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STATE-OF-THE-ART OF THE MANAGEMENT INFORMATION INFRASTRUCTURE OF ARCTIC REGION DEVELOPMENT: CHALLENGES, TRENDS AND LIMITATIONS

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Abstract. *Background*. The study is aimed to development and analysis of the computer-driven technologies for resilience and safety risk-management of the critical infrastructures of regional socio-economic systems in the Arctic region of Russia. It is important to improving the quality of information support of the management activity in this dynamic problem domain. *Materials and methods*. In terms of systems and functional-target approaches the state-of-the-art, role and advanced directions of the information technologies and system development in respect to hot-button issues of regional management and needs of Arctic region have been analyzed. The place of information technologies in research and education, personnel support of regional economy, industrial ecology and socio-economic security management of the region are in detail considered. *Results and conclusions*. It is shown, that an efficient regional management in the Arctic region of Russia is impossible without use of the developed network-centric information infrastructure corresponding to goals and limitations of the Arctic region sustainable and safe development, as well as without systems integration and cooperation at the international level making the special demands to information technologies in the field of security support and management of the socio-economic systems. The ways to enhancement the network-centric information infrastructure for the purpose of management of the Arctic region development are proposed.

Keywords: information technologies, management, regional development, quality, decision support system, safety, Arctic region

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СОВРЕМЕННОЕ СОСТОЯНИЕ ИНФОРМАЦИОННОЙ ИНФРАСТРУКТУРЫ УПРАВЛЕНИЯ РАЗВИТИЕМ АРКТИЧЕСКОГО РЕГИОНА: ВЫЗОВЫ, ТРЕНДЫ, ОГРАНИЧЕНИЯ

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Аннотация. *Актуальность и цели*. Исследование направлено на развитие и анализ компьютерных технологий управления жизнеспособностью и безопасностью критических инфраструктур региональных социально-экономических систем Арктической зоны России для повышения качества информационного обеспечения управленческой деятельности в этой динамичной области. *Материалы и методы*. С позиций системного и функционально-целевого подходов анализируются современная ситуация, роль и перспективные направления развития информационных технологий и систем применительно к актуальным проблемам регионального управления и потребностям Арктического региона. Подробно рассматривается место информационных технологий в научно-образовательной сфере, кадровом обеспечении региональной экономики, промышленной экологии и управлении социально-экономической безопасностью региона. *Результаты и выводы*. Показано, что

эффективное региональное управление в Арктической зоне России невозможно без использования развитой сетевой информационной инфраструктуры, соответствующей целям и ограничениям устойчивого и безопасного развития Арктического региона, а также без системной интеграции и кооперации на международном уровне, предъявляющих специальные требования к информационным технологиям в области обеспечения безопасности и управления социально-экономическими системами. Предложены пути совершенствования сетевой информационной инфраструктуры управления развитием Арктического региона.

Ключевые слова: информационные технологии, управление, региональное развитие, качество, система поддержка принятия решений, безопасность, арктический регион

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Introduction

The Arctic region of Russia (ARR) comprises the areas of the Murmansk, Arkhangelsk and Krasnoyarsk regions, Republics of Karelia, Komi and Sakha (Yakutia), Nenets, Chukchi, Yamal-Nenets autonomous areas. The main peculiarities of the ARR are the following:

– they are mainly raw material resource areas and their importance is permanently growing due to exploitation of newly discovered oil and gas deposits;

– the climate of the areas is severe and in some places extremely hard, vast territories are scarcely populated whereas the systems of communications habitual for more southern areas are lacking;

– the nature is extremely vulnerable and slowly restorable and in some places the aftereffects of the technogenic activity are often irreversible.

This unfavorable combination of the factors has become mostly evident recently. There is observed a damaging basic break going in every sphere that has been caused by objective reasons common for Russia. On the other hand, there is a strong understanding that it is impossible to continue living as before. Thus, the subjective basis for reformation has been provided.

The model of "sustainable development" [1] comes into use more actively. The concept of "sustainable development", first of all, is supposed to grant exploitation of the regional resources so that the interests of both the present and the future generations are taken into account. So the principal basis to regulate various activities in the ARR is restricted by the following factors:

1) Restricting activities in exploiting and processing of the nature resources that cannot be satisfied from other resources, to the amounts necessary to meet only vital needs.

2) Restraining the requirements to keep ecological discipline up to forbidding industrial activity causing overloadings on ecosystems (recultivation of damaged nature landscapes during and after completing industrial activity).

3) Controlling demographic situation in the region to maintain the number of non-indigenous able-bodied population at the necessary minimum level (special social and demographic policy to the indigenous people).

4) Maintaining the necessary ratio between damaged and untouched territories to secure ecological balance in the region; preserving the nature genofond and securing the conditions for traditional activity of the indigenous people.

Regional, interregional and international cooperation and integration for sustainable development of the ARR demand a mighty information support. The information infrastructure constitutes a very important element of the ARR regional infrastructure that backs up the development of the region in spite of the mentioned restrictions. Here information technologies are the elements of this infrastructure. To specify the role and place of the information technologies for the development of ARR it is necessary to analyze the global aims of establishing the Regional Information Infrastructure (RII) [2]. The global aim of the RII is to insure the level of information support that can meet the demands of the present time. This level is determined by completeness, exactness and promptness in delivering the information. Thus, when establishing and developing the RII it is necessary to decide if the current level of information support fits the challenges of ARR development. This is only the first problem. The second problem arises in case if such a level is not enough and it is necessary to define the level of information support necessary for today, for tomorrow and further on. This means what kinds of information are needed with what exactness and promptness. If it turns out

that the level of information support is not enough and it is impossible to raise it by simple quick measures (e.g., by organizational means) and it is necessary to establish or develop the existing information technologies then this will constitute the third problem.

The answer to the first problem is evident. The level of information support is surely insufficient. This refers to coordinated solving of the majority of problems which appear at the regional, interregional and international levels.

It is not so easy to get an answer to the second problem, since here it is dealt with the system task of information analysis of the problem. This problem is to be solved in every case by its own intensity. Sometimes it is enough to analyze the problem qualitatively that is to define what kind of information is needed as well as its exactness and promptness. But very often it is necessary to apply special computer-aided methods and models in order to settle the second problems.

To obtain the answer to the third problem the world practice recommends to use local and distributed computer networks, data bases, including those with distant access, as well as developed means of information processing and presentation such as maps, graphs and tables. There is a great variety of such means. It is not so easy just to choose what exactly is needed to adjust the means for specific task and develop the missing elements. Here it must be kept in mind not only the needs of today, but it is important to minimize the costs for rearranging the given information technologies for the coming challenges of tomorrow.

Problem statement

The answers to all the three questions discussed above make it possible to create the information technologies that secure achieving a corresponding level of information support. In this case the main problems of RII can be settled. They are the following:

1. The information support of socio-economic processes within the ARR taking into account both the aims and restrictions of the regional sustainable development as a whole, and the interregional and international relations. There might be arranged information acquisition, retrieval, processing, transfer and representation of each data type in the form acceptable for the most user categories. In other words, this is a problem of creating a regional information fund of the ARR with methods and means of its arranging, developing and using.
2. The information support of decision-making at various levels of regional management. It is necessary to provide the necessary information acquisition and analysis to be able to assess decision versions, to choose a certain decision version or several versions. The chosen version and its alternatives are to be conveyed to the decision maker.
3. The formation and development of population information needs of the region. Here it is meant that the necessary conditions are created for a person to be interested in raising the level of the personal information support. This is a very important problem since the information technologies won't be retrieved if this problem is not solved. For particular technologies these challenges become specifically target oriented.

Considering international cooperation in ARR the information technologies become very prominent, because the region has become involved in close cooperation with the countries of Northern Europe with their historic, linguistic, cultural, and other peculiarities. The level of applying the information technologies differs greatly. In the Scandinavian countries this level is traditionally very high. The ARR has always been retarded in this field, especially as compared with the Scandinavian neighbors. Thus, when developing the regional information infrastructure of the ARR the first and foremost task is to "pull" the region into the process of assimilating the information resources for prospective regional development. Then it will be reasonable to elaborate a new strategy mostly acceptable for the ARR conditions that can provide using the information technologies in the areas preferable for the region.

Challenges and preferable areas of IT application in the ARR

The recent years in developing the information technologies in the Russian North have demonstrated a line of priority areas in using these technologies to promote development of the region. For example, the joint Norwegian-Russian projects “Barents ICT Cluster”, “Barentswatch”, “Barentsmap” and “Barentsnet” [3] concentrate on the problems of "pulling" the ARR into applying the global information resources and creating the common information environment. The projects draft a direct input for Russian users into the global network Internet as well as access to the data bases of the Russian participants through this network. These projects seem very prospective first of all because they lay down the basis for further creation and devel-

opment of information technologies of the Russian North. The Russian side gets the access to information resources of the western neighbors and a possibility to use modern reliable prompt methods of access. This will surely become an important stimulus to provide an access through the Internet to the existing and newly developed information resources in the ARR. Thus, a common united information environment will be created throughout Northern Europe.

Information technologies in the formatted and newly forming preferable directions of interregional and international integration and cooperation constitute another class of prospective information technologies.

The first class deals with the information technologies in nature resources exploration (forests, fish, mineral resources, oil, gas, etc.). Here one of the main problems is creation of data bases. To solve the problems of integration and cooperation it is necessary to make these data bases accessible by standard means of distance access. Probably it will become necessary to obtain sanctioned access. But these problems can be easily solved in case of mutual interests.

The second vast class of information technologies considers ecological problems. Here it is meant a creation of data bases on polluting sources, models to forecast ecological conditions of the regions, monitoring and prediction of seismic and radiation hazards. Such information technologies have been included into many international projects and are under intensive development now.

The information technologies to solve ARR socio-economic problems are the one of very important class. Here it is meant data bases on population, enterprises, and some other statistical data for the region. The information technologies for sociological analysis and forecast of labour resources in the regions of mutual interest are under development now (e.g., the Finnish-Russian project for the region "Kandalaksha-Alakkurti-Salla"). These technologies are aimed at short term and middle term forecasting and sociological monitoring of able-bodied population of the region.

The areas of information technologies application mainly coincide with the common areas of computer-driven technologies usage adopted in the western countries the only difference being the time lag of information technologies developing attributed to Russia. Note, that in the ARR and Russia as whole information technologies are also widely used in private life, distance education, telemedicine and some other applications typical for the West.

Then, there will be distinguished the following areas of information technologies application preferable for the ARR (the succession is presented according to the time period of using computer equipment):

1. Scientific organizations of the Russian Academy of Sciences;
2. Industrial research institutions;
3. Education (colleges, comprehensive secondary schools, universities);
4. Enterprises of various forms of property;
5. Banks;
6. Administrations of cities and regions.

Computer facilities have been used by academic science and industrial research institutions for a long time already. As long as 50 years ago primitive huge computers were used for scientific calculations. Computer using has never stopped. Computer facilities have always been used by science for calculations and then for computer-aided experimental research including collecting and real-time processing of experimental data.

Computer-aided systems that were designed in scientific research institutions have significantly influenced the development of information technologies in industries. Only not long ago various industries were the main application areas of information technologies in science. But the situation has greatly changed recently. The economic industrial crises put an end to this process and many interesting and useful information technologies for industries have been left behind unclaimed. Nowadays industrial research institutions appear to be in very hard conditions. Some of them are disintegrated, others changed fields of research using their potential. Thus, the former geological survey organizations are now working at land cadastre that is financed by the Federation. The Institute of Micro-Electronics can be given as another example. Here the number of the employees has been greatly reduced, but the profile has been retained. It is also financed by federal programs.

Frankly speaking, industrial research has never played a prominent role in the region. Now there are only very few organizations that are of real importance.

Using computer facilities for education started in the region about 25-30 years ago (in Moscow this happened much earlier). This began with classes equipped with symbol displays and then transformed into PC-equipped classes. They were used for teaching computer science, namely computer architecture, com-

puter languages, graphic means, data bases, etc. Nowadays computers are used to teach other subjects. New computer-aided programs are being created and applied. This trend is especially typical for universities. Here information technologies applied for teaching purposes are under constant supervision. There is a special institute named "The Centre of Innovative Information Technologies" in Petrozavodsk University that is aimed to introduce information technologies into the educational processes.

State industrial enterprises started to use computer facilities under the state program "Computer-Aided Control of Production", i.e. at late 60-es early 70-es. At that time more or less large enterprises established Computer Centers with powerful EC computers (similar to IBM 360/370) and efforts were made to shortly develop computer systems to manage the enterprises, to provide their efficiency, flexibility and so on. Due to various reasons this global state program failed, but the enterprises were equipped by computers and thus at first they were mainly engaged in wage accounting and controlling material supply at the storeshops. Later on the scope of using information technologies greatly changed from enterprise to enterprise and varied from complete absence of information technologies to well computer-equipped enterprises. This is true for both economic management of an enterprise and controlling the technological processes. It's worth noting that there are not so many (only few) enterprises with well developed information technologies in the Russian North and the progress has been achieved here in cooperation with research scientific institutions.

Bank structures are the new sphere of informatization of Russia within the implementation of the state program “Digital economics”. It goes without saying that the Central Federal Bank has been always equipped with high quality computers, but the situation in the regions has been quite different. The number of banks has risen significantly lately and their needs for informatization have been formed. Note that banks are the richest organizations in Russia now. They haven't got any problems with financing information technologies. They introduce special closed bank systems developed by their employees and don't allow any outsiders in.

City and region administrations are also new establishments though they use many of the former executive authority officials. In reality the needs for informatization are quite evident, i.e. systems to decision-making support are badly needed. But in practice applying of information technologies greatly varies from city to city. For example, the level of applying information technologies in Apatity City Administration is rather high: there exist special data bases on labour resources, unemployed, housings, enterprises, etc.; there is a connection to the Internet and to the government information network which is a system for computer-aided clerical work and public service rendering, and some others. There are computer facilities in the administrations of each city, but in some administrations the computers are used only for document processing.

Recently there appeared in the region a lot of private firms and joint stock companies that claim to work in the sphere of information technologies. But in reality such firms are mainly dealers and suppliers of hardware and software and have nothing to do with developing and introducing specifically oriented computer technologies since challenges need much time and not only interest.

Information technologies in science and education are mostly developed in the ARR. Until now science and education have accumulated the best specialists and experts that, in combination with the experience accomplished during the previous years, provides a solid basis for information technologies developing which can meet not only their own needs. Information technologies are spreading from here to other areas, i.e. industries, administrations, private and joint stock companies, and sometimes to banks. Until lately there existed traditional centers of information technologies developing, namely the Kola Science Centre (Apatity and Murmansk cities), Petrozavodsk State University, Karelian Science Centre (Petrozavodsk city). Recently information technologies have been successfully developed in Arkhangelsk too (Northern Arctic Federal University). The main directions of information technologies developing in scientific and educational centers will be considered further.

IT for management of industrial-ecological processes in the ARR

Here the following industries will be mainly mentioned: forestry, woodworking, pulp industry, ore mining, chemical processes, fishering, regional energy sector. The information technologies generally apply specific computer-aided models for technological processes, e.g. simulation or balance models. Various tasks can be solved on the basis of these models, e.g. management of electric energy transfer, optimization of fishering, cost efficiency in forestry, etc.

Developing of information technologies to management support of regional energy sector is well studied in [4, 5]. The information technologies provide data collection, storage, processing, and representation of the energy producing objects. A conceptual framework of the decision-making support system of regional power supply is shown in Fig. 1.

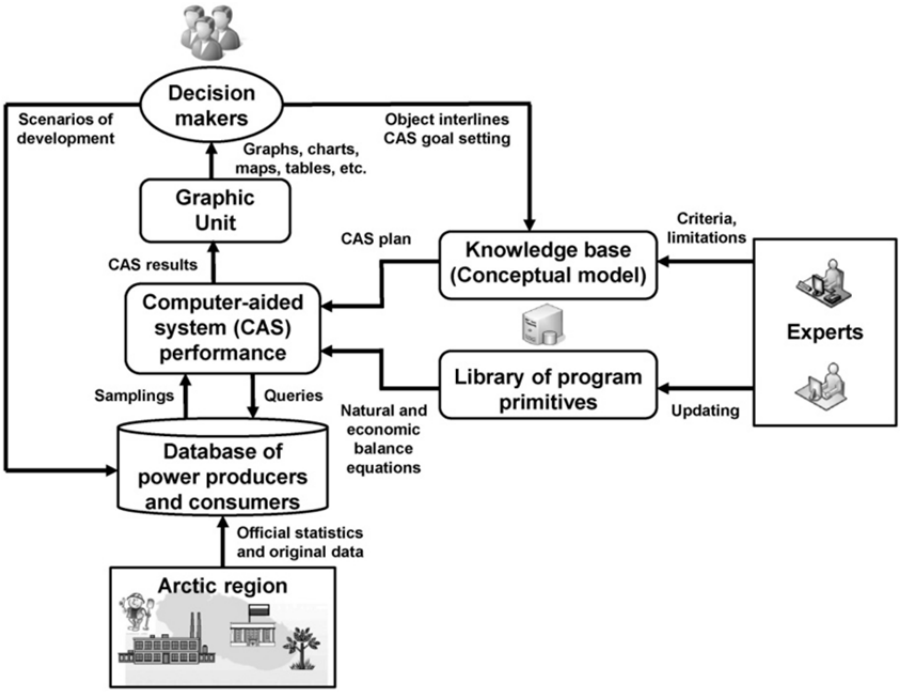

Fig. 1. Decision-making support system of regional power supply

This system use the energy databases with the structure which corresponds to the structure accepted for representation of the regional system of energy production. The data on four types of indices for energy producing enterprises are inputted and analyzed (atomic, hydro, heat-electric plants, various types of boiler shops). These indices include characteristics on energy production, the equipment involved, raw materials, pollutants, and some other economic indices. The user is supplied with the following menu options: calculation on the whole region, an administrative unit or, a chain of hydroelectric stations, and so on. For the first two variants there can be calculated the summed up characteristics of all the energy producers, as well as different types of producers, etc. The user chooses the necessary set of indices. The sets can greatly vary. The results are presented in tables or graphs. The results can support short term and long term solutions to manage the regional energy sector.

At present the trend of applying information technologies to solve the environmental and industrial safety problems of the ARR is presented by a wide range of investigations [2, 4, 6] that are intensively under development, but not always completed. Information technologies are essentially used to evaluate seismic security of the ARR by NORSAR and Kola Science Centre RAS. There are developed special information technologies to control security at nuclear power underground stations [7], and, in the first place, especially radioactive wastes storages [8]. There have been developed the models of transferring radioactive wastes from the Kola Nuclear Power Station. These models utilize a special body of mathematics tested on other polluting sources.

Here the experience of developing the information technologies for insuring the security at ore mines is widely used. This is of vital importance since the problem of technogenic seismicity, the so called rock bursts, comes forth. The information technology of monitoring and prediction of rock bursts in the Khibiny mountains (where apatite is excavated) [5] applies the computer-aided monitoring system of induced seismology, acoustic and electro-magnetic emission, deformation of the rock mass. Various methods of evaluation of stress conditions are being tested as well as the methods of prediction and prevention of rock bursts are being developed. The developed computer-aided prediction technology uses monitoring and numerical modeling methods combined with the methods of artificial intelligence [9]. The latter formalizes and represents special knowledge in the computer system for the field under investigation. Architecture and components of the forecasting system of rock bursts at the underground mine are shown in Fig. 2.

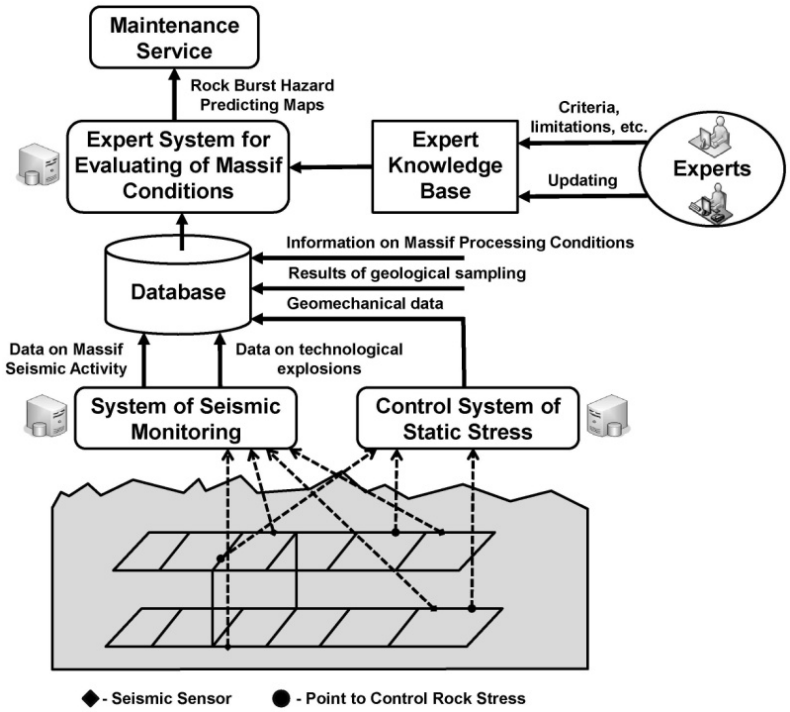

Fig. 2. Forecasting system of rock bursts at the underground mine

Computer-aided system for retrospective analysis and ecological mapping of the ARR under technogenic impact [4, 5] is another example of applying information technologies. This system is designed for operative diagnosis and monitoring of forest ecosystems, especially under technogenic impact. The information technologies are used to analyze ecological aftereffects of industrial activity. This analysis provides operative economic large-scale monitoring over forest ecosystems of the region. The dynamics of anthropogenic impact is reflected topographically for a long term period (60 years, approximately). This makes a basis for developing predicting estimations. The system includes some means to adjust it to particular natural-climatic conditions and, therefore, can be used in different areals: from taiga to broad-leaved forests. Some possible application fields for the system are the following:

– the retrospective dynamic analysis of the technogenic impact to forest ecosystems up to the regional scale;

– the structure clusterization of a forest plantation using some methods of multi-spatial statistic analysis;

– the science-proved support for decision-making in planning of ecological investigations of forest ecosystems;

– the monitoring and prognosis of the state of forest areas in the sense of the integrative index of quality: the decrease of the increment in volume.

All quantitative estimates in the model are based on using of some integral index. This index determines the scale for measuring both external influences and model parameters. The annual diameter increase of conifers has been taken as the index for Kola Peninsula.

The extrapolation tasks break down into subtasks of ecosystem change prognosis because of surrounding influences and internal movements. The latter can be solved properly by using some standard statistic methods, when the prognosis log is comparatively short (thirty-fifty years). Extrapolation of the influence of the external factors is needed in solving the following subtasks: prognosis of the external factors themselves, estimation of effect coefficients of probable combination of these factors on the ecosystem state and the prognosis of the ecosystem state. This information technology has been used to evaluate the conditions in Kola forests.

IT to solve socio-economic problems of the ARR

The computer-driven technologies to solve socio-economic problems of the ARR constitute an information basis for decision-making on regional socio-economic system management. The technologies

based on geographic information system (GIS) technologies are incorporated here. GIS-technologies appeared in the areas of the ARR about 30 years ago. The fields of GIS application are the same as in the West. Another field of information technologies is computer-aided systems aimed at predicting socio-economic development of the region. It is impossible to construct fully formalized models in the given subject domain. Information technologies work with non-formalized knowledge [5, 10]. Specialists and experts in specific problems of the given subject domain possess such knowledge. There exist different approaches to construct the knowledge processing. All this processing is combined by availability of the knowledge bases. There the expert knowledge is distinguished. The knowledge is inputted into the knowledge base and is processed according to certain rules.

The models of regional development are built in the form of scenarios. Scenarios are described by specific mathematical (algebraic) equations for computer-aided analysis that represents the inner image of the scenarios. The outer (for the user) image is given in graphics.

Thus, using the content of the knowledge bases on interrelations within the socio-economic system one can create scenarios of the system behavior under different inner and outer impacts. Moreover, the parameters of the scenarios can be evaluated and thus probable outcomes of the decision-making can be analyzed. Accuracy and reliability of such an analysis is greatly determined by reliability of different kinds of the knowledge inputted into the knowledge base. The developed IT-based methodology to solve socio-economic problems in the field of regional security control of the ARR is schematically represented in Fig. 3.

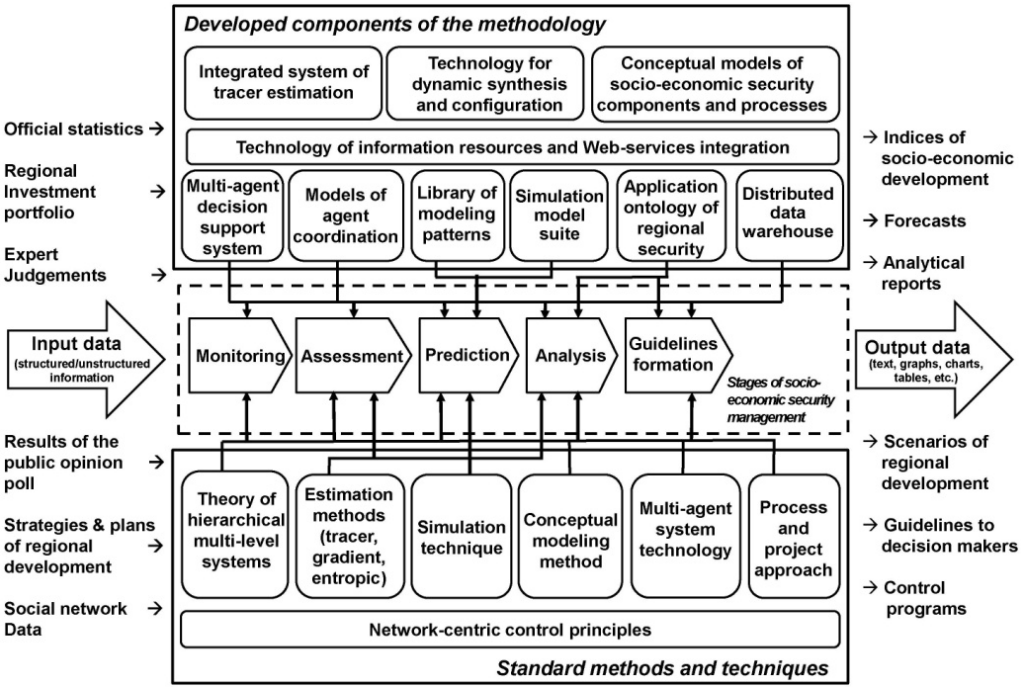

Fig. 3. The methodology for management information support of the ARR socio-economic security

The problems of personnel security and cooperation and integration in higher education are the key problems for the ARR [11]. It is only natural that purposeful higher education can lead both the present and coming generations of the ARR citizens to efficient cooperation. Thus, for the ARR it seems prospective to develop a management system of personnel security [12] to support the ARR regional economy and at the same time a relative network system of distance higher education [13] in the ARR elaborated for implementation of international educational programs.

The information technologies in education are a very important object for computer-aided system application [14], where it can be the only possible effective means of integration and cooperation. In fact, global information networks are providing a favorable environment to transfer educational information, whereas a student working station ensures visual representation of this information and thus individual education can be arranged. Generally, the problem of establishing a network-centric management system for information and analytical support of personnel security and higher education in the ARR [15] applying state-of-the-art information technologies is of vital importance. A conceptual scheme of information technology for management support of personnel security of the ARR is shown in Fig. 4.

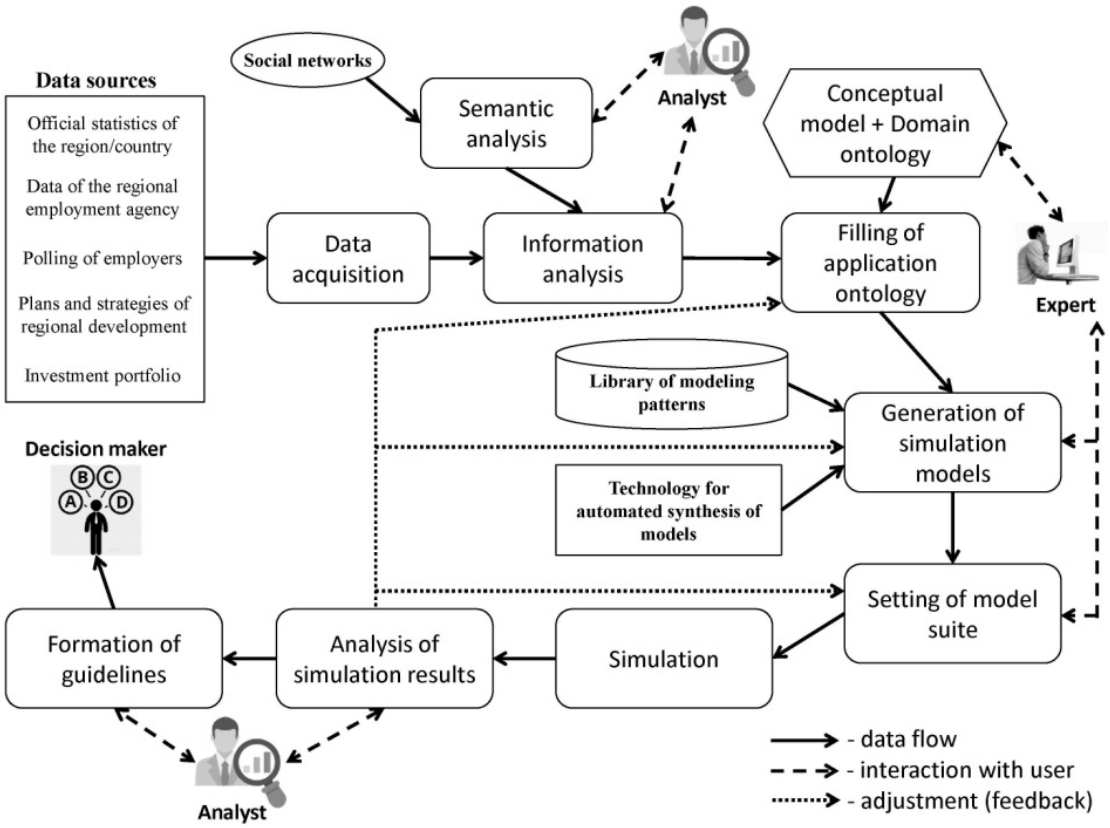

Fig. 4. Information technology for management support of personnel security of the region [16]

Here the process is well under way already. A good historical example started in practice in the 90s is the international Swedish-Russian project to establish an information system for management support of higher education in the Barents region. This project endeavors to solve the problems of integration of information technologies in higher education. The participants of the project were: the University of Umea, Petrozavodsk University, Kola Branch of Petrozavodsk University and other educational organizations. The project was aimed at establishing a distributed management system of higher education support that comprised three centers, namely Umea, Petrozavodsk and Apatity which were connected through Internet. As has been agreed, first of all it was planned to organize distance education for Russian students and personnel (manpower) training for industrial companies of the ARR in such educational programs as information security, tourism and service, international economics, modern logistics, etc. This choice is accounted by the fact that the small number of specialists available at the Russian North at present cannot provide education in these fields to a great number of students and re-educating specialists. The university courses in the mentioned disciplines do not meet the present need for knowledge. Thus, here any help extended by the western countries in arranging such courses may be of extreme importance. Then the problem of tutoring will arise. This problem can be successfully settled by using the methods and means of modern information technologies. Another example which can be mentioned is the state-of-the-art cooperative network of universities, colleges, research institutes and other business and governmental organizations from Russia and other Northern countries interested and concerned with education and research in the ARR. This project is called UArctic (The University of the Arctic). Through forging partnership and cooperation in research and education members of the UArctic enhance human capacity in the ARR, promote resilience and security of ARR critical infrastructures and ARR sustainable socio-economic development.

And, in fine, information technologies in solving of medical and biological problems of the human adaptation in the ARR, i.e. telemedicine. The prospects to use information technologies for health care in the specific North regions are quite evident and do not need any advocation.

Conclusion

The given list of preferable areas is not full but, to our mind, it incorporates many areas of mutual interests for the regions in Northern Europe and Russia, including the ARR. This list reflects the targets and

restrictions of sustainable development of the ARR so that the information technologies are playing an important role in the ARR. The importance of information technologies will be rising without doubt in future.

There are two sets of problems that hamper the development of information technologies in the needs of the ARR. There are the problems of internal and external integration [17].

The first set is characterized by absence of regional IT-programs developed for the Russian part of the Arctic that could somehow coordinate the efforts of various organizations. The main reason here is the absence of financing support of such programs both on the regional and federal levels. Moreover, there are no hopeful prospects since the northern regions of Russia have got losing budgets. Thus, the priorities of informatization [18] are far from the most urgent as compared with the problems of paying out civil workers wages, unemployment benefits, etc. That is why in practice other sources for financing information technologies development are used. Here the program "Informatization of Karelia" is rather an exception. The program has been formulated and even a large conference has been held. But the financing of the program is supposed to be at the expense of the participants. The Karelian Government promised only to allocate an insignificant sum of money to support this program.

As it was assigned in study [18], there are some other reasons that hold back the general development of information technologies in the ARR. There are crises in science and research, reconstruction of industries and some others. Analysis of these reasons and their consequences are far beyond the scope of this paper. Information technologies are designed and developed as applied to the needs of certain enterprises or regions and until now without any reference to the needs of international cooperation. That follows the problem of external integration. Within the ARR such investigations addressed to solve this problem must be integrated with the investigations in other countries. The necessary adjustments in accordance with the international needs of the ARR development must be made.

The contributions and outcomes of our study are used under realization of the Strategy of ARR development and national security support until 2035 in the area of Murmansk region as the proposals and guidelines to enhancement of the management information infrastructure of regional sustainable development and safety.

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