Convergent Decision Support System
with Genetic Algorithms and Cognitive Simulation

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Abstract: For speeding-up consent achievement in a group of distributed actors it is worth to stabilize and organize underlying factors. For coordination and for mutual understanding among group members, we propose technology, which is based on fundamental thermo-dynamical principles and utilizes soft computing, cognitive simulations and ill-defined problem solution techniques. Based on proposed methodology a cloud service is realized. System was tested on a number of real life problems during branch and corporate strategies development.

Keywords: chaos, cloud services, cognitive, consent, convergence, decision, soft computing, networking, support systems, ill-posed problem solution, purposefulness, stabilization, strategic conversation (meeting)

1. INTRODUCTION

Actors (natural or artificial subjects, team members, robots, etc.) have to exploit methodologies and techniques of speed-up group decision making processes in order to challenge continuously changing environmental dynamics. For example, in a global market, corporate executives have to accelerate the processes of mutual understanding regarding targets, required actions and legislative environment. There are several trends, mostly organizational to support these processes such as: bureaucracy reduction; flattening of control hierarchy; horizontal links encouraging responsibility rising [Hollender J. et al., 2010] etc. Present market is getting more complicated and rapid. Its predictability is vanishing. Emotions, Thoughts, feelings, some transcendental states of mind of its actors affect much business planning [Cooper R., 2000]. Such unpredictability require more resources to keep corporate competitive thus time lag for decision making is getting smaller and smaller. Different subjects, have to use appropriate approaches for speed-up group decision making processes. They have to use such typical elements of decision making structures (archetypes), as goals, resources and actions [Raikov A.N., 2008]. Very important characteristics of the decision making processes are stability and purposefulness. It is interesting to note that different teams have comparable behavioral and decision making archetypes under similar conditions that is a global convergence phenomenon.

In prior practice, to build business strategy, it was usual to involve external resources, like consultants. New rules state that a group of people with a problem could discover its solution themselves with limited list of involved experts using expert sourcing methods. In some cases crowd sourcing could be utilized instead of experts. These strategy development processes could be viewed as convergent strategic meetings [Raikov A.N., 2008]. Modern techniques such as cloud computing [Jamsa K., 2013] are very useful to organize decision making processes of the distributed groups of actors. They can provide working environment for the strategic meeting’ participants and exploit knowledge of experts in different fields in the way that significantly speed up decision-making process. We propose an environment which covers two functional parts: 1) interaction with remote experts, and 2) analytical modeling unit. The first system provides communication between actors through the list of prescribed network decision making procedures. The second part utilizes simulation such as cognitive modeling or analysis of hierarchies in order to test developed strategies and to bind distributed and sometimes fragmented knowledge of actors into the solid framework. Result of the system operation is a machine – readable knowledge base which describes the solution of the specified problem and could be utilized by actors (even by artificial agents) in their daily operation. We tested the system through many strategic conversations and meetings with governmental bodies and with corporations in Russia [Raikov A.N. 2009].

2. TYPES OF DECISION MAKING PROCEDURES

We consider several types of network decision making procedures. In general the key point is in collection of the group members’ (or expert’s) opinions concerning the event in the form of questionnaires with optional comments. It is useful to provide semantic scales for the questions, where semantic scales are applicable. On the basis of the experts’ answers a cognitive simulation model [Maximov V., 2001; Avdeeva Z., 2008] of the event is constructed. We name this procedure Expert Comments Formation.
Electronic Brainstorming. Network consensus decision-making on the base of Electronic Brainstorming Method is the most difficult group expert process. Electronic Brainstorming process may be divergent or convergent and is useful for creating new ideas. The members of expert circle have restricted time to watch and listen to other colleagues, or read experts’ messages. They are able only to answer moderator’s questions. It is useful to combine divergent electronic brainstorming process with convergent technology for getting fast experts’ consensus concerning getting new group ideas.

Strategic Conversation (SC). For getting effective strategy development it is necessary to organize a SC on the base of SWOT-analysis, Cognitive simulation and the Analytic Hierarchy Process methods [Maximov V., 2001; Raikov A.N., 2008; Saaty T.L., 1988]. It is supposed to be performed as follows: goal-tree creation; factors revelation, formulation of the problem priorities; the ways of decision finding. In order to formulate targets and paths of development the expert process must be strictly regulated by moderators. Experts should provide answer to moderators’ questions in the shortest way.

Crowdsourcing [Howe J., 2008]. Crowdsourcing systems enlist a lot of of humans to help solve different problems. Numerous such systems have appeared on the internet. Prime examples include Wikipedia, Linux, Mechanical Turk-based systems, and much effort is being directed toward developing many more. This effort appeared under many names, including peer production, user-powered systems, user-generated content, virtual collaborative systems, community systems, social systems, social search, social media, collective intelligence, crowd wisdom, smart mobs, mass collaboration, and human computation. The topic has been discussed extensively in books, popular press, and academia.

Virtual collaboration [Wong P.C. et al, 2009]. Networking experts represent many different subjects. Sometimes they do not have time to get the consensus on the question. The most effective way to get the consensus is use Collaborative Visual Analytics Tool. The designer of this tool is familiar with the situation's complexity and can effectively communicate with experts from another problem fields.

It may be most difficult type of networking experts’ decision-making procedures. For example, in the production of products in the industry may need a series of related expert procedures. Such cases include innovation processes or production process uses for its quality management control. Example of such procedure is provided on the Fig. 1.

The experts’ works has considered mostly efforts in discussing procedures and algorithms. Without restrictions experts do not consider problem convergence. Most of the systems involving experts have divergent characteristics. A lot of questions, such as how to evaluate users to make the decision process convergent, became challenges for sciences and engineers.

Taking into account time deficit of company’s top-managers and members, and fast external events dynamics, strategy development process by small group or a large number of people should not be time consuming. For this, it is necessary to consider information processing laws that provide consent attainment within limited time.

3. STABILITY AND PURPOSEFULNESS

Main criteria characterizing consent achievement process are two factors: stability and purposefulness (convergence) [Raikov A.N., 2008]. If the task is to attain the meeting’s result in limited time and with inviting expertsourcing and crowdsourcing, it is necessary to keep the process convergent, while, group resources and targets could be unclear, fuzzy or ill-defined. Control process of the network meeting should be organized the way that meeting will converge to some goal.

Realizing strategic meeting we can characterize the process of consent attainment as an interaction the members of team, experts group and of the crowd.

Through many experiments we have confirmed that required stability and purposefulness could be attained if meeting procedure is organized the way that it takes into consideration the fundamental thermodynamic principle. Soft computing and cognitive simulation provide sufficient framework of such principles incorporation into meeting procedures [Raikov A.N., 2008; Ulyanov S.V. et al, 1998]. Other items for consideration are methods of cognitive psychology, Eureka Effect [Perkins D., 2001; Gigerenzer G., 2007], fractal theory [Peitgen H.-O. et al., 1986], image recognition, quantum calculation [Ulyanov S. et al, 2001], and other problem specific technologies.

Topological spaces are helpful in solution of such kind of problems, when we are to create the model of the situation using qualitative factors (concepts). It is convenient to make experts to working with a concepts mentioned during...
discussion rather than with plain numbers. Working with concepts, when solutions are accompanied with ill-defined factors, when emotions and thoughts involved [Perkins D., 2001; Gigerenzer G., 2007; Cooper R., 2000], distances between concept points are immeasurable, instability of the solution can be avoided only by human wisdom, which allows to introduce into decision process the qualitative information.

Thus the moderator (the subject who is conducting meeting) can attain the stability and purposefulness of the discussion by [Ulaynov S.V. et al., 1998; Raikov A.N., 2008]:

- information openness of a discussed theme;
- strictness of conversation procedure;
- changing rates of openness and of strictness;
- level of an internal chaos generated during discussions.

Following topological formalisms moderator can also derive the following simple recommendations:

- Separate goals, resources and actions;
- Goals should be categorized as hierarchy goals tree with levels: main, internal and external;
- Variety of means should be separated into finite number of parts;
- Control all aspects of problem’ solution, bindings between goals and resources;
- Never underestimate small factors, etc.

These conditions are necessary for the stability and purposefulness provision of team problems’ solutions. These assumptions and recommendations help the moderator to accelerate in making qualitative resumes regarding what the team is heading to; finding the common consent ways of their mutual strategic solutions.

4. EXPERT SERVICE MODEL

Our practice of using experts’ procedures in network (distributed) environments shows that we have to consider many restrictions that differ network based procedures from the traditional group procedures when actors facing each other [Gubanov D.A. et al., 2011]. For example, experts in the web cannot understand each other quickly; they do not fill each other deep enough. Distributed meeting participants cannot quickly reach agreement and discussions tend to have a divergent dynamics.

One obvious way to leverage these problems is to provide meeting participants with the working environment which can minimize the faults of distributed nature of the meeting in the network. The best way is to use cloud services [Jamsa K., 2013]. From the usability and organizational stand point cloud service provide the following benefits:

- software as a service platform requires less resources for integration and maintenance comparing with traditional software solutions.

Developed cloud service has the following features:

- system implementation ensures high quality of management decisions, not reachable by traditional telecommunication technology;
- use of innovative mechanisms to support decisions (i.e. semantic interpretation of text messages, swift mutual understanding of geographically remote participants and experts, network expertise procedures in real time, strategic planning);
- introduction of quick brainstorming among geographically distributed experts;
- remote moderation of group decision-making process;
- availability - service is provided to clients from anywhere in the world where there is an internet access, from any device supporting internet browsing.

Typical procedure of the decision attainment in the developed environment combines the following steps:

- understand that there is a problem;
- gather information on the issue;
- select the method of analysis of the problem;
- matched to the problem the experts from the roster;
- formulate and send the query to the experts;
- collect answers from experts;
- build a computer model (cognitive, hierarchy etc.);
- solve the direct problems using cognitive simulation;
- solve the inverse problems using cognitive simulation and ill-defined problem solution methods;
- formulate the decision.

Usually it takes several days to pass through all proscribed steps. Some sort of problem usually precedes the network strategic meeting (Network Strategic Conversation). Maybe it could be in coordination or conflicts, unsatisfactory actions of members. This initial state has to be described by the responsible members. Then it is necessary to conduct strategic analysis and to define what and how should be done to develop a plan or the road map.

Experience of carrying out strategic conversations demonstrates that separate proposal or factors of the discussed problem in the middle of network conversation cannot be reconciled essentially or harmonized. Meeting targets or underlying factors could be hardly discovered or formulated. Paths, resources and means of the achievement should be also formally given. In case if the situation require preliminary analysis, moderator can use virtual collaboration method at any step of the meeting procedure.

5. CLOUD SERVICE SUPPORT

Cloud service support and computer simulation are utilized to achieve the effects of synergy and convergence in network group expert decision-making. There is the proper convergent methodology, visual equipment, telecommunication, computers, artificial intelligence
methods, including soft computing and cognitive simulation methods.

Cognitive simulation system provides mechanisms for realization of the procedures:

- Assistance in the selection of the expertise technology utilizing methods of SWOT-analysis, analytical hierarchical processed;
- Expertise request formulation, including formulation of the requirements, scales, depending on chosen expertise method;
- Keeping the register of experts, automated experts selection from the register, experts rating and binding to the problem field;
- Experts invocations through automated requests, experts’ comments collection and storage in the appropriate database;
- Design of the schematics of the related factors, including values of the corresponding relations evaluated by experts. Schematic design depending on the chosen method may be represented as a hierarchy, cognitive model, comparative matrix, etc.;
- Justification of the decision projections, scenarios evaluation using modeling;
- Result representation in a required form.

Typical procedure of network expertise is presented on the Fig. 2.

Multilevel factor hierarchy design. Each level in the hierarchy model may represent goals, sub-goals, criteria, functions, tasks, directions, projects, activities, actors and so on. Usually number of levels in representation hierarchy is limited by four. In some cases building up of the hierarchy is sufficient for actors to make a right decision.

Fig. 2. Network expertise schematics

Graphical result representation in a form of dynamic diagrams is presented on the Fig. 3.

For justification of the solutions, including modeling results, system provides a dashboard, represented on the Fig. 4.

Modeling system provides the following options:

Cognitive modelling and simulation. System provides mechanisms to build up relations of the kind “all to all”. Matrix representation of the relations is illustrated in a form of the directed graph, where nodes represent factors, and arrows represent corresponding relations. Design process helps to understand the problem structure by the decision makers and improves problem understanding by the participants.

Solutions justification based on cognitive modeling. System provides mechanisms for direct problems solving on cognitive graph by evaluation of the temporal dynamics of the result factors for the provided by user input dynamics combination.

Solutions justification using reverse cognitive problem solver. Reverse problem solver utilizes soft computing techniques such as genetic algorithms for acquisition of the optimal input combination which fulfills specified conditions. Sample solution process is represented on the Fig. 5.

Solutions justification based on analytical hierarchical process. It provides powerful mechanisms for evaluation of factors importance. It provides methods for evaluation of factors impact on the target thus on the successful problem solution.
Result representation. As a result, system provides viewers of the expert’s justifications of the solutions drafts. System also provides data export mechanisms for further analysis.

6. APPLICATION EXAMPLE: FORECASTING OF AN R&D PROJECT SUCCESS

Every R&D project can be characterized by the consumer, reputational, scientific and technological or other factors that affect its success in the future. It can be more than thousand factors for the project assessment, but actually it is enough to analyze several key factors to make a decision.

Some R&D project could be characterized by financial parameters of several millions or even billions of dollars. The project may last from one to several years. It is always useful to assess its strategic success, its demand in the market in the future. The general scheme for the project evaluation is usually the same, but evaluation methods may differ.

Project success - is a vague concept. It can be measured in political, economic, social and technological dimensions. Success is not always possible to assess in quantitative terms: profitability, Key Performance Indicators (KPI), money etc. Parameters can be reputational, holistic and others. The forecast is convenient simply to show numerical score, for example, on an enumerable scale from -1 to + 1. The first estimate - no success, the second score - success is guaranteed. Interim assessment shows the magnitude of the risks running the project in question.

The model for success assessment is shown on the Fig. 5. This model is based on the convergent management methodology, which defines the necessary structural conditions to optimize the achievement of scientific, technical and commercial objectives.

The number of factors and their relationships does not depend on the circumstances. They have a paradigmatic character. For example, such relations are relations of communication (contribution) to the success of Management (all components of management, with the exception of marketing, which is a separate factor), reputation (image, merits, popularity, confidence, leadership, etc.), and complexity (integrity, holistic).

Cognitive simulator screen after setting of the simulation model of the R&D project assessment is shown on the Fig. 4.

Key role to assess the success of the R&D project play the experts’ answers to the questions, that help to form the model parameters. Verbally these questions could be described as:

- Estimate the size and growth dynamics of intellectual property?
- Appreciate the opportunity to receive additional funding (access to capital, loans, credits, experience of development funds)?
- Estimate the value of assets, their role, including vision of the project?

Each question is accompanied by the evaluation form with fuzzy scale representation.

After treatment with the experts' answers and creating the model, we seek the solutions of direct and inverse problems (Fig. 4). The solution of the direct problem answers the question: "What happens, if there are some efforts?" (Fig 6). The decision of inverse problem answer to the question: "What should I do for the succeed of the project?" (Fig 7).

The solution of the direct problem shows the comparative chances of success of different exposure scenarios for the implementation of the project. However, this will not always be the best and optimal result. To justify recommendations for obtaining optimal solution actors need address the inverse problem solver. It helps to get balanced team effort.

To solve the inverse problem we use a genetic algorithm and method on the cognitive model. Classical gradient descent based method is also applicable, but it gives substantially less management options than the genetic algorithm results.

Fig. 5. Model for R&D project success assessment

Fig. 6. The solution of direct problem example.
7. CONCLUSIONS

For group of people (team) in any organization the boss gradually becomes a leader and employee receives more satisfaction from his job and a team gets much more resources for the actions. Mutually defined strategy integrates efforts of all members for getting more effective performances and diversifies the busyness of their company. It induces marketing thinking for the employees and increases their motivation to efforts.

Organization control is reoriented towards quality, transparency and responsibility. Perspective and current activities common organization structure variations receive sense and goal.

Presented approach was verified in real practice during creation of: strategic program of complex reconstruction of the territories of the existing site development of Moscow; strategies and development concepts of: Russian market of information technologies, Russian-Israel science and innovative partnership, and also in the fields of high and professional education, public health service, social security program, housing and communal services, youth policy, religion policy of Russia’s regions etc.

This system was selected by customers both on the government and corporate levels, mainly those who have situation rooms, conference rooms to support high-level decision-making process. During the first two years of using this system, it has implemented at the facilities on the federal and regional level in Russia, i.e. the administration of the Russian President, Ministry of Education of Russia etc. At present, we are transforming an existing system into the cloud service in order to provide its services on the global market.

Provided results were implemented successfully in development of several governmental situation centers in Russia and for creation of the development strategies of commercial companies such as: Tumen Oil Company, Kursky Bearing Plant, Cheboksary Electro-Hardware factory etc.

REFERENCES


