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FOUNDATIONS OF THE TECHNICAL NANOSYSTEMS OF INFORMATICS OF THE DIRECT PRODUCTS NANOFABRICATION

Summary. The spontaneous processes of the self-replication and self-organization, which in parallel with the multistage synthesis of products (technology of the so-called *gluey matrix*) establish the basis of *Informatic, Molecular Nanotechnology of the Direct Products Nanofabrication*, has been presented. It call attention on fact, that the fast breeding of basic elements and next differentiating and self-organization of them to the desirable products, are a technology appearing in *Biological Systems of Informatics*, and there can be base of construction for the *Technical Nanosystem of Informatics of the Direct Products Nanofabrication*.

Keywords: gluey matrix, informatic nanotechnology of production, nanofabrication, nanoscience, nanostructures, nanosystems of informatics, self-organization, self-replication

PODSTAWY TECHNICZNYCH NANOSYSTEMÓW INFORMATYKI BEZPOŚREDNIEGO WYTWARZANIA PRODUKTÓW

Streszczenie. Przeanalizowane zostały spontaniczne procesy samoreplikacji i samoorganizacji, które, oprócz wielostopniowej syntezy produktów (technologia tzw. lepkiej matrycy), stanowią podstawę *Informatycznej, Molekularnej Nanotechnologii Bezpośredniego Wytwarzania Produktów*. Zwrócono uwagę na fakt, że szybki wzrost liczby elementów podstawowych, a następnie ich różnicowanie i ich samoorganizacja w pożądane produkty jest technologią występującą w *Biologicznych Systemach Informatyki* i mogą być podstawą konstrukcji *Technicznych Nanosystemów Informatyki Bezpośredniego Wytwarzania Produktów*.

Słowa kluczowe: lepka matryca, informatyczne nanotechnologie wytwarzania, nanoprodukcja, nanonauka, nanostruktury, nanosystemy informatyki, samoorganizacja, samoreplikacja

1. Nanosystems of informatics

The two systems of informatics discussed most often at present are:

- technical systems of informatics about the functional structure presented in fig. 1, where the computers are carriers of the information needed for automatic completion of computational processes,
- biological systems of informatics about the structure and function presented in fig. 2, able to the direct realization of the processes of manufacturing materials needed for biological organisms.

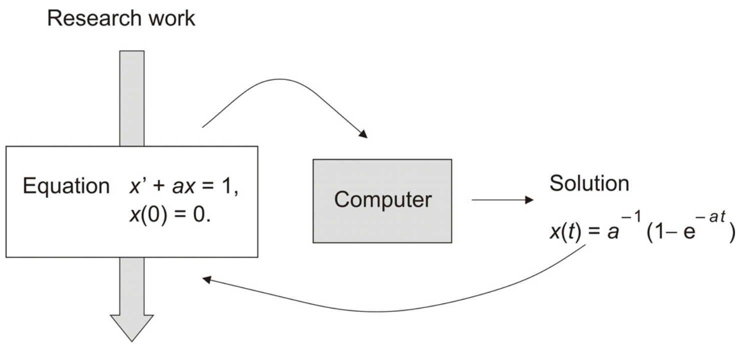

Fig. 1. Computer in the structure of technical system of informatics enabling the realization of the computational processes

Rys. 1. Komputer w strukturze technicznego systemu informatyki realizującego procesy obliczeniowe

In the technical systems of informatics (fig. 1), which the goal is an automatic realization of the computational processes, information about the numbers and mathematical operation which have to be performed on them are fetched from the main memory (PaO) to the central processing unit (CPU), and after execution, the results obtained in CPU, are written to the PaO or the other system register.

In the biological systems of informatics (fig. 2), information about the needed operations on atoms and molecules are extracted from the DNA chain performing a function of secondary or external storage and downloaded into the mixture of freely moving atoms and molecule which can be found in every cell, and next, on the principle of so-called *gluey matrix*, initiates the synthesis processes of the complex molecules e.g. proteins.

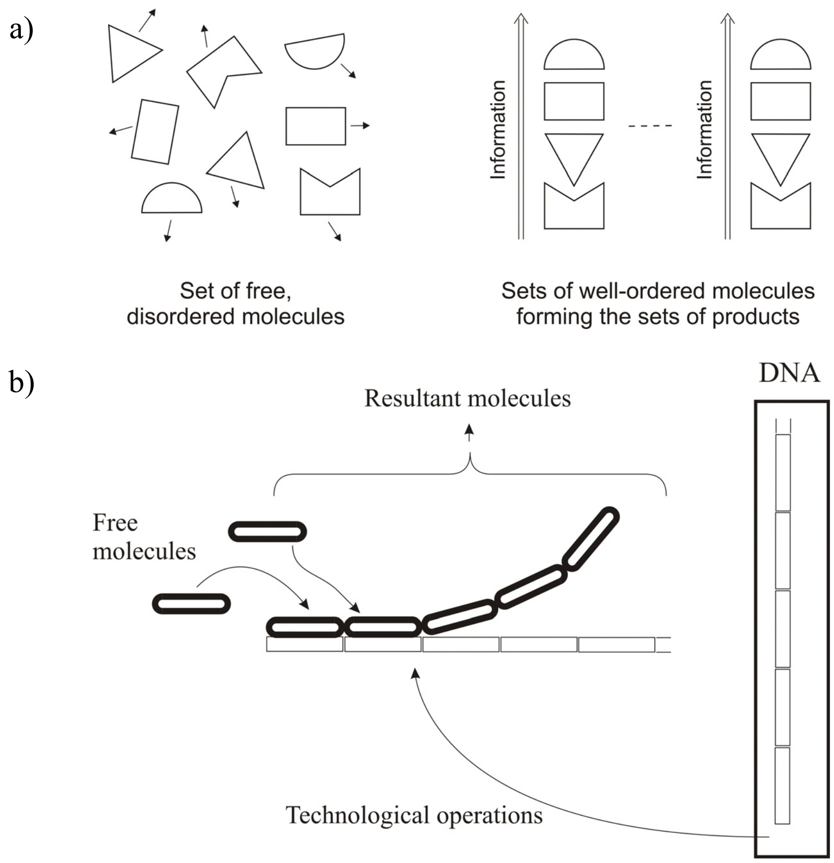

Fig. 2. Biological system of informatics enabling operations with molecules and the direct materials nanofabrication based on them: a) function, b) structure

Rys. 2. Biologiczny system informatyki bezpośredniego molekularnego wytwarzania materiałów: a) funkcja, b) struktura

There is a question, if constructing of such technical systems of informatics, which similarly to the biological system capable of manufacturing wanted products directly, is possible.

In order to answer this question we will carry comparative analysis of these two systems.

In the technical systems of informatics the elementary unit of information is bit with two distinguished states namely „0" and „1". They may represent e.g. states of the certain electronic circuit for example so-called flip-flop.

In the biological systems of informatics the elementary unit of information is *nanobit* which is not represented as a particular state of certain circuit but rather represents the presence of the distinguished molecules in the selected text namely one of four molecules adenine (A), guanine (G), cytosine (C), and thymine (T) in DNA, or adenine, guanine, cytosine, and uracil (U) in an RNA chain.

The area necessary for placing the symbol of one bit in the technical systems of informatics is very large, it is sufficient for placing of the thousands of nanobits in it.

So, the first condition is the miniaturization of the technical systems of informatics.

There is one more problem of the synthesis not a one needed molecule but rather the mass fabrication of needed products. In this case, as an inspiration can serve the solutions from the biological systems of informatics chiefly the processes relevant to the biological embryonic cycle presented in fig. 3 and characterized by the two consecutive phases.

a) b) c)

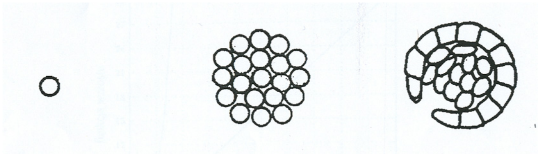

Fig. 3. Illustration of few phases of the embryonic process: a) mother-cell, b) morula stage, c) the beginning of cell differentiation and creation of the future organism
Rys. 3. Ilustracja kilku faz procesu embrionalnego: a) komórka matka, b) stadium moruli, c) początek różnicowania się komórek i tworzenie organów przyszłego organizmu

First phase of the biological embryonic cycle is a self-replication of the mother-cell, descendant cells, and the building of the set of cells called *morula*.

Second phase is differentiation and self-organization of cells of the morula set, and their connecting into ordered sets establishing the ovule of future organism organs.

Self-replication

Let's assume that there is a set of determined elements or environment**.** Let's assume that the energy provided from outside ensures mobility of the elements and as a result, free movement conditions are fulfilled in the environment area. An object means a part of the environment selected in such a way that the exchange of elements between the environment and the object is possible provided that the determined conditions are fulfilled.

Due to the above, the object can gather elements necessary for its development and can develop in accordance with its internal program.

If in a consequence of the object development, the partition of other objects, which are able to continue successive partition, and descendant objects, which are able to continue their independent development processes, takes place; such a phenomenon is called a *self-replication process*.

Self-organization

Let's assume that there is a set of N elements marked with symbols e_1, e_2, ... e_i, ... e_N , all about the same shapes performing a chaotic motions in the determined environment.

An elements of a set N have a such a property, that if two elements e_i and e_k will be found in specific mutual position, they are connecting together and are already permanently staying in such a position. It can be observed that elements of a set N have the appropriateness of the self-organization into strand.

If the set contains N of elements (also in case of described processes of forming the final strand in parallel from a several separately created strand), than the length of longest possible strand amounts d_N . The state, when the all N elements of the set connect together forming the strand about the d_N length, is one of possible steady states finishing this elements' connecting process. That kind of processes, are called a *self-organization processes*.

The basic processes in the direct materials nanofabrication are therefore (regardless of the gluey matrix approach), the processes of self-replication and self-organization, which we will discuss in more details.

The properties (growth, stagnation, and extinction) of the concurrent self-replication and self-organization processes when the concatenation takes place are presented in [8].

2. Self-replication

If through the symbol $S(k)$ we will denote the function describing a growth of number of elements after the time k beginning with the initial condition $S(0) = 1$, two possible situations may arise:

a) the derived elements do not retain the property of self-replication, then:

$$S(k) = 1 + \underbrace{(1 + 1 + ... + 1)}_{k} = 1 + k \tag{1}$$

b) the derived elements retain the property of self-replication, then:

$$\begin{aligned} S(k) &= 2 \cdot S(k-1) = 2 \cdot 2 \cdot S(k-2) = \\ &= 2 \cdot 2 \cdot 2 \cdot S(k-3) = \underbrace{(2 \cdot 2 \cdot 2 \cdot ... \cdot 2)}_{k} \cdot S(0) = 2^k. \end{aligned} \tag{2}$$

The growth defined by Eq. (1) we will call the *linear growth*.

The growth defined by Eq. (2) we will call the *avalanche growth*. The comparison of these two self-replication processes is presented in fig. 4.

3. Self-organization

Let we consider the set N of elements all about shapes so as shown in fig. 5.

For the sake of their shape the elements have the appropriateness of the self-organization into strand so as showed in fig. 6.

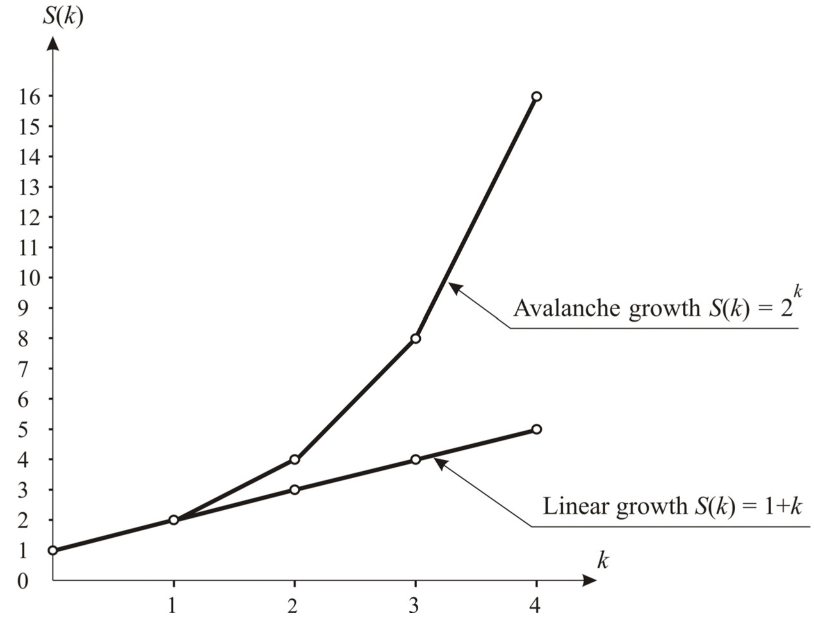

Fig. 4. Growth functions: linear $S(k) = 1 + k$, and avalanche $S(k) = 2^k$
Rys. 4. Przebieg funkcji wzrostu liniowego $S(k) = 1 + k$ i lawinowego $S(k) = 2^k$

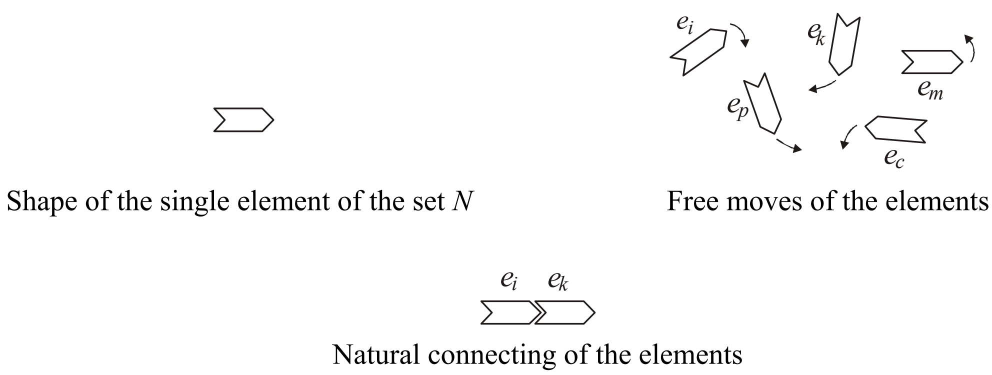

Fig. 5. Exemplary illustration of the shape, free moving and natural connecting of the elements
Rys. 5. Przykładowa ilustracja kształtu, swobodnego ruchu i naturalnego łączenia się elementów

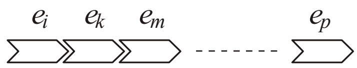

Fig. 6. Self-organizing strand created from the elements of a set N
Rys. 6. Samoorganizująca się nitka utworzona z elementów zbioru N

The cases of strand structure forming the closed circuits of elements or in other words, the closed chains can happen (fig. 7). In our farther considerations on the transient states during the strand creation, we will assume that such case does not appear.

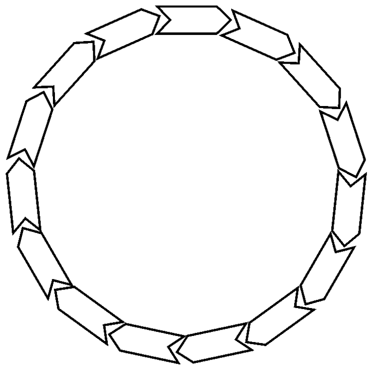

Fig. 7. Case of the strand forming the closed chain
Rys. 7. Przypadek nitki tworzącej obwód zamknięty

Let the step function $\rfloor f(x)$ determines the number of free, unconnected elements of a set N in the x moment.

We will assume that only one connection is created between the elements of a set in the time unit.

So there is

$$\rfloor f(x+1) - \rfloor f(x) = -1, \tag{3}$$

for which the solution with initial condition $f(0) = N$ has the following form:

$$\rfloor f(x) = N - \rfloor x, \tag{4}$$

what means, that the number (4) of unconnected elements of a set N is decreasing constantly so the time interval between two moments which phenomena of linking are taking place, will constantly grow. We will assume, that these time intervals

$$(t_1 - t_0), \quad (t_2 - t_1), \quad (t_3 - t_2), \quad \dots \quad (t_{n+1} - t_n),$$

constitute an arithmetic progression.

So the contractual moments $x_0 = 0,\ x_1 = 1,\ x_2 = 2,\ x_3 = 3,\ x_4 = 4,\ x_5 = 5,\ \dots$ correspond with the real time moments

$$t_0 = 0, \quad t_1 = 1, \quad t_2 = 3, \quad t_3 = 6, \quad t_4 = 10, \quad t_5 = 15, \quad \dots \ .$$

The function graph illustrating in the time the rise of the length of strand created from elements of the set of N elements is presented in fig. 8.

4. Conclusions

In the analysis of processes occurring in the *Informatic, Molecular Nanotechnology of the Direct Products Nanofabrication*, it is possible to distinguish two problems. *Firstly*, these are the processes of manufacturing and connected with them the self-replication phenomenon and *secondly*, these are processes of objects creation lean on the phenomena of the self-organization.

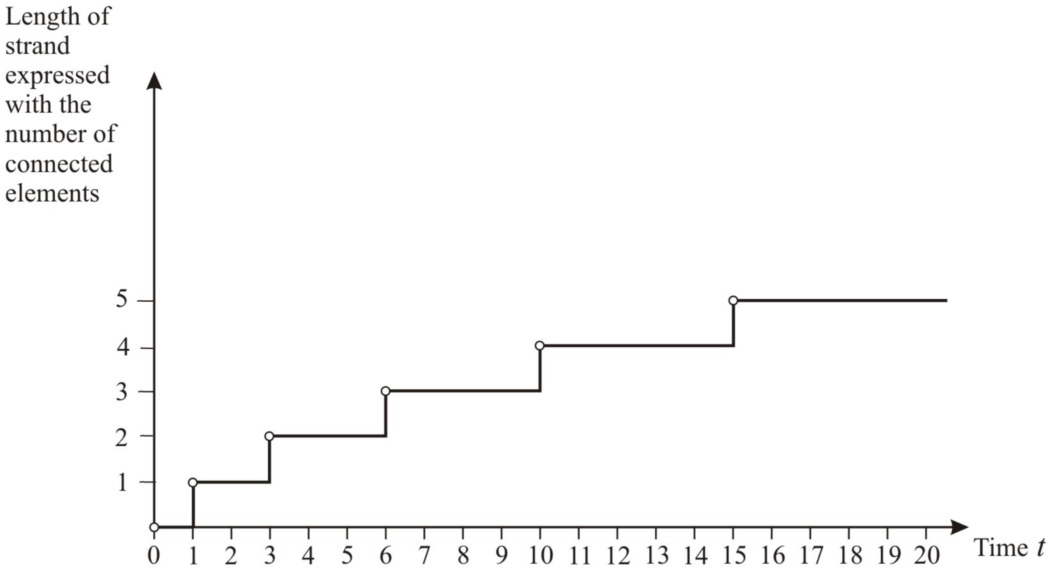

Fig. 8. Rise in the time *t* of the length of strand as a result of the process of self-organization

Rys. 8. Wzrost w czasie *t* długości nitki w wyniku procesu samoorganizacji

The following conclusions are resulting from introduced study. The technical completion of the *Technical Nanosystems of Informatics of the Direct Products Nanofabrication,* similarly to the *Biological Systems of Informatics*, is possible and the following requirements have to be fulfilled:

1. Migration from bit-coding represented by the microcircuits (flip-flops) states to nanobit encoding in which the nanobit in the text is the presence of chosen single molecule e.g. A, G, C, or T (U).
2. Fabrication of the self-reproducing and self-organizing products, namely, the products with internally in the structure encoded program according to which, the products realization has been performed.

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Omówienie

W pracy przedstawiono analizę procesów, jakie powinny zachodzić w *Technicznych Systemach Informatyki*, aby te mogły realizować procesy bezpośredniego wytwarzania produktów na bazie nanotechnologii, podobnie jak to ma miejsce w *Biologicznych Systemach Informatyki*.

W technicznych systemach informatyki (rys. 1), których celem jest automatyczna realizacja procesów obliczeniowych, informacje o liczbach i operacjach matematycznych, które na tych liczbach mają być wykonywane, przekazywane są z pamięci operacyjnej do jednostki arytmetyczno-logicznej, a po ich wykonaniu otrzymane liczby wynikowe zapisywane są bądź to w pamięci operacyjnej, bądź w innym rejestrze systemu. W biologicznych systemach informatyki (rys. 2) informacja o operacjach na atomach i molekułach zostaje z DNA, pełniącego rolę pamięci zewnętrznej, wprowadzona do zbioru swobodnych atomów i molekuł, znajdujących się w każdej z komórek inicjując w nich na zasadzie tak zwanej lepkiej matrycy procesy syntezy złożonych molekuł, np. białek. Aby uzyskać odpowiedź na pytanie, czy możliwe jest skonstruowanie takich *Technicznych Systemów Informatyki*, które podobnie jak *Biologiczne Systemy Informatyki* mogłyby bezpośrednio wytwarzać potrzebne nam produkty, przeprowadzono analizę porównawczą tych dwóch systemów.

Przeanalizowane zostały spontaniczne procesy samoreplikacji (rys. 3 oraz 4) i samoorganizacji (rys. 5, 6, 7 oraz 8), które, oprócz wielostopniowej syntezy produktów (technologia lepkiej matrycy), mogą stanowić podstawę *Informatycznej, Molekularnej Nanotechnologii Bezpośredniego Wytwarzania Produktów*.

Z przedstawionych w pracy rozważań wynika, że realizacja *Technicznych Nanosystemów Informatyki Bezpośredniego Wytwarzania Produktów*, podobnie jak to ma miejsce w *Biologicznych Systemach Informatyki*, jest możliwa i będzie wymagać z jednej strony, przejścia ze stosowanego obecnie w technicznych systemach informatyki kodowania bitowego, w którym symbolami są stany mikroukładów (przerzutników), na kodowanie nanobitowe, w którym symbolami nanobitu nie jest stan jakiegoś układu, ale jest obecność w tekście wybranych pojedynczych molekuł, np. A, G, C lub T (U), natomiast z drugiej strony, doprowadzenia do syntezy samoreplikujących się i samoorganizujących się materiałów, a więc takich, w których strukturze zakodowany jest program, według którego zostały otrzymane.

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