Toward the Methodology for Considering Mentality Properties in eGovernment Problems

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***Abstract*—A general framework for eGovernment is considered. The results of system analysis of different components of eGovernment are proposed. Also the background for considering and modeling of human properties of individuals is described. It is proposed also the models for considering spreading and development of eGovernment in the society. The approach allows forecasting the dynamics of opinion formation, and leading to modeling of the behavior of eGovernment participants. Our approach is based on the attempt to utilize the principles of associative memory from neural networks. Also the models with internal mental structures structure of individuals are considered and results of computer experiments are discussed. Different kinds of opinion evolution are discussed including punctuated equilibrium. Indexes for power distribution in eGovernment are proposed. Further research problems just as recommendations for practical implementations are proposed.**

Keywords—eGovernment, opinion formation, associative memory, reputation, mental patterns, participants, evolutionary approaches, cybersecurity

I. INTRODUCTION

Recently eGovernment became more and more common technologies for society tasks and for society transformations. But practical experience in eGovernment using is far ahead of theoretical foundations of eGovernment. Before in the series of papers [1-4] we had proposed outline of the problems of eGovernment. For example we had considered the eGovernment from the point of view of system analysis [1]; some presumable methodologies for eGovernment considering [2,3]; sustainability of society and of eGovernment [4] ; general models of large social systems [5,6]. But for deep understanding of eGovernment and moreover for practical implementation of eGovernment systems more elaborated concepts, models and methodologies should be developed.

Thus in given paper we propose some approach for accounting mental properties of eGovernment participants, the ways of transformations and the number of related properties, including investigation of system elasticity, calculating power indexes, supply the security of the system etc.

The structure of the paper is next. At section 1 we propose the general scheme of eGovernment droving from the point of view proposed by author concepts. Some detalization of such concepts is proposed at section 2. Section 3 devotes for considering transformations in society and of eGovernment subsystem.

II. CENERAL FRAMEWORK

eGovernment is the society part. So it should be considered in the general frames accepted for considering society and social systems. Usually in general problems of large social systems three 'pillars' had been considered (Figure 1)

All such components (and restrictions on corresponding recourses) also should be considered in eGovernment problems. Remark that scientific community agrees that 'ecology' and 'economy' 'pillars' have more or less developed models. But 'social' 'pillar' has less adequate models. So in discussion of general framework for eGovernment we will concentrates on the methodologies for 'social' aspects. At first stage we will accept that the models for 'ecological' and 'economical' components will supply the forecasts for 'social' components environment. (This is only the approximation because 'social' pillar has impact on other). Following approach from [5, 6] we suppose at the first approximation that he social part of eGovernment consists from N individuals with bonds between them. The individual posses own dynamics of some parameters of social type.

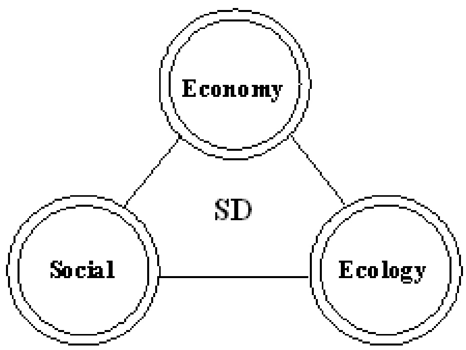

Fig.1. Three 'pillars' of social system

We suppose that the ‘Social’ part of government also has the ‘technical’ part. ‘Technical’ part includes interfaces between participants of eGovernment and administrative (electronic and classical) part. For example ‘technical’ part may include communication lines, computers, analytical and security centres personal interfaces etc. Administration may include top-level leaders, decision-making departments, data collection and processing departments, press centres and many others. Thus at first approximation the eGovernment system may be represented by schemes on the Figures 2, 3. Figures 2 corresponds to traditional arrangement of government. But the Figure 3 display the origin some new aspects of government which include the ‘electronic’ government. The essentially new elements are individuals with access to servers (S) through communications lines and separate departments for decision- making.

Of course such pictures are oversimplified. So it is possible to pose more detailed scheme which can help to understand the structure and role of eGovernment in social system. Remark that evidently hierarchical nature of considered social systems. Such pictures may also help to pose the tasks of investigation and design of eGovernment systems of different level and scales.

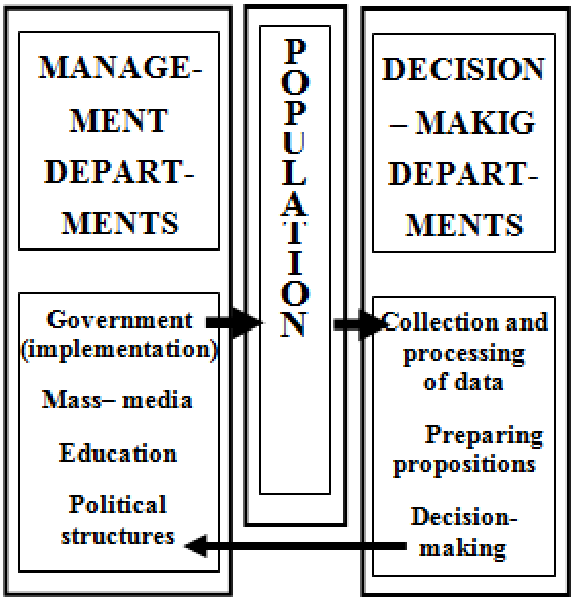

Fig.2. Simple scheme of ‘classical’ government

Of course such presumable schemes also are some approximations for real system. For example because a lack of place we doesn’t show explicitly infrastructures, organizations, forms and industry, cities and villages, social networks and many others. But just such schemes allows for stress some components and aspects of eGovernment. Such pictures illustrate the different presumable scales of eGovernment systems; non-homogeneous character of systems especially of population; hierarchy in systems; interrelations and interactions between subsystems. Probably such pictures may help in classifications and ranking of eGovernment projects and necessary cost evaluation. For example the Scales of projects may expand from local to the country or international level.

It had been stressed by many researchers including author [1-4] that the eGovernment development require the searching of optimal ways for design and financing of eGovernment. Recently it is impossible with applications of mathematical models and approaches. The models are necessary as for global problems (for example for sustainable development) as for searching more local regional commercial projects and solutions. Of course a lot of mathematical models exist for different components of remarked above pillars of system (it may be the goals of separate papers). So here we will concentrate on the aspects most closely related to eGovernment especially to the less formalized (just theoretically).

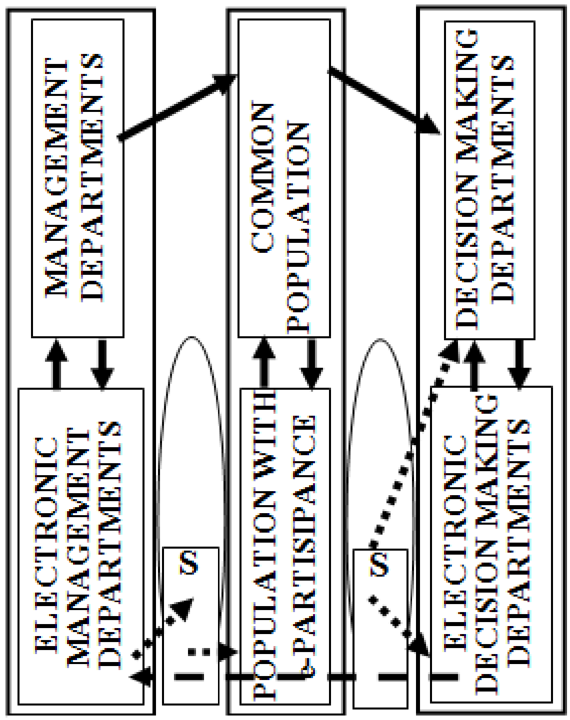

Fig. 3. Scheme with ‘classical’ and ‘electronic‘ government

Namely below we will consider the components related with ‘population’ and ‘government’ blocks from Figures 2,3. Remark that usually any of components of eGovernment include as ‘classical’ as ‘new’ component (‘new’ means related to ‘electronic’ part of eGovernment). The share of ‘new’ components may be evaluated by some formal procedures and indexes. The fracture F (%) of population which use the interfaces (external and through PC) of eGovernment may serves as one of the simple examples. The fracture FG (%) of government departments involved in eGovernment may serves as second example. The part of power in given social system transferred to population through eGovernment is the third example. But just the task of such blocks modelling is very complex (but possible in principle for all pillars and components). For describing one presumable approach for general modelling here we will concentrate mainly on human - related tasks.

III. Short Description Of Associative Memory Approach For Some Social Problems

First of all we stress some problems related to population participants at eGovernment: 1) formation of public opinion on some issue by electronic system; 2) voting on some question through eGovernment; 3) expanding of eGovernment system; 4) evaluation of power distribution between population and administration. Below we propose for illustration the development of methodology the first problem. Remark that in this paper we intend only to illustrate the background of methodology on the base of simplest examples.

A. General ideas

We present here briefly the core idea of the approach and the rough draft of the model that we are going to develop in the research. The proposed model does not pretend to be full and is intended only to demonstrate the basic ideas presented here.

As the first example we consider the simplified problem when all individual are involved in eGovernment system. Lets all individuals pose personal opinion through electronic networks and received some revised information through networks. Remark that the type and volume of information is different. The first is the case of fully open process when all individuals know the opinion of all involved participants. The second case is the backward distribution for all participants only the integral results (for example average opinion – say the percents of supporting individuals or the power of support of some issue).

In order to make easier understanding of the method and to simplify the initial formulas, we consider the idealized society. The opinion development consists of discrete steps, at which the actual exchange of opinion take place. Within each step we identify the sub steps, which describe the dynamic bidding and asking or decision-making processes for every individual. The society consists of N homogeneous participants (in future developments the homogeneous assumption obviously should be removed).

With every participant we associate the state variable $s_i \in S=\{0,\pm1,\pm2,\ldots,\pm M_i\}$, where s_i represents the number of shares that participant i is planning to strength (if $s_i>0$) or to weak (if $s_i<0$) opinion, and M_i is the maximum allowed volume, which represents the power of opinion of participant i_{is} able to accept.

With every pair of participants i and j we associate the variable $c_{ij} \in \mathbf{R}$ – the integral value of reputation that participant j has from the point of view of participant i. This value measures the degree of how well informed; participant j is in the eyes of the participant i. The large positive values of c_{ij} mean that, in the opinion of participant i, participant j is an informed (news, insider) participant, the values close to zero can mean that the participant j is an uninformed (noise, nice) or liquidity participant, while the negative values mean that the participant j is either insider who work against the information he has in order to hide himself, or a participant who is likely to be wrong in his judgment. The reputation variables c_{ij} form a matrix

$$C=\{c_{ij}\}_{i,j=1,\ldots,N} \tag{1}$$

that we call the matrix of reputation. The approach c_{ij} valuation will be discussed later at the end of this section.

As one of the basic characteristics of the system we introduce the concept of a vector field of influence

$$F=\{f_i\}_{i=1,\ldots,N}: f_i=\sum_j c_{ij}\frac{s_j}{M_j},\ c_{ii}=0 \tag{2}$$

where f_i means the integral influence of opinions of all other participants on i participant. The intuition behind this formula is the following. The ratio s_i/M_j represents the opinion intentions of participant j at the current step. It shows the number of opinion participant j is planning to support or reject as a percentage of what his actual power is. The product $c_{ij}\times s_j/M_j$ is the information about intentions of participant j filtered through the matrix of reputation. Thus, the sum (2) represents all the available to participant i information about the actions of other participants, and since it is filtered through the matrix of reputation, it is meaningful and trustworthy to him. We would like to note here, that all the other information, participant i might have, is already incorporated in his initial intensions s_i.

Obviously, the best strategy for rational individual will be to adjust his own initial intentions to the filtered information about others. Speaking formally, we say that every participant is associated with the information utility function, which he is trying to maximize during the decision-making process. It is done by correlating the decision of individual i with the corresponding value of the field of influence f_i.

Thus, we may formulate the evolution equation describing the opinion dynamics (of course it is the simplest possible example of dynamics):

$$s_i(t+1)= \\ =\begin{Bmatrix} s_i+1, & \text{if} \quad f_i(t)>0 \ \text{and} \ s_i(t)<M_i, \\ s_i-1, & \text{if} \quad f_i(t)<0 \ \text{and} \ s_i(t)>-M_i, \\ s_i & \text{otherwise}. \end{Bmatrix} \tag{3}$$

The initial conditions for this dynamic equation are the intentions of each individual to support opinion at the beginning of the opinion forming step. They are formed under the influence of the sources outside the system, and represent the participant's forecast of how well the particular opinion distribution will be doing.

Given the initial conditions for s_i and known values of influence matrix, we may calculate the dynamics of the opinion patterns. Such dynamics is expected to be beneficial for each participant, since it leads to the maximal utilization of the filtered, and therefore useful, information available to him.

Obviously, the system consists of protagonists with different and frequently antagonistic goals. Thus, the actions beneficial for a particular participant do not necessarily benefit the others. Moreover, each participant acts from his own interests and generally, if somebody wins, someone loses. However, all these egoistic individuals comprise the system we consider. Therefore, from the system point of view the question is, whether the defined above dynamics of every participant leads to a meaningful evolution of the whole system, or is this just a disordered, chaotic motion? The answer can be found using the analogy with the physical systems.

As the variable summarizing the evolution of the system, we introduce the concept of 'energy'E, which characterizes the impact all the participants have had on each other in making their supporting/rejection decisions:

$$E = -\sum_i f_i s_i$$

Thus, at any given point in time, 'energy' E characterizes the state of the society. Naturally, we are interested in the evolution of the opinion patterns leading to a state that has the property of stability. By analogy with the physical systems, we will call the state of the system stable if the 'energy' E has a local minimum in this point. As we will see, the system will tend to minimize its energy during the evolution process. To show this, we will first formulate and prove the following statement.

Statement 1. Under the law of evolution (3) the system evolves to a local minimum of energy E.

After energy reaches the local minimum, due to (A1) any change of the state of the system will increase the energy, which is impossible because of (A2). Thus, $s_i(t+1)=s_i(t)$, $\forall\ i$, and the system will retain its stable state until some external forces are applied. Such stable state can be thought as equilibrium, at which opinion pattern takes place. It simply means that all the participants have reached their decisions having maximized their own information utility functions. Since we are assuming that all the external information the participants might have is represented by their initial intentions, evolution occurs. Thus, maximization of individuals' information utility functions leads to the minimum of energy of the system and, therefore, to its coordinated movement during the decision-making step.

The next evolution step begins with the new initial conditions, which contain the new information participants have been able to obtain.

The reputation matrix in the described above model remains invariable during the supporting/rejection or decision-making steps. Obviously, it should change at each evolution step, since participants analyze their own performance as well as the performance of other participants and society as a whole. Therefore, each individual might assign different coefficients to the corresponding elements of the matrix of reputation, which will be enforced at the next evolution step.

Thus, the reputation matrix plays one of the major roles in the proposed model, and the applicability of the model depends, to a great extent, on the correctness and accuracy of the reputation coefficients. The numeric values for the entries of the matrix of reputation are not readily available. However, one of the advantages of the given approach is that it uses already proved and experimentally tested algorithms for the identification of the matrix C via the prior observations of the opinion patterns. This algorithm has the form of the well-known rule from the pattern recognition theory of associative memory models [7]. Its brief idea can be outlined as follows.

Suppose we have recorded information about opinion patterns Z_k, k=1,…,K, where $Z_k=\{s_i\}$ at the time moment k, K is the number of observations, i=1,…,N, N – number of participants. Then the matrix of reputation C can be evaluated as

$$C = \{c_{ij}\},\ c_{ij} = \sum_k \frac{s_{ik}}{M_i} \times \frac{s_{jk}}{M_j},\ c_{ii} = 0 \qquad (4)$$

Of course such model correspond more to the case of opinion formation in parliaments, administrative councils, and cyberspace networks. But a lot of improvements of model can be proposed. Here we describe some of most evident.

Anyway more realistic is situation that only F(%) of population is involved in egovernance processes. Then the frames of the model are the same but for all population only opinions of Ne e-participants are known. This allows further developments. At first the opinion of this Ne participants serves as the information for other part on society by mass-media, social relations etc. Such information serves also as some kind of social questionnaires (with the same difficulties and problems). As such the date of e-participants opinion may serve as the database for other models and approaches. At second the changes in reputations $C=\{c_{ij}\}$ can be introduced. Such changes in reputations may have different reasons – internal and external. Internal changes have internal process of evolution as the source. External changes may have the mass-media influence, straggle of political parties, and education system as the main reasons. Remark that special dynamical equations may be derived for evolution of $C=\{c_{ij}\}$ during time flow [7].

Presumable variety of matrix of reputation properties may follow to a lot of different effects (which we cannot describe here because the lack of space). We only remark here the possibility of periodic solutions for slightly non-symmetrical matrix of reputation and chaotic behaviour of public opinion in the case of sufficiently non-symmetric reputation matrix. Also the abrupt transition between quasi-stable stats of opinion during time in case of non-constant matrix of reputation $C=\{c_{ij}\}$.

B. Accounting the internal structures of eGoverment participants

The next step in development of proposed models is to account the internal structure of participants (we named such participants as 'intellectual').

Let us consider the idealized market as the collection of N intellectual participants. We will consider the process with discrete time steps. Each participant should to do decision (change of state) at each time step in dependence of all participants' states.

Participant's state is described by the variable $S_i(t)\in S=\{0,\pm1,\pm2,\ldots,\pm M_i\}$, which corresponds to the amount of the recourse (opinion, information, materials and so on), which may be gain (if $S_i(t) < 0$) or collect (if $S_i(t) > 0$) by i individual (participant). Here M_i is the maximal volume of its resource (its potential). Interaction of individuals in organization is described by influence matrix $C=\{c_{ij}\}$, $j=1,\ldots,N$, $c_{ij}\in[0,1]$ where c_{ij} – influence coefficient of j individual on i. The influence matrix **C** may reflect the authority power in organization. In simplest model we take $C_{ij}=0$, $i=1,\ldots,N$.

So the collection $Q^R(t)=(\{S^R_l(t)\},\{C^R_{lj}\})$, $i,j=1,\ldots,N$ represents the real state at moment t. Let us consider also $Q^i(t)=(\{S^i_l(t)\},\{C^i_{lj}\})$, $i,j,l=1,\ldots,N$ as ideal pattern of situation from the i participant point of view. Then we can calculate the difference between real and ideal patterns of situation:

$$D_i(t)=\left\|Q^i(t)-Q^R(t)\right\| \tag{5}$$

We suppose that the dynamics of i participant depends on the difference $D_i(t)$ and on the mean influence field by other participants. We accept the influence field $G(t)=\{g_i(t)\}$, $I=1,\ldots,N$ as:

$$g_i(t)=\sum_{j=1}^{N} C^R_{ij}\frac{S^R_j(t)}{M_j} \tag{6}$$

The term $S^R_j(t)/M_j$ in (6) corresponds to the activity of j participant at the moment t. The term $C^R_{ij}(S^R_j(t)/M_j)$ corresponds to activity with reputation accounting. In general case the dynamical law for participant takes the form (F some law for participant's reaction, named frequently activation function):

$$S^R_i(t+1)=F(v_i(t)) \tag{7}$$

where the argument $v_i(t)$ may takes the form:

a) Multiplicative

$$v_i(t)=\alpha(D_i(t))g_i(t) \tag{8}$$

where for example $\alpha(D_i(t))=e^{-kD_i(t)}$. In simplest evident variant we may take:

$$D_i(t)=\sum_{j=1}^{N}\left|S^i_j(t)-S^R_j(t)\right| \tag{9}$$

b) Additive $v_i(t)=g_i(t)+f_i(D_i(t))$, where $f_i(D_i(t))$ – some influence function. The simplest example is:

$$f(D_i(t))=\sum_{j=1}^{N} C^R_{ij}\frac{(S^R_j S^i_j)}{M_j} \tag{10}$$

In this model vector $v_i(t)$ represent the understanding by i participant on the tendencies in system: If $v_i(t) > 0$, then the tendency is to increase the recourse, if $v_i(t)\approx 0$, then the stability is the main tendency, if $v_i(t) < 0$, then the tendency is to reduce the resources.

One of the most usable forms of activation function F in such type models are:

$$S^R_i(t+1)=\begin{cases} S^R_i(t)+1 & \text{if } v_i(t)>\dfrac{\|G(t)\|\left|S^R_i\right|}{M_i} \text{ and } S^R_i(t)<M_i,\\ S^R_i(t)-1 & \text{if } v_i(t)>\dfrac{\|G(t)\|\left|S^R_i\right|}{M_i} \text{ and } S^R_i(t)>-M_i,\\ 0 & \text{otherwise}, \end{cases} \tag{11}$$

where

$$\|G(t)\|=\frac{\sqrt{\sum_{i=1}^{N} g_i^2(t)}}{N} \tag{12}$$

Remark that very interesting development of proposed models consist in introduction time dependence of connections by some dynamical laws. The models described here correspond to the constant bonds.

IV. RESERCH TASKS AND PROBLEMS TO BE SOLVED

Proposed approach allows developing the software and trying to understand some properties of society and particularly eGovernment. Here we describe some examples of computer experiments with the models (5)–(12) which accounting the internal structure of participants and non-constant in time reputation of participants (Figure 4).

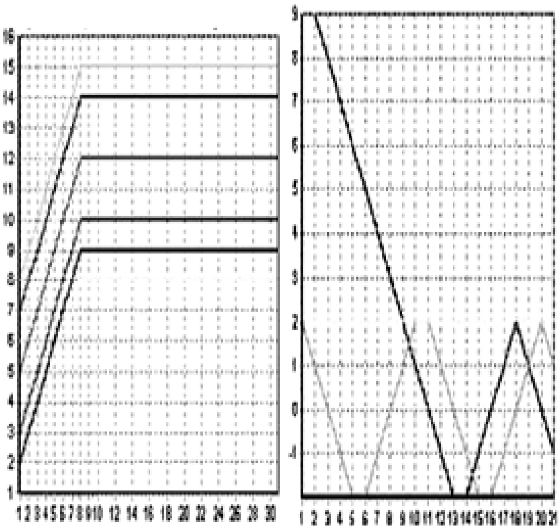

Fig. 4. Example of opinion formation modeling

The horizontal axe corresponds to the steps of evolution of opinion formation. The vertical axe represents the intentions of different participants. The left picture correspond to stabilization of intentions of participants. The right-side picture corresponds to the case of society with changeable reputations during evolution.

The right picture illustrates the possibilities of oscillations of the opinion. The oscillations are intrinsic for society with asymmetrical reputation of participants. Moreover the society with mostly asymmetrically informed participants may have chaotic behavior. Other very interesting phenomenon is the possibilities of sudden changes of stable opinion patterns in the case of variable reputation of participants. It may correspond to real phenomena in the society. Also it may correlate with phenomena of punctuated equilibrium in biology.

Of course till now our computational investigations are model with artificial date and further investigations will be interesting. But just now some prospective issues may be discussed.

First of all proposed internal representation may be considered as some correlate to ontology of participant. Also it may be interesting for considering classical problem of reputation. At second the approach reminiscent usual multi-agent approach. The description of participant remember participant with special representation of the internal and external worlds by network structure. Also the prospective feature in the approach is the associative memory in proposed models. Remark that recently we had found the possibility of multi-valued solution existing in case of individuals which can anticipate the future [8].

V. CONCLUSION

Thus in proposed paper we consider the approach for system analysis and modeling which implement some properties of real society and eGovernment. The main distinctive features are the accounting of internal properties of participants. As the authors envisage, the modeling principles, described in section 3 can lead to the formulation and solution of the following problems:

1. Development of models of opinion patterns for the specific real problems.
2. Investigation of the control and security problems of eGovernment on the base of proposed approach.
3. Introducing and investigation different indexes of eGovernment operating, especially of power of e-participants community.
4. Numerical simulation of specific local eGovernment problems.
5. Analysis of the eGovernment spreading in society on the base of proposed methodology.
6. Forming proposition for building general tasks computing systems of investigation and managing eGovernment with accounting all aspects remarked above.
7. Proposed approach allows re-formulate the problems of cyber security of networks and more generally security of society.

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