Reengineering Systems' Architecture for Service Oriented Businesses

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Abstract: *Service oriented technology and management have captured the attention of researchers and systems developers on the last few years for the purpose of finding methods to increase the companies' agility, to provide flexible business processes that would increase the value of services provided to customers. The orientation on services appears due to the presence of multiple organizational levels and to the increasing need for integration, flexibility and agility. The development of service oriented architectures in conjunction with reutilization of existing software entails both integration techniques and software migration strategies. The paper presents an approach on reengineering organization's architectures for service oriented business.*

Keywords*: service oriented architecture, reengineering architecture, business management, migration strategy, integration strategy.*

1. Business Management and Service Oriented Architecture

Service Oriented Architecture (SOA) may be seen as a model for solving problems of company integration at application level. SOA is trying to achieve company integration by providing application functionality as services to end user applications and to other applications [1]. SOA is based on a conventional request/response mechanism (figure 1). A service consumer invokes a services provider through the network and waits until the operation at the provider takes place. Thus, SOA divides an application into the service coordinator that represents the user functionality and the service providers that implement the functionality. While the coordinator tends to be unique for a particular application, a service may be reused and shared by multiple composite applications. The service coordinator explicitly specifies and invokes the services needed [2].

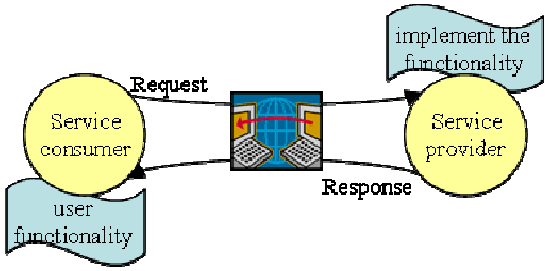

Fig. 1. Request/Response Mechanism in SOA

In 2007, SOA was concentrated mostly on Business Process Execution Language (BPEL) and Enterprise Service Bus (ESB) top components like Web Services, and, in 2008, first, on Service Component Architecture (SCA), which has represented delivery of composite applications and has reduced complexity and implementation costs for each part, and second, on Service Data Objects (SDO), which put the stress on independent data access language [3]. Definitions, mappings, business rules, information security and other characteristics are stored into a metadata deposit.

Service Oriented Architectures provide flexible software components that allow to organizations quickly adapted to the permanent demands for change of the market. In response to these challenges, organizations must achieve cultural, operational and structural changes, in order to become service oriented. Also, they must change the traditional and connected business processes into disconnected services and to adjust them vertically to the IT services provided by virtual resources [4], to notice the market changes and respond to them [5] and to reallocate dynamically the resources according to the change of priorities and demands [6].

The success in achieving the creation of new operational and business models involves the existence of an integrated approach on information technology, of proper modeled business processes, of modern management, of an organizational structure and culture that is open to change. In the context of management and service oriented technology, financial evaluation of technology investments, concerning especially infrastructure and service oriented platforms, is very important in order to answer the questions "How much should we invest?" and " What is the value that we will get from our investment?" [7]. Based on research and consultation of innovators in the managerial and service oriented technology fields, six management recommendations have been proposed in order to increase business value [8]:

a) "*Service-oriented architecture should not be viewed as a standalone investment*". Service Oriented Architecture should be included into the company application and the information architecture that define the business unit architecture and cooperation. In order to minimize development redundancy, which might increase costs and lead to inefficiency, it is necessary to create a general image of the company regarding the characteristics of present and future service oriented technology.

b) "*Service-oriented architecture governance is required fairly early in the cycle of commitment to the new service paradigm for the enterprise to be successful with it*". Furthermore, it is recommended that middle and high level managers from different business units should be appointed as links in the organizational effort of implementation of service oriented systems, of management practice and architecture [9].

c) *The creation of an "Excellence Service Center" within the organization* in order to: ❶ sustain the organizational absorption of new methods and practices, ❷ ensure the existence of a deposit of learning and ❸ build a structure that would transfer knowledge to the proper people, the business processes and the business units and achieve a high level of success. The Excellence Service Center is seen as a catalyst for an offensive strategy that aims at promoting optimal absorption of new practices, to obtain and share high-value practical information and to create a mechanism for company's participation to the benefits of service model implementation.

d) "*Institutionalize the provision of corporate- level guidance about service-oriented technology and management for the business units, and implement metrics for adoption and performance to gauge progress and outcome value*".

e) "*Leverage business unit architecture review councils to ensure compliance with service-oriented architecture standards*". In most organizations, conformity with technological standards refers to optimization of technological standards - including software,

hardware and telecommunication services – in order to ensure a very high level of performance.

f) "*Work to develop common and normalized business semantics to define business services consistently*". Service orientation concerns people, processes, technologies, the ways of interaction with information technology and systems in order to execute processes inside a disconnected environment. Service orientation is about semantics that can be exploited, the organizational changes and new methods of thinking about service providers and their clients.

The architectural model present in general inside an organization can explain the use of service orientation (figure 2).

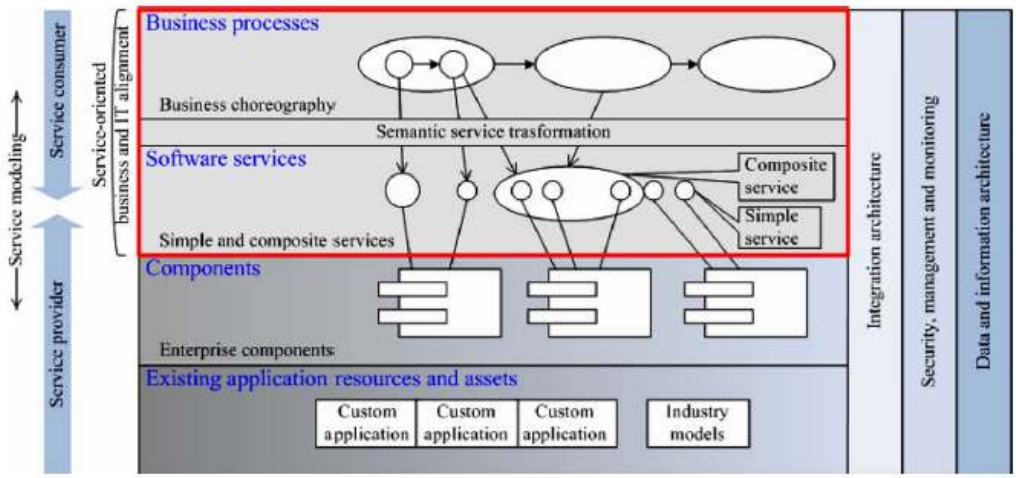

Fig. 2. Service Oriented Architectural Environment [8]

Independent IT services may include one or more business functions and transactions and may be accessed by the business services without the need for knowledge about their implementation details [10]. These services are assimilated to reusable objects (which represent repeatable business tasks and activities) and may be accessed through a network that allows the business to adapt with agility to environment changes [11]. The most important transformations in passing to a service oriented architecture involve ❶ semantics (adjustment of information technology, business characteristics, organization architecture), ❷ reutilization (by the use of a methodology to evaluate the business from different points of view and in the identification of the basic blocks of the business) and ❸ information (where take place the elimination of mistaken information, by the use of hybrid style of architecture that connects the principles of business information, event-directed architecture and service oriented architecture).

2. SOA Transaction Environment

Taking into account the managerial recommendations and the practice in this field, in order to achieve success in the transition to SOA, it is recommended that any organization should create a transition environment that should be based on management instruments for the existing knowledge within the organization, the elements under transition should be included into a management program, and at the organization level should be developed a policy of organization change management.

The identification of transition elements to SOA is done starting from existing instruments and knowledge. Thus, at organization level should be created a knowledge base

regarding concepts like SOA, BI (Business Intelligence), KM (Knowledge Management) as well as the best practices and benchmarks regarding transition to SOA. On this ground shall be created the model of cooperation, the objects deposits (business rules and others), shall be implemented the registry (services, metadata, standards, master data management service, etc.), benchmarks library (e.g., the use of ESB - Enterprise Service Bus), semantic web technology etc. In creating the knowledge base at organization level should be taken into consideration the existing intellectual property management policy.

Regarding the transition to SOA, the most important stages that have been identified are as follows: establishing the transition vision/strategy, creating the architecture plans and models, systems engineering, creating of infrastructure, identification and implementation of transformation and transition projects, operations and systems management.

The necessary transition stages should be included into a management program. The program management has the following objectives: allocation of resources and the budget on each stage, detailing the implementation plan, setting the deadlines, setting the service registration processes, approval, certification, publishing, analysis of business, data standardization, settling policies that should be followed (e.g. SOA, software engineering, security, etc.), monitoring and regulation policies. The main activities that could be found on the level of different stages are presented in figure 3.

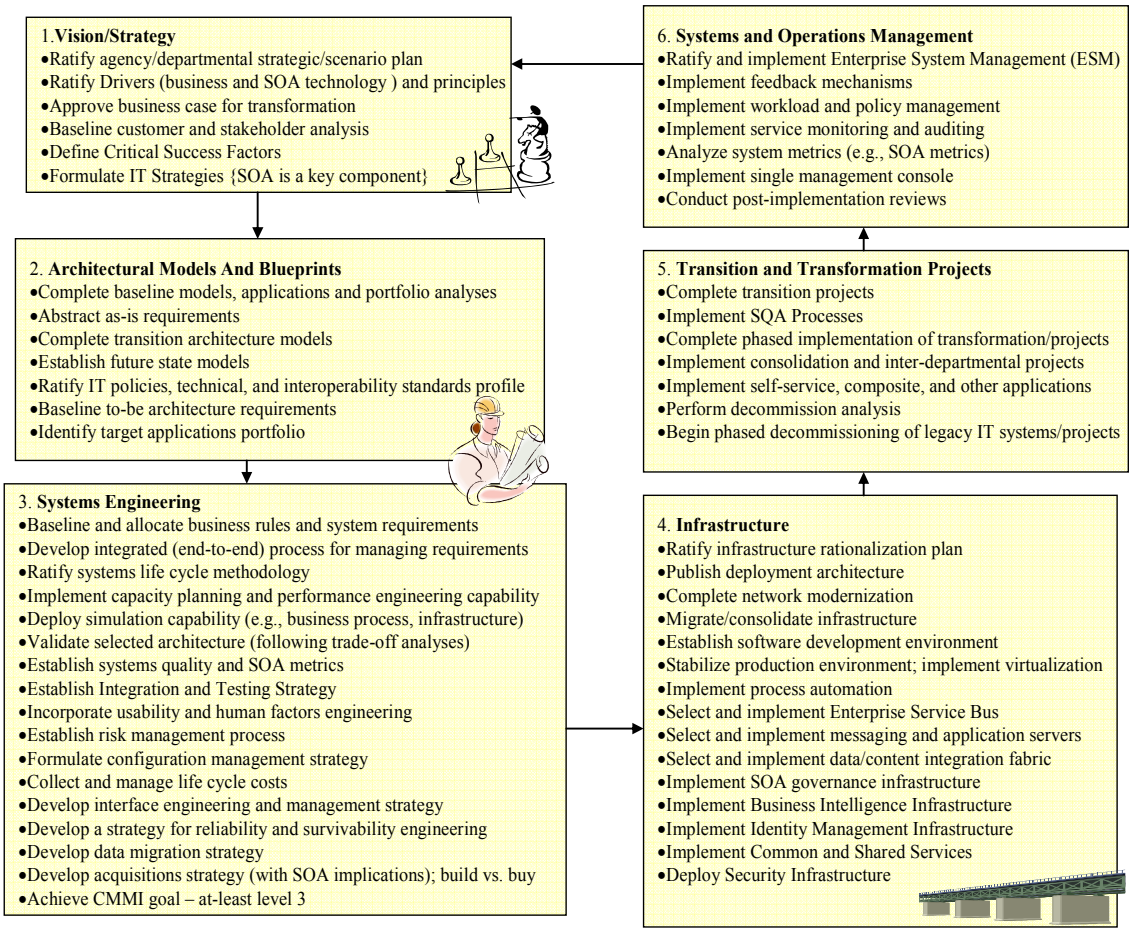

Fig. 3. SOA Transition Environment (after [12])

Organization change management should be ensured even from the start of the transition process. It is recommended that the change management team should include both

managers from the middle and high levels of the company and IT specialists. Among the activities that might be provided for this purpose we will mention: reengineering of facilities, setting the competence base, appointing the SOA mentors, reengineering the existing standard documents, development of stuff training and reallocation programs, implementation of the quality management system, defining communication strategies, creating the excellence centers, creating the users groups, developing alliance creation strategies, etc.

The transition environment should allow, inside the analyses, the calculation of specific indicators of the transition to service oriented architecture. Next, we shall present several indicators that may be used in making architecture reengineering decisions during the transition to SOA.

From the financial point of view, there are different methods of evaluating the investment, such as: Internal Rate of Return (IRR), which compares the presents benefits to the capital cost of the company; Net Present Value (NPV), which evaluates the potential of resource investments, the Payback period, which determines the period of time in which the gained benefit shall equal the initial project cost, and than quantifies the project's risk; the Return of Investment (ROI) – determines the average annual rate of profit gained for the initial investment.

From the financial measurement instruments presented, we recommend the use of ROI, which is accepted as financial measure for the evaluation of benefits offered by IT solutions and combines the characteristics of NPV, IRR and payback period. The main components of ROI are (1): the estimated time period of investment, the estimated cost and benefit [13].

$$ROI = \frac{\frac{NB}{t}}{ITC} \times 100 \quad (1)$$

ROI represents the annual average rate of benefit, gained from the initial investment; *ITC* – the initial total cost of investment; *t* – the number of years; *NB* – net benefit on the estimated time period *t* of the investment, calculated according to the formula (2):

$$NB = \sum_{i=1}^{t} (TB_i - TC_i) \quad (2)$$

In the above formula, TB_i represents the total benefit of the solution in the year *i*; TC_i – the total cost of the solution in the year *i*.

Concerning the estimation on the benefits associated with the solution of transition to SOA, the next stages must be followed: ❶ identification of the main benefits associated with the SOA transition solution; ❷ grouping them into categories (for example, direct and indirect benefits); ❸ value estimation. The monetary value of direct benefits may result from increasing income and/or decreasing costs (table 1).

Table 1. Direct benefit, associated with SOA transition solution

Benefits	**Mathematic formula**
Increasing income	
1.Increasing income from new services (IB)	$IB = \sum_i n_i \times IS_i$ (3) n_i represents the number of new services from category *i*, IS_i represents the income from the service *i*
2.Increase of efficiency due to reuse of services (RB)	$RB = t \times WC$ (4) *t* represents the time saved as a result of finalization of migration by reuse of services, *WC* wage costs needed for migration

Benefits	Mathematic formula
3.Use of integration (InB)	$InB = I_r \times CC$ (5) I_r represents the cost reduction index (standard factor of reutilization), CC represents the cost for the creation of a service
Reducing costs	
1.Reducing costs by integration of services (CIB) (after [14])	$CIB = SBC - SIC$ (6) SBC represents the service build cost, SIC represents the service integration cost
2.Reducing acquisition costs (ACB)	$ACB = AC \times I_{ac}$ (7) AC represents the acquisition costs, I_{ac} – the index of the reduction of acquisition costs.
3. Reducing training costs by service reutilization (TCB)	$TCB = TC \times I_{tc}$ (8) TC represents the organization training costs for new services, I_{tc} –training cost reduction index.

Costs associated with the transition solution, which are part of the total costs, may include initial and annulled costs. The initial costs include: software, hardware and implementation costs, which practically represent the SOA transition costs. SOA transition annual costs include: personnel cost, opportunity cost, maintenance cost (table 2).

Table 2. Annual costs associated with the transition to SOA

Category of cost	Mathematic formula
1.Cost of personnel (CP)	$CP = WC * t$ (9) where t represents the time of developing the service (from the project creation stage to the implementation stage) or the time for the change of the service (the time needed to adapt the service to the new demands), WC - wage costs
2.Cost of opportunity (CO)	$CO = MC + TC + OCO$ (10) MC represents governance methodologies costs, TC represents the associated technologies cost, OCO represents the other cost of opportunity
3.Cost of maintenance (CM)	$CM = (1 - I_{cr})TC + SC + HC + OMC$ (11) I_{cr} represents the index of cost reduction (reutilization standard factor), TC represents training costs, SC – software costs (license, subscription taxes, database, operation system, server, network, maintenance, other), HC – hardware costs, OMC – other maintenance costs.

The implementation risk associated with the solution must also be taken into account during the transition to SOA. By implementing the solution, a benefit must be obtained and this should surpass the capital costs and compensate the risk associated with the project. From the evaluation risks, we have chosen the Rate of investment (R_i), calculated as a ratio between ROI and the rate of interest (R_d), which represents a more accurate evaluation of the average benefit of the project [13]:

$$R_i = \frac{ROI}{R_d} \quad (12)$$

The chosen solution has a high risk, if $R_i < 2$, a medium risk, if $2 \le R_i \le 4$, a low risk, if $R_i > 4$.

In creating an evaluation environment, the team must put the stress on the evaluation of the SOA transition initiative considering reaching the organization objectives rapidly and with a low risk, and not so much on finding the perfect evaluation method. Organizations are encouraged to apply methods of measuring transition solutions and to provide the practical experience that would allow finding possible problems and would improve evaluation methods.

3. Reengineering architecture from SOA perspective

At the present there are different point of view on SOA, which leads to the formulation of different opinions on the manner of structuring businesses and the way of projecting the company's IT architecture. A present problem is that very few published papers offer practical methods of engineering and reengineering, as well as rules for the construction of SOA architecture.

Considering the state of research in this field and the fact that SOA is an architectural style, reengineering according to SOA may be explained in terms of migration and integration. Within the reengineering stage, a very important step to identify applications that need integration or migration. The base idea of the integration strategy is that applications are not modified or decomposed internally into reusable components, but are interconnected externally using web services and possibly an Enterprise Service Bus (ESB). Migration assumes going through some structural stages that involve a change in the way of creating applications and their interfaces, and through organizational stages that involve adjusting objectives of key people (managers, main sponsors, project managers and developers) to the processes. Therefore, the strategies of applications transition to SOA may be put into two categories [15]:

- integration, involving consolidation of existing and future applications through the use of integration technology;
- migration, involving gradual transition to new applications with reusable components or complete replacement with packages build according to SOA.

In choosing the reengineering strategy, strategic analyses are used, which are based on the business value, the technical value, flexibility and growth. The decision model for choosing the transition option combines strategic and technical factors with cost-benefit analyses for decisions of migration versus integration. The main recommended analyses are: a) strategic analyses for making migration or integration based on company factors, b) architectural analyses based on intangible cost-benefit analyses on strategic decisions c) tangible cost-benefit analyses of projects changed for the development of the solution.

The decision making process is iterative, during which the users go through different iterations in order to determine solutions with a better cost and are technically adapted. Each iteration identifies and eliminates unacceptable or unavailable solution platforms, configurations that are too expensive or solutions with disproportionate time of implementation. The number of iterations depends on the number of available candidate solutions. Architectural analyses evaluate in detail the choices of integration or migration and then develop a complete architectural configuration based on SOA and the corresponding platforms. De decision model aims at finding the best and most economic decisions.

Also, in developing the SOA transition strategy, the organization must take into account the needs and resources available for every separate option. Transition strategy often entails software applications and some of those need different approaches in order to ensure

the project's success. In some cases, a single option may be selected that may satisfy all the demands of the transition plan, and in some cases many options are needed that should allow reengineering of architecture without affecting the organization's activity. In the transition process the following options may be found: replacing of packages, new developments, reengineering, coexistence and conversion.

The strategy of reengineering by integration may use [15]: ❶ partial integration, which involves adding to existing applications an interface based on web services, the applications communicating through the use of SOAP or other protocols and web services or ❷ complete integration, which involves applications communicating through ESB (figure 4).

In the case of partial integration Web Services (WS) hide the details of service provider from the service clients and the final instruments, and the adaptors convert data and protocols service providers and service clients. Those may be simple programs or sophisticated protocols converters, which convert levels of technologies and the semantics between clients and service providers. In the case of complete integration, the communication between applications is manipulated by ESB, leading to the next generation of integration platform of company's application (Enterprise Application Integration - EAI).

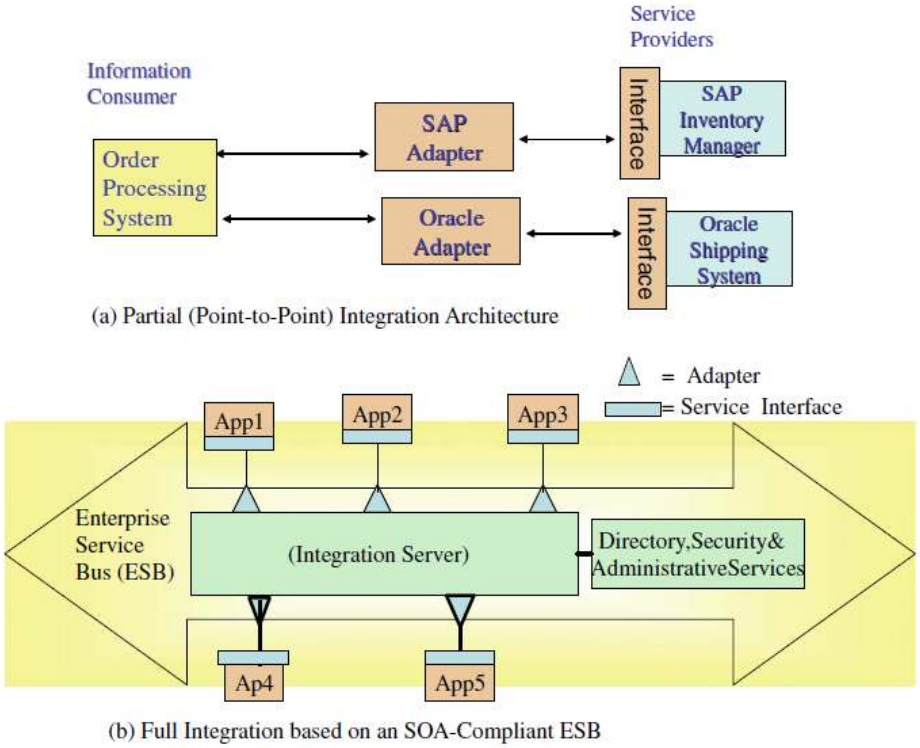

Fig. 4. Integration Technologies ([15])

Integration strategies are used for the gradual transition to SOA of existing applications. Complete integration provides some benefits, such as: • extends the lifespan of existing systems by transforming them into system useful to the new applications that allow SOA, • capitalizing the investment in the existing systems by taking over their capabilities, • minimizing risks and costs involved by the conversion of the application (applications are not decomposed, they stay intact and are just using SOA as means of communication).

The most important problem that the integration strategy is confronted with is that it does not change the basic characteristics of the applications that are integrated. If the applications to be integrated are old, impossible to reuse, difficult to keep and hard to update, the integration will not solve all these problems. In such cases migration of existing system is

recommended. Furthermore, integration is complex (system change involves rebuilding the interfaces), fragile (interfaces may fail) and expensive ("up to 50% of large enterprise's IT budget is spent on interfaces and integration" [16]).

Amongst the most important integration strategies are: enterprise service bus (ESB), enterprise application integration (EAI), enterprise information integration (EII), message-oriented middleware (MOM), integration brokers, orchestration, workflow, composite application development, and mashup.

Concerning integration through the use of ESB, we can say that this is the most effective way to cope with the challenges of complex integration and represents the technical solution that provides the greatest business flexibility and efficient connectivity between dissimilar applications. ESB is practically an architectural pattern that facilitates and simplifies the integration of business through transport, event and mediation services. ESB combines service oriented and event driven approaches for the purpose of simplifying the integration of business units, integration of platforms and development of heterogeneous environments. At the same time, it offers all capabilities of SOA and EDA models. Existing ESB infrastructures provides means of communication based on messages in combination with web service technology. Evolution of web service standards such as WS-Eventing, WS-Notification, WS-MetadataExchange, WS-ReliableMessaging, WS-Security, WS-Choreography and others, combined with the components of SOAP infrastructure (Simple Object Access Protocol), such as network devices and operation systems will provide in the future much of the ESB functionality that we must at the present receive from ESB providers [17].

The reengineering strategy by migration may use [15]: ❶ gradual migration, which involves parts of an application being converted in one or more reusable components at a certain moment or ❷ complete replacement, which entails replacing completely one time the source application, generally with a commercial package compatible with SOA. Migration takes place from the existing systems to the target systems. The source systems are restructured internally and changed into the target systems, in our case into reusable business components according to SOA, with clearly defined interfaces, preferably through web services. The main reason for migration is the internal change of applications that are inflexible and difficult to reuse/maintain into new service oriented components that can be assembled quickly to form different business applications.

Gradual migration involves fewer steps per period of time and uses existing technologies in order to hide the transition from client applications and final users. The target and existing systems coexist during the stage of migration. The general approach is the use of a migration gate to separate the migration stages so that the final users would not know whether information comes from the new component or the old system.

Concerning gradual migration which involves conversion of applications, it has the advantage that it keeps the investment into the existing applications and minimizes costs for restructuring the final users. It can be achieved ❶ rapidly and shall entail transition costs to another platform or ❷ slowly and shall entail reiteration of migrated applications. Also, conversion may be extremely expensive. If an application is closely related to the system architecture, and the target system is very different from the source system, the system's conversion will demand much effort from developers with effects regarding the increase of migration time, the cost and errors in the conversion code.

ESB may be used as migration gate because, as shown in figure 4.b, it mediates between different applications and may help to hide interaction between applications. Complete migration replaces an existing application with a new one in one single step. It entails complete rewriting or replacement with a new package. Complete rewriting is not viable in many practical cases because it is not easy to rewrite many application systems.

Replacement with a new package means that it should meet budgetary, performance and functional demands of the existing system, a task which is not easy to accomplish.

The choice between rewriting the system and buying a new package is based on factors like the available time for implementation of the new system, the cost issues, the internal experience for the development of the new products and the availability of new products. Applications migration is expensive and risky and entails costs and benefits that must be closely measured [18]. Once the migration accomplished, the applications will use ESB in order to communicate between them.

Identifying the strategy or the strategies of integration and/or migration needed during the architecture reengineering stage involves the necessity to define the testing strategy regarding the chosen options. Furthermore, the reengineering strategy must include at the global level the human factors involved, the risk management processes, the management plan of the selected configuration, as well as the cost management on the entire period of transition. Moreover, when buying opportunities appear, an acquisition strategy must be developed.

4. Conclusions

At the present, the business environment tends to become one in which cooperation plays a central role in achieving a successful business. From this standpoint, the integration of existing systems and the acquisition of new flexible systems represent an important objective for any organization. SOA is seen as a model of providing flexible business processes and solving integration problems of applications. Reengineering organizations' architecture by transition to SOA is a complex and long process, which demands rigorous analyses and well-founded transition strategies. At the present there are few practical methods for engineering, reengineering and building of the architecture. Strategy of passing to SOA must not be done for its own purpose, but must follow the strategic goals of the organization.

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