🏆 *reviewed paper*

City Computer Architecture. Corporate Information Systems Approach

Vasily Popovich, Manfred Schrenk, Oksana Smirnova, Nataly Zhukova, Yaroslav Shalamaiko

(Prof. V. Popovich, SPIIRAS, 14 Liniya, St. Petersburg, Russia, popovich@mail.iias.spb.su)
(DI M. Schrenk, CEIT ALANOVA Am Concorde Park 2, Gebäude F A-2320 Schwechat, schrenk@multimediaplan.at)
(Dr. O. Smirnova, SPIIRAS, 14 Liniya, St. Petersburg, Russia, sov@oogis.ru)
(Dr. N. Zhukova, SPIIRAS, 14 Liniya, St. Petersburg, Russia, gukova@oogis.ru)
(Dr. Y. Shalamaiko, SPIIRAS, 14 Liniya, St. Petersburg, Russia, shal@oogis.ru)

1 ABSTRACT

During recent years under the CORP conferences umbrella the ideas around "electronic city" phenomena have been discussed. Important part of the discussed problems is a computer architecture of modern urbanization. Number of computers and computers' networks grows dramatically from year to year. And there comes a time to understand what a phenomena we should deal with.

The proposed idea is to take a look at the computer architecture of a modern city under the angle of Corporate Information System (CIS) approach. CIS idea implies that the computer system is a technical and technological base for the corporate management. A core of corporate management is decision making process at different levels: from individual to government.

The following sections have been selected for this paper:

- Analysis of computer architecture (CA) for up to date city by data from official, public and scientific sources.

- Demands for CA investigation.

- CA as a base for corporate management.

- Conclusions and recommendations for the city CA development and control.

2 INTRODUCTION

Emergence of high technology, forming of global telecommunication networks and information systems open up possibilities of the urban information space creation. The problem of developing an effective system of the urban information space control is not a new one and has been repeatedly discussed over several years at diverse conferences including the CORP (Drewe, 2010; Guth, 2010; A Al-Hairing, 2010; Kim, 2010; Beregovskih, 2010) as well as in papers and monographs (Bucher, 2008; Foth, 2009; Aurigi, 2005).

City informatization assumes a consolidation of all information resources of the city, their processing and analysis, and provides an access to them at different levels of the city management. As a rule, three levels of management are singled out:

- urban level, which provides a centralized monitoring and management of the city in whole as well as coordination with higher federal agencies;

- territorial level providing for monitoring and management of selected (usually for megalopolis) sectors;

- object level providing for control and management of a concrete building.

City informatization should be realized step-by-step: at the first stage it is necessary to solve the problem of creating the uniform city network (UCN), at the second stage – to create uniform data warehouse, at the third stage - to develop and implement standards for new application systems and technologies for integration of the existing systems into the uniform information city system, at the fourth stage – to provide an access to information resources of the city through the city information portal.

Availability of the uniform city network plays a key role in the city informatization. The network is meant as some aggregate that unites information network and resources within the city range. Besides to widespread global and local computer networks, to the city's information networks can also be attributed telecommunication networks, such as television, radio and telephone networks.

Uniform data warehouse is understood as object-oriented, integrated, unchangeable, chronology supporting data sets intended for the management support. Availability of the uniform data warehouse will allow for

creating the uniform center of data systematization and analysis. Such center should be build on the basis of GRID technologies and equipped with advanced hardware.

Availability of development application systems standards provides a compatibility of application systems and, as a consequence, allows to organize an execution of complex business processes with data, to provide a possibility of electronic interaction of subsystems, conversion to electronic workflow and electronic commerce.

City information portal allows citizens to receive quick personalized access to complete information about the city.

Main goal of the city informatization is an effective and coordinated management of the city's vital activity and ensuring of high level comfort for individuals including the city permanent residents and the city visitors engaged in business, recreation, tourism, etc.

3   CHARACTERISTICS OF THE CITY ADVANCED INFORMATION SYSTEM

Scope of the informatization for the modern city is diversified enough; it incorporates different problems solving from social, economic, technological ones to communication network development. The main of the above directions are considered below.

Finances and dues – serve as the city key systems, and their further development provides for integration into other systems and complexes of the city economy.

Property of the city. There exists a huge number of data bases, registers, cadasters containing information about the city public property, housing, non-residential premises, leasing terms. At that, consolidation of these information resources into a uniform integrated system is one of the main problems.
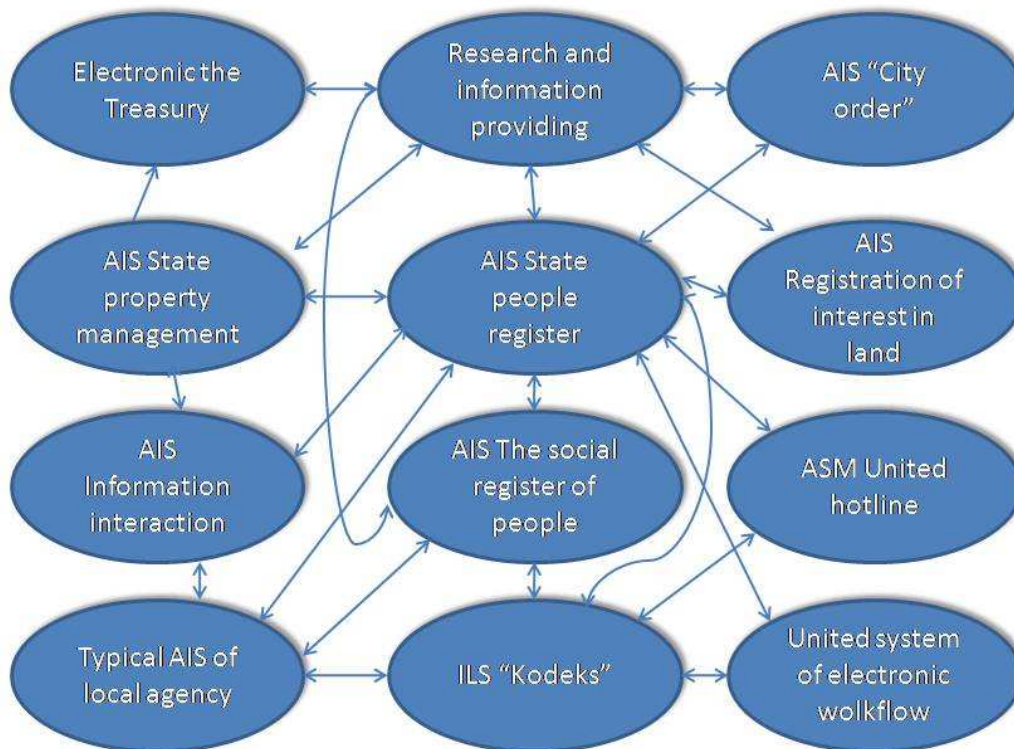

Fig. 1: Main information projects realized by the Administration of St. Petersburg (Russia)

People of the city. There exist various databases which collect information about people. Solving the problem that concerns the city safety as well as transparency of all operating modes of the city management system and city economy assumes a development of a uniform information system that accumulates all resources containing information about people of the city.

Safety - is one of the top priority problems. To date the structures that secure the law-enforcement in the city already have information resources available, so the important problem is to unify and integrate these resources with other systems.

City economy – is a complex of enterprises, organizations, institutions situated within the city territory and intended for serving material, cultural and domestic demands of people living in the city. Information systems used in the city economy, as a rule, are obsolete and require an essential modernization.

Territorial management – management of the city districts and communities. Information systems of territorial management need integration with other city systems.

Fig. 1 shows the structure of information projects realized for the city of St. Petersburg (Russia) under the project: "Electronic Petersburg". The projects are intended either for the informatization of this or that direction in the city development or for the organization of information interaction of some existing projects.

4   STANDARD STRUCTURE OF CITY INFORMATION SYSTEM

Typical structure of city automated information system includes a set of information systems covering the key lines of city development. For the system part integration solutions have been developed with the use of "point-to-point" technology. Standard structure of the information system is shown in Fig. 2.
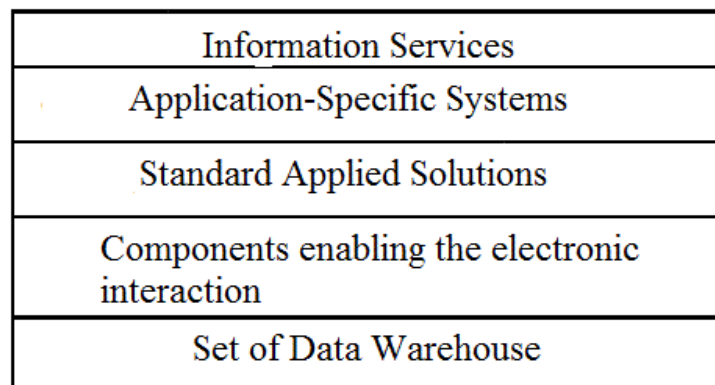

Fig. 2. Standard structure of information system by direction.

Set of data warehouses enabling the information gathering and the users' access to it is the system information basis.

Components enabling the electronic interaction constitute an aggregate of hardware united in one or several networks which allows to use all information and databases accumulated during the information system development.

Standard applied solutions that are currently available from many developers allow to effectively carry out the management functions for the basic components of the city economy and infrastructure. Application-specific systems being created over years represent an addition to standard professional applied systems and provide solutions of the specialized problems.

Information services provide an access to the part of information available in information system to organs of the city government and various strata of society like civil society, business, scientific and educational community, etc.

5   PROBLEMS OF STANDARD CITY INFORMATION SYSTEMS ORGANIZATION

The following disadvantages could be attributed to the currently existing city information systems:

- great number of autonomous networks often overlapping each other in functions (class of being solved problems) and in service areas;
- total decentralization of the city computer networks: a united centre of networks' management allowing for the most effective managing the city information resources does not exist;
- in most cases the city computer networks are rather designed according to the long ago established traditions and conventional principles in this field than according to the principles of optimality and advisability (especially, I&R and information management systems);

- low level of the city information resources integration; separation of information databases, use of various computer systems, protocols and program decisions at the data bases' development make extremely difficult the search and systematization of information resources, development of program decisions, and also significantly increase the cost of forming the uniform city data space. Also information doubling is observed in various city information systems. So, it is necessary to develop models of data representation and tools for data consolidation.

- availability of great number of outdated systems, that should be replaced by the modern ones. Process of new systems development and implementation is rather expensive and time consuming.

- availability of great number of operative systems that should be integrated within the uniform city system. As a rule, the above systems were developed with the use of various technologies and standards. Currently a transition to the ready-made solutions and to standard systems which over years provide optimal and reliable functioning of large information projects is considered the most advantageous at developing large information projects. In order arrange for the application of existing systems it is necessary to solve the following problems: to develop integral decisions; to provide for resources centralization, to develop data harmonization, integration and fusion mechanisms.

- absence of a uniform city information portal. The uniform portal is intended to integrate the whole complex of government urban organization services and to provide access to them at any time.

- absence of a reliable mechanism of data processing and decision marking support at different levels of the city management organization. Here, a specific of data processing consists in the necessity of co-processing of bulk heterogeneous data. At that, the processing should be performed on-line in order to provide the users and management at all levels with actual information. At the organization of decision-making support it is necessary to carry out the system analysis of all available data collection and to provide the user with the information according to the list of being solved problems.

Currently, the above listed problems to some extent can be solved within the corporate information systems. The developed approaches to development and support of such systems can be effectively applied to construction of the city information systems. Availability of construction principles, integration of existing decisions and development of the uniform architecture for city management system will allow for more effective interaction between different levels of city management and townspeople.

Difficulties at the city information system development are obviously determined by an objective complexity of large-scale information systems' construction. The more difficult are the systems and the problems to be solved the more difficult will be the technological architectures and technological decisions put in the systems' basis. Moreover, the government sector is most subjected to risks of inefficient systems development, for instance, according to American Center for Technology in Government the government sector failures reach 70-80% on average (CTG Home Page, 2010) in information projects while in all other fields this index comprises 54%. One third of all problems is related to shortcomings at design of the common management system architecture.

Thus, a crucial problem is to develop the common structure of the uniform city information system intended for government authorities, local governments, all structures participating in the city management, and also for business and citizen that will increase the efficiency of the city operating management structures and will provide for the centralized management and optimal distribution of information resources.

6 COMMON STRUCTURE OF CITY INFORMATION SYSTEM

City information system is a complex of interconnected organizational and technical means for information gathering, transferring, processing, storing and representing, that are used for decision support in favor of citizens, business and city authorities.

Development of the city information system assumes a construction of territorially-distributed peers performing various functions and rendering various information services to the consumers. The city management system developed based on network-centric approach will allow for uniting in the uniform

system the city information resources, monitoring and management systems, data, information and knowledge about a city, video, photo, etc.

Process of developing the city information system architecture can be divided into two stages:

1. Development of a computer communications subsystem. The stage assumes creation of the city common computer infrastructure. This stage includes construction of a computing infrastructure (data processing centers, servers, networks, etc.), communication infrastructure for data and information transferring, basic services for network users (telecommunication, remote access, wireless technologies, etc.).

2. Development or integration of city information systems. The stage assumes a development of information systems and services responsible for an execution of the city organizational and technical functions like financially-budgetary systems, geoinformation systems, etc.

Structure of the city information system is shown in Fig. 3, and the following components are included into the system structure (Popovich, 2010):

1. subsystem of information reception;

2. subsystem of information gathering and storing;

3. subsystem of information processing;

4. subsystem of information representation;

5. subsystem of decision-making support;

6. subsystem of information safety and protection;

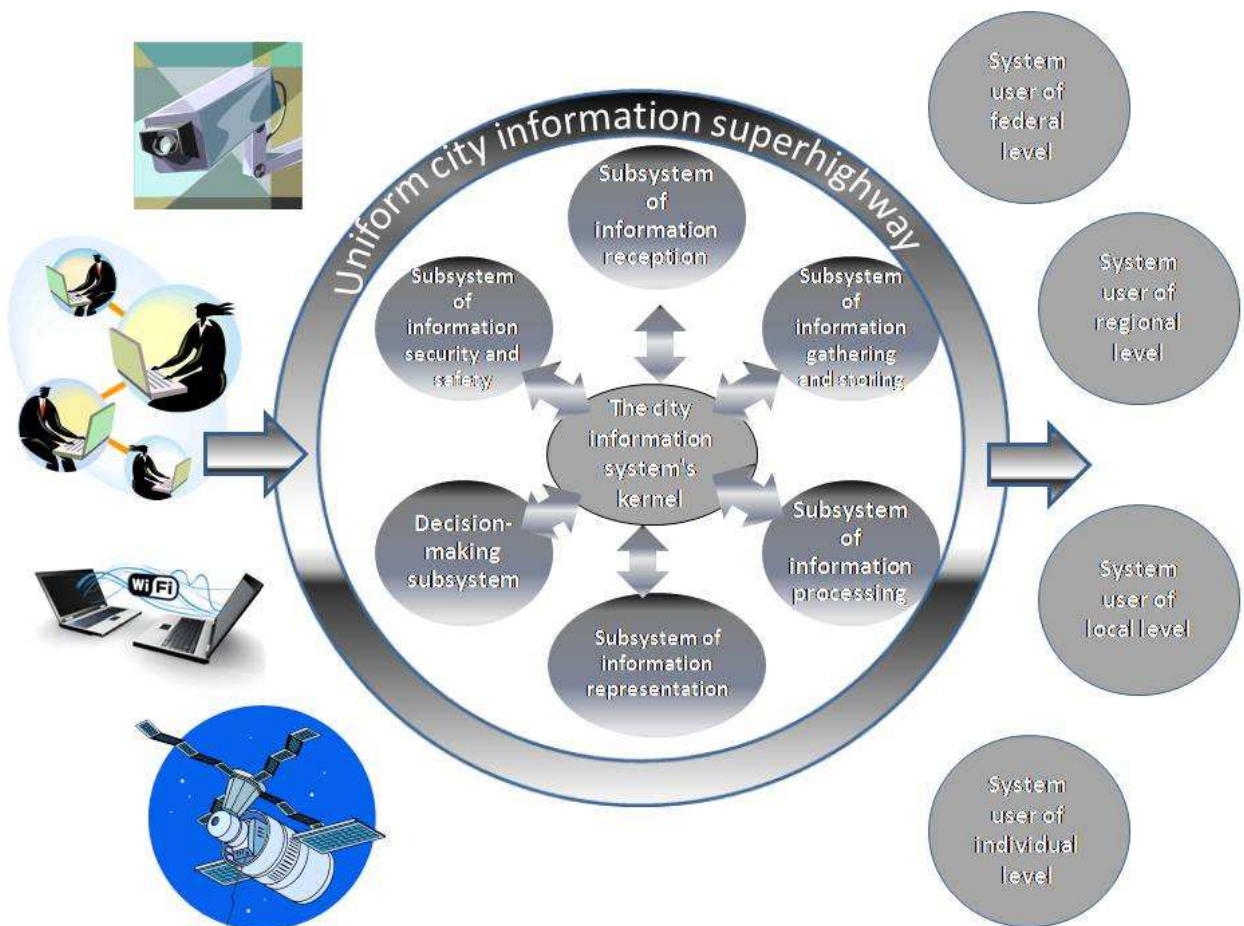7. computer communications;

8. hardware.

Fig. 3 Structure of city information system.

Each subsystem is responsible for certain functions realization and works with corresponding information, i.e. from the point of view of corporate networks each subsystem is an "owner" of certain processes and is responsible for their realization as well as for the information urgency and accuracy used in these processes. As channels for citizens and business interaction with a city, beside the traditional ones (physical organizations offices, telephone systems, mail), the channels based on Internet technologies or mobile communications can be used.

The subsystem of information reception receives data coming from heterogeneous sources. Satellite systems, systems of video observation, city management-information systems, systems of information acquisition from citizens, environment observation and monitoring systems, existing databases, etc. can be used as data sources.

Subsystem of information gathering and storing. The subsystem assumes gathering and storing of various data types, such as results of measurements (the data from the subsystem of information reception), not formalized data (text, numbers), formalized data (data presented in a standard format) for their subsequent use.

Subsystem of information processing. First and foremost the information processing assumes to solve data harmonization, integration and fusion problems (Popovich, 2005).

Data harmonization assumes a definition of basic concepts and their relations (ontology) over the corresponding subject domains and/or responsibility spheres.

The basic aspects of data harmonization are:

- providing access to a great number of heterogeneous data sources;
- providing access to data bases, data warehouses and other information resources;
- data transformation to a format necessary for the user or to a format of definite application; this process includes decoding, recognition, transferring, etc.

Information integration provides for consolidation of information from heterogeneous sources and access to information resources for solving applied problems. Integration inevitably leads to data amount growth, and, as a rule, the integration is stipulated by a necessity to operate with data in real or close to real time.

Data fusion allows for obtaining new quality of information and reducing its amount. Data fusion is the most difficult stage of information transformation. In (Blasch, 2002) data fusion is defined as a process of data consolidation from heterogeneous sources. The purpose of data fusion is defined as reception of higher quality information.

The subsystem of information representation provides an access of citizens to city information resources through a uniform city portal. Arranging the uniform centralized users' authentication and support of the access rights hierarchy as well as the users actions' journalling are supposed. The city information portal allows to: inform citizens fully and objectively about services and social security measures available; provide "transparent", continuous and operative interaction between state and managing entities, at that, an essential costs and time reduction can be reached at the state and managing levels; provide optimization of interaction between the state structures as well as between the structures and the citizens.

The central component of the developed city information system is the decision-making subsystem for various levels of management: federal, regional, local and individual. The given subsystem provides:

- users with authentic and actual information from heterogeneous data sources;
- real time monitoring of the city objects' conditions;
- analysis, prognosis, modelling and other types of intelligent data processing.

The city information system assumes an availability of the uniform city information superhighway providing citizens with services of rapid access to the city computer management system. The uniform city information superhighway is intended for information interchange between services of local, regional and federal levels, and also between the enterprises located on the city territory and townspeople. Besides, the uniform city superhighway can provide functioning of educational institutions, medical institutions, libraries, business, culture and entertainments.

The city information system's kernel is a set of hardware, communication facilities, software, information resources (integrated databases) and professional personnel providing the organization of business processes performance and interaction between system components.

Hardware of city information system can be divided into:

- server – contains a complex of infrastructural servers and application servers intended for processing and storing the system information;
- user – contains workplaces of the users who directly fulfill the functions relative to data processing as assigned to information system;
- administrative – contains workplaces of network and security administrators responsible for working capacity of the system.

Indispensable property of the city information system is a high degree of heterogeneity since it is impossible to satisfy requirements of thousand users by means of single-type software and hardware. Such network as a must will use various types of computers from mainframes to personal computers, several types of operating systems and set of various programs.

The subsystem of information security and safety implies a combination and coordination of organizational measures and technical (including software and hardware) means within the limits of city information system.

7 CONCLUSION

Creation of the city common information field will allow to provide a substantial enhancement of production efficiency, economy of natural resources and to increase the degree of environmental protection. Moreover, the information will allow for increasing economy transparency, overall performance of all public authorities and urban services, along with efficiency of social and economic functions execution.

8 REFERENCES

CTG Home Page: http://www.ctg.albany.edu/. 2010

POPOVICH V., SCHRENK M., VLASOV S., IVAKIN Ya. Network Centric City. Computer Science Vision of Urbanization In: Proceedings of 15th International on Urban Planning, Regional Development and Information Society REAL CORP 2010, pp. 457-465. Schweitzer, 2010.

POPOVICH V., VORONIN M. Harmonization, integration and fusion data – three sources and three components of geoinformation technologies. In: Proceedings of 2nd International Workshop Information Fusion and GIS, pp/ 152-158. St.Petersburg, 2005.

BLASCH E. Fundamentals of Information Fusion and Applications, Tutorial, TD2, Fusion 2002.

DREWE, P. What about time in urban planning and design in the ICT age? In: Proceedings of 10th Symposium of Information and Communication Technology (ICT) in Urban Planning and Spatial Development and Impacts of ICT on Physical Space. Eds. M. Schrenk. Vienna, 2005.

GUTH, D. Emergence of suburban employment centers in German metropolitan regions: Impacts on commuter traffic, 1987-2007. In: Proceedings of 15th International Conference on Urban Planning, Regional Development and Information Society. Eds. M. Schrenk, V. Popovich, P. Zeile. Schweitzer, 2010.

A AL-HAIRIG, T., J AL-JARALAH, A. Googlization Factors of Saudi Eastern Province Virtual Cities. Factors Analysis of Eastern Provaince Virtual Cities. In: Proceedings of 15th International Conference on Urban Planning, Regional Development and Information Society. Eds. M. Schrenk, V. Popovich, P. Zeile. Schwechat, 2010.

KIM, S., CHO, Y. Bridging the Physical and the Virtual: Creating a Social Network via Media-Enhanced Street Furniture. In: Proceedings of 15th International Conference on Urban Planning, Regional Development and Information Society. Eds. M. Schrenk, V. Popovich, P. Zeile. Schwechat, 2010.

BEREGOVSKIH, A., GRISHECHKINA, I., SHALAKHINA, D., MILLER, S., PETROVICH, M. Russian Urban Planning: modern ideas (Legislative Base, Spatial Planning, Transport and Ecology, GIS Technology). In: Proceedings of 15th International Conference on Urban Planning, Regional Development and Information Society. Eds. M. Schrenk, V. Popovich, P. Zeile. Schwechat, 2010.

BUCHER, U., FINKA, M. The Electronic City. BWV Verlag, 2008.

FOTH, M. Handbook of research on urban informatics: the practice and promise of the real-time city. IGI Global snippet, 2009.

AURIGI, A. Making the digital city: the early shaping of urban Internet space. Ashgate Publishing, Ltd., 2005.