On the Evolutionary Process of Network State Space Texturing

O.A.Tsukanova
Faculty of Business Informatics
National Research University Higher School of Economics
Moscow, Russia
olga.a.tsukanova@gmail.com

S.V.Maltseva
Faculty of Business Informatics
National Research University Higher School of Economics
Moscow, Russia
smaltseva@hse.ru

***Abstract* — Different types of mathematical models (both classical and innovative) of the social networks are considered. Conceptual approach to methodology of network community control on the base of textured state space is offered and proofed. Network community is considered as an aggregate information resource, composed of the subject clusters.**

Keywords — multy-layered texture; network community evolution; aggregate information resource.

I. INTRODUCTION

Resource potential of the modern social networks and network communities is of unquestionable interest to the decision-making systems nowadays. These social structures are weakly organized. Their information resources are disintegrated and need to be functionally concentrated. Therefore, information resources management is one of the most important tasks in social structures. Since such structures can be considered as systems with the state-space, so can this task be stated as: "Building of controllable state space in community of practice by means of mathematical simulation". Thus, the possibility of environment modeling on the basis of evolutionary modeling as applied to textured resource environment must be taken into consideration. The single (aggregate) information resource in its dynamic mapping is investigated.

Social network is often considered as a "social structure, engaging set of agents (individual or collective subjects) and defined set of relations (the whole range of communication ties between agents)". But so long as information resources are mentioned, it would be true to consider social networks and network communities on the other part, i.e. to abstract from the personalities and format these structures as a range of agent information resources.

As a result, network community is represented as a dynamic resource system, changing its configuration with time. The changes can be caused by new information inclusion, forming of a new subject community, new group member inclusion etc. The dynamics of resource state changing can be described as a process of gradual improvement or evolution.

II. REVIEW OF MATHEMATICAL MODELS OF NETWORK COMMUNITIES

Implementation of network communities in professional-oriented environment is one of the innovative approaches to the collective decision-making and information resource control.

There are different types of mathematical models that can be used to describe the so-called «communities of practice» (or professional-oriented communities), depending on goals of community making. Researchers give the description of the wide variety of classical theoretical models that are suitable for different network communities. Among them the following types of mathematical models:

- Optimization theoretical models (threshold model, independent cascades model, etc.);
- Simulation models;
- Game-theoretical models (models that are optimal for describing the user interaction in social networks and network communities);
- Stochastic models (models that are based on behavior of community members, depending on influence of different factors – individual, social and administrative);
- Theoretical models of informational influence, control and confrontation (on the base of Markoff process and influence graph).

All these types can also be used as a base to modeling of concrete community of practice. But to apply above-mentioned and other classical theoretical models, the modern model of network environment should be formed. This new model should reflect the specifics of the unstable, «floating» structure of network communities and take into account the goals of community-making. To this effect suits the conception of multidimensional texture that is often used in geology and also in some latest researches on information processing. This model illustrates the dynamic model of network community environment and will be described therein under.

III. STATIC STRUCTURE OF THE NETWORK COMMUNITY

So, we are considering the **static** structure of network community as a range of information resources. Let it be represented by the finite number of subject clusters – n (the consolidation of information resources, belonging to the same subject, is meant under the "subject cluster"). Thus, in instant moment of time t_0, it is rational to illustrate the structure of network community as a one-dimensional directed graph (fig.1).

978-0-7695-5072-5/13 $26.00
DOI 10.1109/CBI.2013.65

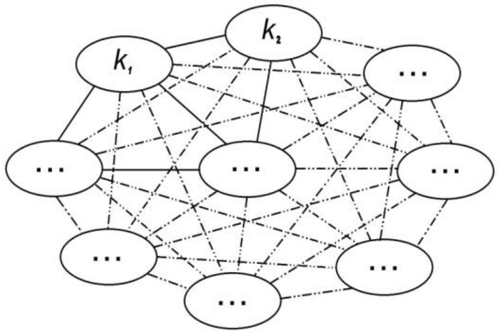

Fig.1. Network community as a graph structure.

In the figure 1 the following conventional signs are used: information resource clusters (k_i , $i = 1, \ldots, n$) are symbolized as ovals, and relations (s_j, $j = 1, \ldots, m$) between clusters of different subject area – as lines.

Thus, the structure of the network community is represented by the oriented graph G: = <K,S>, where:

- $K = (k_1, k_2, \ldots, k_n)$ is nonempty set of subject non-overlapping clusters of information resources;
- $S = (s_1, s_2, \ldots, s_m)$ is the set of intercluster relations.

Therefore, network community, considered in a form of an aggregate information resource, is represented by a whole range of nonempty subject clusters and a range of ties between them.

Subject clusters are used for the information resource consolidation for the purpose of systematization of clusters with the identical subject orientation. So, these clusters are storages of similar information.

Relations between clusters ensure the following aims, for example:

- the possibility of using the whole data array, that is represented by the aggregate source;
- joint using of several subject clusters in collaboration for the common aim.

Further development of environment model requires using the dynamic procedures.

IV. Dynamic Change of States in Network Communities (or Textured Environment Building)

The whole range of graph dynamics researches in different branches of knowledge, e.g. in different mathematical sciences and theoretical physics [1, 2], can be used as a methodological base in the case of network communities investigation. So, as it was already mentioned above, the state changing of network community elements can be represented as a multidimensional textured environment. Each layer of this environment illustrates a new clusterization in connection with changes in filling of aggregate information resource. The layers are considered as sequentially evolable with time, or gaining the perfect quality with every qualitative change (for network community development).

Considering the community structure change with the conversion from the moment t_i to the moment t_i+1, it may be noted that the period of time for the conversion to the next (higher) layer is not constant and depends on the significance for the network community of new information resource adding.

The structure change in moment t_i (important to the network community) serves as a criterion of conversion to the next layer.

This conversion occurs in the following cases:

1. The changes of the object structure (e.g. adding the new agent to the community or new subject cluster organization);
2. The changes in relations between objects;
3. Simultaneous changes of both the object structure and relations between objects.

This way the new layer of higher evolutional level of texture is formed. And the formed texture is a representation of evolutional development process.

The order of new texture layers appearance is illustrated in the figures 2 and 3.

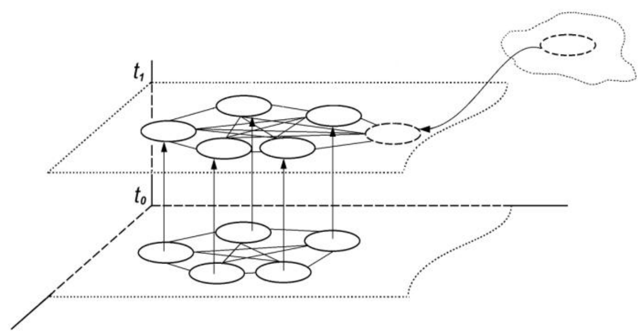

Fig.2. New layer (t_1) forming in case of adding information resource of an absolutely new subject

The diagram in the figure 2 can serve as an example of conversion to the next layer in case of adding the new information resource. If this resource is useful for network community, has the cognitive component and presents the new subject to community, then the new cluster will be formed and the whole system goes to the higher level of evolution (t_1). If not, there will not be any structure change and new texture layer will not be formed.

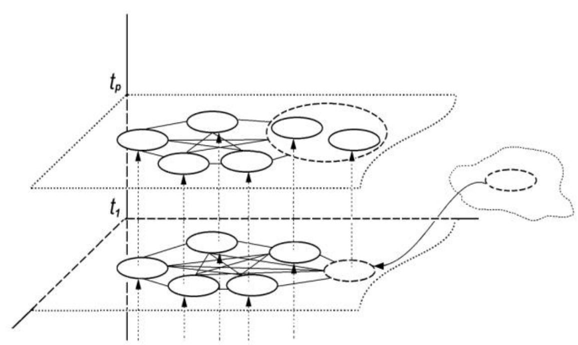

Fig.3. New layer forming (t_p) in case of adding the useful information resource of a common subject

There is another practical example of the new layer forming in the figure 3. The newly included information resource is useful for the aims and qualitative development of community. It also has the cognitive component, but doesn't bring the new subject to community. So we can add it to one of the already existed subject clusters (t_p).

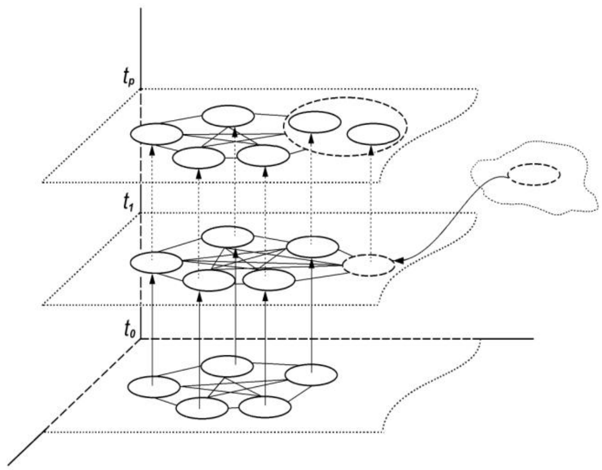

Fig.4. Network community state space evolution in the form of textured resource environment

Thus we have the following picture of network community environment: the network community state space evolution can be illustrated in a form of multilayer texture. Using the above mentioned examples (that are shown in the fig.2 and the fig.3) in combination, this textured environment has a form, represented in the figure 4.

V. Logic of the Control Mechanisms

In case of setting the task of information resource management, directed at the qualitative development of the network community, the semantic component of incoming information takes on a particularly important value. So, the suggested mathematical models should make it possible to transform the incoming information into knowledge (both information and knowledge must be in a mathematical representation for the ease of mathematical and programming processing).

The aims of information resource control in the controlled network community can be attained by means of the different optimization methods and algorithms. As an example of such methods the following optimization mechanisms can be suggested:

1. Accumulation optimization mechanism that defines the resource accumulation process in the concerned system. This mechanism makes it possible to create an "evolable data library". Thus the knowledge component gains the special importance in this case, because exactly this component allows meeting the requirements of the qualitative and useful data filling of controlled state space in professional-oriented network communities.
2. Acceleration optimization mechanism that makes it possible to increase the speed of transition process to the new, higher level of the textured environment that means the higher level of the network community qualitative development. The suggested model allows to draw the different manipulation methods for the previously mentioned aims. The manipulation supposes the selective influence on the certain subsystem resource, depending on its weight and authority in the concrete network community. Thus the accurate choice of controlled object, character and intensity of control influence, working out the development criteria and deviation parameters get the special importance.

In the first place, the semantic component, the substantiveness criteria and allowable thesaurus should be defined for the aims of qualitative filling and development of the network community.

Semantic component and substantiveness criteria depend on the specifics of using the information resources in the concrete systems.

For the aim of allowable thesaurus defining, the 2 main control strategies should be marked out:

1. Supporting the information content on the «harmless» level for the network community. This goal can be reached by the way of blocking the elements that cause the deviation from the defined bounds. This strategy allows to keep the community operation on the stable level.
2. Implementation of the corrective influences. That means the controlled expansion of the allowable thesaurus boundaries or giving permission to include (in definite cases) some elements of the «alarming» thesaurus. Such permission will be reasonable, if the possibility of new subject areas development is established. This possibility can be provided in consequence of the growth of interest to the injected subjects.

VI. Development Prospects of Network Community Control

As a result of considered procedure of state change in the network community (or the procedure of multidimensional textured environment building), the network community evolves, forming something like informal cognitive institute. It is methodologically notable, that most of the main processes in this institute have self-organizational character. And these essential, self-organized processes can be made controllable with the help of adding the optimization methods to the executive system.

As an example of practical optimization methods, the following mechanisms are to be mentioned and taken into consideration:

- Acceleration of conversion to the higher layers of evolutional texture;
- Information resource accumulation with the aim of the evolable data library building;
- Investigation into the opinions of community members;
- Investigation into the reputation of community members;

- Evaluation of the relation closeness between network community members;
- Network community objects manipulation (selective influence on individual objects) in case of one control centre.
- Selective influence on individual network objects in case of several control centers and their possible confrontation.
- The conciliation of the interests of executive groups (or individual leaders) in case of several separate control centers.

The presented model of multilayered textured network environment can be used as a base model for further development of network community control model that describes the control procedures for effective progress of network community.

REFERENCES

[1] Bombelli L., Lee J., Meyer D., Sorkin R.D. Space-time as a causal set. Physical Review Letters, 59/1987. 521-524 p.

[2] Rideout D.P., Sorkin R.D. A Classical sequential growth dynamics for causal sets. Physical Review D, 61/2000. 16 p.