SIMULATION OF INTELLECTUAL COMPUTER SYSTEMS OF PROCESSING MEDIA DATA

Ravil Muhamediyev, Yury Shunin, Victor Gopeyenko

Information Systems Management Institute
Department of Natural Sciences and Computer Technologies
E-mail: ravil@inbox.lv, shunin@isma.lv, Viktors.Gopejenko@isma.lv

The problems of observing system's simulation (a media dots in wide view) are considered. A classification of systems of video observation, base function of such systems and processes of analysing media dates are described. The approach to the analysing of video observation systems is proposed. Some simulation models based on stochastic Petri nets and results are discussed

Now in all spheres of living systems of video observation and other media systems are actively applied. They allow conducting round-the-clock supervision over object, to supervise access, to operate technical devices remotely, to fix emergencies and to inform secure structures, so to provide safety and safety of people and material assets. The main source of the information in such systems is video stream, but not only this one. The various media-information sources can be generalized, using media-dots concept - an elements, which are capable to accept, reproduce and process media data. Much plenty of resources (memory and computing capacities) is required for processing and storing of media data. One of the problems is how to find optimum for using resources (processors, memory) so that there was the least number of refusals for the information processing. One of variants of the decision of this problem is the maximal processing of video information in the point of its reception.

Keywords: *video observation, Petri nets, simulation model, media dots, program agents*

1. Introduction

In connection with avalanche growth of volumes of the transmitted information and capacity of carriers of the data there is an urgent task of formation of the general concept of processing of large-scale flows media data. The concept of media dots, which are understood as every possible source of media data, is formulated. At the same time, in discussion of problems of objects management a metaphor of active dots uniting various management executive devices can be useful.

The association of various sources of media data within the framework of the uniform concept allows to generalize a task of construction of contextually dependent systems of the graphic user interface (GUI) both intellectual means of the control and management. These means or, otherwise, intellectual agents, being in media dots space, can solve tasks appropriate to a special-purpose designation of systems and to have by many similar features. Hence, the various systems based on use of means of a video and audio-control can be managed by functionally close program systems. One of kinds of similar technical systems (but not unique), are IP cameras. It is quite possible to consider a community of the program agents, placed in a network and general interfaces and called as required through media dots system. So can operate the systems of recognition (for example, image recognition), systems of video-supervision, systems of the media-content collection in educational institutions, etc.. Alongside with it, the intellectual agents can be characterized by some own behaviour ensuring an achievement of the purposes facing a system. The behaviour of similar systems can have much common with a behaviour of artificial alive essences-animates.

2. Avalanche Growth of Volumes of the Transmitted Information and Capacities of Carriers

The growth of capacities of information carriers is an objective process, which is observed during all computer history. In essence, this process is one more display of the famous Moore's law [1]. Periodically, alongside with an avalanche growth of volumes of the transmitted and stored information, the expansion of number and change of popularity of carriers of the data are observed. The increase of its quality and volume leads to a necessity to store and to process Tbytes and Pbytes [2]. From the one side this is a treasure, but, from the other side, it is a "breed" in which to reach useful "layer" is not so easy. One of particular ways of the task solution of the data large volumes is the segmentation or personification of Internet-space [3]. However, the business is not limited in information searching in the Internet. There are information media-sources, which transfer the data in a real time scale, for example, technological computers, measuring instruments and sensors, IP-cameras, video-servers, etc.

3. Media-Active Dots

Let's consider various media data sources.

1. Systems of video-supervision, which can be advanced up to monitoring systems of city or area (Fig.1). The example of the project of the monitoring system of area of city is described, for example, in [4].

2. The systems of «smart» buildings too can be a rather volumetric media-data source) are considered [5, 6]. The monitoring system and managements of a «smart» building can contain some media-data sources intended for supervision over a condition of rooms and technical subsystems, and also management blocks (Fig.2).

3. The project of a mobile system of supervision (Fig. 3).

4. The systems of security supervision, in which increasing popularity win IP-cameras [7, 8]. The modern variants of systems of video-supervision and security signal system include algorithms of recognition of the people, cars and some situations (sharp acceleration of movement, fall of the man etc.) [9].

5. The monitoring system of warehouses and rooms, with adjustable zones of the control. One of popular tasks in these systems is the systems of the faces recognition [10].

6. Systems of supervision and control used in educational institutions, for example, at schools [11], where the cameras are used for the control of study rooms and sports grounds.

7. Project of a control system educational content of higher-school (Fig.4). The general concept of a system is illustrated on Fig.5. Generally, an educational media-content, formed by the teacher can be transferred directly in a network in a real time scale and saved on server. The isometric projection of building used for control learning content. User selects floor of building by mouse strike (Fig. 4, fragment A; Fig. 6) then he selects media dot on the floor scheme (Fig. 4, fragment B).

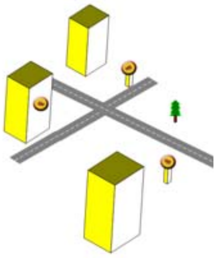


Figure 1. Town control system

Figure 2. Media-Active dots in a SMART HOUSE. Green signs are media dots, red ones is active dots

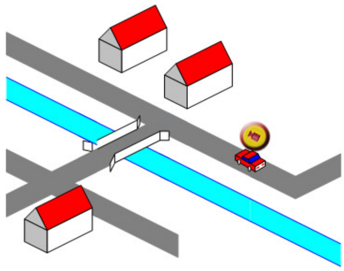


Figure 3. Mobile M-dots

Figure. 4. Graphical user interface for control media dots in higher school

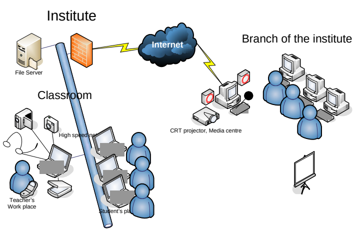


Figure 5. Concept of Higher School e-Learning system

Figure 6. Floors schema

The various media-information sources can be generalized, using media-dots concept.

Let's name *media or multi-media dot* (*M-dot*) an element, which is capable to accept and/or reproduce media data. Under media data we understand any kinds of the data, which can be perceived or are reproduced by modern computer and communication means and their combinations. First of all, we shall mean audiovisual data - a video and sound. On the other hand, the *active dot (A-dot*) is an element capable to operate by object or system. This pair we shall name MA- dot or simply MA, at least, two dots of view on MA are possible. A practical variety of media-information sources can be presented by particular examples.

Examples of M- dots: WEB-pages, WEB-cameras, IP-cameras, Computer (e.g., information on its screen) measuring instruments and sensors.

Examples of A-dots: Control facility of a «smart» house. Regulators of heat providing devices, illumination devices, Computers, Alarm devices, Restriction access devices, Control facility mobile devices.

There is a natural question: whether the association of so diverse systems and media-sources is justified within the framework of general paradigm? On our sight, in all listed examples the needs of practical use are rather similar. In all cases the reception and processing of media data, and, as a rule, in a real time scale is meant. Hence, in the first, the contextually dependent means of GUI, ensuring the simplicity of media-information sources are necessary. The example of the project similar GUI for media-content management of higher school is described below. In the second, the intellectual means of the control and managements allowing to lower volume of the processable data up to a «reasonable» level are necessary by allocating its only that corresponds to a special-purpose systems designation or user needs. Such means or intellectual agents can doing autonomous, prepare timetable of viewing for users and detecting systems.

4. IP-Cameras and Intellectual Detecting

The IP-camera supplied with a microphone to become a source of a video and audio-information. At presence of means of wireless communication the IP-camera is capable to work on distance up to several tens meters from an access point. Overview of cameras considered in [13].

For cameras management the software as commercial [14, 15, 16], and conditional free-of-charge [17] are used. Many manufacturers deliver the advanced software together with IP by cameras. As a rule, the cameras are capable to react to the following events [18]:

- Change of a level of a sound, perceived by a microphone
- Switching a source of a signal (for example, from the infra-red camera on a usual video-camera)
- Movement
- Change of intensity of light
- Approach of given time intervals.

The camera makes record of video signal or sequence of the staff. In other words, the modern cameras are capable to execute detecting some signals. The intellectual system should be capable on something greater. *Intellectual detecting* we shall define as an ability of system to react not only to signals, but also on images. Such a task can be solved by the *agent of intellectual detecting* expanding list of recognized situations in a field of sight of the camera. Generally, the agent can have a memory and an ability of recognition both static and dynamic images. In this case media recognition of dynamic images becomes basic. The first step in this direction is the Advanced Video Motion Detection and Unattended Object Detection technology, used in cameras of new generation [19]. As the development of the movement detector (video motion detector) the detector of criminal situations can be offered. The prototype is the system described in [8], where are applied both motionless, and mobile cameras. It is possible to speak also about *detectors technogenic situations*, which could serve for revealing dangerous situations, for example, connected with automobile movement, risk situations at the airports, at factories etc., and also unusual condition distinguished from habitual, that can be an attribute of danger etc. The *agent of intellectual search* in media-dots space can serve a means of recognition of similar images in media-dots space, searching the definite objects etc.

5. Strategies of Media-Data Processing. *Model of Random Work Scanning of Security Space*

The systems of security supervision in which the increasing popularity win IP-cameras. But there are some serious technical problems in data volumes processing. The ways of decisions of these problems which we can point out as more effective, are the following:

- Development of optimal strategies of servers' (or processor's) charging, designated for software agents. The choosing of processors, when the charging and distance for a source are taken into account, can diminish the probability of troubles in data processing;
- Self-teaching of agents. Using of various strategies of agents' self-teaching, including an imitation of natural ways of teaching [20,21], will allow to adopt them for changes in media-points space;
- Using of strategies of transmitted media-information volumes. The first approach can be concluded in dislocation of agents of intellectual detection directly in collection points of media-data. Thus, the translation of a part of algorithm of data processing closer to a point of data receiving can diminish the data amount for the next stage of data processing. Nowadays, there are examples of video-cameras with mounted software, which detect the movement and, recognize the available subject [15];
- The second approach is concluded in using of pseudo-chaotic strategies of media-points activation which is similar to a natural way of vision field of human eye. E.g., in decision of security video-observation we could not fulfil the full-scale processing of the whole data flux, coming from all observation cameras. It will be enough to analyse the particular images of video-data from various cameras, which are chosen in random way. This approach is demonstrated on Fig. 7, 8 and 9. In particular, the Fig.7 shows the 'linear set' (security wall)' model. Each camera scans the observation field randomly changing the orientation angle $\varphi(t)$. The same way is used for 'radial set' model (Fig.8). Fig.9 demonstrates the algorithm of movement a video-camera. The orientation angle $\varphi(t)$ is change according the logistic map law (e.g. the well-known logistic map of Verhulst) [22,23]: $x_{t+1} = rx_t(1 - x_t)$.

For 3<r<4 the generation of chaos is observed. Thus, the algorithm of random walk scanning of active media dot is: $\Delta\varphi_{t+1} = 90^\circ[(rx_t(1 - x_t) - 0,5]$.

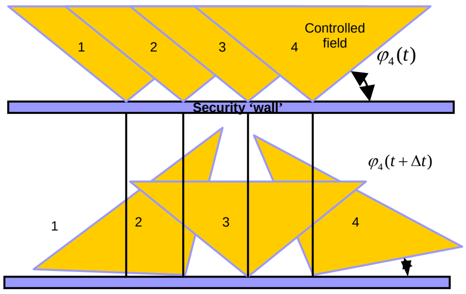


Figure 7. Media and active dots models: dots' linear set

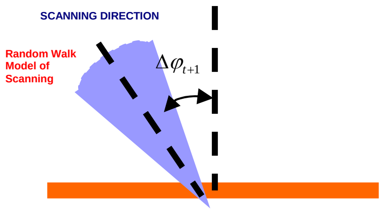


Figure 9. Random Walk Model of Scanning

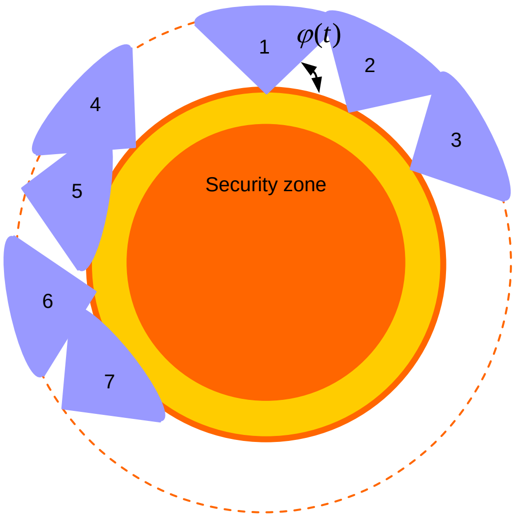


Figure 8. Media and active dots models: dots' radial set

Random Walk Model of Space Scanning is a chaotically determinate process of rotations of a number of active media dots. After detection of an object a system of observation concentrate its attention on the object and controls it. It is an intellectual action, based on observed image recognition.

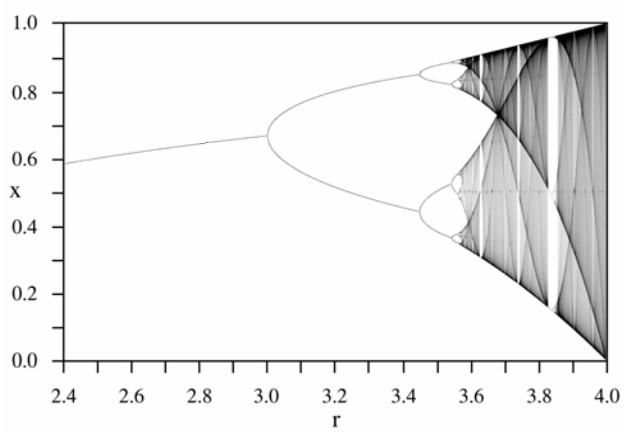


Figure 10. Verhulst's logistic map: the equilibrium point of iterations 'x' via the growth parameter 'r'

The **Random Walk Model of Space Scanning** is a chaotically determinate process of rotations of a number of active media dots. The task is to optimise the number media-points and their spatial distribution. After detection of an object a system of observation concentrate it's attention on the object and controls it. It is an intellectual action, based on observed image recognition. Various types of image recognition systems can be used. Signal systems include algorithms of recognition of the people, cars and some situations (sharp acceleration of movement, fall of the man, etc.) (see, e.g. Fig.11a,11b).

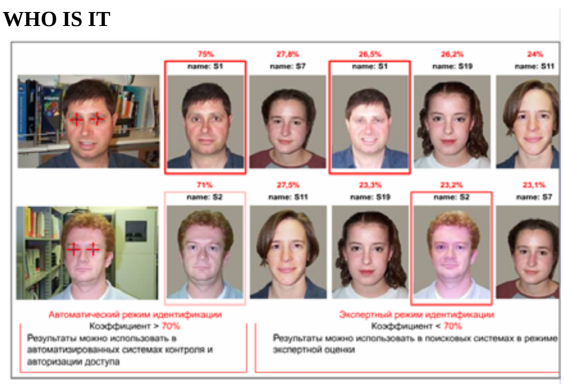


Figure 11a. Face control system

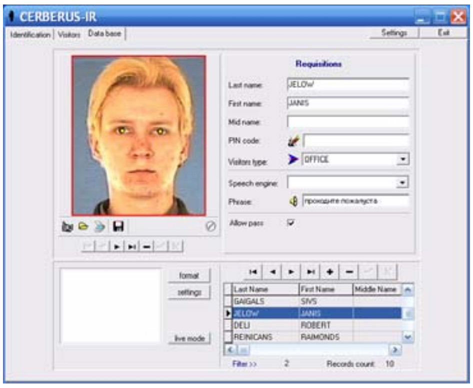


Figure 11b. Cerberus image recognition system

6. Logistic Nets Formalization by Petri Nets

Gradual withdrawal from MPR II methodology (focused on a large-lot production and as a rule long life cycles of products) and transition to development of management techniques and technologies incorporated by term Supply Chain Management (SCM) is now being observed [24]. The purpose of the logistical chain management is to connect all participants in the uniform integrated system. The set of logistical chains forms more complex structure - a logistical network. That is why is actual the task of logistical network optimisation. The dynamical character of business processes make, it necessary to construct the adaptive system, capable to be adjusted according to the changing conditions.

In essence, the question is if an intellectual agent of logistical network is capable to "adjust" for the current problem and to change "appropriately" according to the new conditions [24].

Petri nets are often used as formal model of logistic nets. Formal definition of a network can be found, for example, in [25]. In the same place some expansions of Petri nets are considered, allowing increasing their expressive capacity. Some examples of the Petri nets and their expansions applications for the business processes analysis are shown in [26-28].

Presence of different type peaks and corresponding rules of network work (transitions operation rules) allows dynamic parallel asynchronous processes analysing. There is a set of modifications (expansions) of classical Petri networks. For example, it is possible to apply time nets to estimate the time of transaction [6,7]. In this case, time intervals are corresponded by transitions. Fuzzy Petri nets are based on the concepts of fuzzy logic entered by L.Zade. In [31] fuzzy Petri nets are used for hybrid system modelling. Other expansions – coloured nets [32], stochastic nets, predicate nets, etc. are also used.

Usually, the graph of achievable markings is applied to analyse the properties of nets. Imitation modelling is used to analyse the nets with the big expressive capacity.

There are no algorithms that correct the network structure in classical networks and their expansions. Hence, the classical nets are appropriate for static chains modelling. To optimise such networks the classical algorithms and the weak artificial intelligence algorithms [34] that optimise the network using the criterion of expenses and time reduction are used

We shall name block of intellectual management in logistical network as an intellectual agent of logistical net. In difference from classical algorithms of optimisation, intellectual management assumes self-training and new strategy of behaviour development. If during the repeated passing through the chain the self-training process is basically possible, than the task of the new strategy development is more difficult. Obviously, it assumes not only the change of the network single chain elements but also the possible change of its structure. Usually, time and resources meant for this task solution are limited and the aim can be formulated unclear. In such way the behaviour strategy development task looks like a living organism or its model – animate. [35, 36].

Let's consider the models of logistical network elements (Fig. 12a, b, c, d). Elementary models with initial markings are shown in the top of the figure. The final markings achieved during transition are pointed in the bottom of the figure. We shall name the final markings as the "target markings" according to semantics of nets.

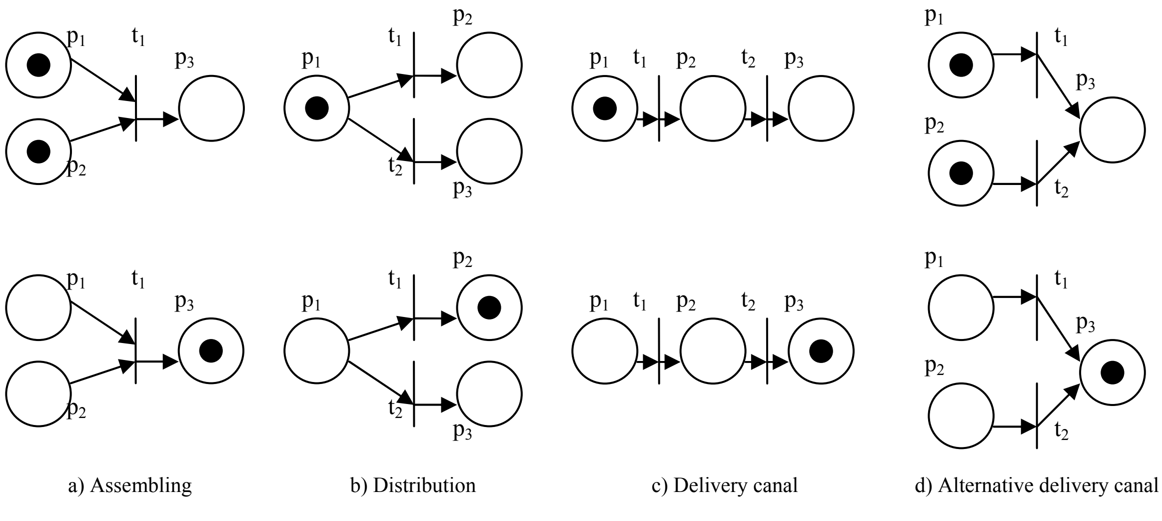


Figure 12. Models of elements of logistical network

Peaks of the network can be interpreted as following:

a) p_1, p_2 – warehouses, t_1 – assembly process, p_3 – warehouse of finished goods;
b) p_1 - production warehouse, t_1, t_2 – delivery, p_2, p_3 – consumer;
c) p_1 – warehouse, p_2 – intermediary, p_3 – consumer, t_1, t_2 – delivery;
d) p_1, p_2 – warehouses, t_1, t_2 – delivery, p_3 – consumer.

In the most simple case, when the orders of network arches and/or time of transition operations are known the problem of optimisation is reduced to a task of token arrangement in such way so that there were more tokens where the weights are smaller.

What to do, if the order of arches or time (probabilities, weights) of transitions operations is unknown? One of decisions is to try various variants, choosing the best by the criterion of optimisation. Actually it means some kind of self-training strategy in the network. The self-training process can imitate the natural strategy of training which, according to [36], includes the following:

- Generating new tactics of behaviour;
- Correspondence of these tactics to physical laws of environment;
- The presence of nonlinear oscillator;
- A predicative functioning;
- Work history consideration.

If the Petri nets are used as the formalism that describes the logistical circuits, the predicative functioning is provided by the rules of the transition operations.

7. An Approach to Taking into Account the "Physical" Laws of the Environment

To taking into account of physical laws of environment means that from all of set of variants of behaviour are excluded obviously unsuitable (it is impossible to deliver faster the plane speed, it is impossible to have an unlimited source of the finance, etc.)

In our case, the "physical" environment for work of the agent is the subset of Petri nets (time nets). Hence, it is necessary to consider only "appropriate" markings that provide the set of target markings from all sets of initial markings. There is no necessity to consider obviously impasses.

If x is any positive integer and 0, w is positive and is greater than 0. m (p_i) – markings of the place p_i, on any step during the work of the net, then the set of markings m (p_1)=x, m (p_2)= x , m (p_3)=w are the target markings of the subnet on Fig. 1a or in the vector form g_a=(xxw). The target markings of the subnets are resulted in Table 1.

Table 1. Target markings of elementary subnets (Fig.1)

Subnet on Fig.1	Vector of target markings set (g)
a	xxw
b	xww
c	xxw
d	xxw

Definition 1. We shall name the initial marking of the net m_0 as "appropriate" if one of the target markings *g* can be achieved from m_0 at the defined operation rule. For example, for the net on Figure 2a the "appropriate" markings are (110), (120)..., (ww0). The task of marking approachability corresponds to the NP-full [37]. Therefore, the algorithm or a method is necessary for the calculation of the "appropriate" markings set.

Let's define net R as "reverse" of the net N if the places and transitions of these networks coincide, however, the directions of the network N arches are changed to the opposite directions in comparison to the network M. Formally, M (X) is a rectangular matrix of connections of net X, in which element

x_{ij} = 1 if the arch goes from the place p_i to t_j;

x_{ij} =-1 if the arch goes from t_j transition to the place p_i;

x_{ij} = 0 if the place p_i is not connected to the transition t_j.

E (X) is the set of "appropriate" markings of the net X.

Definition 2. We shall name the net R = (P_r, T_r, M (R)) reversed N=(P_n,T_n,M_n(N)) net, if $P_r = P_n$, $T_r = T_n$, and M (R) = j * M (N), where the scalar j =-1. It is enough to calculate set of markings of net R to calculate the set E (N). Elementary nets that are reversed for the nets on Fig.1 are represented on Fig.2. It is evident that after transition operations the network markings on Fig. 2 and on Fig. 1(top) will coincide.

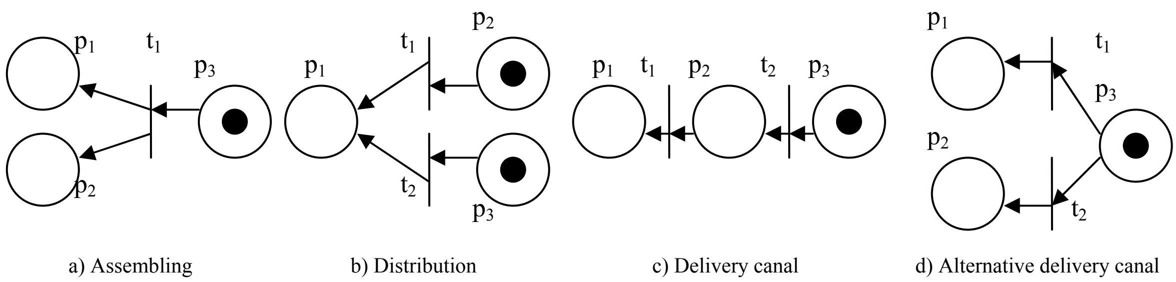
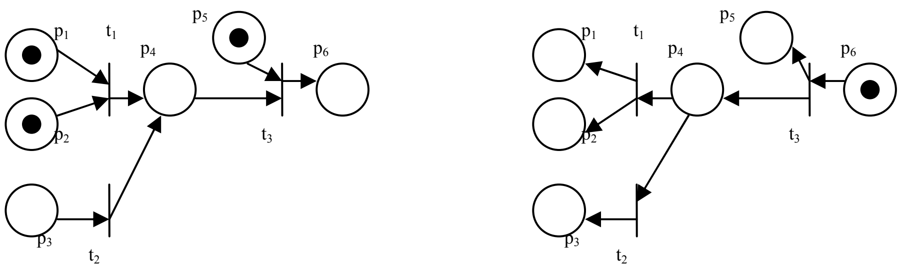


Figure 13. Reverse nets

Let's consider an example to illustrate the described approach. We have the nets N_1 and R_1 (Fig.3a, b). The Table 2 represents the connection matrix for the net N_1 - $M(N_1)$. To calculate the reversed net connections matrix it is necessary to solve the following expression: $M(R_1) = -1* M(N_1)$. The result is represented in Table 2.

Table 2. Connection matrix for N_1

p \ t	**1**	**2**	**3**
1	1	0	0
2	1	0	0
3	0	1	0
4	-1	-1	1
5	0	0	1
6	0	0	-1



a) Net N_1. b) Net R_1.

Figure 14. «Direct» and «reverse» nets

Table 3. Connection matrix for R_1

p \ t	**1**	**2**	**3**
1	-1	0	0
2	-1	0	0
3	0	-1	0
4	1	1	-1
5	0	0	-1
6	0	0	1

To calculate the set of "appropriate" markings the of net - $E(N_1)$ it is enough to calculate the graph of achievable markings (GAM) of R_1. For one of the target marks sets $g_1(N_1)$=000001, GAM of the net is represented on Fig. 15.

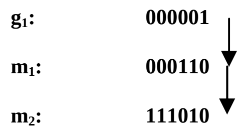


Figure 15. GAM of net N_1

The set $E(N_1)$ includes m_1 and m_2. It is obvious that the mark m_1 for the net N_1 is intermediate. It means, that m_1 always can be founded from m_2. Calculation of all E sets in any network can represent a difficult task. Let's introduce concept of the final marking.

Definition 3. The set of reverse net's *F (R)* final marking of will consist of such $f_i \subset E(R)$ marks that any transition cannot work or that does not vary during any transition operation (probably also, that these are zero marks). In other words, the final marking includes the set of deadlock markings of the net and the set of markings that do not vary during any transition operation. It is obvious, that $|F(R)| \leq |E(N)|$. Though it is possible to believe, that generally algorithmic complexity of the sets *F (R)* and *E (N)* calculation is equivalent, nevertheless, in many cases the elements quantity in *F (R)* is lower than in *E (N)*, this allows lowering the requirements for memory during the network analysis. In particular, in an example, $E(N_1)=(m_1, m_2)$, and $F(R_1)=(m_2)$.

8. The New Tactics of Behaviour Generation

Until now we have considered nets with steady structure. So the quantity of places, transitions, arches and connections between the peaks of the net is fixed. New knowledge in our model is an occurrence of the new peaks and connections. Obviously, that first of all it is necessary to subject transformations of those net parts that influence the optimised parameters (time, cost) most of all. Similarly to the PERT diagrams we shall name the given parts of the network as critical. The concept of the critical part of the net follows from the semantics of the processes simulated by the model.

Generally, amount of possible net modifications can't be restricted. Nevertheless, it is possible to offer the following sequence of net modification steps from the common principles:

- Revealing the critical nodes and ways.
- Critical nodes optimisation using "logical" network modification. In other words, addition or removal of the peaks and arches with an answer to the question - « What will be if...? ». In the case of the logistical network this is, for example, the finding of the new channels of deliveries or commodity markets. Thus, "logical" modification consists in the change of the critical nodes and ways, calculation of the "appropriate" markings and the analysis of the received result to reveal the optimal modification.
- Network modification.
- Go to the step 1 if the parameters (time or transactions costs) are changed.
- Go to the step 1 "spontaneously" even without the net parameters change after casual interval of time dT
- Note, that the efficient system of modification should reveal contradictions during net modification, and also should take into account the previous experience of changes and carry out selection of dT size.

Conclusions

An increase o of the transmitted data volumes, the growth of speed of transfer and the decrease of a storage cost initiates the development of the general concept of media data processing. Considering various sources of media-information within the framework of a media dots metaphor, it is possible to discuss the unified means of the user interface, system of working in parallel programs of processing agents who are carrying out recognition of situations, and also consider own behaviour of the agents in media-dots space.

The ways of the logistical circuits by Petri nets description are considered. Various expansions of Petri nets are applied to the description of the logistical networks. Generally, evident models can be used to calculate some parameters and optimise static logistical chains. The logistical net can be transformed depending on the business process aims in the real environment. For changeable circuits modelling the concept of the intellectual agent of the logistical network is offered. The behaviour of such agent is carried out on the basis of the principles of the artificial alive essences - animates, in particular self-training. The goal of the agent is to change the net accordingly to the change of the conditions. For example, it must change in the case of single transactions cost change or change of the critical ways. The way to simulate natural strategy of agent training is proposed.

In some cases the speed of net change and transformation variants checking limitations can be critical. To reduce the amount of possible model's initial markings, the algorithm of "appropriate" set of initial markings calculations is offered. It allows reducing the amount of "logical" network changes variants and steps.

References

1. Moore's Law – *http://en.wikipedia.org/wiki/Moore's_law*
2. Hector, G.-M., Jeffry, U. *Data bases systems*. Moscow: Williams, 2004. 1088 p.
3. Jones, M.T. *Programming of artificial intelligence in applications.* Moscow: DMK Press, 2004. 312 p.
4. *http://articles.security-bridge.com/articles/10/11889/ Security TV in the town*
5. The Smart House System. A technical overview – *http://www.circuitcellar.com/library/print/hcs-pdf/31-Stauffer.pdf*
6. Bysrtrov, A.V. Intellectual building conception and innovative technologies of insurance business,. *Artificial Intelligence News,* No 6, 2003.
7. *http://www.sec4all.ru/content/view/141/27/ Network IP-cameras*
8. *http://www.bos.dn.ua/view_article.php?id_article=210. IP-systems of video-supervision*
9. Orwell 2k-City. *http://elvees.ru/index.php?id=239#c271. Systems of video-supervision with the computer sight*
10. *http://www.frsservice.lv/ Image recognition.*
11. *http://www.proxim.com/learn/library/appnotes/education.pdf. Wireless Networking Solution For K-12 education*
12. Vorotnikov, S.A. *Information Systems of Robo-technic Devices*. Moscow: MSTU, 2005. 384 p.
13. *www.ravil.astersoft,net MA-dots. IP-cameras.ppt*

14. *http://www.ivimg.com/products/ ViewCommander NVR*
15. LuxRiot is a Digital Video Recording and Remote Surveillance software package for the Windows based PC – *http://www.mondots.lv/lv/luxriot_s.php*
16. *http://www.smartvideo.ru/download/ Digital supervision programmes*
17. *http://www.zoneminder.com/ ZoneMinder the top Linux video camera security and surveillance solution*
18. *http://www.industrialnetworking.com/products/spec_sheets/Mobotix/M1M_Manual_Intro.pdf Mobotix-Concept. Network-CCTV&WebCam.*
19. *http://www.webcam-production.com/pdf/en/sony_snc-cs50p.pdf The Sony SNC-CS50*1 Network Camera*
20. *www.iont.ru/projects/rfbr/90197/Preprint.pdf. Searching animates models*
21. Nepomnyaschih, V.A. Searching of general principles of adaptive behaviour of alive organisms and animates, *Artificial Intelligence News*, No 2**,** 2002.
22. *Gutzwiller, M.* Chaos in Classical and Quantum Mechanics*. New York: Springer-Verlag, 1990.*
23. Muhamediyev, R.I., Shunin, Yu.N., Gopeyenko, V.I. Media and active dots strategies. In: *1st International Conference Innovative Information Technologies, November 8-10, 2007, Vilnius. Innovative Infotechnologies for Science, Business and Education: Programme and Theses, No1.* Vilnius, 2007, pp.28-29.
24. Muhamediyev, R.I., Shunin, YU.N., Gopeyenko, V.I. Media and Active Dots Optimal Development Strategies, *Computer Modelling and New Technologies,* Vol.11, No4, 2007, pp. 53-59.
25. Piterson, J. *Theory of Petri net and system modelling*. Moscow: Mir, 1984. 264 p.
26. Nikolic, D.M., Panic, B., Vujosevic, M. Bullwhip Effect and Supply Chain Modelling and Analysis using CPN Tools. In: *Proceedings of the Fifth Workshop and Tutorial on Practical Use of Coloured Petri Nets and the CPN Tools / K. Jensen (ed.) October 2004.* Aarhus, Denmark: Department of Computer Science, University of Aarhus, PB-570, 2004, pp. 219-234.
27. Betz, S., Klink, S., Koschmider, A., Oberweis, A. Automatic user support for business process modelling. *Institute of Applied Informatics and Description Methods.* Karlsruhe, Germany: Karlsruhe University (TH), 2005.
28. Shakirova, N.F. Petri net simulation of players behaviour on financial market. E- journal – *Investigated in Russia*, 2002 – http://zhurnal.ape.relarn.ru/articles/2002/185.pdf
29. *Timed Petri nets* – http://icebear.cmsa.wmin.ac.uk/~alison/embedded/lecture5.html
30. Zaitcev, D.A. Invariants of Timed Petri nets, *Cybernetics and analyzing of system*, No2, 2004, pp. 92-106.
31. Li, X., Yu, W., Perez, S. Adaptive fuzzy Petri nets for supervisory hybrid systems modelling. In: *15th Triennial World Congress.* Barcelona. Spain, 2004 – http://www.ctrl.cinvestav.mx/~yuw/pdf/ifac02.pdf
32. *Very Brief Introduction to Coloured Petri Nets* – http://www.daimi.au.dk/CPnets/intro/verybrief.html
33. *Simulation software for Petry net models* – www.informatik.uni-hamburg.de/TGI/PetriNets
34. Jones, M.T. Programming of artificial intelligence in applications. Moscow: DMK, 2004. 312 p.
35. Jones, M.T. *AI application programming.* Massachusetts: Charles River Media, Inc. Hingham, 2003.
36. Mosalov, O.P., Redko, V.G. Simulation searching behaviour of animate – www.iont.ru/projects/rfbr/90197/Preprint.pdf
37. Nepomnyaschih, V.A. General principle searching of adaptive behaviour of living things and animates, *AI news,* No 2, 2002, pp. 567-577.
38. Emelyanova, G.M., Zaitceva, E.I. Simulation of interactive conclusion procedure of expert systems with microbiological images recognition, *Bulletin of Novgorod's state university*, No19, 2001.