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

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ABSTRACT

Modern expert systems have some limitations such as vulnerabilities, the unity of solution strategy, development problems, repair and maintenance. These limitations could be covered by Service-Oriented Architecture (SOA), due to the advantages and various applications of this architecture and its combination to expert systems. The main purpose of this paper is to survey service-oriented architecture to provide solutions for using this style in order to eliminate the short comings and optimize services in expert systems. In this paper, several metrics for evaluating expert systems based on service-oriented architecture are presented. These metrics are in six branches: agility, integrity, usability and reusability, business objectives, accessibility, offering new and applied services. For each metric some properties are presented which the expert systems show more powerful in evaluation.

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1. INTRODUCTION

Service-Oriented Architecture (SOA) is considered as the latest generation of information systems architecture which was first introduced in 2000 at which the architecture of the existent software has reached the extreme of its capabilities. This 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 [1]. SOA can be regarded as a mature form of component-based architecture, object-oriented design and distribution systems that used widespread during a few recent years.This form serves as a complementary approach to help organizations to manage their challenges. One of the most important challenges is the daily increasing growth of information systems by which organizations need to quickly respond to new business demands.

Service-orientation emerged as a design approach in support of achieving the following goals and benefit associated with SOA and service-oriented computing: Increased intrinsic interoperability, increased federation, increased vendor diversification options, increased business and technology domain alignment, increased return on investment (ROI), increased organizational agility, reduced IT burden [12].

Authors and companies supporting SOA 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 SOA. Capability of reusing system or program code was placed at the center of attention by software production and development methods [2]. Protecting product of short life cycle is another application of SOA, about which several articles including service supply and scientific application

have been published while offering some easier scientific infrastructure for implementation of software products [3]. SOA also reduces expenses used by information technology and business services in two ways so as to improve capital recovery [4]. A key role of SOA is direct mapping of business processes to information technology. Further, considering that SOA is not a huge and other 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, SOA's flexibility and easy transformation from one service suppliers to another apply to both in-house and external services [5].

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 [6]. 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 [7]. 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 [8].

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 [8], 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 [9].

Considering various advantages and applications of SOA, if this style of software architecture is combined with expert systems, the most important constraints of expert systems such as systems, vulnerabilityand 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.

The main purpose of this paper is to survey service-oriented architecture to provide solutions for using this style in order to eliminate the short comings and optimize services in expert systems. In this paper, several metrics for evaluating expert systems based on service-oriented architecture are presented. These metrics are in six branches: agility, integrity, usability and reusability, business objectives, accessibility, offering new and applied services. For each metric some properties are presented which the expert systems show more powerful in evaluation.

2. CURRENT APPROACHES

This section examines three SOA approaches, namely: (a) costs control approach in expert systems based on SOA, (b) reasoning tree approach within expert systems based on SOA and finally (c) self-service software approach within expert systems based on SOA. 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. [10]. Having studied costs control system and knowledge management system and also offering a costs control structure based on SOA, these professionals have proposed a basis for optimizing expert systems based on SOA. 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 SOA, namely, the article's first approach that is related to application of SOA in optimizing expert systems.

Table 1. Examination of first approach: Costs control approach in expert systems based on SOA

Approach	Costs control approach in expert systems based on SOA
Qualities	1. It provides a basis for optimizing expert systems based on a costs control structure which is based on SOA, 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 SOA 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 SOA 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.

2.2. Reasoning Tree Approach within Expert Systems Based on Service-Oriented Architecture

This approach is based on the work of LI et al. [9]. These professional proposed a new approach, socalled soft-bus, based on SOA as well as a basis for optimizing expert systems applying SOA.

Qualities of medical expert systems in combination with SOA 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 SOA; this approach is the article's second approach related to the application of SOA in optimizing expert systems.

Table 2. Reasoning tree approach within expert systems based on SOA

Approach	Reasoning tree approach within expert systems based on SOA
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 SOA 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.

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. [11]. These professionals proposed an approach for detection of various types of fish based on digital photos and also on SOA and accordingly suggested a basis for optimizing expert systems using SOA.

Self-service software approach provides a new system for automatic detection of fish based on digital photos. This system which is based on SOA is intended to offer self-service software for public.

Table 3 presents examination of self-service software approach within expert systems based on SOA; this approach is the present article's third approach related to the application of SOA in optimizing expert systems.

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

Approach	self-service software within expert systems based on SOA
Qualities	1. This approach provides a system based on SOA so as to offer self-service software for public. 2. Through using web service and SOA, 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 pre-processing service, image training service, image recognition service, morphological ontology generation service and owl. 4. This approach, applying SOA and web service technology, has achieved success in providing self-service software for public. 5. In addition, fish detection system which is based on SOA can successfully upload and pre-process 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 colour into consideration as ontologymetric is another defect of the system.

3. COMPARISON OF THE APPROACHES USING EVALUATION METRIC

Considering numerous applications of SOA 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 SOA, there is a need to propose metrics for evaluation of coming and existing expert systems based on SOA. Therefore, the article has proposed several metric for evaluation of expert systems based on SOA.

Our metrics are in six branches: agility, integrity, usability and reusability, business objectives, accessibility, offering new and applied services, which have been shown by Table 4 Through examining advantages and applications of SOA as well as expert systems' limitations, some metrics were proposed and each Metric was characterized by the qualities. The more these qualities are achieved, the more powerful the proposed approach becomes in evaluation of expert systems.

Table 4. Metrics for evaluation of expert systems approaches based on SOA

Metric Number	Metric	Abbreviation	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

3.1. Evaluation of Approaches Based on Proposed Metrics

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

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

Metric	Examination of metrics 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.***Understand ability and trainability are obtained by precise determination of functions while analysing 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 ***Ur3.*** The presenting services with accurate information can improve their reusability with some changes in functionality of each service and offer new services at each layer.
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 metrics 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 6 includes evaluation of the second approach. In this table, the proposed metrics are considered for the second approach and the qualities to satisfy each Metric are discussed.

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

Metric	Examination of metrics 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 SOA infrastructures.

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

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

Metric	Examination of metrics qualities in this approach
Agility	***Ag1.***Provision of self-service software for public with the help of SOA 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 pre-processing service, image training service, image recognition service, morphological ontology generation service and owl.
Usability and reusability	***Ur1.***Combining SOA and web service technology and also providing self-service software have led to such possibilities as training, detection, and consultancy. ***Ur2.***SOA 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, pre-processing 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 pre-processing service, image training service, image recognition service, morphological ontology generation service and owl.

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 SOA.

Table 8 summaries the Comparison of the three approaches for the evaluation based on the metrics. From the table 8, we got the following results:

- Result 1: The first approach, so called costs control approach within expert systems based on SOA, provided Usability and reusability (*Ur*) metric in the first place; and in the second place, it provided Offering new & applied services (*Os*), Business objectives (*Bo*), and Agility (*Ag*) metrics.
- Result 2: The second approach, so called creation of reasoning tree within expert systems based on SOA, provided Business objectives (*Bo*), Agility (*Ag*), Usability and reusability (*Ur*) metrics in the first place; and in the second place, it provided offering new & applied services (*Os*) metric.
- Result 3: The third approach, so called creation of self-service software within expert systems based on SOA, provided Usability and reusability (*Ur*) metric in thefirst place; and in the second place, it provided Offering new & applied services (*Os*), Business objectives (*Bo*), and Agility (*Ag*) metrics.
- Result 4: Finally, it can be concluded all three approaches are enable to provide integrity (*In*) and Accessibility (*Ac*) metrics.

Table 8. Comparing evaluation of three approaches

	Agility	Integrity	Usability and reusability	Business objectives	Accessibility	Offering new&applied services
First approach	Ag1,Ag2	In1	Ur1,Ur2,Ur3	Bo1,Bo3	Ac1	Os1,Os2
Second approach	Ag1,Ag2	In1	Ur2,Ur3	Bo1,Bo3	Ac1	Os1
Thirdapproach	Ag1	In1	Ur1,Ur2	Bo3	Ac1	Os1

4. RESULTS AND FURTHER RESEARCH

Considering the qualities mentioned for the application of SOA within expert systems based on the three proposed approaches, it is concluded that: (a) 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, (b) updating and expansion of expert systems, (c) the ability of platform linking which improves designers' cooperation, (d) efficiency and development and reduces project risks, (e) logical categorization of expert database and ability to integrate expert systems, (f) standard interface and scalability of expert systems, and (g) provision of self-service software.

Furthermore, proposing metrics for evaluation of expert systems based on SOA and then evaluating the three approaches according to the metrics in this paper, it was revealed that all the three approaches are successful in satisfying qualities of evaluation metrics and that more success of SOA 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 SOA 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, and 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 SOA and the possibility of developing this style of architecture in production and updating software and also by examining the applications of SOA in optimizing expert systems, the authors suggest conducting an applied study on presentation and implementation of an expert system with the specifications of SOA. In addition, taking into account various advantages and applications of SOA and also by combining this style of software architecture with expert systems, some other metrics (such as complexity, efficiency, flexibility, reliability, adaptability, service quality assurance, gradual development and implementation) can be considered to evaluate expert systems based on SOA.

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