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An ERP Framework Based on Service Oriented Architecture and Cloud Computing Environment
Case: IRISL Container Department

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Abstract: **Nowadays in the business world, all levels of all organizations need a concise planning. Regarding high-speed growth in globalization and competition trend, moving the organizations to the creation of integrated software systems with using latest technologies is a necessity. One of the most significant among the above-mentioned software systems is ERP. Both SOA and cloud deals with delivering services to business with improved agility increased speed and reduced cost that can lead to greater innovation and effective returns on investment. In this paper, after study about functional and nonfunctional requirements of ERP systems, by a framework, It will be study and research about achievement in ERP systems after engaging SOA and cloud computing and their impacts on ERP. Such that these impacts will resolve so many of shortages and needs of conventional ERP as well as reduction of risks and costs of implementation of ERP in organizations. Finally, we used ATAM for evaluating the framework. The idea of the experts in both business and ICT gathered by questionnaire and the data analyzed via TOPSIS method. Similar research for using strength of SOA and cloud computing in traditional ERP in shipping industry is a novelty.**

Keywords-ERP; SOA; Cloud Computing; IRISL[1]

I. INTRODUCTION

The concept of SOA, as related to cloud computing is simple. It is necessary to understand that when we are dealing with clouds, we are dealing with services, and when we are dealing with services, we should deal with SOA. In SOA world we talk of services and only services, where services are in form of software, live components, and objects (technical things), but when it comes to realization in the real world it is outcome based. It is generally found people saying 'we are doing SOA so we are ready for the cloud', but the difference between SOA services and the cloud context is huge. Typically, Cloud focuses only towards the outcome, not the technology. "In the cloud, the service terminology you are focusing on is a relationship between service provider and consumer, not technology provider and consumer"[3]. SOA based design involves in defining sets of services that may exist physically within the data center, on a public cloud, or

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perhaps in both places (hybrid cloud) and we need to consider the quality of the services design, the granularity, or how well the services approach a "functional primitive," and thus providing more value. In ERP SOA-Cloud Integrated environment, all the services are not hosted but are owned by the ERPs only. In order to achieve the business objective using such integrated architecture service governance is needed which includes the location of services, service security, services dependencies, service monitoring, service compliances etc. According to D.S. Linthicum "Governance places a layer of processes and technology around the services so that anything occurring will be quickly known"[7].

II. ERP SYSTEM REQUIREMENTS

The goal of requirements engineering process in ERP is providing the required documents. This process has four parts include the Feasibility study, Requirements elicitation, and analysis, Requirements specifications, Requirements validation.

Generally, ERP system requirements divided into two categories. Functional and nonfunctional. In systems engineering and requirements engineering, Nonfunctional requirements (NFR) are requirements that specify criteria that can be used to judge the operation of a system, rather than specific behaviors. They are on the opposite of functional requirements that define specific behaviors or functions.

Functional Requirements should be consistent, Complete, Feasible, Required, Accurate, Traceable and verifiable.

On the other hand, nonfunctional requirements have not direct relation with the special functions of the software system and the main nonfunctional requirements are product requirements. Nevertheless, there are so many defections in conventional ERP systems such as:

-High cost for primary implementation of ERP for purchasing hardware, Software, providing appropriate high speed and secure infrastructure.

-Time-consuming while implementation

-The necessity of engaging too many ICT experts for maintenance and development of ERP system

-Dependency to a unique hardware and software platform

-Difficult development

-Lack of mobility

Besides too many other defections. Therefore integrating ERP system with SOA and cloud computing architecture can compensate above defections and makes ERP in aligned with new technology and services.

III. SOA

Service-oriented architectures are typically highly dynamic and flexible: Components and services are not only loosely coupled and communicate according to standardized protocols but also interface specifications are exchanged at run-time. Thus, clients can replace services at run-time.

The basic features of SOA:

a) Separate functional entity.

b) Access to large amounts of data under a low frequency.

c) The way to transmit the message based on the text.

The key features of SOA [3]:

a) Providing application development and integrated architecture, strategy on the level of thought way, and no longer only focusing on the technical level.

b) Providing a model of the component that is a functional unit that can be used.

c) Providing the way to integrate the functional units and make them interact with each other.

d) Providing the standardized interfaces, which are independent of the operating systems, hardware platforms, and programming languages

This might be advantageous if a new service provides a better alternative to the former one concerning functionality or quality of service. Alternatively, it might become necessary for self- healing purposes, e.g., if a service is not reachable any longer because of network problems. [4]

Table 1: Compares conventional ERP with ERP based on SOA

Conventional ERP	ERP Based on SOA Architecture
Costly communications	Value creator communications
Based on performance	Based on process
Build for survive	Build for change
One tome development	Gradual Development
Non interoperable software	Various software collection
Single platform	Platform independent
Sever connection	Loosely connection
Component orient	Massage orient

A. SOA in ERP

SOA is a commonly used term these days in describing where software is going as it has relation to enterprise management systems. SOA refers to a flexible set of design principles used in integrating various computer applications. Essentially, SOA provides a way for a "consumer" of services, such as web-based applications and services, to be aware of services available to it.

In ERP, it implies that the software landscape is shifting from technology based on specific business services to a "messaging infrastructure" that translates and routes information from system to system, or application to application, without those systems needing to connect directly. You can add or change or update with a link, than by having to tear apart systems or build complex new code.[5]

Simple examples of business services that can be easily understood are actions like "find a customer record" or "get credit rating." Messaging enables one code unit to seek the requested information from another, even if they haven't spoken to each other before, by extracting pieces of data and business logic that the consumer requests. The overall logic is the logical extension of object-oriented programming principles first developed in the 80's and 90's. [6]

What we see today is ERP vendors increasingly embracing the SOA concept to enable connectivity to other ERP components, as well as to outside services. Frequently the ERP vendors develop their own "middleware" to handle the software part of a service SOA using their own homegrown integration software. Thus, the key architecture is kept in-house Most major ERP vendors have announced strategies to rebuild their ERP applications with integration with set of services. [5]

IV. CLOUD COMPUTING

A. Essential Characteristics of Cloud Computing

Cloud computing (or called utility computing) refers to an ICT service model and platform that provides on-demand based IT services over the Internet. Although there are a variety of definitions of cloud computing, the NIST[1] definition (version 15) considered as the most accurate and comprehensive. According to NIST's definition, cloud computing is composed of five essential characteristics, three service models, and four deployment models. The five essential characteristics are on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured Service [7].

B. Cloud Service Models

Cloud Computing integrates all the technical advantages of Parallel Computing, Distributed Computing, Grid Computing, Utility Computing and so on. It is a kind of business model called "all resources are services"[5]. According to the type of service, Cloud Computing can be divided into three different service levels [6]: SaaS, PaaS and IaaS. The three levels of Cloud Computing services as Figure 1[6]:

a) SaaS[2]: The SaaS's service providers have deployed a variety of application software or systems in their own servers. The application software or systems are managed and maintained by the service providers. Meanwhile, the service providers also provide the hardware facilities which the software need to run the system. What it provides is an application framework.

b) PaaS[3]: The direct customers of PaaS are system developers The PaaS's providers provide users with the required system development environment, hardware resources, server platforms, databases, application servers, and other services. The users can just simply develop the software application on the platforms provided by the service providers. What it provides is an integrated environment.

c) IaaS[4]: The IaaS is also known as the hardware platform. It is mainly to provide users with virtualized computing resources, communication resources, storage resources and network resources. It includes all the hardware facilities such as CPU, memories, servers, etc. What it provides is a software application environment [12].

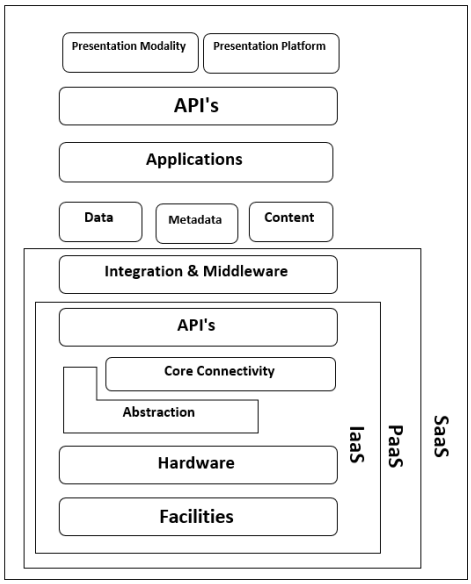

Fig. 1: Cloud Reference Model Diagram

According to the researches, Cloud computing services have 25 impacts in organizations performance [11]:

Table 2: Comparison of ERP systems before and after moving on to cloud [11]

ERP Characteristics	Before Moving to Clouds	After Moving to Clouds
Need for technical IT support for fail over environments	✔	✘
Need for ERP Development team	✔	✘
Need for extra hardware and software resources and licenses	✔	✘
Need to configure latest technology updates	✔	✘
Need to arrange own extra and cooling	✔	✘
Lack of competition and accuracy trust	✘	✔
Lack of confidentiality	✘	✔

[1] National Institute of Standards and Technology
[2] Software as a Service
[3] Platform as a Service
[4] Infrastructure as a Service

Lack of trust on security policies and access control rules	✗	✓
Daily storage and backup burden	✓	✗
Huge cost	✓	✗
High speed internet connection	✗	✓
Subscription and registration charges	✗	✓
Need for requirements gathering and elicitation	✓	✗
Need for project management	✓	✗
Need for coding	✓	✗
Need for testing	✓	✗
Need for deployment	✓	✗
More loss of control of and application or resources risks	✗	✓
Conflicts between opposing goals of different clients, either play it together if not neec to separate them	✗	✓
Higher risks of resource availability and failure	✗	✓
Lack of trust in data alteration before storing	✗	✓
Denial of denial service attack in critical server health situations	✗	✓
Higher risks of stress load and congestions	✗	✓
Difficult to audit	✗	✓
Monitoring of clients logs and information by third party	✗	✓

On the other hand, there are 6-cost reduction in organizations after implementation of Could ERP as below [11]:

Table 3: Cost reduction when moving ERP on to cloud [11]

Factors	Reductions
Requirement Elicitation and gathering cost	25%
Testing efforts	10%
IT labor and development team cost	50%
Capital utilization improvements	75%
Technical IT support cost	40%
Overall project cost	(30-40)%

C. Cloud SOA

SOA and cloud computing are related completely, specifically, SOA is an architectural pattern that guides business solutions to create, organize and reuse its computing components, while cloud computing is a set of enabling technology that services a bigger, more flexible platform for enterprise to build their SOA solutions[11]. In other words, SOA and cloud computing will coexist, complement, and support each other. Enterprises believe that the two greatest challenges that they have experienced in managing their profitability are threat from competitors and cost of managing changing demands of the business e.g. agility. As the market, demand changes there will a change in enterprise solution. This evolution converted the single tier application to distributed cloud application. To understand the SOA and Cloud together, we can take an analogy of library. The books in a library represents services that the customer can access, here library is analogous to cloud, which comprises on number of books (services). Books (services) are reusable and several books might make up a complete topic (application). Series of books to be used in order and a sort of link (interface) to connect to one book to other in order to complete one topic (application) requires a defined process or architecture SOA related requirements are to provide improved governance and management of services within the cloud environment where they may not be under direct control. Governance is a word that monitors prominence within the SOA environment; it is applicable at two phases of SOA development e.g. design time and run time. Design time governance relates to defining policies for services and run time governance monitors actually applying those design time policies to real time traffic [8].

For successful cloud computing application, the solid architecture is required e.g. SOA is required .SOA provides an architecture necessary to integrate your existing enterprise IT assets with the emerging world of cloud computing. The lack of proper SOA architecture leads to failure in cloud computing world. Service Oriented Architecture and the cloud; today, the popular cloud platform services are running mostly at the operating systems and programming languages rather than at the level of SOA platform. They support standards such as Linux and Java, rather than WS- Messaging and WSDL. To be useful for SOA, Cloud platforms should include enterprise service buses, service registries and other SOA platform components in other words SOA- as a service [3]. We proposed architecture in our study that uses SOA principles to create an overall strategic plan and architectural framework, There are important overlaps between cloud computing and SOA, The key benefit of SOA –cloud integrated enterprise solution is the ability to make system to system interface consistent in the enterprise architecture. This also facilitates the “on demand” access to virtualized IT resources that are hosted outside of your own data center. Cloud computing itself is a deploying architecture not an architectural approach. SOA provides a backbone to allow both the enterprise back-end servers and front-end applications to easily access cloud services. The integrated SOA cloud architecture for SME moves successfully the existing SOA architecture to support new cloud capabilities [2, 3].

V. PROPOSING FRAMEWORK

The approach to the Combination of SOA and Cloud computing in ERP should be organizational. Because SOA can help the flexibility between ERP and Cloud computing so that any modification in the types of interaction among organizations can be managed by SOA protocols. As it has been illustrated in table 1 there are some capabilities in SOA and cloud computing which can cover the defections of conventional ERP. SOA and its standards , protocols and services are used for interoperability between web applications in ERP while cloud computing architecture services the users for accessing to the modules of ERP systems via cloud., Elaboration between Cloud computing and SOA can make the organization and its ERP system a very effective, Efficient and dynamic

Table 4: Elaboration between SOA and cloud computing [9]

Factors	Cloud Computing	SOA
Security	Regarding to the assesments ,its security degree is not acceptable	SOA with its key protocols and concepts has high degree security
Reliability	Environment can be safe but risks are evident	Has safe environment and data are moved safely
Integrity	Is integrated	Easy in integration and orchestration
Interoperability	Difficult movement of big volume of data, which makes the system unsafe and slow. Non interoperable	This is the main feature of SOA that facilitates movement of data
Reusability	Service ineffeciency	Creating of services with more efficiency and code reusability
CRM	Better accessing to the resources	Cost Saving in accessing to the resources
Enterprise Resource Planning	More productivity in facilities and change management	More security and accessibility
Message exchange	Connection is sever and message exchange is costly	Loosely coupled in connections and message exchange is cost effective
Agility	Quick Development	Platforms improvments

Therefore SOA with the factors in table 4 can improve cloud computing services .These factors can improve all sections of cloud computing architecture such as infrastructure, operators, implementation. Data movement in the cloud environment, may cause some errors , inconsistency or resource misallocation which can be resolved by SOA [9].

A. Opportunities of integration between Conventional ERP System and Cloud Services

By employing cloud services, enterprises gain many benefits. Some known benefits are reducing initial investment [9], extending existing business process, short implementation period compare with make a new one by themselves and maximum flexibility of payment and easy to perform system upgrading [5]. These opportunities are also mentioned by each interviewee. However, whether these benefits can be fully gained depends on the integration between conventional ERP systems and cloud services. In this section, opportunities brought by integrating are analyzed at three different cloud service levels.

1)Integration between ERP and SaaS

As discussion in previous sections, SaaS brings new functions and the integration between conventional ERP systems and SaaS enables business process automation, data synchronized and seamless user interfaces. Two opportunities should be paid attention to. The first one is that business productivities are enhanced because automated business process requires less manual efforts, and data synchronizing mechanism reduces data inconsistence. In this case processing duration could be shortened and occasional errors caused by manual work could be eliminated. For example, by transferring sales order records from SaaS application back to ERP financing module automatically, the billing process will not be interrupted by waiting for manually entering the data. Moreover, seamlessly integrated user interface will help to improve user experiences which could also contribute to business productivity enhancement. A typical integration case is integrating logon and authorization features, so that users don't need to enter username and password when switching from ERP to SaaS application. The second one is, the value of SaaS purchase is maximized because SaaS functionalities could be better utilized up to the service contract limitation. For example, service contract may give a limitation on requesting frequency of 100 times per hour which is far beyond human being's capability, while requests initiated by the ERP system could easily reach this threshold.

2) Integration between ERP and PaaS

The nature of PaaS is all about development lifecycle but not business process. This point is commonly confirmed by interviewee1, 2 and 4. It then leads to a fact that enterprise users may not gain benefits from integrating directly related to business performance. However, integration between ERP system development environment and PaaS truly affect all aspects of technical management including programing, testing, deploying and maintaining. If looking into how integrated development platforms works, it's easy to understand that the major opportunity here is to make deploying process more efficient and reliable. For example, a pair of new

applications can be automatically distributed to both ERP and PaaS sides respectively. This automated process is helpful to reduce manual work for developers and also eliminate human being's mistakes.

3) Integration between ERP and IaaS

Hardware resources are runtime environment of ERP systems. Although IaaS is not directly related to ERP systems, it does affect many aspects of ERP systems such as the IT personnel and the performance. Therefore, integrating with IaaS brings the following opportunities. The first one is that

extra hardware resources are brought into existing infrastructure but not need to maintain self-hosting servers. This enhances the capability of ERP systems so that performance can be upgraded. The second one is that IaaS provider takes the responsibility of maintaining resources outside the enterprise, so in-house maintenance work will be simplified. As a result, integration with IaaS decreases the demand on local IT personnel.However, like every coin has two sides; integration between conventional ERP systems and cloud services brings challenges as well [13] .

B. Proposed framework

Most of the enterprises run their business processes via a single or heterogeneous systems which act similar as separate Iceland. Among all these enterprises , IRISL has also such defections in the structure of its traditional ERP and needs a model to resolve most the mentioned defections.. Business processes of such enterprises can not migrate to the cloud environment easily. According to the researches (forrester research), one of the most importnant obstacles and challenges for migrating the SAP ERP to the cloud environment is that SAP as an ERP has not optimized for cloud computing yet . Enterprises are moving to the cloud environment gradually.Therefore until then a strong framework is required in order to the integration of current software modules and ERP with the cloud environment. Afterward, the framework should be able to be connected to the other cloud environments. For achieving the mentioned result, we get help from ESB. According to Figure 2 which is our proposed framework and has been designed according to the current software modules of IRISL container department, we designed a framework by which , some external organizations such as port authority, customs, IMO,… are intended to make a bidirectional communications with some internal modules of the ERP of the mentioned department such as financial, ship management ,… via a cloud environment. In this case, the resources should be allocated to the best manner in the cloud environment .

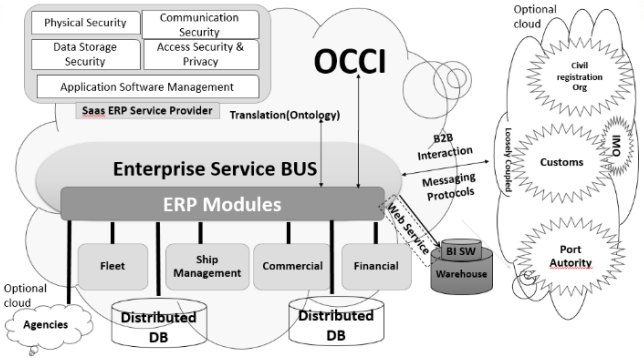

Fig. 2: Proposed Framework

In this framework , ESB is in charge of management and method of the communication between ERP modules and cloud environement with external software systems. The real value of ESB is preperation of an infrastructure for SOA in compliance with organization needs.

These needs are providing appropriate service level, centralizied managability and integration in heterogeneous environment.

One of the most important sections of ESB in this framework is OCCI[1] whose main responsibility is assesment and management of primary input communications from external software systems to ERP modules or conversely.At the first step , this layer checks that this is the first time connection with ERP modules via cloud environment or not. If the communicastion request to be for the first time, some parameters such as TOE[2](type of the organizations that are intended to make inside or outside commuinication) , connection ID ,conection time, source & destination , ….. will be gathered. According to the SOA features(HDDI,WSDL and SOAP) , Inside this layer some information about the allowed organizations and allowed connection type for communication will be resided. This will accelerate the communication speed between organizations as well as improving the security and risk level of that communication.

After stablishing connection between both ends , requested information will be received (or sent) from the destination. As there may be some inconsistency between data model of the destination system with the source system, the received information will be sent to Ontology layer. This layer will match the received information with the ERP data model from 3 aspects: communication,data and storage .After standardization of the data in accordance with ERP and cloud standards , the information will be delivered to the ESB. Moreover ESB as its natural task, will guarantee security of this communication session.With use of above mentioned advantages , an ESB based on cloud computing architecture , will allow the organizations to reply to the integration in cloud environment efficiently and

[1] Open Cloud Computing Interface

[2] Type of Enterprise

independent of software infrastructure , database and software language.One of the achievements of using cloud computing services in this model is taking advantae of its security services and embedding this type of service to ERP. Therfore security concerns such as physical, data and communication security which is based on AAA(Authentication, Authorization and accounting) model , will be fulfilled by using Saas in this model.The security issues that has been considered in this model are as table 5:

Table 5: Security issues of the model

Security issue	Concerns
Physical security	Rules & Guidelines
Communication Security	Transmission Security Network Security
Access Security	IDS,Firewall
Data Storage Security	Backup Disaster Recovery Encryption` Privacy
Application Software Management	Data Security Data Integrity Identity Management

IRISL has to many agents in all over the world which needs to connect to the central database as well as external software systems such as port authority, customs , ….The main part of IRISL in Container department which carries more than 9 millions container per year by 31 ocean going vessels. .This framework has been designed as the agencies are connected or not to the cloud services.. In addition the received data can be used by othe ERP software modules in case of need.In addition one of the achivements of this framework is ability of better management and distributing databases as well as obtaining the infrastructure of an OLAP[1] system in order to proving BI[2]. [15]

VI. FRAMEWORK EVALUATION

In order to evaluating this model we use ATAM method in the container department of IRISL3 Company. The Software Engineering Institute concurs: "The most important results are improved architectures. The ATAM aids in eliciting sets of quality requirements along multiple dimensions, analyzing the effects of each requirement in isolation, and then understanding the interactions of these requirements".[14]In this allignment we depicted the utility tree of IRISL container dept as below:

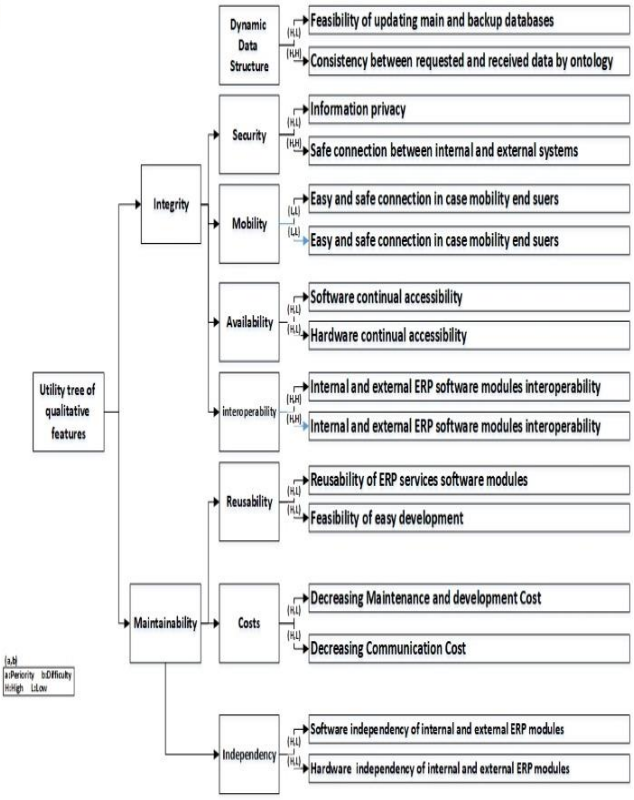

Fig. 3: ATAM utility tree

The items in above tree extracted from the idea of the domain experts in container shipping industry and the model recnciled with the tree. At the next step the output of the studies and interview with domain experts summaraized in table 6. In that table main and compulsar ERP requirements are compared with utilty tree scenarios and each rowe of the table is compared with proposed framework.

Table 6: comparing ERP requirements with utility tree

Analysis in utility tree	Main Requirement	Compulsory requirements
- Dynamicity in data Structure - interoperability	Communication with survival software	- Communication with civil registration ,customs ,port authority and IMO systems - Easy communication with other modules of adjacent ERP or in other clouds
-Independency - Cost - Reusability	Software ,Hardware &	No need to changing the hardware and

[1] Online Analytical Processing
[2] Business Intelligence
[3] Islamic Republic of Iran Shipping Lines

	location independent	software platform -Ease of creating new service -Ease of changing a service
- Accessibility - Security	Data Support	Automatic and secure backup & restore of data (disaster recovery)
- Accessibility - Security	Data Security	Secure connection between ERP modules with destination software
- Dynamicity of data structure - Accessibility	Data Refinery	Creating data warehouse and OLAP in aligned with BI
-Cost - Reusability - independency	Low Cost	Low cost for ERP infrastructure , hardware and software
- Accessibility - mobility	Users easy access	Distribution database and easy access of agencies to the ERP modules in all over the world

The covering all the requests in utility tree with the model asked by a questionare and its data analysed by TOPSIS[1] method.The average table of the experts according to liket scale is as figure 4.

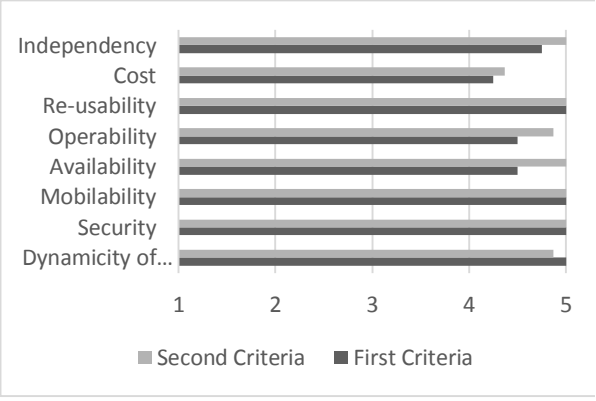

Fig. 4: Average table of experts

The findings in this evaluation illustrates that implemantion of the proposed model can have huge impact in increasing of the speed for data interoperability between IRISL conevntional ERP with the software systems which are independent to IRISL with lower cost , more availabilty and higher security.

VII - CONCLUSION

In this research that the same has not been done in IRISL so far, we explained that conventional ERP has so many defects which prevent pervasing and fulfilling all needs of modern companies. Therefore we have to engage in some new services and technologies in order to update ERP features as well as the answer to the new needs. In this paper, After study about the functional and nonfunctional requirements of ERP systems, we proposed a framework for combining SOA and cloud computing architecture with ERP.For evaluating this framework, we used ATAM technology in container department of IRISL. By study about the needs of the mentioned department, The framework evaluated by domain experts and after analyzing the received, fulfilling all the above needs by the framework was approved.

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