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SOME ACHIEVEMENTS IN THE INVESTIGATION OF DATA TRANSMISSION NETWORKS BY USING A FLEXIBLE SIMULATION SYSTEM

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BUDAPEST

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1/ INTRODUCTION

In view of the complexity and the great variety of data transmission networks /e.g. data banks, time-sharing systems, etc./ and the stochastic nature of their information flow, it is desirable to use simulation in order to get some information in advance on their performance [1],[2]. In this paper we would like to describe the design philosophy of a simulation system which is applicable to these networks generally and to present some results of its application.

2/ THE STRUCTURE OF THE SIMULATION SYSTEM

Considering the wide variety of data networks [3] used for teleprocessing with regard to the topology, elements involved and tasks to be solved, it seems reasonable to construct a simulation system on the basis of modular program segments. By linking the segments a simulating program for a particular configuration can be assembled. Obviously the program has to describe the configuration under investigation, i.e. the outlay of the whole network, and its elements, their topological location, and the procedures taking place in the network which affect the information flow itself /commands regarding priorities, queueing etc./. The description has to be such that it provides for the connection and interaction of the component parts. [4]

<u>Considerations based on the network topology</u>

The generalized outlay of the network can be seen in Fig. 1 a. From this it is clear that:

a/ the multipoint data link /on the right lower part of the figure/ can be substituted by a single compound terminal /marked with dotted line/ with respect to the network, assuming that the "inner life" of this network section will be additionally described by simulation. This results in a reduction of the uniform configuration to be handled.

b/ the whole reduced network can be built from basic network modules shown in Fig. 1b.

c/ any network consits of the following four elements:
- data transmission channels,
- topological node facilities,
- data terminals,
- procedures /communication software/.

Modular segmentation of the simulation system

In order to get a flexible system which enables us to simulate various configurations, its elements are described by separate subroutine functions. The independent variables of these functions are obtained as the corresponding output values from the subroutines of the topologically neighbouring elements, and vice versa. The communication network software subroutine is in a special position, since in the simulation system it has direct communication with every element. The pseudotime of the process is an input variable to the element subroutines. The subroutines have to provide for check points at which the whole program can collect the information required for evaluating the results of the simulation. The determination of the interacting variables in a particular case is very simple, in accordance with statement b/.

Using an additional program segment which is based on the evaluations, it is easy to alter particular elements or their given parameters, and by repetition of this process we may synthesize the optimum solution with respect to prescribed aspects.

The overall outlay of the simulating program can be seen in Fig. 2, while the flow diagram for the output function-generating part at the receiving end of a synchronous decision feedback-type data transmission channel is shown in Fig. 3. The block error distribution in the channel is assumed to follow the Poisson distribution law.

3/ INVESTIGATIONS ON THE BUFFER MEMORY OF A CONCENTRATOR TYPE NODE

Study of the information flow in the nodes of the network is of particular importance. We have investigated the distribution of the buffer memory contents of a concentrator-type node using the basic network module of the simulation system.

The number of input channels varied from 1 to 8 using equal nominal transfer rates. The channels were assumed to be operating according to the "decision feedback" principle, as shown in Fig. 3; i.e. they were described by first order Markov processes. The error probabilities in the input channels as well as in the output channel were equal. The simulation was undertaken at three values of the block error probability: 10^{-1}, 3.10^{-2} and 10^{-2}.

In order to ensure ergodicity of the process, the effective input rate to the node has to be less than the output. Accordingly we chose a nominal transfer rate in the output channel n+1 times larger than that in the input, where n represents the number of input channels. This choice makes it possible to get some information on the distribution of the memory contents as a function of the input to output transfer rate ratio. Fig. 4 shows the probability of memory overflow /P_M/ as a function of the output to input transfer rate /X/, where M=n has been choosen as the unit of buffer capacity. As it is generally necessary to avoid loss of information in the case of overflow, some or all of the input channels have to be silenced for some time. This means that the efficiency of the system is reduced, and so a correlation of the buffer memory size and overall systems efficiency can be derived from the results of the simulation. Another interesting result is shown on Fig. 5, which presents the distributions of buffer contents for systems with one and eight input channels. The quasiperiodical feature of the curve obtained for eight input channels is due to the relation of the input and output information quantities.

The mathematical description of the process altering the buffer contents is given in the appendix. [5]

APPENDIX

MATHEMATICAL DESCRIPTION OF THE PROCESS IN THE BUFFER MEMORY

The state diagram of the system is shown in Fig. 1A, where states a designate the memory content indicated in their indexes and the p values designate the corresponding transition probabilities. Designating the probabilities of the states by P, it holds that

$$P_i = \sum_{k=k_o}^{n+1} p_{-k} P_{i+k} \qquad \text{where} \quad \begin{cases} k_o = -n & \text{in case} \quad i \geq n \quad \text{and} \\ k_o = 0 & \text{if} \quad 0 < i < n \end{cases}$$

for $i = 0$

$$P_o = \frac{\sum_{k=1}^{n+1} p_{-k} P_k}{\sum_{k=o}^{n} p_k} \quad \text{will hold}$$

where $\sum_{k=-n}^{n+1} p_k = 1$

A simplified model is shown in Fig. 2A. For this case it can be shown that

$$P_i = (1 - R)R^i$$

where $R = \frac{p_{+1}}{p_{-1}}$ and $R < 1$

For a Poisson block error distribution and a first order Markov process describing the decision feedback system

$$p_{+1} = p_x^2\left(1 - p_y^2\right)$$

and

$$p_{-1} = p_y^2\left(1 - p_x^2\right)$$

where p_x and p_y represent the block input and output probabilities, respectively. Using this model and correcting input to output rate by the factor n/n+1 , the approximation tends to improve with decreasing i and n, since the number of neglected states decreases with them. The calculated results in the i=0 points and for the distribution for n=1 were in good agreement with the results of the simulation.

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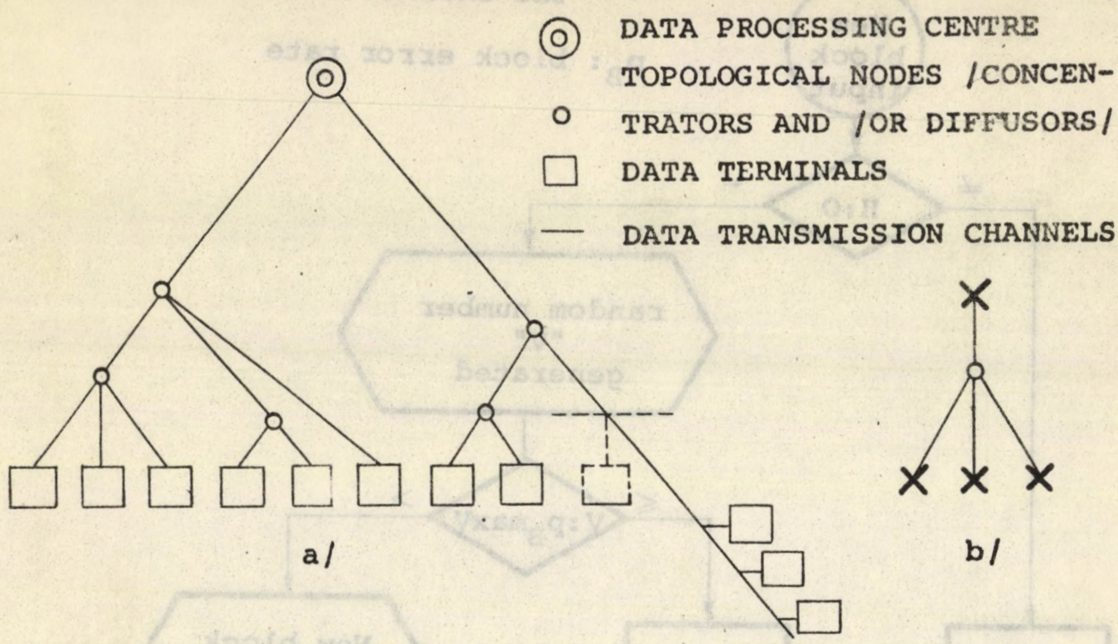

DATA PROCESSING CENTRE
TOPOLOGICAL NODES /CONCENTRATORS AND /OR DIFFUSORS/
DATA TERMINALS
DATA TRANSMISSION CHANNELS
a/
b/

Fig. 1

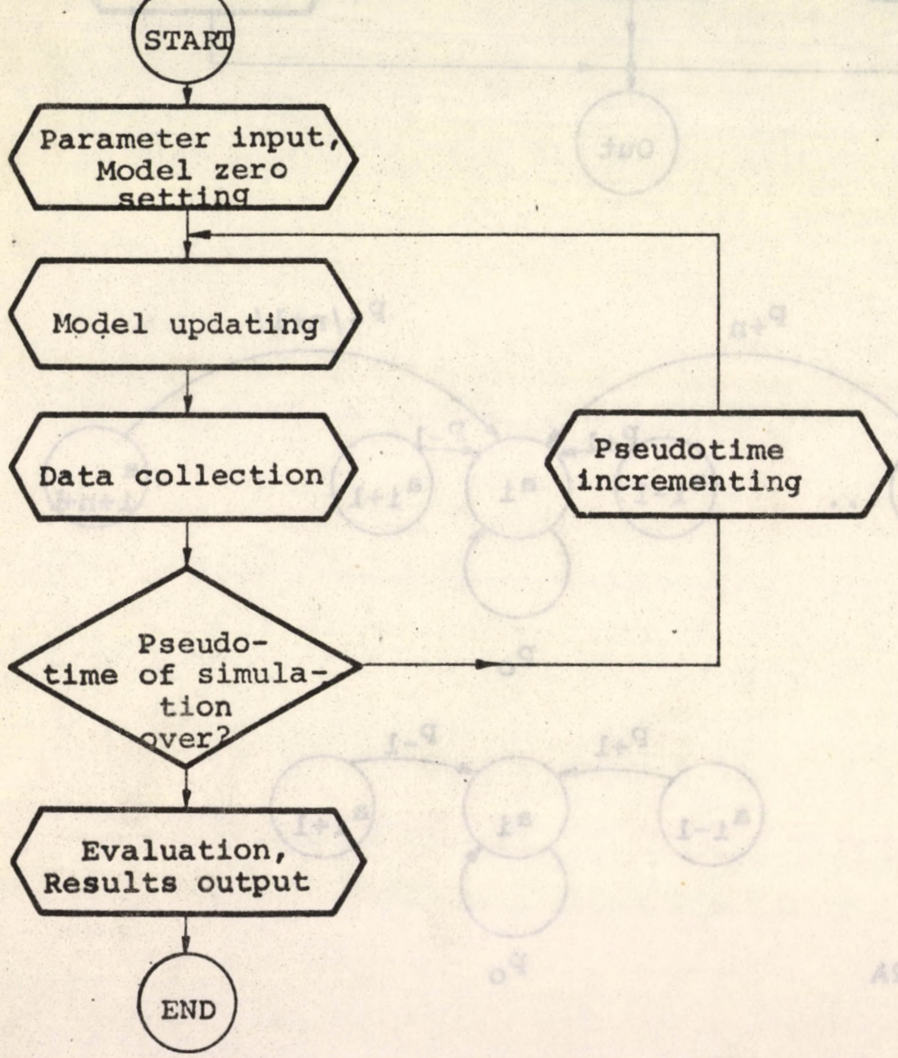

START
Parameter input, Model zero setting
Model updating
Data collection
Pseudotime incrementing
Pseudotime of simulation over?
Evaluation, Results output
END

Fig. 2

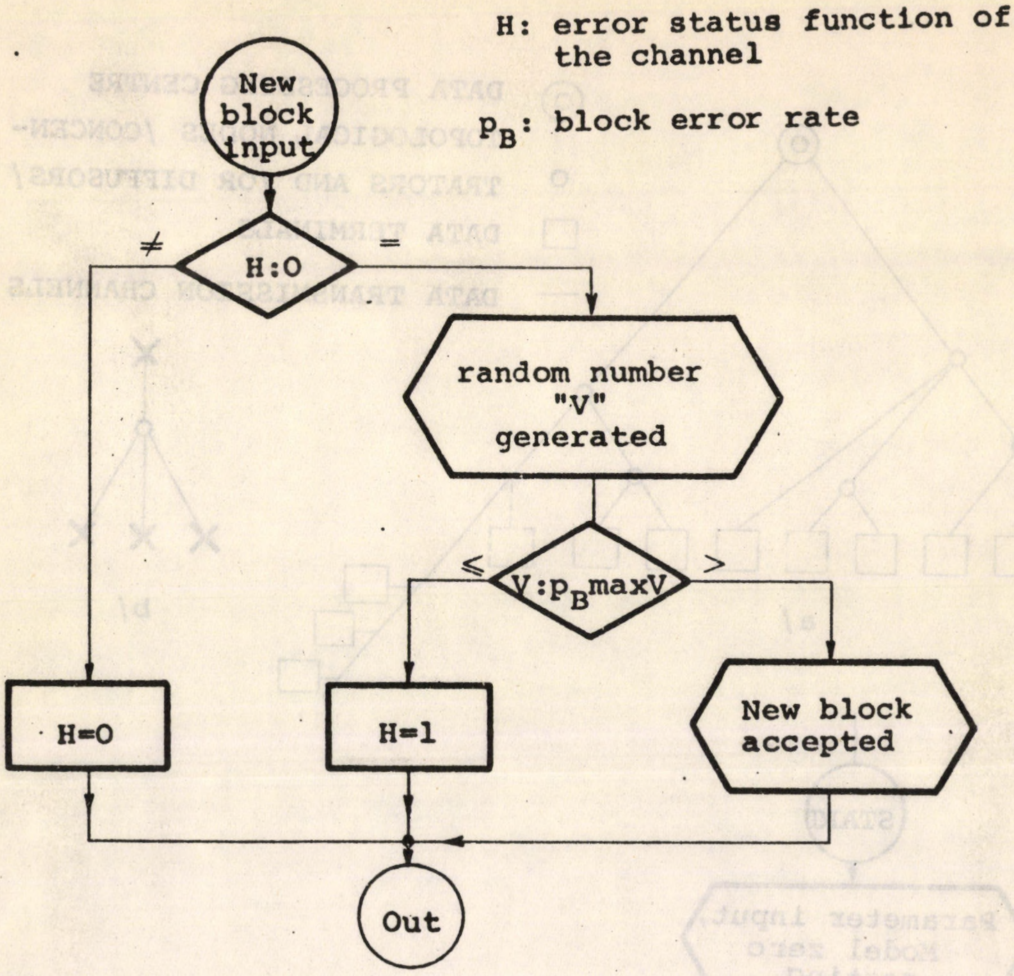


Fig. 3

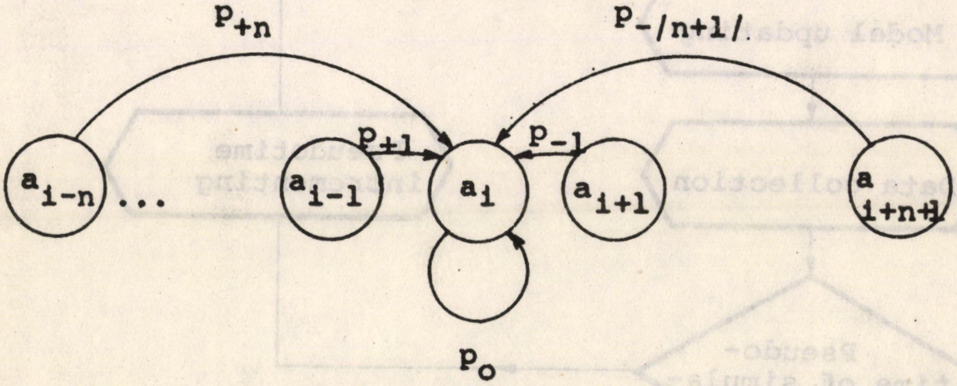


Fig. 1A

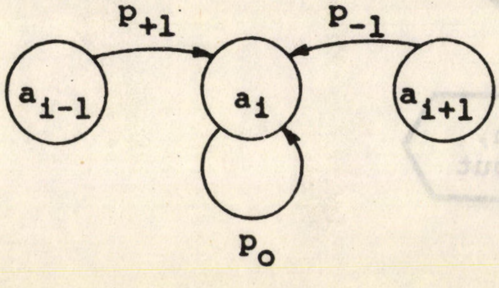
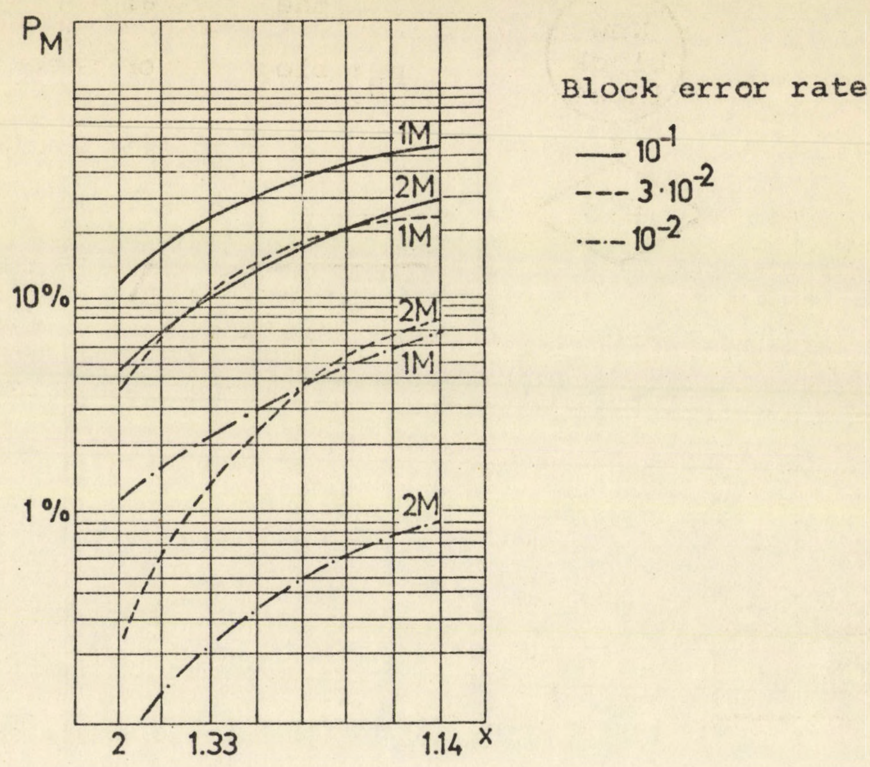
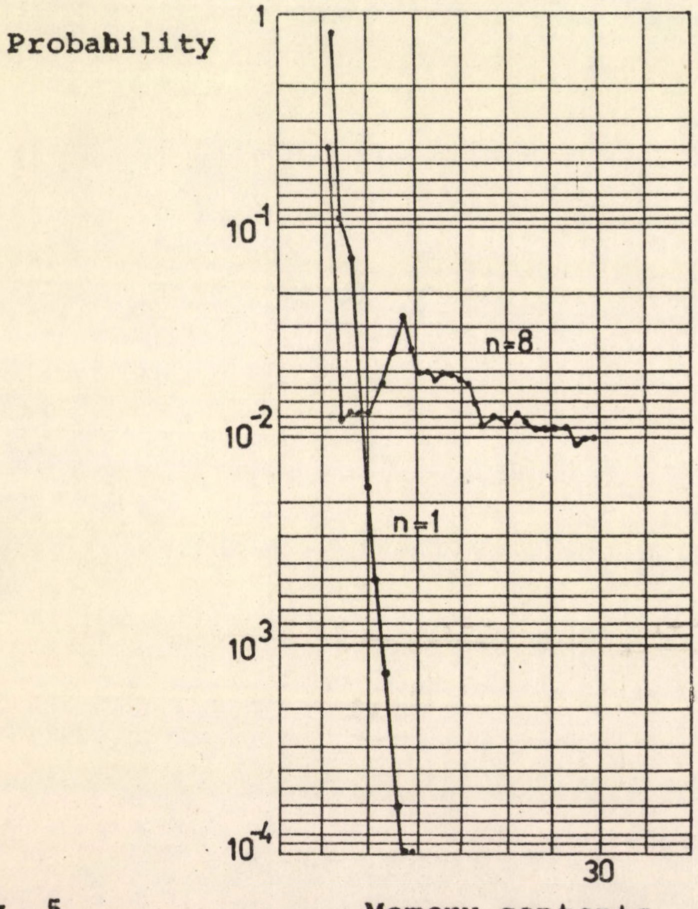


Fig. 2A



P_M
Block error rate
10^{-1}
$3 \cdot 10^{-2}$
10^{-2}
1M
2M
10%
1%
2
1.33
1.14
x

Fig. 4



Probability
1
10^{-1}
10^{-2}
10^{3}
10^{-4}
n=8
n=1
30
Memory contents

Fig. 5

Kiadja a Központi Fizikai Kutató Intézet
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Felelős szerkesztő: Sándory Mihály
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