A new Framework for Quality-Based SOA Migration

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Abstract – Several software migration frameworks are presented to support the planning and the implementation activities needed to migrate the legacy software components to a new software paradigm like SOA “Service-Oriented Architecture”. However, the migration process has a quality challenge that required more research attention. Legacy to SOA migration process is required to deploy and consider some sort of quality evaluation and measurements to make sure that the migrated systems will be able to conduct reliable and efficient business results in any given services transaction. This paper is introduced to provide a new proposal framework for quality-based SOA migration that adopted measured qualified phases of service identification, target architecture design, service implementation, deployment, and evaluation.

Keywords: SOA Migration Framework, SOA Migration Measurements, SOA Migration Quality Requirements

1 Introduction

Many organizations are still relying on complex legacy systems to automate their business practices and collect, process, and analyze its business data. These systems are heterogeneous, distributed, constantly evolving, dynamic, long-lived, and mission critical that presented as a backbone of the enterprise operations. To optimize business value, there is a need to modernize these systems using a new software paradigm like SOA. SOA migration process enables the organization to benefits from the new service-orientation capabilities, making the legacy functionalities more robust, efficient and cost effective to align easily with the new business opportunities.

Despite the fact that the SOA migration process is succeeded to make the legacy systems running under modern paradigm and derived benefits from its new features, there are some of legacy limitations and problems are still exist, and some of the migration outcomes are not efficient as expected. Therefore, SOA migration process should execute under qualified approach that consider the quality characteristics in all its migration phases. This paper presented to discuss how to design, implement, and evaluate new quality-based SOA-migration framework that improve the quality level of the migration products.

2 Legacy to SOA Evolution: A Systematic Literature Review

We conducted a systematic literature review to collect legacy to SOA evolution approaches (Selected paper from our previous work [1]) reported from 2005 to 2014 (publications with high citation count) such as:

- Architecture-Driven Modernization - ADM [2]
- IBM’s SOMA Method [3], [4]
- Service Migration and Reuse Technique - SMART [5], [6]
- SOA Migration Framework SOA-MF [7], [8]
- SOA Migration - SOAMIG [9]
- Consolidation framework of structural legacy to SOA Migration [10]
- Advanced Software based-service provisioning and migration of legacy Software [11]

And found that the most presented legacy migration frameworks are considered deeply technical analysis of understanding the legacy system and the transition steps to the target system. However, considering the quality requirements and measurements throughout the migration tasks still need more research contributions to avoid repeating of legacy issues and limitations in the new environment, and to produce more reliable, integrity, and efficiently SOA solution.

We conduct a comparison between several selected approaches on four subjects (Migration Phases, Legacy Paradigm Change, Migration Goals, and the Quality Considerations and Evaluation Measurements) [1], due to the limitation of paper size, we describe a brief comparison example Table 1:

<table>
<thead>
<tr>
<th>Method</th>
<th>Quality Considerations and Evaluation, Measurements</th>
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<tr>
<td></td>
<td>- Refer to software assurance and metrics that should to be adopted during transformation processes.</td>
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<tr>
<td>SOMA Method [3], [4]</td>
<td>- Provides support of monitoring and management the business processes and performance in the production environment.</td>
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<td></td>
<td>- Provides linkages to runtime management aspects.</td>
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3 Proposal Model for Migration Quality Requirements

Building qualified migration framework is the main goal of this research, which required to consider specific quality characteristics and controls. In this section we provide a new proposal model (Figure 1: Quality Requirements Model in SOA Migration) represents the major quality requirements that needed to deal with the quality challenges during the SOA migration processes. This model of quality requirements is based on three migration directions (Target System Design, Migration Implementation (Process Integrity), and Evaluation and Measurements).

This model’ scope is determined based on the most migration phases that affected in the solution outcomes efficiency.

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<tr>
<td></td>
<td>- Used testing and migration cut-over tools.</td>
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<tr>
<td>ARTIST Project [11]</td>
<td>- The evaluation measurements are not considered, but the ARTIST consider quality check and V&amp;V certifications model to make sure that the project deliverables are match good level of migration quality.</td>
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SOA-MF, SOAMIG, and others migration architectures. We concluded that the most critical quality directions that formulate the quality level in SOA-Migration process could classified into three topics:

- SOA Architecture Design
- SOA Process Integrity
- SOA Evaluation and Measurements

3.1 SOA Architecture Design- SAD

The quality requirements in target system planning and design phase are intend to choose the architecture design and its related SOA technologies, which eventually plays an important role in the efficiency and adaptability of the future SOA system. Basically, target system understanding can be viewed from two perspectives: functional characteristics and technical characteristics:

- The functional characteristics include the potential functionalities to-be evolved from the legacy code. This process is referred to service design and application composition. It also defines to what level of granularity the services are to be defined and, accordingly, the orchestration of the services has to be managed to support business processes. Various functional and non-functional properties should also be considered, such as maintainability, interoperability, responsiveness, performance, security, and availability.

- The technical characteristics of the target environment include service technology (SOAP or REST-based), messaging technologies, communication protocols, service description languages, and service discovery mechanisms.

The proposed model figure 1 (Quality Requirements Model in SOA Migration) is considered six major characteristics that shape the power of SOA architecture design, including Flexibility, Manageability, Security, Maintainability, Governance, and Virtualization.

3.2 SOA Process Integrity – SPI

SOA process integrity is the ability to conduct reliable business activity in a consistent SOA environment with seamless integration at every interacted and participated service. In general, process integrity is the critical component of SOA implementation, the ability to synchronize between services, human tasks, information, applications, domains and users in a secure, scalable SOA environment. Business must be agile enough to deliver the same reliability, consistency and predictability in an open service-oriented system as in a tightly coupled closed system. In SOA, the role of migration/integration is not only to bridge the islands legacy systems, but also to deal with the process integrity/consistency issues. Process integrity has three main elements:
**Transaction integrity**: Ensures that individual updates of business and IT resources are linked and processed as a single unit of work, all completing successfully or being rolled back in case of technical or business failure.

**Interaction integrity**: Ensures that elements of people interactions with business and IT systems are interact and remembered wherever and whenever those interactions occur in secure, scalable, and reliable environment.

**Information integrity**: Helps deliver trusted, secured information to business processes, regardless of delivery channel, operational platform (IT or people), and information lineage, in which the information to be meaningful, accurate, correctness, and aligned.

So, the quality requirements model recommended to apply some sort of integrity mechanisms to avoid the pitfalls that could be encountered when extending SOA infrastructure from limited-scope projects to a broader enterprise wide implementation, and describes how the considering of the integration quality can help to deliver on the promises of service-orientation approach [12].

### 3.3 SOA Evaluation Measurements - SEM

After converting legacy systems to be services by transformation the legacy code (migration approach) or by exposing/interfacing the legacy functionalities (integration approach), these services have to be deployed. Some necessary activities are required to manage and control the behavior of services during usage. Monitoring the service behavior is very important to maintain the service performance, validation, integrity, etc… Service controlling has been a research challenge in the SOA domain due to the dynamic uses of the services in the SOA context. Build business logic using the legacy services is needed to be controlled to validate the integration process workflow, services input/output, and services data mapping. Another important topic is service quality measurements, measuring the services description, security, data consistency, and others measurements that support the services quality. The mentioned quality model is considered these kinds of research issues by providing several considerations during the design phase, and provides integration evaluation metrics to measure and evaluate the evolved services.

### 4 SOA Migration Framework - SMF

SMF is presented as a new proposal of SOA migration framework that considers the quality requirements as an essential need throughout all the migration activities, and adopted the E4 approach [13] of the process measurements to evaluate the migration processes.

As shown in figure 2, SMF includes five major migration phases that applied the E4 measurement approach (see point 5 SMF and E4 Evaluation measurements).
4.1 Quality-Based SOA System Identification

System identification phase is presented as a migration planning phase, interested in four elements (Feasibility Study, Legacy Code Analysis, Service Identification, and Service Specification) that addresses the issues of making the migration feasibility study, this phase is aim to decide if the existing legacy systems are needed and ready to be migrated to SOA solution from the technical and business perspectives, discuss which technical methodology and approach is a proper one used to understand the existing legacy code and its component’s structures and functionalities, and also this phase is concerning in how to identify the candidate part of the legacy code to be re-presented as a reusable service in the target SOA architecture.

4.2 Quality-Derived SOA Migration Design

Design phase is aim to understand the SOA key principles, architecture, and environment. Define the main SOA components to be designed, and which technology, standards to be used. Also, in this phase some issues like performance, security, governance, integrity, and others SOA characteristics to be discussed. Design phase support to facilitate the representation of the desired SOA architecture, enables the design of the target architecture with major components of the SOA environment, standards to be used, quality of service (QoS) expectations, and interaction patterns between services.

In SMF the design phase is considered that the architecture design should align between the legacy systems characteristics and the enterprise business models toward efficient migration process. So, to achieve this objective, SMF provides the required architecture tools for the design components including SOA Reference Architecture, Enterprise Semantic Context and Information models, Enterprise Business Process Model, Integrity Enablement’s, and Governance Controls.

4.3 Quality-Oriented SOA Implementation

Several techniques are presented to implement the migration process. SMF adopted the wrapping technique (fastest, less risky and cost effective technique) to migrate the legacy systems by interfacing it to other software via web services. It is a black-box modernization technique, since it focuses on the interface of the legacy systems, hiding the complexity of its logic. Also, the re-engineering technique is target to add the SOA capabilities and functionalities to the existing legacy systems via reverse engineering, and redesigning the existing software.

SMF is adopted the integration strategy to migrate to SOA architecture, and use the mix between the re-engineering and wrapping strategies to implement the services needed to build the migration solution. Integration enables disparate resources to share business data. SMF provides its implementation approach in the following steps:

- Validate the migration business drivers
- Determine which architectural layer to perform the integration activities
- Identify the implementation access type
- Designing Service Implementation
- Identify the integration application form
- Implement the integration architecture

4.4 Quality-Guaranteed SOA Deployment

After implemented the necessary services which exposing the candidate legacy functionalities, the exposed services are then deployed in the service infrastructure and tested to determine if the expected functionalities are formed and integrated correctly. A successful deployment is require a service provisioning that includes activities such as publishing and discovering services in a repository, maintaining Quality of Services (QoS), versioning, testing, and evolution of services that lead to the proper functioning of the services and ensure that the SOA environment operates reliably and efficiently.

SMF considered in the guaranteed the deployment and versioning phase by allowing service implementations to evolve without breaking existing consumers, leading to more services loosely coupled, minimize the impact of versioning, and reduce the amount of deployed code. In SOA, service versioning considered the coexistence of multiple versions of the same service, which allows each consumer to use the target version that it is designed and tested for. In this multiple coexisting versions of the same service, the system allows for the independent life cycles of services and their consumers and minimizes the overall impact of changes to new version.

4.5 Quality-Assurance SOA Measurements

Having deployed services is not enough to move the existing legacy enterprise systems from the islands platforms to SOA environment. SMF is considered that in order to complete the migration project efficiently and successfully, there is a need to a right kind of service, well designed and properly built service, efficient service communication, and reliable service that is able to satisfy the current and the future business requirements. Proposal SMF migration framework is focuses on how we can improve the quality factors on SOA-Migration.

SMF describes the migration process:

\[
\text{System}_1/\text{N} \quad \text{Legacy Architecture} \quad \text{ARC} \Rightarrow \text{System}_1/\text{N} \quad \text{SOSE} \quad \text{ARC} \quad (I)
\]

Where \(\text{ARC}\) is refer to Software Architecture

and also describes the migration metrics and measurement as follows:
4.6 SMF Quality Relationships

SMF designed its quality level based on 3 bases:

1- The quality of the migration approach that built on the business-driven concept, and to maximize the ROI from the migration process.

2- The quality of each migration activity which presented by the artifacts produced to support it, these artifacts are aligned with the proposed quality model, such as (Template, Model, Reference Design, Assessment Guidance, Recommendation, Best Practices, Techniques, and Metrics), for more details see Table 2 that describes some of SMF Artifacts.

3- Evaluating the migration phases by using the E4 approach which adopted the concept of Establish, Extract, Evaluate, and Execute. To control the risk and to determine the areas of improvement (will described in the next section).

<table>
<thead>
<tr>
<th>SMF Artifact</th>
<th>Description and Function</th>
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<tr>
<td>Legacy Issues Template</td>
<td>List of the common legacy systems issues that gathering from academy and industry experiences, understand how the existing legacy issues affected the current business operations which support to determine the level of the business criticality.</td>
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</table>

Table 2: Examples of SMF Artifact Products

- **Migration Risk Assessment**
  - List of risk assessment questioners from business and technical perspectives, this assessment support to understand and identifying the challenges and its mitigations and rollback methods, determine the resources and existing capabilities which support the migration decision.

- **SMF Quality Evaluation**
  - Considering five items of quality evaluation including validation, integrity, interoperability, loose coupling, and island characteristics. This evaluation represents the most important quality aspects that support the SMF efficiency.

- **LCA Model**
  - Model of legacy code and system understanding, including Reverse Engineering and Visualization Quality Check, Delta Analysis, and Documentation Understanding.

- **SMF-RA Reference Architecture [14]**
  - SMF reference architecture is facilitates services and design communications and provides a representation of progress and evolution of the legacy to SOA solution in high-level abstraction diagram. **SMF-RA** represents the logical design of the legacy to SOA solution, provides architecture layers that represent the separation of concern, and the relations between the architecture blocks, and used as a blueprint that supports the project stakeholders using templates and guidelines during the migration and the solution development life-cycle.

- **Integration Efficiency Considerations [15]**
  - Provide efficiency considerations and recommendations to design the integration architecture, including Messaging Infrastructure, Message Broker, Web Services, Web Services Wrappers, Direct Database and Adapters Access, and ESB.

- **SMF Services Evaluating (Metrics Table)**
  - Metrics table to evaluate and measure the service functionality, quality, and efficiency. This assessment will guide to understand the maturity level of the migration services throughout the migration phases, and put spots on the area of improvements and issues.

5 SMF-E4 Evaluation Measurements

As mentioned in the previous point, evaluating and measuring each migration activity is one of the most essential quality requirement that recommended by the SMF quality model. For this purpose, we adopted the E4-Measurement Process, The E4–measurement process (Figure 4) consists of four essential steps: Establish concrete objectives and the measurement and analysis scope and activities. Extract measurements for the established need. Evaluate this information in view of a specific background of actual status and goals. Execute a decision to reduce the differences between actual status and goal.
The E4 measurement process [13]

The following figure 5, represented that each SMF activity applied the E4 measurement approach to serve and comply with the required quality aspects enabled by the migration quality model (figure 1). And then produced one or more artifact products to support the migration tasks as follows:

**Figure 4: The E4 measurement process [13]**

The following Table 3, we provide an example illustrated in general form how the E4 approach can be applied in SMF first stage of qualified-based system identification:

**Table 3: SMF and E4 Application**

- **Establish**: the measurements intentions are based on the consideration of the legacy systems limitations and challenges, and its expected goals from the new SOA paradigm in aligning with the enterprise business needs.
  - **Strategy**: draw the best possible software migration process
  - **Concept**: choose a class of software systems as
  - **Development**: keep the requirements of the quality improvement
  - **Evolution**: determine the appropriateness of the migrated systems in the new paradigm

- **Extract**: extract the right information that supports the established measurements, and extracted using a goal-driven method.
  - **Strategy**: analyze the current and the estimated architecture
  - **Concept**: determine the risk analysis and the expected ROI benefits
  - **Development**: understanding legacy functionalities
  - **Evolution**: determine the potential services

- **Evaluate**: evaluate the legacy and the new paradigm characteristics.
  - **Strategy**: evaluating the migration decision
  - **Concept**: determine the metrics values of the legacy and the SOA systems
  - **Development**: align with the business requirements
  - **Evolution**: determine the migration approach

- **Execute**: make the decision and implement the start implement the change.
  - **Strategy**: choose the business unit for migration
  - **Concept**: select the appropriate tools and resources
  - **Development**: implement the desired services
  - **Evolution**: keep the development in standards and high quality level

### 6 Conclusion

To improve the quality level of the SOA migrated systems, we concluded that there is a need to apply a qualified software migration framework that considered the quality requirements in its migration activities. In this paper, we present 5-phase and 21 major activities of qualified SOA migration framework SMF which applied the E4 measurements process to measure and evaluate the migration stages and its sub-processes.

We provide the following contributions:

- Design new SOA Migration Framework-SMF of quality-based SOA migration, that consists of five phases: quality-based system identification and architecture design, quality-oriented SOA implementation, quality-guaranteed SOA deployment, and quality-assurance migration measurements.

- Provide new model of SOA migration quality requirements, and applied it in the SMF framework.
And adopted the process measurements E4 in the new SMF approach, which support to measure and improve the quality level of the migration activities.

- Design and implement several artifacts products that support the process of quality improvement such as (Template, Model, Reference Design, Assessment Guidance, Recommendation, Best Practices, Techniques, and Evaluation Metrics).

7 References


