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Representation of subjects' capacities in an architectural model of the information system

The article presents the results of modeling characteristics of subjects of the information system on the basis of the architecture framework of J. Zachman. We discuss a set of attributes of a subject role, the results of the analysis of sources of requirements for the IT capacities of subjects, including management practices for the information technology infrastructure ITIL, ITSM, CobiT, MOF and others, and justify their relevance to specification of requirements for particular knowledge, skills and experience of specialists in relation to a particular item of control.

As an example for the role of technical support specialist there is description of its architectural model look at the system that allows to define the required competence. Problems of correlating of identified requirements to professional competence level provided by the industry professional standards, and range of training directions and specialties of professional education.

Thus the architectural model of the information system can justify the structure and staff list of IT services, formulate professional qualification and experience requirements. The results of the study are used in the learning process in a number of universities of Vologda.

Information system architecture, system life cycle, information technology infrastructure management, national qualifications framework, range of IT professions, educational standards, professional competence, professional standards.

Andrey M.
POLYANSKY
Ph.D. in Technics, Associate Professor of Automation and Computer Engineering Department Vologda State Technical University
ampol@yandex.ru

In recent years, attention of the developers of information systems (hereinafter – IS) was riveted on the development of architectural models of systems. Architecture of IS usually refers to a visual representation of the most important for different members of the system life cycle properties and relations between its relatively independent entities: subjects and objects within the system and the external environment, as well as processes occurring in the system. Architectural model of a specific IP shows in respect of which actors, objects and processes and by whom an activity is implemented, allows to visualize key linkages in the system and coordinate between the parties of the system life cycle the most significant

aspects of its structure and relationships between elements. Moreover, coordination is important in the stage of requirements specification or design of the system and in later stages of its life cycle as well.

A significant impetus to the development of works on designing architectural models of information systems in the budget sector of the Russian Federation was the Concept of using information technology in activities of the federal bodies of the state power until 2010, approved by the Federal Government on September 27, 2004, № 1244-p [1]; the Concept of regional information until 2010, approved by the Federal Government on July 17, 2006, № 1024-p [2]; the Concept of building e-government in the Russian Federation until 2010, approved by the Federal Government on May, 6, 2008, № 632-p [3]. For example, in [2] there is a "stratified" architecture of e-government in the region, which can be summarized as follows:

- models of efficiency;
- architecture of activity:
  a) state functions and services,
  b) administrative processes;
- component architecture of application systems:
  a) architecture of application subsystems,
  b) architecture of software components (services);
- information architecture:
  a) subject ontologies,
  b) hierarchy of information objects,
  c) state metadata;
- technology Architecture:
  a) system environment,
  b) network environment (infrastructure),
  c) profiles of standards;
- security restrictions.

The paper notes that for each of layers a family of hierarchical directories must be developed and maintained state-wide. Architectural model of e-government in the region also includes four types of software: methodological, regulatory, organizational, personnel and technological. Each of the above layers and, in particular, their relations should be analyzed in terms of these types of software.

The most appropriate for describing structured architectural aspects of IS and the subsequent detailed requirements for capacities of various subjects of the system is a scheme of development of IS architecture, proposed by John Zahman [4]. In this model, at the top, the most general level of views of various participants in the life cycle of the system there is an interconnected set of views and the most significant aspects of its implementation, allowing a consistent decomposition of both by detailed elaboration of aspects of consideration and by detailed elaboration of points of view on the system as a whole.

According to Zachman's ideas, six aspects of architectural representation are commonly used that describe: objects and their accounting data; subjects of interaction; motives and goals of participation of subjects in the system in conjunction with goals of the system and results of its operations; spatial distribution and relationship of subjects and objects of interaction; actual function description of actors and processes in the system; events, their logical and temporal relationship (operating time). The latter aspect allows us to show dynamics reflecting on the path goals of the system in its functioning over time. Along with operating characteristics it is useful to consider the fact that characteristics of the system change over time, and for different elements in different ways (different duration and stages of life cycles).

The ideas, contained in [4], influenced the development of projects of foreign and domestic standards [5, 6], have been reflected in the work of many scientists, including Russian. Thus, in the writings of E.Z. Zinder [7] the idea of an architectural approach spreads on the model of an enterprise as a whole, not only on its IT infrastructure, and there is the emphasis on the need to display the development of the system in a model over time.

The work of E. Zabegalin [8] proposes to reflect structural, functional, logical and chronological aspects of the creation and operation of the company and its IS in construction of architectural models.

In [6] it is noted that: "Standard enterprise architecture and methodology must be able to represent human aspects such as organizational and operational roles, abilities, skills, know-how, competence, responsibilities, authority and relevance to an organization ... There is also the need for models that establish the responsibilities for staff in decision-making, opportunities, in socio-technical models (motivation, interest, incentives, etc.), in models that set skills and abilities of employees, organizational models". At the same time, in famous architectural models (e.g. in ARIS) less attention is paid to such an important aspect, as a subjective, human factor, including motives and abilities of people to benefit activities in the interests of the system. This publication contains a summary of the results of research conducted by the author to fill the above gap.

A set of characteristics of the subject model in the architectural representation of IS, or attributes of the subject, largely depends on whose point of view a model reflects: for different observers one or another attribute will be important depending on the role played by the observer in the system life cycle.

Status of the subject has essential importance: an individual or legal person. The most common attributes of the subject include: interests, motives and goals for participating in the system; powers and obligations; the cost of keeping or budget, which the subject has in relationship with the system; life cycle stage in which the subject is. For an individual person, in addition, its position, role and status in the system are important; education specialty; occupation; work experience; competence; ability to perform his functions and interaction within the framework of the project and so on; for a legal person - legal entity registration details; names of executives and senior representatives of the subject, points of contact with them, and so on.

Of all the possible set of attributes of the subject – an individual person we will consider his professional characteristics and competence on how he uses IS in accordance with his official duties. Under the competence we mean the amount of knowledge and skills of the subject and the level of his ability to independently and/or in concert with others to apply them according with the objectives of his activities.

Sources of requirements for the competence of subjects of IS are very diverse: it can be regulations of units, systems or their components, orders of activities, official regulations and instructions, models of business processes, operational and technical documentation on the system and so on, that allows you to specify requirements for specific tool knowledge and skills, but also determines complexity and scale of the tasks in relation to a particular area or facility management.

There are internationally accepted management practices of information technology (hereinafter – IT) infrastructure: ITIL – Information Technology Infrastructure Library [9], ITSM – Information Technology Service Management [10], CobiT – Control Objectives for Information and related Technology [11] MOF – Microsoft Operations Framework [12] and others). They contain detailed descriptions of support processes and development of IS in all stages of their life cycle and can build a fairly detailed descriptions of activities that IT professionals have to perform within a particular role, to determine the levels of responsibility for the entrusted objects and solving problems. In addition, models of these processes allow to judge the appropriate level of competence of users who are recipients of a set of IT services.

Finally, private architectural representation of a system that forms in the view on a representative system of a particular role, involves displaying only those aspects (subjects, objects, events and processes) that lie within the competence and interests of the observer [13].

The representative of the role should have competence resulting from this architectural presentation, i.e. the ability to apply their knowledge, skills and personal qualities for successful activity in the system according to current events and the development strategy for IS.

For example, for the point of view on the system, which is characteristic for the role of a specialist of equipment IS support the architectural model contains:

1. The list of instances of classes of the system subjects and its environment: suppliers of equipment, components, materials and service organizations; owners of equipment; users; regulators and others. Key attributes of the subject: details of a legal entity, full name of executives and senior representatives, the contact points, the role and status of the subjects in the system; their powers and obligations according to supported hardware; in addition to the characteristics of individuals the following attribute such as competence in the use of equipment is important; the ability to perform their job functions on the equipment (e.g. quality, productivity); the ability to interact with the technical support expert and so on.

2. The list of instances of object classes of specialist's activity with their professional attributes such as the name and brand (model) of the equipment, its technical and other characteristics that are important for a specialist to perform its role; destination indicators in the system; the volume of guarantees by the object supplier; peculiarities of the acceptance, commissioning, maintenance, diagnosis and repairing; a person responsible for the object and users (for this attribute in the model there is communication with the list of classes of subjects); performance standards; life cycle stage in which the object is, and so on. When using automated IT management data about the objects are collected in a database of configuration items of the system.

Just as for the actors, the description of the properties of objects can be accomplished with varying degrees of details depending on the responsibilities and duties of a specialist, in addition, material (equipment) and information (software and information resources) objects are characterized by significantly different sets of attributes description.

3. Description of elements of professional relationships "seen" by the specialist that are in the area of his responsibility: the scheme and topology of information networks, supporting infrastructure; placement diagram of software and information resources in the workplace and server systems; layout of equipment in rooms, closets and desks; wiring diagrams of the equipment; automation scheme (for industrial systems); distribution of access rights of subjects to objects, such as access label system; a list of support services for systems with service areas and so on.

4. Description of processes involving a specialist, including processes of IT infrastructure management, with the necessary degree of detail (down to the steps for diagnosing and repairing some equipment samples). This description also presents resources, results, management impacts, legal and technical rules governing the process; norms of resources consumption and cost characteristics; operating time and events that require decisions and/or documentation; strategic points and process parameter values in them, including final results; the role of stakeholders in the process; reached values of efficiency and collaboration and so on. An example of software implementation of the management system of IT services based on the standard model of business processes, performed with the participation of the author, is given in [14].

5. Relationship of processes and events in time is usually represented with schedule for routine procedures, participation in developing and establishing the system, implementation of application and control activities, reporting and so on.

6. The objectives of the system, support services and specialist's own goals related to labor relations, professional career and so on. This aspect of the model allows to objectively

correlate the vectors of goals of different stakeholders and interpret the result as recommended forms and methods of interaction between them to achieve the goals of the system be the least contentious way to build potential career paths within the specialist system and, consequently, provide his rational motivation to engage constructively in the system.

By all those aspects groups the system architecture and the other sources discussed above can quite clearly and in detail determine and record the required volumes of knowledge and skills of a specialist, and an appropriate level of ability to independently and/or in concert with others to apply them according to the objectives of his activities .

Another important property of an architectural model of IS is using as a tool for modeling future requirements according to the organization's development strategy of the system. Thus, we can get a detailed set of requirements for the competence of specialists, which is in demand not only at the moment, but also in the foreseeable future.

The practical applicability of the detailed requirements can be used, for example, during the qualifying examinations, appraisals and other evaluations of professional abilities and suitability for purpose of existing staff. However, when there is a need to involve personnel from the external environment it is not lawfully to require knowledge of specific aspects of the structure and functioning of the system with which they have not worked. There is an inverse to previously considered problem of generalizations of qualifications to the level determined by professional standards, as well as model programs and standards of professional education.

When describing more general requirements for the qualification of the expert, which are also to be displayed in the architectural model of the subject, there are problems relating them to certain levels of professional competence provided by industry professional standards, as well as determining the range of training areas and disciplines of professional education, providing basic training for the successful implementation of the considered role and formulation of requirements to the scope and specifics of the job, knowledge and experience gained by the specialist, usually expressed in the requirements for length of service in the specialty.

The base of defining the range of training areas and specialities, corresponding to the requirements for performing a specific role, is the National Classification of specialties in Education (OK 009-2003) [15], and existing educational standards and standards of the new generation, which higher school goes over now, contain detailed list of knowledge and skills required to a graduate student. If the requirements for the role are set out in the same paradigm as the educational standards it is not difficult to define the range of occupations that are suitable for it. However, in practice in program, technical and operational documentation of IS conceptual apparatus is often used, which differs from the apparatus of educational standards and programs (such as English loans in a free translation or a non-academic jargon terms), and this is often a significant problem in the identification of specific professions.

Current qualifications for IT professionals in organizations rely usually on Qualifying directory for managers, professionals and other employees, approved by Ministry of Labor on August 21, 1998, № 37 [16]. Titles of employees, which qualifying features are included in the Directory, are set in accordance with the national classification of occupations of workers, employees and job wage categories of OK-016-94, enforced on 1 January 1996 and can serve to describe requirements to the entity as the value of the attribute "occupation". Qualification characteristic of each job in accordance with this document has three sections.

In the "Duties" section there is a set of basic labor standards which may be assigned in whole or in part to the employee occupying this position, taking into account technological homogeneity and interdependence of work, and ensuring optimal specialization.

The "Must Know" section contains the basic requirements for an employee with respect to expertise and knowledge of legislative and regulatory acts, regulations, instructions and other guidance materials, methods and means that the employee must apply in the performance of official duties.

The "Requirements for qualifications" section defines the level of employee training needed to perform specified duties and requirements for the length of service. Levels of required training are given in accordance with Law of the Russian Federation "On Education".

Along with detailed study of position qualifications within these sections, the Directory focuses largely on the scope of activities related to systems design and development and much lesser – on their operation, although with the growth of the use of IS and technologies in the economy correlation of amounts of development and maintenance of systems has been steadily changing in favor of the latter.

If special knowledge is created and fixed during the base specialty training, retraining and the raising of the level of skill and supported by relevant documents, the requirements for work experience should be specified depending on the duration of the cycle of works carried out by the specialist, and the degree of success of their result, which is extremely difficult to objectively confirm, for example, when changing employer.

For example, for a developer of IT solutions two or three consecutive cycles of successful projects can be the evidence of the adequacy of previous qualifying experience "step", at the same time for a service engineer, system administrator or programmer accompanying system intensity of repetitive processes can be quite different, and for one "step" skills of 2 – 3 years accumulated amount and stability of skill can be significantly different depending on the intensity of system events. Moreover, the higher quality of designed and built information system, more stable business system that supports it, the less experience for a certain period of time the staff serving it gets. For the category of "managers" an objective measure of expertise may be in the design of work organization the positive result of the same two or three time successive projects, while functional – two or three years of successful development and implementation of IT budgets. Thus, the attribute value of "experience" in describing a class instance of a system subject is better to give not in calendar but system time, in accordance with the duration of the cycle of works which are character for the role.

The above issues should be resolved in the development of professional standards in the field of information technologies. The urgency of development of professional standards in engineering has been repeatedly emphasized by the country's leadership. So, this year in April the Russian President D. Medvedev approved the list of instructions after a meeting of the Commission on the Modernization and Technological Development of the Russian economy, which took place March 30, 2011, in which he entrusted the Government of the Russian Federation together with employers' associations, self-regulatory and commercial organizations, including the dominant state participation, and involving representatives of the expert community until 1 December 2011 with development on the basis of the national qualification framework sectoral qualification framework containing a set of requirements for engineering and technical specialists, corresponding to the priority directions of modernization and technological development of the economy of Russia.

In recent years, the IT community has already done quite a lot of work to develop a new range of IT professions, which more accurately mirrors the realities of the support processes of modern information systems [17]. A number of occupations in this range are directly related to the IS service support and can act as the values of the attribute "profession" to describe the model of the subject.

These are profession such as:

- programmer;
- system architect;
- system administrator;
- technical support specialist;
- systems analyst;
- database administrator;
- manager of information technologies;
- specialist in repairing digital technology products;
- specialist in information resources;
- specialist in information systems.

For each of the above professions in accordance with a specific qualification level in the project of professional standards lists of duties were developed, requirements for basic knowledge, skills needed to perform them were given. Qualification levels provided by the projects of professional standards, in general correspond to the draft of the National Qualifications Framework of the Russian Federation and education levels as defined by the Law of the Russian Federation "On Education".

For example, given in [17] the draft of profession standard "Specialist in Information Systems" describes the profession of specialists involved in the creation and operation of information systems that automate the tasks of organizational management (accounting, analysis, monitoring, planning, implementation, etc.) of commercial companies and public institutions and involves five skill levels, for each of which detailed description of the main duties is given with a list of knowledge and skills required to perform any such duty.

Among the duties of the specialist of the first qualifying level, requiring only a secondary vocational education or vocational training (retraining) include:

- programming in the development of IS;
- conducting internal testing of IS;
- formation of internal documents on the results of the job;
- participation in the creation of documentation for use of IS;
- setting IS;
- conducting training for users of IS;
- participation in expert testing of IS during the pilot operation;
- elimination of user feedback on the results of expert testing of IS during the pilot operation;
- technical support of information system during its operation;
- self-development.

The second and third qualifying levels already require minimum high school preparation of bachelor of science, and the fourth and fifth – of graduate, and contain much more voluminous list of duties, particularly in the field of IT management. All levels, except the first, suggest the passing of a voluntary professional certification, although such a unified system of certification in the country has not been yet and there is only a "branded" certification to possess certain IT products and technologies.

The project of a new range of IT professions has caused lively discussion, not all of its ideas are uncertain, especially in terms of ensuring human resources for the future of the IT industry, but other alternatives for the court of public opinion are not represented. Comparing materials of draft standards to the requirements of competence derived from the architectural model of the system, we can quite accurately determine the necessary professional identity and level of qualification of candidates for the respective job.

The next step in determining the values of the role attributes of IT service professionals is defining titles, which requires the drafting of staff list. Because the range of professions and qualification levels for each of the roles are already installed, on the base of the same architectural model of IS and the recommendations of the above-mentioned methods of organization of IT infrastructure we need to determine the amount of responsibility, authority and additional administrative functions, as well as the necessary schema of matching occupations and positions for each profession.

The essential difficulty in the formation of the staff list can be the industry membership of an organization and the presence in it of special categories of posts, different from the existing range of IT professions. Thus, in the IT civil service specialists are mostly in the category of providing specialists, who are characterized by gradation of posts, differing substantially from both the Qualifying directory for managers, professionals and other employees [16] and the recommendations of the project of professional standards in the field of information technologies [17]. Subject of determining compliance with qualification levels, groups of civil service positions and places of Qualifying directory (ETKS) requires separate development.

Beyond the roles of IT service professionals the system of requirements for the competence of users based on the architecture of information systems and other design may be build. Just as for the roles of IT professionals from the finished architectural model by increasing specialization of roles the amount of views about the system and processes occurring in it is selected, which is required for the representative to perform the role of his duties and powers.

The only difference – the requirements for IT competence will not help in forming such attributes of the subject as "profession" and "specialty" to support that it is necessary to develop an architectural model of the entire organization, not just the IS.

Thus, the mapping and specification of requirements for the competence of representatives of different roles of participants of the life cycle of IS on the base of its architectural model can justify the structure and staffing of IT services, to formulate professional, qualification and experience requirements for personnel, and as a consequence more rational use of the organization human resources and facilities for their training and skills development.

The materials of the present study are used by the author in the preparation of students of specialties 220201 – "Management and Information in Engineering Systems", in the directions of baccalaureate 220200 – "Automation and Control" and 230100 – "Computer Science" in the "Vologda State Technical University" and specialty 080801 – "Applied Computer Science in Economics" at the branch of St. Petersburg State Engineering and Economic University in Vologda.

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