Presenting Metrics for Evaluation of Expert Systems Based on Service-Oriented Architecture

Ali Nayebpour
Department of Computer Engineering, Science &Research Branch, Islamic Azad University, Qazvin, Iran
Ainbpr@yahoo.com
Hassan Rashidi
Department of Computer Engineering, Qazvin Branch, Islamic Azad University, Qazvin, Iran
hrashi@gmail.com

Abstract

Due to theadvantages and variousapplicationsof Service-OrientedArchitecture and combination of this styleof software architecture withexpert systems, most importantlimitations of expert systems including vulnerabilities,theunity ofsolutionstrategy, development problems, repair and maintenanceisreliablecoverage.With a achieve to success inagile, integration, usability and reusability, with a success in businessobjectives,availability and presentingof newandapplicable servicesforexpert systems with possibility usage ofservice-orientedarchitecture.The main purposeofthis paper is, to survey service-oriented architectureto providesolutions tousethis styleofarchitectureinexpert systemsin order toeliminatetheshortcomings and optimizationof these systems.Also Inthispaper,metricsforevaluatingexpert systemsbased onservice-orientedarchitectureis presented.

These metricsincludessix title:agility,integrity, usability andreusability, business objectives, accessibility, Offeringnewandapplied services, and for eachmetric some properties presented. It's obviousprovidingmoreproperties shows the systems powerful inevaluation.

Keywords: Service-OrientedArchitecture, expert systems, evaluation metrics

1. Introduction

Service-oriented architecture is considered as the latest generation of information systems architecture which was first introduced in 2000 and then became widespread during a few recent years (Shams&Mahjoorian, 2010). Service-based architecture i.e. service-oriented architecture serves as a model of developing software systems in which the use and organization of a wide range of resources including programs and data is done in such a way that uniform and with-clear-definitions utilization of these capabilities is possible irrespective of establishment platform, object specifications and range (Bieberstein et al., 2005). Considering the daily increasing growth of information systems, organizations need to quickly respond to new business demands (Erl,2005). At the same time, architecture of the existent software has reached the extreme of its capabilities; therefore, service-oriented architecture is a complementary step to help organizations manage their challenges. Service-oriented architecture can be regarded as a mature form of component-based architecture, object-oriented design and distribution systems.

Of the most important benefits and applications of service-oriented architecture are making a rapid change in the systems, integrating systems and platforms, reusing program or system codes, protecting products of short life cycle, reducing costs and improving capital recovery, serving a key role in the connection between business and information technology, facilitating development and gradual implementation of software products, and finally flexibility and easy transformation from one service supplier to another.

Authors and companies supporting service-oriented architecture have mentioned many reasons in terms of its advantages and applications; rapid change of systems allows systems' agility which can be resulted from system applications, geographical change or upgrading platforms, or even a change in technology supplier. Easy integration into internal and external partners, namely, integration of systems and platforms is the most important issue dealt with by service-oriented architecture. Capability of reusing system or program code was

placed at the center of attention by software production and development methods (Erl, 2007). Protecting product of short life cycle is another application of service-oriented architecture, about which several articles including service supply and scientific application have been published while offering some easier scientific infrastructure for implementation of software products (Krishnan&Bhatia, 2009). Service-oriented architecture also reduces expenses used by information technology and business services in two ways so as to improve capital recovery (Viinikkala et al, 2008). A key role of service-oriented architecture is direct mapping of business processes to information technology. Further, considering that service-oriented architecture is not a huge and…. project, rather it is informed through gradual revolution and transformation of current systems and step-by-step introducing of new services; gradual development and implementation is undeniable. And finally, service-oriented architecture's flexibility and easy transformation from one service suppliers to another apply to both in-house and external services (Shams&Mahjoorian, 2010).

With respect to expert systems, it can be said that subset of expert systems serves as one of the most successful approximate solutions for the classical problems of artificial intelligence. Expert systems are computer programs that envisage some non-algorithm professions to solve a particular type of problems (Cebi et al, 2009). This system is knowledge-oriented software with capability of reasoning and rule adjustment utilizing user interface. It can analyze, and propose a solution for, a particular issue based on the received information (Etik et al, 2009).On the other hand, expert systems are of high usability in such a wide range of areas as industries, commerce and financial applications, commercial planning, security systems, mine and oil exploration, genetic engineering, automobile design and manufacture, camera lens design, and airlines' flight scheduling(Ghazanfari&Kazemi, 2008).

Despite various advantages of expert systems such as enhancing accessibility, decreasing costs and risks, durability, multiple professions, enhancing reliability, capability of explanation and perfect response, stability, knowledge distribution and rapid response (Ghazanfari&Kazemi, 2008), they have some restrictions like knowledge and experience limited to a particular field, lack of analysis possibility in case of unexpected events, vulnerability of systems, solution strategy unity, lack of system interfaces' uniformity, and problems of development, repair and maintenance (Li et al, 2010).

Considering various advantages and applications of service-oriented architecture, if this style of software architecture is combined with expert systems, the most important constraints of expert systems such as systems, vulnerability, solution strategy unity, lack of system interfaces' uniformity, problems of development, repair and maintenance can be removed. As the result, expert systems become agile, integrated and accessible with capabilities of using and reusing and satisfying business objectives and some novel services and applications can be offered for expert systems.

This article intends to examine service-oriented architecture in terms of offering some strategies for agile-making, integrating, systems' gradual development and implementation, and easy transformation from one service supplier to another and also to apply this style of architecture to expert systems in order to remove limitations of, and improving, expert systems. In addition, some criteria are offered for evaluation of expert systems which are based on service-oriented architecture. Evaluation of the approached proposed based on these criteria allows more suitable examination of service-oriented architecture within expert systems.

2. Current approaches

This section examines three service-oriented architecture approaches, namely, (a) costs control approach in expert systems based on service-oriented architecture, (b) reasoning tree approach within expert systems based on service-oriented architecture and finally (c) self-service software approachwithin expert systems based on service-oriented architecture. Qualities, advantages (strong points) and disadvantages (weak points) of each approach are discussed.

2.1. Costs control approach in expert systems based on service-oriented architecture

This approach is based on the work of Peng et al.(2009). Having studied costs control system and knowledge management system and also offering a costs control structure based on service-oriented architecture, these professionals have proposed a basis for optimizing expert systems based on service-oriented architecture. Furthermore, through display of knowledge and reasoning engine, some expert systems can be provided that enable knowledge and reasoning ability to discover a separate way.Table 1 presents examination of costs control approach within experts systems based on service-oriented architecture, namely, the article's first approach that is related to application of service-oriented architecture in optimizing expert systems.

Approach	Costs control approach in expert systems based on service-oriented architecture
Qualities	1. It provides a basis for optimizing expert systems based on a costs control structure which is based on service-oriented architecture, while studying costs control system and knowledge management system

	2. It evaluates project management through offering costs management by means of managing such activities as collection, analysis, and categorization of costs-related information and also controlling project costs 3. By means of this approach, designing architecture of costs control expert system based on service-oriented architecture is done within three layers and five services. 4. Services offered by this approach are data service, management service, deposition service, registry service and service requestor.
Strong points	1. This approach provides a system of great ability to immediate prediction and supervision 2. Costs control strategy with a combination of base knowledge and expert system provides appropriate control system and resources for smart costs management which leads to a good management, advanced technology and design required by the project. 3. Costs control expert system based on service-oriented architecture has a hierarchical structure with weak connection for repair and maintenance, updating and expansion of the system. 4. An application of this approach is its ability of platform linking which improves designers' cooperation, efficiency, and development and reduces project risks 5. Another advantage is providing a user interface which notices insertion and deletion operations within database and completes reasoning by means of searching database.
Weak points	1. This approach can be applied as a structure and method to create a costs control expert system; however, only essential capabilities are detected. 2. Within this approach, the structure rectification should be done in a large scale in order to be used for product costs control.

Table 1. Examination of first approach: Costs control approach in expert systems based on service-oriented architecture

2.2. Reasoning tree approach within expert systems based on service-oriented architecture

This approach is based on the work of LI et al.(2010). These professional proposed a new approach, so-called soft-bus, based on service-oriented architecture as well as a basis for optimizing expert systems applying service-oriented architecture.

Qualities of medical expert systems in combination with service-oriented architecture and the notion of soft bus suggest a new architecture of medical expert system which applies a new definition for medical expert system architecture and leads to the creation of expert system's reasoning tree. This method provides a new architecture of such advantages as increasing inquiry and detection efficiency, reasonably categorizing expert database, having access to expert system integration, standard interface and system scalability. Table 2 presents examination of reasoning tree approach within expert systems based on service-oriented architecture; this approach is the article's second approach related to the application of service-oriented architecture in optimizing expert systems.

Approach	Reasoning tree approach within expert systems based on service-oriented architecture
Qualities	1. Within this architecture approach, soft-bus service has been provided as an applied architecture style in which all functions exist as independent services with an appropriate definition of user interface request. 2. Aim of soft-bus service is to combine service-oriented technologies, to provide a centralized management of various web services, and to offer a system for heterogeneous information technology environment. 3. Soft-bus service allows communications, integration, security, support for transactions and service quality control required for the performance of service-oriented architecture infrastructures. 4. Using soft-bus service architecture provides the medical expert system platform in four layers: presentation layer (service consumers), middle layer, business service layer (service suppliers), and applied layer (fine grained components). 5. Considering medical majors and reconstructing definition of medical expert systems, this approach creates a reasoning tree which is of great importance to enhance inquiry efficiency and detection and reasonable categorization of database. 6. Medical expert system platform is divided into five major modules including inquiry and detection system, systems management system, knowledge acquisition system, medical knowledge (of various kind) service system (for example internal medical knowledge services, children medical knowledge, Chinese medical knowledge system) which are responsible for explanation and management of user interface's uniform standards
Strong points	1. Based on this new architecture, effective integration of existing medical expert systems can be realized 2. This approach allows sharing and reusing resources based on standard interface; at the same time, medical expert system management and expert systems globalization can be achieved. 3. Increasing scalability and maintainability of medical expert system, improving the pace of system development based on the standards of medical knowledge, and also utilizing quickly the existing medical knowledge resources all are achieved in order to expand functions and amplitude of medical expert systems. 4. By means of soft-bus architecture services, the address of service suppliers and transportation protocol get clear for customers because customers are only in touch with soft-bus service and this service hides address of real service suppliers and transportation protocol.
Weak points	1. The most important defect of this system is its reliance on soft-bus service as the main interface between services provided by the system and reasoning tree; in case of soft-bus service's breaking down, the whole system is troubled.

Table 2.Reasoning tree approach within expert systems based on service-oriented architecture

2.3. Self-service software approach within expert systems based on service-oriented architecture

This approach is based on the work of Zheng et al.(2011). These professionals proposed an approach for detection of various types of fish based on digital photos and also on service-oriented architecture and accordingly suggested a basis for optimizing expert systems using service-oriented architecture.
Self-service software approach provides a new system for automatic detection of fish based on digital photos. This systems which is based on service-oriented architecture is intended to offer self-service software for public. Table 3 presents examination of self-service software approach within expert systems based on service-oriented architecture; this approach is the present article's third approach related to the application of service-oriented architecture in optimizing expert systems.

Approach	self-service software within expert systems based on service-oriented architecture
Qualities	1. This approach provides a system based on service-oriented architecture so as to offer self-service software for public. 2. Through using web service and service-oriented architecture, an expert system which has much more advantages (including effective search and retrieval of resources, sharing both algorithms and data, transforming digital photos, appropriate use of services, storage and transferring a large amount of data) is provided. 3. This approach is based on four layers of presentation, business, service, and data. Service layer includes five types of services, namely, image preprocessing service, image training service, image recognition service, morphological ontology generation service and owl. 4. This approach, applying service-oriented architecture and web service technology, has achieved success in providing self-service software for public. 5. In addition, fish detection system which is based on service-oriented architecture can successfully upload and preprocess images and extract and match specifications using user interface.
Strong points	1. Some major advantages of this system are fish detection (compared to other fish ontology systems), sharing original images of fish, data processing, and envisaging algorithms. 2. Offering a powerful user interface and self-service software is the most important advantage of this approach. 3. Services of this system provide training, detection, and consultancy possibilities.
Weak points	1. Large volume of images in database, probability of Internet attack, and database management are this system's shortcomings. 2. The system's lack of ability to take color into consideration as an ontology criterion is another defect of the system.

Table 3. Examination of the third approach: self-service software within expert systems based on service-oriented architecture

3. Comparison of the approaches using evaluation criteria

Considering numerous applications of service-oriented architecture within different areas, application of this style of software architecture in the field of expert systems, and finally three approaches proposed by this article to create expert software based on service-oriented architecture, there is a need to propose criteria for evaluation of coming and existing expert systems based on service-oriented architecture. Therefore, the article has proposed some criteria for evaluation of expert systems based on service-oriented architecture. These criteria include agility, integrity, usability and reusability, business objectives, accessibility, and provision of new, applied services, which have been shown by Table 4 Through examining advantages and applications of service-oriented architecture as well as expert systems' limitations, some criteria were proposed and each criterion was characterized by the qualities. The more these qualities are achieved, the more powerful the proposed approach becomes in evaluation of expert systems.

Criterion number	Criterion name	Required qualities
1	Agility	Ag1.Fast change of system due to system functions, geographical change, upgrading platform or change of technology providers Ag2. Using modern communicative and information technologies and systems to establish appropriate and on-time connections
2	Integrity	In1. Integrating systems based on supplied services In2. Establishing strong and reliable interactions
3	Usability and reusability	Ur1. Offering understandable and trainable services Ur2. Offering services for effective use of service consumers Ur3. Future reusability with minimum effort Ur4. Intractability of the program, order and creation of help services
4	Business objectives	Bo1. Improving capital recovery: removing and replacing middle-ware with standard web service technologies Bo2. Linking business and information technology: offering services usable by various units Bo3. Offering processes with a service-oriented perspective and process management at business level
5	Accessibility	Ac1. Providing a strong use interface to be used by the final user
6	Offering new, applied services	Os1. Offering services in the form of applied services Os2. Defining weak-connection and applied services

Table 4. Criteria for evaluation of expert systems approaches based on service-oriented architecture

3.1. Evaluation of approaches based on proposed criteria

This section deals with evaluation of approaches according to the proposed criteria. First, each approach is examined according to the criteria and finally, three approaches are evaluated and compared. Table 5 includes evaluation of first approach. In this table, the proposed criteria are considered for the first approach and the qualities to satisfy each criterion are discussed.

Criterion	Examination of criterion qualities in this approach
Agility	Ag1. Offering good management, and advance technologies and design required by the project based on costs control strategy in combination with base knowledge and expert system leads to appropriate control of systems and resources in order to manage organizational costs. Ag2. Improving designers' cooperation, efficiency, development and reduction of project risks all are achieved by means of platform liking.
Integrity	In1. In this approach, services are placed at different levels according to their efficiency; and this is effective in integrating the system to offer more suitable services In1. Offering registry service for registry and categorization, explanation, repair, and maintenance of information related to web sources and public access mechanism; and also releasing various kinds of sources and examples to source suppliers
Usability and reusability	Ur1. Understandability and trainability are obtained by precise determination of functions while analyzing qualities needed by services Ur2. Offering weak-connection and integrated services at different levels according to efficiency of each service and offering a strong user interface which completes reasoning through perfect database search both lead to an effective use of system by service consumers
Business objectives	Bo1. Improving capital recovery by means of standard web service technologies Bo3. Offering project management service through five management axes in order to make information decisions based on criteria and connection with other services
Accessibility	Ac1. Improving designers' cooperation, efficiency, development and reduction of project risks all are achieved by means of platform liking Ac1. Offering a strong user interface which completes reasoning through perfect database search in combination with applied services leads to creation of a strong user interface
Offering new, applied services	Os1. Designing the architecture of costs control expert system based on service-oriented structure at three different levels and five services Os2. This approach's services include data service, project management service, solution service, registry service, and service requestor all of which are very useful in the application of this approach in costs management.

Table 5. Evaluation of the first approach based on evaluation criteria

Table 6 includes evaluation of the second approach. In this table, the proposed criteria are considered for the second approach and the qualities to satisfy each criterion are discussed.

Criterion	Examination of criterion qualities in this approach
Agility	Ag1. Formation of reasoning tree considering medical majors and reconstruction of the definition of medical expert systems which are of great importance for improving inquiry efficiency and detection and reasonable categorization of database Ag2. Using the soft-bus service as the main connection between the services supplied by the system and reasoning tree, an appropriate and on-time connections are generated among different parts of the system Ag2. By means of soft-bus service, the address of service suppliers and transportation protocol get clear for customers because customers are only in touch with soft-bus service and this service hides address of real service suppliers and transportation protocol.
Integrity	In1. Through establishing appropriate and on-time connections among different parts of the system, soft-bus service allows integrated services to be provided in the system In1. By means of reasoning tree, the system is allowed to integrate existing medical expert systems
Usability and reusability	Ur2. Using soft-bus service allows more effective use of system services by users, combination of service-oriented technologies, provision of a centralized management of various web services, and provision of a system for heterogeneous information technology environment. Ur3. While combining soft-bus service with reasoning tree, this approach allows enhancing scalability and maintainability of medical expert systems, improving the pace of system development according to medical knowledge standards, and utilizing existing medical knowledge sources faster
Business objectives	Bo1. Improving capital recovery with the help of soft-bus service leads to centralized management of various web services Bo3. This system has considered a separate layer for business processes; business services layer can provide different technologies so as to achieve a unified business service in the system.
Accessibility	Ac1. It allows sharing and reusing sources by means of standard interface; on the other hand it helps us to realize medical expert systems management and expert systems globalization
Offering new, applied services	Os1. Using the architecture of soft-bus service provides a medical expert systems platform of 4 layers: presentation layer (service consumers), middle layer, business service layer (service suppliers) and applied layer (fine grained components) Os1. The most important service offered by this approach is soft-bus service which provides communications, integration, security, transaction protection and service quality control required by the performance of service-oriented architecture infrastructures.

Table 6. Evaluation of the second approach based on evaluation criteria

Table 7 includes evaluation of the third approach. In this table, the proposed criteria are considered for the third approach and the qualities to satisfy each criterion are discussed.

Criterion	Examination of criterion qualities in this approach
Agility	Ag1. Provision of self-service software for public with the help of service-oriented architecture and web service technology
Integrity	In1. This approach is based on four layers of presentation, business, service, and data. Service layer includes five types of services, namely, image preprocessing service, image training service, image recognition service, morphological ontology generation service and owl.
Usability and reusability	Ur1. Combining service-oriented architecture and web service technology and also providing self-service software have led to such possibilities as training, detection, and consultancy Ur2. Service-oriented architecture and adoption of web service technology are applied to offer self-service software for public
Business objectives	Bo3. Offering business layer for management in order to process business rationale
Accessibility	Ac1. Through providing self-service software, the possibilities of training, detection, and consultancy are generated Ac1. Possibilities of uploading images, preprocessing images, and extracting and matching specifications by means of user interface
Offering new, applied services	Os1. This approach is based on four layers of presentation, business, service, and data. Service layer includes five types of services, namely, image preprocessing service, image training service, image recognition service, morphological ontology generation service and owl.

Table 7. Evaluation of the third approach based on evaluation criteria

By examining advantages, disadvantages and qualities of these approaches and also considering evaluations conducted for them, it can be concluded that all the three approaches are successful in optimizing expert systems by means of service-oriented architecture.

The most important specification of the first approach, so-called costs control approach within expert systems based on service-oriented architecture, is satisfying business objectives. While combining qualities of web service, this approach provides a particular project management service of five managerial exes for system decision-making and management.The most important specification of the second approach, so-called creation of reasoning tree within expert systems based on service-oriented architecture, is to meet integrity. While combining the application of soft-bus service, this approach allows provision of integrated services in the system by means of creating appropriate and on-time connection among different parts of the system. Using reasoning tree approach also allows integrating the existing medical expert systems.The most important specification of the third approach, so-called creation of self-service software within expert systems based on service-oriented architecture, is to satisfy accessibility. Proving a strong user interface and self-service software, this approach creates possibilities of training, detection, and consultancy.

4. Results and further research

Considering the qualities mentioned for the application of service-oriented architecture within expert systems based on the three proposed approaches, it is concluded that capabilities of this type of software architecture in providing various qualities can perfectly be proved; those qualities include provision of a hierarchical structure with weak connection for repair and maintenance, updating and expansion of expert systems, the ability of platform linking which improves designers' cooperation, efficiency, and development and reduces project risks, logical categorization of expert database and ability to integrate expert systems, standard interface and scalability of expert systems, and provision of self-service software.

Furthermore, proposing criteria for evaluation of expert systems based on service-oriented architecture and then evaluating the three approaches according to the criteria, it was revealed that all the three approaches are successful in satisfying qualities of evaluation criteria and that more success of service-oriented architecture depends on satisfying agility, integrity, usability and reusability, business objective and accessibility as well as offering new, applied service for expert systems.Taking into consideration various advantages and applications of service-oriented architecture and also combining this type of software architecture with expert systems,Therefore, the most important constraints of expert systems such as systems' vulnerability, solution strategy unity, lack of system interfaces' uniformity, problems of development, repair and maintenance can be removed. As the result, expert systems become agile, integrated and accessible with capabilities of using and reusing and satisfying business objectives and some novel services and applications can be offered for expert systems.

By considering the specific qualities of service-oriented architecture and the possibility of developing this style of architecture in production and updating software and also by examining the applications of service-oriented architecture in optimizing expert systems, the author suggests conducting an applied study on presentation and implementation of an expert system with the specifications of service-oriented architecture. In addition, taking into account various advantages and applications of service-oriented architecture and also

by combining this style of software architecture with expert systems, some other criteria (such as complexity, efficiency, flexibility, reliability, adaptability, service quality assurance, gradual development and implementation) can be considered to evaluate expert systems based on service-oriented architecture.

References

Bieberstein, N., & Bose, S., &Fiammante, M., & Jones, K., & Shah, R. (2005).*Service-Oriented Architecture Compass: Business Value, Planning, and Enterprise Roadmap*. IBM Press.

Cebi, S., &Celik, M., &Kahraman, C., &Deha, E. I. (2009).*An expert system towards solving ship auxiliary machinery troubleshooting:SHIPAMTSOLVER*. Expert Systems with Applications. 36, 7219–7227.

Erl, T.(2005).*Service-Oriented Architecture: Concepts, Technology, and Design*. Prentice Hall PTR

Erl, T., (2007). *SOA, Principles of Service Design*.Prentice Hall PTR

Etik, N., &Allahverdi, N., &Sert, I. U., &Saritas, I. (2009).*Fuzzy expert system design for operating room air-condition control systems*. Expert Systems with Applications. 36, (6), 9753–9758.

Ghazanfari, M., &Kazemi, Z. (2008).*The Principle of Expert Systems*.Science & Technology university Press.

Krishnan, S., & Bhatia.K, (2009). SOAs for scientific applications: Experiences andchallenges. Future Generation Computer Systems. 25, 466-473.

Li, X., &Xu, Q., &Chen, J., & Dong, H. (2010).*Research of the Medical Expert System under a NewArchitecture*.New Trends in Information Science and Service Science (NISS).4th International Conference.

Peng, J., & Yi, H., & Lu, Y. (2009). Research on Cost Control Based on Expert System and SOA Structure.ISECS International Colloquium on Computing, Communication, Control, and Management.

Shams, F., &Mahjoorian, A. (2010).*The Principles, Fundaments and Methods of Service Oriented Enterprise Architecture*. ShahidBeheshti University Press.

Viinikkala, M., &Jaakkola, V. P., &Kuikka, S., (2008).*Value added web services for industrial operations and maintenance.* 7th International Conference on Enterprise Information Systems.ICEIS. 24–28 May, Miami, Florida, USA.

Zheng, X., &Zhong, J., & Zhang, Y. (2011).*A SOA-based Fish Recognition System Prototype*. Third International Conference on Intelligent Human-Machine Systems and Cybernetics.