and related further activities has to be licensed to the concessionaires due to liberalisation of services, as already applied in the majority of European countries.

The validity and the applicability of MTIS and related further activities strongly depend on the services that will be selected and offered to citizens; the decision to offer payable or free of charge services is also related to the social impact that will have to be decided by the government.

The offer of terminal equipment must remain as liberalized as it is now.

Satellite communications should be treated in the same way as in the EC.

The government should monitor and control the concessionaires, especially in the case of their monopolistic status.

Concessionaires should provide only the licensed services. This will lead into reorganisation of PTT, RTV to provide adequate economical effects. Actual synergistic results are expected to emerge as a consequence.

Corresponding social effects can be expected as well, for accelerated increase in telecommunications and information services and infrastructure open new, highly specialized, productive and non-polluting jobs. Export of services, at present represented by analog voice telecommunications traffic, should overgrow into the integrated services, forming preferred export activity.

4 Development strategy

The **unification** of **telecommunications infrastructure** and **information services** makes available a very wide range of services owing to the continuous decrease of costs of information technology and in parallel to the harmonisation of tariffs.

The **strategy** requested to activate the process of modernisation and unification may be based on the following items:

1. identification of priorities in sectors,
2. identification of priorities in technology, telecommunications and informatics necessary to fulfil the priorities selected for sectors,
3. economic analysis and cost evaluation of implementation of priorities,
4. accurate analysis and decision between: consolidation of what already exists or development of new services.
5. provision of appropriate standards and technical regulations, and their accommodation with the European community standards.

Every single network existing in Slovenia (PTT, Electricity, Railways, RTV) has its own historical genesis; a synergy between the above networks must be analyzed and implemented whenever necessary. The objective of the above synergy is to produce a scale production effect made obligatory by the size of Slovenia.

The strategic pattern defined at governmental level must take into consideration not only the social effect of the modernisation plan but also the economical and industrial. The decision to implement the modernisation plan in under-developed areas in Slovenia compared with the developed areas represents a key issue to calculate the risks of implementing/not-implementing.

MTIS represents the **initial phase** of the **Master Plan** of modernisation and is a subset of it. The production of the Master Plan is the technical result of the accomplishment and approval of MTIS. General methodology of Master Plan should be aligned with the MTIS methodology; however a strict monitoring activity is requested for Master Plan.

Priority investments in telecommunications field should not be conditioned by the Master Plan approval, but they have to run in parallel, for possible procedural barriers must not prevent extremely necessary development.

5 State of the art

5.1 General

The development policy and provision of telecommunications services has completely changed with deregulation, liberalisation and the technical and technological advance in the world. The reorganisation of the PTT service in Slovenia has not yet taken place, but it is included in the development plan and is envisaged to proceed.

Given a range of functional networks built in parallel with public networks, the telecommunications activity is rather uneconomically organised. Involved is not a rival supply of public telecommunications services on a basic infrastructure, as is the case in Europe, but an excessive building of infrastructure networks of the same type.

During 1992 the economical and political situation in Slovenia have brought the attention of the government to the stabilization of the country and to the approval of a new and complete set of laws and regulations. The actors playing the function of the "service providers" have not been included within the priorities of the activities yet; in parallel, the process of privatization is not yet operational and the link between service providers (actors) and industry is still undefined.

The large national companies operating in the service areas are passing through reorganization and the unbalanced situation between the activities at former Yugoslav level combined with export activities catch a relevant attention, but still without specific implementation plans.

Not whole domestic industry has adequate level of competitiveness to compete with the European industry; this requires the development of the research of strategic partners to facilitate the introduction of new technologies in telecommunications and information technology areas.

The Slovenian know-how in telecommunications and information technology areas is potentially adequate to fulfil the objectives; nevertheless, the qualification of the resources to enter into the "phase of services" or "post-industrial society" is not yet in process; in addition, the spirit of commercially oriented service providers is not yet spread out at all levels and in all governmental bodies.

The national standards for telecommunications infrastructure elements, their management and maintenance are mostly inadequate or non existing; however, the greater part of investors into telecommunications infrastructures follows the CCITT recommendations and ISO standards upon their own consideration.

5.2 Telecommunications services

At present there are six different telecommunications services available in Slovenia for the domestic market.

1. **Telephony:** There are 500.000 telephone subscribers and only 2.500 public telephones, what is insufficient.

2. **Data transmission:** (SIPAX.25): X.25 is available for 380 subscribers; this density is about ten times less than European average. More than 2.500 users use PTT leased lines.

3. **Mobile communications:** An analogue mobile system has 5.000 subscribers and is in the intensive phase of development.

4. **Telex:** Telex is on decline because it is replaced by the modern technique of fax; 2.000 connections are available.

5. **Fax:** 6.400 faxes are officially installed: The availability of fax service through personal computers and workstations is not yet spread enough.

6. **Cable TV:** There is a rough estimation of 120.000 subscribers that are already linked to cable TV distribution networks. There's no exact figures about cable distribution system providers. For the majority of them there are no official manager, investor and/or owner. The regulation of cable distribution systems by appropriate legislation is still missing.

5.3 Information services

Only widespread information services are mentioned:

1. **Automatic call distribution:** The PTT has organised and maintains several automatic call distribution services providing online information on telephone subscribers' numbers and various prerecorded information (weather and traffic reports, etc.).
2. **Electronic mail:** First installations are in the process in academic research institutions based on the X.400 and X.500 standards (ARNES). Very few medium and large companies adopt the service Smail.400 provided by PTT, mostly for mail transmission at international level (100 users).
3. **Videotex (VINET):** An experimental VINET system connects more than 440 subscribers for the following services: information services, non-standard electronic mail, electronic phone directory and telex.
4. **Paging:** Teleray enabled cordless massage transfer to 4.000 users. Paging system operates in accordance with RDS system, known as CENELEC EN 50 067 standard adopted by majority of West European countries and by Slovenia as well.
5. **Governmental information services:** databases contain information on governmental, parliamentary and jurisdictional documents, official gazette, etc.
6. **Information services of Slovene Chamber of Economy:** commercial and economic data basis are available off-line; on-line interactive access to the data will be available in near future.
7. **Shared cataloguing information system:** contains information about recent articles, periodicals, books and research reports available in Slovenian libraries.
8. **TV and radio programs:** can be treated as information services for great number of subscribers.
9. At the end let us mention also non formal organised DECNET network, superimposed on leased telephone lines and SIPAX.25, which interconnects more than 300 computers located in various institutions in Slovenia. There are several other networks used by Slovene Chamber of Economy, governmental and local administration etc., which will not be further discussed.

5.4 Service providers

At present the **Slovenian PTT** is the major provider of the telecommunications services. PTT is (currently, i.e. in July 1993 still) organised into nine companies, each with individual autonomy. About 8.000 employees are in PTT with rough 2.500 people in telecommunications sector; during 1991 telecommunications activity have contributed for around 2/3 of PTT revenues.

The level of penetration of telephone lines in Slovenia is about 25 lines per 100 inhabitants, to be compared with the EC average which is about 35 lines per 100 inhabitants. The quality of public services is critical particularly because of the underdeveloped public infrastructure. The process of digitalization of the public infrastructure in Slovenia is activated following the recommendations of the European Council of 1986, but not completed. The optical communication backbone is under development and the reorganisation of telecommunications and of PTT organisations together with restructuring of the network has not started yet. All the above points reduce the competitiveness of the Slovenian services mostly in the international arena.

RTV and governmental administration are actually service providers for many years. In the last few years telecommunications services are also increasingly offered by various registered providers such as Teleray for paging and Mobitel for mobile telephony.

5.5 Public and dedicated telecommunications networks

Public telephone network: The telephone network in Slovenia is built hierarchical. Combined international and transit exchange is located in Ljubljana and connected to 12 main exchanges and other lower level exchanges. 53% of exchanges are in crossbar technology and 29% of them are analog SPC exchanges. Four years ago

the first digital exchanges ESWD, SI and AXE were installed in Slovenia what represents now 18% of total capacity. Nine out of twelve main exchanges are digitalized.

The transmission network has been built-up mainly on metal cables and the analogue cable and radio-relay systems. Recently we have commenced introducing optical cables and digital radio-relay systems.

Railways telecommunications network: Railways have their own functional network with the 55% of nodes older than 25 years, not expandable to additional users and under serious technical degradation. Telegraphic network has the technology of 1964 with limited equipment and different cabling. The global status of Slovenian railway telecommunications is today inadequate to play the role of the bridge between Italy, Hungary, Austria and Croatia.

The electric power supply telecommunications network: Concerning the electric power network, the voltage distribution is dominated by 110 kV lines with 1160 km, followed by 380 kV lines with 400 km and finally by 220 kV lines with 300 km. The communication lines are bound to electro-energetic wires.

The underground cables are in the last few years intensively replaced by optical cables implemented in aired ground wires, which are cheaper and more reliable in normal conditions.

RTV broadcasting and cable-TV networks: RTV broadcasting system is devoted to 500.000 radio and TV and to 150.000 only radio subscribers. About 20% of TV subscribers are connected to cable distribution network, provided by several domestic and international companies.

5.6 Sectorial plans

Only the review of major actors will be stated, for which the development plans exist. The plans are not coordinated. Their consolidation is one of Master Plan tasks, which must be done as soon as possible.

The introduction of digital, transparent network controlled by sophisticated computers has meant that many of the functions that were previously carried out inside of the network and could be carried out only by the controlling administration, can now be performed outside the network by the increasingly sophisticated terminal equipment.

PTT services: PTT is the most important service provider in Slovenia. We plan an annual 6% growth in the number of main telephone subscriber lines by the year 2000 so that the average of 40 telephone lines per 100 inhabitants will be reached. The use of packet switching X.25 public data network will be more intensive in the first half of the decade then in the second half, so that the number of 5.000 users is planned to be reached at the end of the century. The number of fax subscribers at that time would be 25.000.

The range of services that can be offered by the switching systems is increasing. Telecommunications exchanges can now perform many additional functions in addition to switching simple calls. The exchange can also store, process and retrieve information.

The analog mobile telephony grows rapidly and will reach in 1995 15.000 analog terminals. They will be gradually substituted by digital GSM terminals. We envisage to have 70.000 GSM telephone terminals by the year 2000.

The number of videotex users is envisaged to reach 4.000 and the number of ISDN users 16.000 by the end of the century.

In the medium and long term, modern telecommunications networks will be more and more independent of the service being carried. They will be able to carry a broad range of services independently of network operation.

In the terminal equipment market the trends towards integration of functions will show up strongly in near future.

PTT network: We plan to introduce by 1995 the digital transmission systems to connect the international exchange in Ljubljana with all main exchanges in Slovenia. One branch of the main transmission lines is envisaged to go from Austria via Kranj, Ljubljana and Novo mesto to Croatia and the other one from Austria or Hungary to Italy.

We expect that the demand of multimedia telecommunications will increase rapidly, and that the telephone network will be gradually replaced by N-ISDN and later on by B-ISDN network. The development would require high-speed and high-capacity transmission and switch-

ing. Slovenia has started to introduce the common channel signalling system SS7, a precondition for the building of the intelligent network, enabling centralised network management and fast and easy implementation of new data, broad-band and multi-media services. Such networks are already operating in the world. We plan to include the 155 Mbit/s MAN network in the second half of the decade and the B-ISDN network after the year 2000. At the same time we plan to introduce value added services.

In the middle of the decade we shall be included in satellite communications on international lines. Satellite based systems are capable of providing transmission capacity with very wide geographic coverage and the ability to provide point to point, point to multi-point or multi-point to multi-point services.

A standardised concept of the universal computer controlled Telecommunications Management Network (TMN) has been widely adopted in the world. This system enables an efficient administration, control and management of network resources, traffic and services, as well as the maintenance and further building of networks. In the middle of the decade we plan to link the control centres in Slovenia and to built TMN modules for the control of the entire Slovenian telecommunications network.

Slovene Railways: The objective of the modernisation plan of Slovenian Railways is the construction of digital network infrastructure based on ISDN concept. Telecommunications system must assure safe and reliable railway traffic. Such a system consists of digital transmission system, switching system, radio communication system, station telecommunication system, information system and control and operating system for the Slovene Railways telecommunications infrastructure.

Telecommunication system will necessarily be based on standards and regulations enabling specific tasks of the railways and the conjunction with the public network. The international traffic and data exchange with the railway directions in neighbouring countries must be assured.

Electric power distribution system: The appropriate telecommunication system must meet the requirements for following functions:

- data processing for the system control,
- high capacity inter computer and computer to terminal connections in individual power distribution companies and in the distribution centre,
- integration of dedicated telephone network with public telephone network,
- transmission of long-distance security data,
- remote maintenance and abnormal state control,
- transmission of meteorological and seismic data.

RTV dedicated network: The modernisation plan of RTV telecommunication network comprises:

- fixed communications which serve to distribute RTV programmes from production centres to central transmitters at transmission stations,
- interconnection among RTV programme production centres.
- international bilateral programme communications with Austria, Italy, Croatia and Hungary,
- Fixed communications via satellite for exchanging RTV programmes with the European Broadcasting Union,
- mobile program communications for RTV programmes and their transmission,
- communications for supervision of transmission and converter functional networks as well as computer data transmission (telesignalling, telemeasurement, etc.). Regarding Cable-TV network evolution, the growing potential for two way use brings Cable TV networks into the mainstream of telecommunications policy considerations.

Academic and research Community: It is composed of:

- more than 3.700 researchers in 50 autonomous institutes and in more than 150 research and development departments in the companies,
- more than 1.700 lecturers and 37.000 students on 2 Slovenian Universities. With regard to the innovative spirit of the academic sector, which is traditionally higher then in the other sectors, the prevailing need is data communications, comprising electronic mail, electronic conference system, shared cataloguing system and scientific, technological information system, multimedia communications, computer added learning, etc.

Banking, payments, taxes, custom duties and insurance: For those activities the existing network can be used for performing and development of their own services. The services can now be performed outside the network by the appropriate infrastructure and terminal equipment. Taxes, banking and payments require immediate set up of Electronic Data Interchange (EDI). Tax and custom duties must be processed with high priority needed for immediate control of goods and financial flows. In the European Community the above mentioned functions are subjected already to the EDI.

Tourism: Tourism activities together with airtraffic and travel agencies can be connected to the existing networks or to the international networks, such as Amadeus. The similar analysis can be carried out for specific needs in health service or in any domain requiring intensive and fast access to data basis.

Governmental administration: It has considerable amount of specific telecommunications and information needs.

The Ministry of Environment Protection and Regulation established The Geographic information centre which need high capacity (2 to 34 Mbit/s) links among the regional nodes in the Geographic information system.

The Ministry of Defence and the Ministry of Interior: The design of telecommunication infrastructure for both actors must consider the synergy of their needs. The management and the control aspects can be combined with technical, logistic, personal and economics aspects. The security aspect can be covered by joint information system based on the modern telecommunications tools and alternative interconnections. High level of data protection requires the supervision over:

- access to the workstations, terminals and personal computers,
- access to the data and data bases,
- access to the lines,
- access to the transmission equipment.

Specific needs may be also identified by the following actors: Republic Administration of Telecommunications, Republic Institute of Informatics, Institute for Standardisation and Measurements, Agency for Quality, Republic Institute of Statistics, etc.

Local administration: there is an intensive need to establish the data connections among regional centres and the corespondent governmental bodies enabling management and processing of taxes, land-register, health care, pension-fund, company-register, etc.

Industry: The greater part of the companies has or will have the possibility of data interchange through the existing networks. One of the best possibilities is offered by EDI services. The small and the medium size companies will be able to use the information services provided by the Chamber of Economy of Slovenia on the local or governmental level.

Education and health care: An intensive growth in computer equipment can be noticed in the elementary and medium school level. The introduction of voluntary health care system could be a motive for evolution of global and universal information system in Slovenia.

5.7 European status

Telecommunications are already, and will increasingly be of the critical importance to economic, social and cultural development in Europe.

Since 1984 the Commission of the European Communities (CEC) has presented a **Program of Development of Telecommunications** for Member States. Five major axes have been decided:

1. development of future telecommunications networks: integrated services digital network, mobile communications and broadband communications;
2. creation of a European market for terminals and equipment;
3. activation of research and development program covering the technologies of broadband communication;
4. development of services and network in all the Member States;
5. definition of the European strategy for the international markets.

Since 1984 a considerable progress has been achieved through decisions, standards, directives, regulations and recommendations.

The international technical standardisation represents the key for the success of the modernisation of infrastructures and services. Through standardisation, the continuity and coherence of future markets is guaranteed; in addition the same equipment may be used in different environments, the investments are protected and scale production with low costs may be envisaged. Finally new services and products may be developed based on the modern concepts of Open System Interconnection. Particularly the usage of the open standards for the public tenders of the telecommunications institutions brings the access to public markets to all European actors.

Some examples are relevant to understand the spirit of the European strategy:

- CADDIA: cooperation program for the automation of the exchange of data and documentation related to input/output activities together with the management and financial control of agricultural markets;
- AIM (Advanced Informatics in Medicine in Europe): program with the objective to integrate information technology and social/medical care.
- EUREKA-8/COSINE, project, which introduced the first OSI based telecommunication infrastructure in Europe and has together with high definition television project and with the project for road infrastructure development, the highest priority among the CEC projects.

The optical fibre transmission has been introduced 15 years ago. Up to the year 1988 the cost per meter was reduced for the factor of 10 times. In general, the total cost of transmission is reduced 50% every ten years. Thanks to the optical fibre technology, new services such as video conference, video telephone and broadband TV may be introduced. The CEC has set up the program RACE to facilitate the penetration of the related new services.

In 1987 the Commission of the European Communities has approved **The Green Paper on the Development of the Common Market for Telecommunications Services and Equipment** ([1]). The purpose of the Green Paper is to start a common thinking process to be a basis for discussions aimed at the achievement of maximum synergy between current developments in the Member States. It includes new areas of convergency of telecommunications and informatics such as Environment, together with the liberalisation of supplying of equipment to national administrations with the scope to eliminate monopolistic activities. Current 1992 in view of the single market, additional decisions have been taken by the Commission related to the rationale of the European tariffs and to the compatibility and interpretability of telecommunications services at European level.

Every European Community member state has decided for its domestic market the most appropriate strategy of the organisation and restructuring of telecommunications administrations in view of unification of telecommunications services. A relevant position is achieved by France as leader in the Videotex/Videotel services, by Great Britain in the area of privatisation of some services, by Italy in the area of the private TV and by Germany with separation of national service providers into highly specialised bodies.

6 Guidelines for future development of the unified modernization plan

6.1 Services

The range of services available in Europe today, as a reference for this analysis, is identified as a third generation of services. The **first generation** services was based on analog telecommunications infrastructure with limited capabilities of network control and management. The characteristic of **second generation** services is digital voice and data transmission and improved network control relative to the first generation. The **third generation** services may be developed only with a new generation of telecommunications infrastructure based on B-ISDN. Examples of the third generation services are:

- videophone,
- videoconference,
- high speed coloured telefax,
- high speed data transmission,
- CAD/CAM transmission,
- remote printing and publishing,
- high performance networking,
- multimedia communications,
- HDTV,
- EDI - electronic data interchange,
- upper-layer OSI services.

The process of service implementation requests not only a methodology that is common to all the services but also an analysis, specific for each service. The analysis is the prerequisite to evaluate the cost effectiveness ratios that will enable the decision makers to decide whether or not to activate the services. The ratios are based on the social impact, the cost per call, the subscriber fees versus the free of charge options, the number of users in the short and medium term, the investments and the maintenance. Other ratios may complement this analysis; however, the performance ratio of the service - that is price of the service/quality of the service - will be essential for the success of the service itself.

6.2 The process of unification

The traditional approach to **unification** among different worlds is based on the fact that there is a need of synergy, so the process must be activated; worlds that are separated then became unified. The world of **telecommunications** and the world of **information technology** are fitting to this scheme. However, the individual technological evolution of each of the two worlds has brought them to be unified spontaneously, through the automatic convergency of their technologies.

As a matter of fact, the right way of developing the process of unification must not be done through the convergency of technologies, being this automatic, but through the definition and harmonization of user needs. A need is considered the collection of economical, social and political objectives of a sector, and the major sectors have been already explored in the previous paragraphs. Practically, the appropriate way of activating the unification process must be based on the convergency of needs of the different sectors. Based on the full knowledge of the needs of every sector, the consolidation of the needs can be achieved through information technology and telecommunications as integrators: telecommunications and information technology do not need to be integrated, because they already are in this status, but they produce both the integration and the unification of the needs of the sectors.

With this in mind, the individual needs of the sectors are identified, their consolidation is achieved, the way how to solve the need is designed through unified solutions based automatically on information services and telecommunications infrastructure.

One example may be useful: in order to modernize and develop Tourism sector, it is necessary to identify the general need of the sector. Let us assume that the needs are:

- access to booking centres by all Slovenian travel agencies;
- access to hotel, bank, congress centres and restaurant catalogues with tariff by all or part of main tourist centres inside Slovenia and along the borders;

– access to major international booking systems and databases.

With the above needs defined by the sector, request for the solution (including computer system, i.e. hardware and software as well as their telecommunication lines) will be delegated to an appropriate team that will submit to the sector some proposals of solutions with related budget, costs and timing of implementation.

Again, if switched lines or private lines or optical fibres or digital networks will be used, this should not be the priority for the sector, but will be fundamental for the providers of the technologies. The **priority** of the sector is **to provide services** and not technologies.

The quality of services provided by the tourism will then be jointly monitored by the sector and by the providers of technologies keeping in mind the optimisation of the usage of existing networks, workstations and installed systems.

Four *classes* of public networks are in use in Slovenia today:

1. PTT public network, enabling transmission of voice (and data) through telephone lines and modems,

2. leased line network, enabling transmission through PTT owned lines,

3. SIPAX special X.25 public network; it is intended exclusively for data transfer among computer systems,

4. functional network of Slovenian RTV covering the needs of radio broadcasting.

The above four networks must be analyzed in term of their adequacy to the data/information transfer, requested by different sectors; only under this condition any lack of adequacy will produce an improvement of technology. The objective is to satisfy the needs of sectors and to provide services with classes of networks having the appropriate functionalities.

As far as information services are concerned, every sector should define also their needs of processing, data access, data transfer, inter-computer communications and data protection. All these needs will have a solution once more based on a joint unified telecommunications and information technology platform.

The unification process must be considered as a **principle** and not as a consequence; unification is an objective. The effect of a good unification is the right service with the good quality and appropriate price/performance. In conclusion, telecommunications and information technology facilitate the objective to provide services; they both go across the sectors, they generate a link and they play the role of catalyst of the harmonious process of unification.

The integration role of telecommunications and in information services is not sufficient to speed up the development. The Government has to confer the concessions and determine the competent holders of public telecommunications infrastructure and information services development.

6.3 Main Telecommunications Network

The technological bases for further development of telecommunications networks converge according to the world-wide digital network standardization process. Plesiochronous Digital Hierarchy (PDH) will be progressively replaced by Synchronous Digital Hierarchy (SDH), a suitable basis for high speed networks. Some world-wide pilots have successfully been tested already.

Asynchronous Transfer Mode (ATM) could be introduced as leased line network and, via switched network, finally becomes a platform for narrow-band (N-ISDN) and broad-band (B-ISDN) integrated services digital network (voice, data and video services).

There has been a significant advance in the area of fibre optical communications in the past few years. There are several advantages to built the network based on fibre optic technology:

– installation of optical fibre system is cheaper than installation of coaxial cable system at length higher than 100 meters;

– powerful radio links highly pollute environment with electro-magnetic radiation;

– intensive introduction of low-power wireless local subscriber loops is in progress, substituting the expensive cooper cables;

- high speed optical fibre technology is more appropriate than radio and satellite technology due to lower signal latency;
- the fibre optic cable consists of several tiny optical fibres; doubling the number of optical fibres within the same cable increases the total investment only by 10%;
- there's no electro-magnetic interference in fibre optic cables;
- optical fibres enable high bandwidth transmissions over long distances.

Parallel construction of more main networks is uneconomical. Therefore, to design a new telecommunications **backbone** is a high priority task in order to optimize both capacity and routing problems in networks. It is necessary to find out the optimal number of installed fibres and the most suitable topology of the network (multiple interconnected rings give sufficient self-healing properties and provide maximal accessability).

6.4 Master plan

Sectorial development plans, mentioned above, do not consider synergy effects. There has to be a governmental decision to set up the synergical solution, i.e. **Master Plan of Telecommunications**.

After the approval of global modernization plan MTIS by the governmental institutions, the preparation of the Master Plan must be envisaged. Master Plan must be completed as soon as possible. Besides it, the structure of state administration has to be rearranged according to the Master Plan and the appropriate mechanism of independent supervision has to be established.

Master Plan must specify the decision about actual configuration of main telecommunications network, capacity of lines and interconnections to the infrastructure of neighbouring countries to upgrade the transit traffic.

All sectorial plans has to be modified and coordinated according to the finally adopted Master Plan.

6.5 Alternative scenarios of further development

The basic objective of MTIS is the identification of needs for the introduction of new services through unification of technologies. With respect to the development of the national market, different **scenarios** may be envisaged. Three scenarios are fundamental and give the complete picture of national needs, together with costs and investments.

Natural scenario: The principles of scenario are:

1. development of public telecommunications system as scheduled by national development plan;
2. introduction and testing of new services covered by a budget that must be fixed every year;
3. evolution of informatization on the national level with a growth rate, consistent with the market trends;
4. *spontaneous* informatization of local and central administrations, due to the present lack of a coordinated national plan;
5. *spontaneous* telematization of the territory;
6. tariff of public services and new telematic services defined independently of any specific financial plan to support underdeveloped geographical and sectorial areas.

Accelerated scenario: The principles regulating the scenario are based on hypothesis of development of services and informatics with a rate higher than the market growth rate:

1. financing acceleration of informatization of some priority sectors, mainly related to the economics, administration and social environments;
2. development of specific solutions for niches; examples are the creation of land register computer and telecommunication support within Geographical Information Systems (GIS), control the environment quality, automatization of medical informatization system;

3. accelerated development of public telecommunications with consistent plan of investments;
4. development of class of services and tariff that may accelerate the modernization of the republic;
5. intensive introduction of new services, starting from those using X.25 network;
6. solid program of informatization of local and central public administration;
7. definition of medium/long term plans with the scope to rationalize the national industries in telecommunications and information technology.

Survival scenario: The principles governing this scenario suppose the national network development with the rate under the market growth rate and with a deregulated growth of the other private networks. Within this scenario, the investments available for the development of the sectors are low. Such a scenario corresponds to political decisions of not investing in some sector or disinvesting in other sectors or finally to partially privilege only few strategic sectors.

Even if the survival scenario could be considered as *restrictive* and *limitative*, compared with the first two scenarios, it has however a specific area of existence and influence; the environment of this scenario is identified with private investments in telecommunications and information technology.

For some sectors and for some services private service providers may replace public service providers due to lack of capability and budget of the latter. Survival scenario was used in Slovenia till now, forming the current poor state of the art within telecommunications in Slovenia. For example, due to low tariff rates the public PTT can not successfully establish the system of public telephones, but in the same time private service providers can provide the same service on their own tariff principles.

Each of the above three scenarios must be **qualified** through a feasibility study with estimation of the market need, the technical and technological needs and the niches of interest. Risk areas and the budget must be determined considering the consequences of the introduction of services for the national industry, for the institutions managing the public networks and for the social environment.

7 Methodology

Regulation, executive and supervision must be completely **separated** to provide successful modernization of telecommunications infrastructure and integration into Europe.

Regulatory role is provided by the State administration:

- Parliament should adopt appropriate legislative;
- Office for standardization and metrology should adopt appropriate standards and technical regulations;
- the Government should provide necessary organizational structure of State administration;
- Ministry of transport and communications should carry out all the operational tasks, given by the Government or by the Parliament.

Executive role is left to the (competitive) service providers.

We propose that the independent external **supervision** over the modernization of telecommunications would be provided by Commission for Development of Telecommunications (Komisija za razvoj telekomunikacij - KRT). KRT would be nominated by the Government or by the Parliament and its main task would be to monitor the preparation and execution of the Master Plan in order to promote and accelerate the development and to assure the synergic effects.

Modernization process may be divided into two phases: the beginning phase and the main phase of modernization.

The **beginning phase** is currently in progress. On the 22^{nd} session on October 1992, The Slovenian Government passed the Proposal of activities in the field of telecommunications develop-

ment in Slovenia. After that, the Minister of science and technology nominated in accordance with the Minister of transport and communications the Commission for Policy and Strategy of further Telecommunications Development in Slovenia which elaborated the global modernization plan MTIS, presented in this paper. MTIS was also meant to give the argumentation for investments in telecommunications infrastructure on the occasion of adopting the budget for 1993.

The **main phase** would start after the approval of the modernization plan MTIS. At that stage the Master Plan would be prepared and introduced to the Government. After adoption, the Master plan would be executed. The above mentioned Commission for Development of Telecommunications KRT would be responsible for preparation and execution of the Master Plan. KRT would report on the modernization progress to the Minister of transport and communications and to the Government.

To accelerate the elaboration of the Master Plan the Ministry of Transport and Communications would establish a professional **Working Team for Master Plan**. The Working Team should perform the following tasks:

- identification of needs upon new services in the future development of telecommunications services,
- collection of relevant data and coordination of sectorial plans;
- elaboration of elements for Master Plan;
- preparation of legislation proposals;
- preparation of KRT sessions,
- execution of KRT decisions,
- implementation of priority investment plans, etc.

The Working Team should consist of at least four members (telecommunications profile, information technology profile, economic profile and research&development profile).

The commissions for the development of the telecommunications and information services exist in all countries of European Community for more than 10 years or even more than 20 years (France, United Kingdom).

8 Implementation plan

Short, medium and long term plans will be defined by Master Plan according to the governmental decision, which of the three possible scenarios (survival, natural or accelerated) should be selected for telecommunications development.

Authorized investor for priority plan of investments in 1993 should be PTT up to the liberalization of services and granting of concessions.

Priority investments for 1993 should not be deferred and dependent on the adoption of the Master Plan. However, it is necessary to start with the investments into telecommunications infrastructure *immediately*. This action would produce the following effects:

- accelerate the *development of Slovenia*,
- enable Slovenia to play the role of a *transit country* at the crossing between East and West and between North and South,
- provide the appropriate *technological basis* to achieve the objectives of MTIS.

Development role: It is well known that there is a proportion between the GNP level and the status of telecommunications development. The increased investment into telecommunications would then:

1. accelerate development in general,
2. relax the economic crisis, particularly in the telecommunication industry,
3. enable Slovene telecommunications industry to build at home the references needed for further potential export activities.

Transit role of Slovenia at the crossing between East and West, North and South: The layout of Slovenian 13 main switching centres and 4 international transit points (to Italy, Hungary, Austria and Croatia) enable the design of telecommunication network in the shape of cross. The telecommunication cross must be completed until the end of 1994; otherwise, Slovenia will

become an isolated telecommunications island in this part of Europe.

In the case that the number or the structure of the administrative centres in Slovenia will be changed, the connections to the new nodes will have to be taken into account.

Technological basis: The main national telecommunications network is rather underdeveloped compared to the regional and local public networks. The reasons are:

1. local self-imposed contributions that enable local and regional public network development;

2. regionally-organized PTT companies (till July 1993) that supported investments into local and regional networks and neglected investment into the backbone of national telecommunications network.

The underdevelopment of the main telecommunications links cause a high percentage of unsuccessful call set-ups. An accelerated digitalization and modernization of the communication backbone is the only reasonable way to be followed.

In addition, the investment into the **fibre optic** connections among the network nodes is economically reasonable, for it justifies and saves investment because of:

1. technological limitations of metallic cables;

2. high quality and reliable transmission through optical fibres, mostly in the case of realization of main connections in the shape of the rings in separated routes; this dictates high level of coordination and synergy consideration among PTT, Railways, Electricity and RTV in designing the network;

3. long life cycle of fibre optic cables;

4. the technological perspective for further development guarantees the leading role of fibre optic cables within the next 15 years and enables the enlargement of network capacity by replacing only terminal transmission or switching equipment;

5. the technological adequacy for the digitalization of main telecommunications network.

The investment must be made by strictly considering the unification principle and using solution with the best synergic modernization effect (with tight collaboration of PTT, Railways, Electricity and RTV), giving secure services (to satisfy the needs and strict requirements of Defence and Interior ministries).

The **Master Plan** must include as many operational plans as there are selected sectors. The operational plan summarizes the activities, the timing, the cost and the responsible body for every sector and niche, with the record of risks and advantages.

Production of Master Plan should go *step by step*; the Working Team must give higher priority to the largest and the most important sectors.

The **responsibility** of the members of KRT, Working Team and Governmental bodies represents the key parameter to make the Master Plan happen.

It is underlined that the leader of each sector must have the authority to request all the data from the institutions belonging to the sector of his competence, plans and elements that will enable him to produce the sectorial plan. A periodical reporting is produced by the leaders of every sector and submitted to the Working Team for the consolidation process.

9 Conclusion

The most efficient way to modernize the telecommunications infrastructure in Slovenia is achieved by integration of financial, technological and professional potentials. The final results of harmonious development would be technologically unified and transparent telecommunications network, better service quality, greater variety of services and lower cost of telecommunications services.

At the first stage of the modernization process the most important task is to establish a basic integration mechanisms which would lead to the preparation of the Master Plan, acceptable for service providers and for major actors in the field of telecommunications. The Master Plan must consider the most modern telecommunications techniques recognized in the world and enable high transmission capacities suitable for present and future wideband information or telecommu-

nications services. The main telecommunication transmission equipment must be based on fibre optics, which offer new possibilities for telecommunications network design.

Limited funds and short time available for development require a rational use of resources. Therefore, the forming of an inter-sectorial Commission for Development of Telecommunications KRT was proposed. KRT would provide the coordination of sectorial plans and preparation and realization of the Master Plan.

In MTIS we propose to the Slovenian Government to accept the accelerated scenario of the development of telecommunication infrastructure and services.

The process of evaluating and approving of the global modernization plan MTIS slowed down after general elections in December 1992, when new Government has been formed.

In the case that the modernization plan will be rejected or postponed, the telecommunications development will become unbalanced and without appropriate coordination. The negative effects will progressively be stronger and therefore more difficult to overcome. Besides that, the main international traffic flows will avoid Slovenia and will form an isolated island in the middle of Europe. Finally, the lack of information links will have negative effect on social and economic development, particularly on the national economy.

10 Appendix

Members of the Commission for Policy and Strategy of further Telecommunications Development:

President of the Commission: dr. Gorazd Kandus, Jožef Stefan Institute.

Commission members (in alphabetic order): mag. Cene Bavec, Ministry of Science and Technology, dr. Jure Beseničar, Ministry of Environment Protection, mr. Tomaž Banovec, Institute of Statistics, mr. Tine Brajnik, Ministry of Defence, mr. Bogo Brvar, Ministry of Internal Affairs, dr. Marko Jagodič, Iskra Tel and University of Ljubljana, mr. Ivica Kranjčevič, SP PTT, mr. Peter Mori, RTV Slovenia, dr. Branislav Popovič, Iskra Telekom, mr. Niko Schlamberger, Institute of (Public Administration) Informatics, mr. Stanko Starec, Slovene Railways, mr. Vladimir Šmit, Electricity, spec. Mitja Vavpotič, SP PTT, dr. Jože Vugrinec, Telecommunications Administration and mr. Miran Zrimec, SDK.

Secretary of the Commission: mag. Iztok Tvrdy, representing Ministry of Science and Technology.

Acknowledgement: The authors thank Mr. V. Rampolla for helpful discussions and dr. P. Tancig, former Minister of Science and Technology, for enabling and supporting the elaboration of the MTIS.

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Report: ACPC'93

October 4 – 6, 1993, Gmunden, Austria

Borut Robič

The Austrian Center for Parallel Computation (ACPC) is a co-operative organization founded to promote research and education in the field of software for parallel computer systems. The areas in which ACPC is active include algorithms, languages, compilers, programming environments, and applications for parallel and high-performance computing systems. The Second International Conference of the ACPC took place in Gmunden, Austria, from October 4 to October 6, 1993. Authors from 17 countries submitted 44 papers, from which 15 were selected and presented at the conference in four sections covering Architecures, Algorithms, Languages, and Programming Evironments.

William G. Hoover (U. of California at Davis/Livermore) talked about the impact of ever-faster ever-cheaper computational power on physics and materials science. With massively-parallel teraflops computers on the near horizon the transition from millions to billions of degrees of freedom is quite near. This development suggests connecting the microscopic models, such as Atomistic Molecular Dynamics, with macroscopic approaches, such as Lagrangian Continuum Mechanics, so as to combine microscopic realism with macroscopic size in dealing with real problems. *Lawrence Snyder* (U. of Washington, Seattle) presented a practical formulation of parallel programming languages based on analogy with sequantial programming languages. The essential components are a machine model, a programming model and a programming language. For the parallel case, the Candidate Type Architecture is used as the machine model, Phase Abstractions are used as the programming model, and the Orca family of languages are used to illustrate language design. The Phase Abstraction/Orca approach presented at the conference is unique among parallel programming models and languages in providing control over process granularity and other essential characteristics of a parallel computation, such as portability and scalability. For example, one can convert a properly written binary tree code into one based on the properties of a mesh simply by providing a different communication topology; no program text need be modified. *Al Geist* (Oak Ridge National Laboratory) described some features of the latest release of Parallel Virtual Machine, a software package that permits a user defined collection of serial, parallel, and vector computers to appear as one large distributed memory computer. He also described future research focuses on making PVM a high-speed, portable message-passing core that can easily be integrated into complex software such as schedulers, performance monitors, debuggers, programming environments, applications etc. *Piyush Mehrotra* (ICASE, Nasa Langley Research Center) provided a short overview of High Performance Fortran (HPF), an international effort to build a set of standard extensions of Fortran 90 for exploiting wide variety of parallel architectures. Then he presented some of HPF's limitations. In particular, HPF provides an excellent support for simple data parallel algorithms, while there are a number of scientific codes for which HPF may not be adequite. Mehrotra explored several extensions which provide support where HPF fails. Other presentations considered Identifying the Available Parallelism Using Static Analysis (*Kalogeropulos*), High-Performance Computing on a Honeycomb Architecture (*Robič, Šilc*), Rational Number Arithmetic by Parallel P-adic Algorithms (*Limongelly, Loidl*), and Generating Parallel Code from Equations in the ObjectMath Programming Environments (*Fritzson, Andersson*), to mention only four of them.

Commercial massively parallel computers were presented in a special section named Industrial Program. Here, some ongoing projects and future plans were uncovered by Siemens/Nixdorf (KSR1 family), Cray Research Inc. (CRAY T3 family), Intel (Paragon), and nCUBE Corp. (nCUBE 2E). For example, the Cray's MPP systems will use DEC Alpha processor. Cray Research Inc. expects that the new RISC microprocessor technologies will enable its T3D MPP to achieve a peak performance of 1 TFLOPS in 1995/96. Further expected technological advances will lead to T3X MPP with the capability to deliver sustained several-TFLOPS performance in 1997/98.

The organization of the conference, which took place at the beatifull lake Traunsee, was excellent. The proceedings are published in *J. Volkert (ed) Parallel Computation, Lecture Notes in Computer Science*, Vol.734, Springer-Verlag, 1993.

Report: AI-ED'93

23rd - 27th August 1993, Edinburgh, Scotland

Pavol Navrat

General and Learning of Programming View

The World Conference on Artificial Intelligence in Education has been a major event in this area worldwide. In fact, this was the first time ever that scientists met at such an occasion organised explicitly as a world conference. In his opening address, Prof. Howe (representing the hosting institutions) welcomed in Scotland more than 270 participants from all continents and many different countries, noticing especially the presence of people from new independent countries in Europe, such as Slovakia or Ukraina. The Conference was sponsored by the Association of the Advancement of Computing in Education, with several other co- sponsors. It was hosted by several Scottish institutions, whose joint effort resulted in a well organised event based on a genuine hospitality and perfect management performed in a friendly atmosphere and in an informal way. If persons were to be named, than definitely Helen Pain and Paul Brna, who served as co-chairs of the local organising committee, and Stellan Ohlsson, who chaired the programme committee. They are also editors of the Conference proceedings. For presentation at the Conference, there were selected 63 full papers and 60 poster session papers together with 6 invited lectures. This can be regarded as a truly representative collection giving an overview of the state of the art including current trends in research. Kurt VanLehn had the honour of presenting a keynote lecture. He is well known in the field especially due to his results in modelling of students in learning. In his talk, he explained his approach to simulation of human learning by a machine learning program. Similarly to the keynote lecture, also the other five invited lectures were devoted to important specific problems. The speakers presented their views based on own research results. Michael Baker concentrated on a role of negotiation and argumentation in learning through dialogue. Diana Laurillard investigated the relation between learning and teaching. Setsuko Otsuki presented an environment for discovery learning which uses some artificial intelligence techniques. Hans Spada discussed the changing role of cognitive modeling for computerised instruction. Finally, Barbara Y. White described an approach to science education based on intermediate abstractions and causal models. The Conference programme included a set of tutorials. One could choose one out of three topics offered in an afternoon session. Chris Dede stressed the difference between the artificial intelligence approach to learning and teaching and the traditional instructional media in the tutorial Introduction to Artificial education. Interactive learning environments: where they've come from and where they're going was the theme of the tutorial presented by Elliot Soloway and Kate Bielaczyc. It was especially exciting to witness Soloway who can be made resposible for quite some pioneering work in the area, to present that and other works in a broader perspective. Michael Zock was a tutor of Natural language generation: the potential of a new discipline for the classroom. Another set of events was that of workshops. There were selected six themes:

- Graphical representations, reasoning and communication
- Music education: an artificial intellligence perspective
- Collaborative problem solving: theoretical frameworks and innovative systems
- Distance education
- Real-world issues in deploying intelligent tutoring systems
- Simulations for learning: design, development, and use.

The choice of themes already gives some picture about the problems considered most relevant for discussions. The papers presented at the Conference were grouped into following sections:

- Architectures
- Authoring tools
- Case-based reasoning
- Dialogue and Explanation
- Exploratory environments
- Formal reasoning
- Learning design skills
- Meta/situational
- Models of learning
- Pedagogical tools
- Pedagogical planning and instructional dialogues
- Problem solving

- Representations and notations
- Student modelling (numeric)
- Student modelling (symbolic)
- Troubleshooting

The field of Artificial intelligence in education is an interdisciplinary one almost by definition. The researchers come not only from disciplines of artificial intelligence and education, but also from cognitive and social psychology, computer science, empirical psychology, software engineering as well. The views from different perspectives can be very illuminating for colleagues in the field. Moreover, the Conference has shown that interdisciplinary collaboration takes place and proves to be fruitful. Endeavours within the field of Artificial intelligence in education are motivated by the need of more efficient methods of teaching and learning. The field attempts to analyse theoretically the processes of learning and of teaching. It develops methods of evaluation of these processes. It also delivers computer based systems which support various phases of learning and teaching. At the Conference, there were presented works aiming to contribute to each of these goals. As can be seen from the above list of sections, the variety of research interests is indeed quite wide, while at the same time it remains well within the general scope. Nevertheless, the participants had to make selection for the obvious technical reason of running several sections in parallel. I concentrated mostly on issues related to learning of programming. Programming is a special domain which attracts researchers. There are several important issues which have been found deserving their attention. Investigation into the contents of the knowledge on programming attempts to identify what knowledge is important to learn. Bowles and Brna motivated use of programming techniques which they find more appropriate than programming plans in learning Prolog programming and presented a set of basic techniques. Voddiraju and Kaminski also studied Prolog programming. They presented a body of metaknowledge, i.e. rules describing when to use which rule from a knowledge base on Prolog programming. Rozinajova and Navrat presented a body of knowledge on selection of proper data type which is independent from a programming language. It is quite clear, however, that with the question of contents (that is the respective knowledge) here is related a question of form (how is it represented). The widely accepted notion of programming plans has received a criticism mainly from psychologists. Davies and Castell question the belief that simply accumulating a greater repertoire of plan knowledge would be sufficient to develop the expertise. Their experiments suggest an important role of design skills. The process of learning to program is an interesting domain to conduct studies from the educational point of view. Bielaczyc focused on the role of individual in collaborative explanation and metacognitive strategies in learning and problem solving. Another view on the learning of programming concentrates on methods and tools to support the process. Several tools or environments were presented which support at least certain portion of the programming process. Gegg-Harrison reported on automated program debugging. Vanneste and de Decker approached to program analysis using reverse engineering. Mobus, Thole and Schroder focused on help design within their iconic programming environment. It is clear that by far not all interesting papers can be mentioned here. Besides, the Conference was not only the place to present papers, but provided also a very creative environment for interesting discussions and new contacts.

Call for Papers

IEA/AIE-94
The Seventh International Conference on Industrial & Engineering Applications of Artificial Intelligence & Expert Systems

May 31 - June 3, 1994, The Hyatt Regency on Town Lake, Austin, Texas 78704, USA

General Chair:
Moonis Ali, Southwest Texas State University
Program Chair:
Frank Anger, University of West Florida
Program Co-Chair:
Bernard Widrow, Stanford University
Sponsored by:
The International Society of Applied Intelligence
Organized in Cooperation with:
ACM/SIGART, American Association for Artificial Intelligence, Institution of Electrical Engineers, IEEE Computer Society, INNS/SIG, Canadian Society for Computational Studies of Intelligence, Institute of Measurement and Control, Japanese Society of Applied Intelligence, Southwest Texas State Univ, European Coordinating Committee for Artificial Intelligence

IEA/AIE-94 continues the tradition of emphasizing applications of artificial intelligence and expert/knowledge-based systems to engineering and industrial problems. Topics of interest include, but are not limited to:

Computer Aided Design/Manufacturing, Dependability & AI/ES, Distributed AI Architectures, Expert & Diagnostic Systems, Intelligent Databases, Intelligent Interfaces, Intelligent Tutoring, Knowledge Acquisition, Knowledge Representation, Machine Learning, Machine Vision, Model-Based & Qualitative Reasoning, Natural Language Processing, Neural Networks, Pattern Recognition, Planning & Scheduling, Practical Applications, Reasoning Under Uncertainty, Robotics, Sensor Fusion, Intelligent Software Development Tools, System Dependability, Temporal and Spatial Reasoning, Verification & Validation.

Authors are invited to submit four copies of papers, written in English, of up to 10 single-spaced pages, presenting the results of original research or innovative practical applications relevant to one or more of the listed areas of interest. Practical experiences with state-of-the-art AI methodologies are also acceptable when they reflect lessons of unique value to the conference attendees. Shorter works, up to 6 pages, to be presented in 10 minutes, may be submitted as short papers representing work in progress or suggesting possible research directions. (Please indicate "short paper" in the submission letter in this case.) Submissions should be received by the Program Chair by November 5, 1993. Notification of the review process will be made by January 22, 1994, and final copies of papers will be due for inclusion in the conference proceedings by February 22, 1994.

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The proceedings will be published and will be available at the conference. Copies of the proceedings of earlier conferences are available - contact:

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Slovenian Artificial Intelligence Society (SLAIS) and AI Activities in Slovenia

Bogdan Filipič

1 History

Research in Artificial Intelligence in Slovenia started in 1972 at the Computer Science Department of the Jožef Stefan Institute, Ljubljana, and later also at the Faculty of Electrical Engineering and Computer Science, University of Ljubljana. The AI laboratories at these two institutions were formally founded in 1979 and 1981, respectively. Both laboratories are lead by Professor Ivan Bratko and closely cooperate.

Initially, research was concerned with heuristic search, including knowledge-based approaches to computer chess. The emphasis then gradually shifted and expanded to the areas of machine learning, knowledge representation, computer-aided multi-attribute decision making, qualitative reasoning and modelling, and combinatorial optimisation. This provided a solid basis for later application projects. In 1982, the development and implementation of AI tools started and soon resulted in practical applications. By now, over 60 application oriented projects were accomplished in a number of domains including: financial, management, project/enterprise assessment, metallurgy, geology, mechanical engineering, civil engineering and medicine. Most of the applications were based on Assistant Professional, an inductive learning system, and DEX, a computer-aided decision making system. These two systems, developed by the Jožef Stefan Institute AI Laboratory, are also commercially available. Several other systems have the status of academic software, including GINESYS, RETIS, LINUS, and m-FOIL. These systems implement various approaches to machine learning: attribute-based learning, regression tree learning and inductive logic programming. They compare favourably with the best comparable systems worldwide.

In addition to the work done at the Jožef Stefan Institute and the Faculty of Electrical Engineering and Computer Science, research in AI was also carried out at some other institutions, including the Institute of Chemistry, Ljubljana, and the Faculty of Technical Sciences, University of Maribor. Prior to the foundation of SLAIS, the AI researchers were associated within YUGAI, the Yugoslav Artificial Intelligence Group.

The following AI related international meetings were organised in Slovenia: ISSEK (International School for the Synthesis of Expert Knowledge) Workshops at Bled in 1984, 1986 and 1992, the conference EWSL-87 (European Working Session on Learning), Bled, 1987, and the COST-13 Workshop on Qualitative Modelling, Ljubljana, 1987. Slovenian researchers also organised a seminar on AI Technology in Ljubljana in 1985, and co-organised the CAS Summer Symposium on AI in Dubrovnik in 1988 and 1990.

2 SLAIS

SLAIS was founded and admitted as a member society to ECCAI (European Coordinating Committee for Artificial Intelligence) in 1992. It currently has 71 members. Most of them are from universities and research institutes, while others come from industrial and commercial organisations. Elected by the General Assembly of the society, the SLAIS board consists of 10 members with a two year term. The chairman of the society is currently Ivan Bratko. The SLAIS secretariat is hosted by the Jožef Stefan Institute.

SLAIS promotes theoretical and applied research as well as the transfer of AI technology to industrial and commercial environments. Besides covering the traditional AI subfields active since the beginning of the research in AI in Slovenia, the society also associates researchers and practitioners working on neural networks, genetic algorithms, natural language processing and computer vision.

The society promotes AI related events, such as, for example, the Inductive Logic Programming Workshop ILP-93 organised at Bled in April 1993. SLAIS is also a co-organiser of the newly founded Slovenian Electrical Engineering and Computer Science Conference with an active AI session. At the Ljubljana AI Laboratories, seminars open for participants from other institutions are held on regular basis where new research results and applications are presented. A local library specialised in AI literature is located at the Jožef Stefan Institute.

Much of the communication related to the SLAIS activities is done through computer network and electronic conferencing facilities. The `Artificial_Intelligence` electronic conference has been active since January 1992. Reports on SLAIS activities will also be published in the Informatica journal.

3 International Activities

Slovenian AI researchers have been participating in EEC funded research projects, including COST-13 (project Machine Learning and Knowledge Acquisi-

tion), ESPRIT II (project ECOLES in Machine Learning) and project ESPRIT III (project Inductive Logic Programming). The Jožef Stefan AI Laboratory is a node in two European Networks of Excellence for Computational Logic and Machine Learning. It is also a funding member of the International School for the Synthesis of Expert Knowledge (ISSEK), joining a group of laboratories from Australia, Austria, Great Britain, Italy, Slovenia and USA conducting research in computer-aided synthesis of new knowledge. International cooperation is also based on academic links and agreements of cooperation with academic institutions from various European countries.

Research results that are best recognised internationally include: innovative application of qualitative modelling, deep knowledge and machine learning techniques in the KARDIO expert system for the diagnosis of heart disorders, and significant contributions to machine learning from noisy data. The KARDIO project is described in the book KARDIO: a Study in Deep and Qualitative Knowledge for Expert Systems (by I. Bratko, I. Mozetič and N. Lavrač, published by the MIT Press in 1989). Professor Bratko is also the author of the widely accepted textbook Prolog Programming for Artificial Intelligence, published by Addison-Wesley (second edition 1990), and translated to German, Italian, French, Japanese, Russian and Slovenian.

In addition, Slovenian researchers have contributed papers to major international AI conferences, including IJCAI and ECAI, and publications in international journals and books. Also, they have been members of editorial boards of international journals and program committees of international conferences, including ECAI, EWSL and ECML.

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ECCAI representatives: Ivan Bratko and Matjaž Gams

Announcement and First Call for Papers

The Fourth International Workshop on Inductive Logic Programming (ILP94)

September 12 – 14, 1994
Bad Honnef/Bonn, Germany

General Information

Originating from the intersection of Machine Learning and Logic Programming, Inductive Logic Programming (ILP) is an important and rapidly developing field that focuses on theory, methods, and applications of learning in relational, first-order logic formalisms. ILP94 is the fourth in a series of international workshops designed to bring together developers and users of ILP in a format that allows a detailed exchange of ideas and discussions. Reflecting the growing maturity of the field, ILP94 for the first time will offer a systems and application exhibit as an opportunity to demonstrate the practical results and capabilities of ILP.

Submission of papers

Reflecting the broadening scope of the field, ILP94 invites papers covering on the three main aspects of ILP, namely inductive data analysis and learning in first-order formalisms, inductive synthesis of non-trivial logic programs from examples, and inductive tools for software engineering. Possible topics include, but are not restricted to:

- complexity of learning in logical formalisms
- relationships between ILP and neighboring areas
- higher-order learning
- predicate invention
- learning of integrity constraints
- theory revision and restructuring
- multiple predicate learning
- learning in relational formalisms
- handling of noise
- declarative bias
- architectures for ILP
- comparative analyses of ILP methods
- application discussions

Ideally, papers should fit into one of the following categories:

Theory. Theory papers prove results about a new or known ILP problem or method, discuss the relationship with neighboring fields, or present a unified analysis of several methods.

Methods. Method papers present details of new algorithms, ideally including theoretical and complexity analysis, and empirical results on important applications. Ideally, a method paper would be accompanied by a system demo.

Applications. Application papers describe one or more real-life ILP applications in detail, justifying the use of ILP techniques, and giving a reproducible presentation of experiments and results. Ideally, an application paper would be accompanied by an application demo.

Please submit *four paper copies* of your paper to the workshop chair

Stefan Wrobel
GMD, I3.KI
Schloß Birlinghoven
53757 Sankt Augustin, Germany.
E-Mail: ilp-94@gmd.de
Fax: +49/2241/14-2889 Tel: +49/2241/14-2670

to be received on or before **May 31, 1994**. There is no fixed page limit on submissions, but length should be reasonable and adequate for the topic. Please use LaTeX if at all possible. Authors will be notified of acceptance or rejection until **July 15, 1994**, and camery-ready copy will be due on **August 9, 1994**.

Program Committee

Francesco Bergadano (Italy)
Ivan Bratko (Slovenia)
Wray Buntine (USA)
William W. Cohen (USA)
Luc de Raedt (Belgium)
Koichi Furukawa (Japan)
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Stan Matwin (Canada)
Stephen Muggleton (UK)
Céline Rouveirol (France)
Claude Sammut (Australia)

Proceedings

To keep submission dates close to the workshop, accepted papers will be published as a GMD technical

report to be distributed at the workshop and officially available to others from GMD afterwards. Publication of an edited book is planned for after the workshop.

Systems and Applications Exhibition

ILP94 offers participants an opportunity to demonstrate their systems and/or applications. Please announce your intention to demo to the conference office until **August 1, 1994**, specifying precisely what type of hardware and software you need.

Location

ILP94 will take place in Bad Honnef, a small resort town close to Bonn in the Rhine valley and adjacent to the Siebengebirge nature park. Participants will be able to take advantage of Bad Honnef's vicinity to medieval castles and of the new wine season that starts at the time of the workshop.

Registration and Conference Office

Please address all correspondence regarding registration to:

Christine Harms
ILP94
c/o GMD
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53757 Sankt Augustin, Germany
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E-Mail ilp-94@gmd.de

If you send (preferably by E-Mail) the following information to Christine Harms, you will be sent a complete registration brochure as soon as it is available:

Last name:
First name:
Institution:
Zip code, city:
Country:
E-Mail:
Fax:
Intend to submit a paper?

Important Dates

Paper submission deadline:	**May 31, 1994**
Notification of acceptance:	**July 15, 1994**
Demo requests:	**August 1, 1994**
Camera-ready copy due:	**August 9, 1994**
Early registration:	**August 9, 1994**

Workshop: **September 12 – 14, 1994**

Call for Papers

Distributed and Parallel Real Time Systems

Special Issue of INFORMATICA

Guest Editors:
Marcin Paprzycki, Janusz Zalewski
University of Texas-Perian Basin

We would like to invite papers for the Special Issue of INFORMATICA, An International Journal of Computing and Informatics published in English by the Slovene Society Informatika and the Josef Stefan Institute in Ljubjana, Slovenia.

The scope of the volume will encompass a variety of issues associated with the recent developments in the area of distributed and parallel real-time computing. Papers related to both hardware and software aspects of cuncurrency will be considered. Their focus should be on the timeliness and responsiveness aspects (bounded response time) of respective solutions. Sample topics may include:

- multiprocessor buses and architectures
- real time aspects of local area networks
- message scheduling in distributed systems
- distributed and parallel operating systems
- task allocation and load balancing in real time
- interprocess synchronization and communication for real time
- specification and programming languages
- formal methods in specification and design
- debugging of distributed real-time systems
- designing parallel and distributed applications
- distributed real-time databases
- dependability, realiability and safety in distributed real-time systems
- standardization.

Only previously unpublished work will be accepted for the volume. All papers will be refereed.
Due dates:

* February 15, 1994 Submission deadline
* May 1, 1994 Notification of the authors
* June 1, 1994 Camera-ready versions due

All correspondence and requests for sample copies of INFORMATICA should be addressed to the Guest Editors at the following address:

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THE MINISTRY OF SCIENCE AND TECHNOLOGY OF THE REPUBLIC OF SLOVENIA

The Ministry of Science and Technology also includes the Standards and Metrology Institute of the Republic of Slovenia, and the Industrial Property Protection Office of the Republic of Slovenia.

Scientific Research and Development Potential

The statistical data for 1991 showed that there were 230 research and development institutions, organizations or organizational units in Slovenia, of which 73 were independent, 32 were at the universities, and 23 at medical institutions. The remainder were for the most part departments in industry. Altogether, they employed 13,000 people, of whom 5500 were researchers and 4900 expert or technical staff.

In the past 10 years, the number of researchers has almost doubled: the number of Ph.D. graduates increased from 1100 to 1484, while the number of M.Sc.'s rose from 650 to 1121. The 'Young Researchers' (i.e. postgraduate students) programme has greatly helped towards revitalizing research. The average age of researchers has been brought down to 40, with one-fifth of them being younger than 29.

The table below shows the distribution of researchers according to educational level and fields of research:

	Ph.D.	M.Sc.
Natural Sciences	315	217
Engineering-Technology	308	406
Medical Sciences	262	174
Agricultural Sciences	122	69
Social Sciences	278	187
Humanities	199	68
Total	1484	1121

Financing Research and Development

Statistical estimates indicate that US$ 260 million (1.7% of GNP) was spent on research and development in Slovenia in 1991. Half of this comes from public expenditure, mainly the state budget. In the last three years, R&D expenditure by business organizations has stagnated, a result of the current economic crisis. This crisis has led to the financial decline and increased insolvency of firms and companies. These cannot be replaced by the growing number of mainly small businesses. The shortfall was addressed by increased public-sector R&D spending: its share of GNP doubled from the mid-seventies to 0.86% in 1993.

Overall, public funds available for Research & Development are distributed in the following proportions: basic research (35%), applied research (20%), R&D infrastructure (facilities) (20%) and education (25%).

Research Planning

The Science and Technology Council of the Republic of Slovenia, considering initiatives and suggestions from researchers, research organizations, professional associations and government organizations, is preparing the draft of a national research program (NRP). This includes priority topics for the national research policy in basic and applied research, education of expert staff and equipping institutions with research facilities. The NRP also defines the mechanisms for accelerating scientific, technological and similar development in Slovenia. The government will harmonize the NRP with its general development policy, and submit it first to the parliamentary Committee for Science, Technology and Development and after that to parliament as a whole. Parliament approves the NRP each year, thus setting the basis for deciding the level of public support for R&D.

The Ministry of Science and Technology provides organizational support for the NRP, but it is mainly a government institution responsible for controlling expenditure of the R&D budget, in compliance with the NRP and the criteria provided by the Law on Research Activities: International quality standards of groups and projects, relevance to social development, economic efficiency and rationality of the project. The Ministry finances research or co-finances development projects through public bidding and partly finances infrastructure research institutions (national institutes), while it directly finances management and top-level science.

The focal points of R&D policy in Slovenia are:
- maintaining the high level and quality of research activities,
- stimulating cooperation between research and industrial institutions,
- (co)financing and tax assistance for companies engaged in technical development and other applied research projects,
- research training and professional development of leading experts,
- close involvement in international research and development projects,
- establishing and operating facilities for the transfer of technology and experience.

In evaluating the programs and projects, and in deciding on financing, the Ministry works closely with expert organizations and Slovene and foreign experts. In doing this, it takes into consideration mainly the opinions of the research leaders and of expert councils consisting of national research coordinators and recognized experts.

The Ministry of Science and Technology of the Republic of Slovenia. Address: Slovenska c. 50, 61000 Ljubljana. Tel. +386 61 131 11 07, Fax +38 61 132 41 40.

JOŽEF STEFAN INSTITUTE

Jožef Stefan (1835-1893) was one of the most prominent physicists of the 19th century. Born to Slovene parents, he obtained his Ph.D. at Vienna University, where he was later Director of the Physics Institute, Vice-President of the Vienna Academy of Sciences and a member of several scientific institutions in Europe. Stefan explored many areas in hydrodynamics, optics, acoustics, electricity, magnetism and the kinetic theory of gases. Among other things, he originated the law that the total radiation from a black body is proportional to the 4th power of its absolute temperature, known as the Stefan-Boltzmann law.

The Jožef Stefan Institute (JSI) is a research organisation for pure and applied research in the natural sciences and technology. Both are closely interconnected in research departments composed of different task teams. Emphasis in basic research is given to the development and education of young scientists, while applied research and development serve for the transfer of advanced knowledge, contributing to the development of the national economy and society in general.

At present the Institute, with a total of about 800 staff, has 500 researchers, about 250 of whom are postgraduates, over 200 of whom have doctorates (Ph.D.), and around 150 of whom have permanent professorships or temporary teaching assignments at the Universities.

In view of its activities and status, the JSI plays the role of a national institute, complementing the role of the universities and bridging the gap between basic science and applications.

Research at the JSI includes the following major fields: physics; chemistry; electronics, informatics and computer sciences; biochemistry; ecology; reactor technology; applied mathematics. Most of the activities are more or less closely connected to information sciences, in particular computer sciences, artificial intelligence, language and speech technologies, computer-aided design, computer architectures, biocybernetics and robotics, computer automation and control, professional electronics, digital communications and networks, and applied mathematics.

The Institute is located in Ljubljana, the capital of the independent state of Slovenia (or S♡nia). The capital today is considered a crossroad between East, West and Mediterranean Europe, offering excellent productive capabilities and solid business opportunities, with strong international connections. Ljubljana is connected to important centers such as Prague, Budapest, Vienna, Zagreb, Milan, Rome, Monaco, Nice, Bern and Munich, all within a radius of 600 km.

In the last year on the site of the Jožef Stefan Institute, the Technology park "Ljubljana" has been proposed as part of the national strategy for technological development to foster synergies between research and industry, to promote joint ventures between university bodies, research institutes and innovative industry, to act as an incubator for high-tech initiatives and to accelerate the development cycle of innovative products.

At the present time, part of the Institute is being reorganized into several high-tech units supported by and connected within the Technology park at the "Jožef Stefan" Institute, established as the beginning of a regional Technology park "Ljubljana". The project is being developed at a particularly historical moment, characterized by the process of state reorganisation, privatisation and private initiative. The national Technology Park will take the form of a shareholding company and will host an independent venture-capital institution.

The promoters and operational entities of the project are the Republic of Slovenia, Ministry of Science and Technology and the Jožef Stefan Institute. The framework of the operation also includes the University of Ljubljana, the National Institute of Chemistry, the Institute for Electronics and Vacuum Technology and the Institute for Materials and Construction Research among others. In addition, the project is supported by the Ministry of Economic Relations and Development, the National Chamber of Economy and the City of Ljubljana.

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Contact person for the Park: Iztok Lesjak, M.Sc.
Public relations: Ines Černe

INFORMATION FOR CONTRIBUTORS

1 Submissions and Refereeing

Please submit three copies of the manuscript with good copies of the figures and photographs to one of the editors from the Editorial Board or to the Contact Person. At least two referees outside the author's country will examine it, and they are invited to make as many remarks as possible directly on the manuscript, from typing errors to global philosophical disagreements. The chosen editor will send the author copies with remarks. If the paper is accepted, the editor will also send copies to the Contact Person. The Executive Board will inform the author that the paper has been accepted, in which case it will be published within one year of receipt of the original figures on separate sheets and the text on an IBM PC DOS floppy disk or by e-mail – both in ASCII and the Informatica LaTeX format. Style (attached) and examples of papers can be obtained by e-mail from the Contact Person.

2 News, letters, opinions

Opinions, news, calls for conferences, calls for papers, etc. should be sent directly to the Contact Person.

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\parindent 1em
\leftmargini 2em \leftmargin\leftmargini
\leftmarginv .5em \leftmarginvi .5em
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\def\labelitemiii{--}
\setcounter{secnumdepth}{3}
\def\maketitle{\twocolumn[%
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  \uppercase{\@title}}\vss\bigskip\bigskip \vbox{
  \hsize=\textwidth \@author}\bigskip\smallskip
  \vbox{\hsize=\textwidth {\bf Keywords:}
    \@keywords}
  \bigskip \hbox{{\bf Edited by:} \@edited}
  \smallskip
  \hbox{{\bf Received:}
    \hbox to 10em{ \@received\hss}
    {\bf Revised:}\hbox to 10em{ \@revised\hss}
    {\bf Accepted:}\hbox to 10em{ \@accepted\hss}}
  \bigskip \vbox{\hsize=\textwidth
    \leftskip=3em \rightskip=3em \sl \@abstract}
  \bigskip\bigskip]\titletrue}
\def\maketitleauthor{\twocolumn[%
  \vbox{\hsize=\textwidth \Large\bf\raggedright
  \@title}\vss \bigskip\bigskip
  \vbox{\hsize=\textwidth \@author}
  \bigskip\bigskip] \gdef\@title{}\titletrue}
\def\makeonlytitle{\twocolumn[%
  \vbox{\hsize=\textwidth \Large\bf\raggedright
  \@title}\vss\bigskip\bigskip]
  \gdef\@title{}\titletrue}
\def\@title{} \def\@author{}
\def\@titleH{} \def\@authorH{}
\def\@keywords{} \def\@edited{} \def\@abstract{}
\def\@received{} \def\@revised{} \def\@accepted{}
\def\authoreven#1{\gdef\@authorH{#1}}
\def\titleodd#1{\gdef\@titleH{\uppercase{#1}}}
\def\keywords#1{\gdef\@keywords{#1}}
\def\edited#1{\gdef\@edited{#1}}
\def\received#1{\gdef\@received{#1}}
\def\revised#1{\gdef\@revised{#1}}
\def\accepted#1{\gdef\@accepted{#1}}
\long\def\abstract#1{\gdef\@abstract{#1}}
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  {2.3ex plus .2ex}{\Large\bf\raggedright}}
\def\subsection{\@startsection{subsection}
  {2}{\z@}{-3.25ex plus -1ex minus -.2ex}
  {1.5ex plus .2ex}{\large\bf\raggedright}}
\def\subsubsection{\@startsection{subsubsection}
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  {1.5ex plus .2ex}{\normalsize\bf\raggedright}}
\def\@evenhead{\hbox to 3em{\bf\thepage\hss}
  {\small\journal\hfil \iftitle\else
  \@authorH \fi}\global\titlefalse}
\def\@oddhead{{\small\iftitle\else \@titleH \fi
  \hfil\journal}\hbox to 3em{\hss\bf\thepage}
  \global\titlefalse}
\def\@evenfoot{\hfil} \def\@oddfoot{\hfil}
\endinput
```

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☐ SCIENTIFIC QUALITY

☐ Originality

☐ Significance

☐ Relevance

☐ Soundness

☐ Presentation

☐ READABILITY

☐ Interesting

☐ Generality

☐ Presentation

☐ Language

☐ FINAL RECOMMENDATION

☐ Highly recommended

☐ Accept without changes

☐ Accept with minor changes

☐ Accept with major changes

☐ Author should prepare a major revision

☐ Reject

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