ICIC Express Letters ICIC International ©2009 ISSN 1881-803X
Volume 4, Number 4, **August 2010** pp. **1–6**

Towards a dynamic and vigorous SOA ESB for C4I Architecture Framework

Abdullah S Alghamdi, Iftikhar Ahmad, Muhammad Nasir
Department of Software Engineering, College of Computer & Information Sciences,
King Saud University, P.O. Box 51178, Riyadh 11543,
Kingdom of Saudi Arabia.
{ghamdi, iftikhar, mnasir}@ksu.edu.sa

ABSTRACT. *An ESB is a middleware that provides services such as message routing and transformation. Further, it has the capabilities to ease the pains of connecting heterogeneous C4I systems among various defense forces. The purpose of this paper is to propose an approach based on criteria for selecting SOA Enterprise Service Bus (ESB) for C4I architecture framework. This assay mechanism is based on two types of criteria such as main criteria and sub-criteria. We used multi-criteria decision making (MCDM) technique for analyzing different SOA Enterprise Service Buses (ESBs). The results indicate that Mule and Fiorano ESBs are more dynamic and vigorous for architecting C4I system.*

Keywords: System of systems (SOS), Service Oriented Architecture (SOA), Command, Control, Communications, Computers and Intelligence (C4I) system, Multi Criteria Decision Making (MCDM), Enterprise Services Buses (ESBs)

1. Introduction. The growing adoption of C4I systems in defense and civil areas had made it more imperative and attractive. Therefore, this justifies that the defense strategists, researchers and system developers are taking much interest in C4I systems. Presently there are many issues in the integration of heterogeneous C4I systems that may be minimized using SOA ESBs. There are many ESBs available in the market today but the problem is which one is more suitable. Therefore selecting a SOA ESB has become a difficult task because many factors have to be considered. This paper describes an assessing mechanism of six ESBs namely Mule, GlassFish, Fiorano, ServiceMix, Sonic and Fuse keeping in view the C4I System as a base, so as to ascertain which ESB fulfills the requirements of the system of systems (SOS). The assessing mechanism consists of two criteria such as main criteria and sub-criteria. We evaluated and rated the SOA ESBs on the bases of main criteria and sub-criteria which are further processed by assigning priorities, and calculating weights. The rest of paper is divided into the following sections, related work, methodology and implementation, results, and conclusion.

2. Related Work. The C4I systems are used in various departments such as; defense, police, investigation, road, rail, airports, oil and gas where command and control scenarios exist. The main focus of these systems is defense applications. The purpose of a C4I system is to help the commander to accomplish his objective in any crucial situation [1]. A SOA ESB provides secure message transfer service between applications and interoperability using web services and related technologies. SOA ESB provides loosely coupled services. This can be used to connect different army wing’s systems to communicate with each other and share certain information. The applications communicate with each other by services invoking in a location independent fashion using SOA ESB. ESB assists as an infrastructure backbone for SOA applications and services and ease enterprise integration.ESB notably reduces cost and time to create new processes through reutilization of existing applications and data. ESB is considered much reliable for delivering messaging across services even over hardware layer, and in critical circumstances like network or software failure, the shot messages are buffered and secured by ESBs and delivered when the system is up and running again [2]. To make a secured defense system is a great deal in its true sense because of tremendous rise in threats in day-to-day world. At this point of time many Enterprise System Buses (ESB) are available to connect different system and synchronize them so that they can easily communicate with each other [3]. Different companies are providing their ESBs. It is very difficult to choose an ESB in accordance with the set parameters and requirements.

Much work has been done in the area of ESBs evaluation with respect to user needs because it is a challenging task. Many researchers used different mechanism to compare and evaluate them based on certain criteria. But the important criteria are those that lead closely to a particular ESB that fulfill the requirements of SOA application. Researchers usually compare general ESBs, open source ESBs or commercial ESBs. Every researcher imposes their own list of criteria to conduct their evaluation and the most commonly base is price. Price is an important factor but it turns futile when open source ESB are compared. One of the distinct works is done by Woolley [4] who applied Vollmer and Gilpin’s evaluation criteria to two open sources ESBs, such as Apache Service Mix and Mule Source Mule. He included current offering, strategy, market pressure and integration into the list of criteria. Woolley suggested that Mule ESB is the best and after this Fiorano ESB. Other ESBs were BEA System Equalogic Service Bus, IBM WebSphere Enterprise Service Bus and Apache ServiceMix.

Desmet et al. [5] compared two open sources ESBs such as Apache ServiceMix and Mule Source Mule, and also two commercial ESBs like IBM WebSphere Enterprise Service Bus and BEA Systems Aqualogic Service Bus. This research was on performance. Because of the flexibility ESBs may turn into bottleneck if complicated messages use it with many processes. Hence, the performance is an important criterion for evaluation. They rated Open ESBs first and commercial ESBs after them. ESB rates were based on the performance test results. MacVittie [6] also evaluated commercial ESBs. He used integration, price and core bus feature as evaluation criteria. He rated BEA Aqualogic Service Bus first and second to Oracle SOA Suite. The others were Fiorano, Cape Clear, Tibco Software, IBM WebSphere Enterprise Service Bus, Sonic and Software AG. This is based on information provides by the consumers or was taken from the previous studies. Tobias et al. [7] evaluated open sources enterprise services buses such as Fuse, Mule and Open ESB on the basis of criteria like stateless, stateful, extensibility and failover. They rated Fuse as first and Mule as second and Open ESB as third. Their study revealed the need to identify critical information resources and expose them through loosely coupled, reusable, and composable services for successful composition into workflows. Interoperability is an important issue in designing and development process of C4I systems. Other multi-criteria based approaches are used and applied by Alghamdi [8], Chien-Chang Chou [15], and Kunio Shibata et al. [16].

4. Enterprise Service Buses (ESBs)

4.1 Mule ESB. This ESB offers simple development model and lightweight architecture, so integrating, interoperability and creating services are easy and fast. This does not need to replace or change existing system and it can easily work with any existing infrastructure and deploy in any topology with or without an application container. This ESB also provide same performance and reliability challenges that are required for large SOA implementations [9].

4.2 GlassFish ESB. This ESB provides lightweight integration platform with fast development tools and deploy SOA components with free dependencies and flexibility. This provides an easy way to integrate and provides interoperability. It contains GlassFish application server, NetBeans tooling, JBI runtime for deploying solutions, integration engines, adapters for external systems, and simple installer [10].

4.3 Fuse ESB. This ESB can easily be embedded at endpoints that allow distributed systems to intelligently interact without mandating a centralized server. Further, it has pluggable architecture supports. This allows organizations to use their service solution in their SOA with pluggable architecture [11].

4.4 Sonic ESB. This ESB simplifies integration and flexible reuse of business components using a standard-based SOA. This allows different army wings to dynamically configure the reliable connection, reconciliation, control of services and their interactions. This also provides intelligent routing with highly scalable service interaction without performance bottleneck or single point of failure. This ESB also provides endpoint connectivity for web services that are reliable, scalable and secure integration of web service-enabled applications [12].

4.5 Fiorano ESB. This ESB is able to perform middleware infrastructure platform for web-services that supports intelligently directed communication and platform relationship between loosely coupled (SOA) and decoupled (EDA) components .This also provides failover, security, monitoring, load-balancing and other management services using the JMX (Java Management Extensions) standard. This increases process performance with higher message throughput and enhances availability [13].

4.6 Apache ServiceMix ESB

This is an open ESB that support both SOA and EDA to create a physical enterprise ESB. Further, it provides integration between different applications and support JBI implementation [9]. It also supports a number of binding components such as Java EE Connector Architecture (JCA), ActiveMQ JMS and Jencks etc. This ESB also supports asynchronous communication [14].

5. Methodology and Implementation. The methodology incorporated in this evaluation consists of goal selection, decision of criteria; determine the alternatives, building hierarchy, assignment of priorities, calculation of weights, and consistency test. Further, this work is implemented using multi-criteria decision making software.

5.1 Goal Selection. First of all, we selected a goal for this work. The goal is selection of dynamic and vigorous SOA ESB for C4I architecture framework. Six ESBs such as Mule, Fiorano, GlassFish, ServiceMix, Sonic and Fuse are selected for assay purpose.

5.2 Decision of Criteria. Secondly, we decided criteria and sub-criteria. The main criteria consist of Interoperability', 'Extensibility', 'Messaging', 'Easiness', and 'Availability'. The main criteria are further divided into sub-criteria. The criterion 'Interoperability' is divided into sub-criteria namely 'Syntactic', 'Semantic' and 'Network'. In the same way, the criterion ‘Messaging’ is divided into ‘Reliability’, ‘Security’ and ‘Speed’. The ‘Availability’ is further divided into sub-criteria such as ‘State less’, ‘State full’ and ‘Failover’. The selection of criteria and sub-criteria is based on the works as done by many other researchers [10-14].

5.3 Determine the alternatives. Thirdly, we determined the alternatives such as Fiorano, Mule, Sonic. ServiceMix, GlassFish and Fuse. These alternatives are the focus of this work.

5.4 Building Hierarchy. The hierarchy is built on the bases of criteria, sub-criteria and alternatives as shown in Figure 2. The goal “selection of dynamic and vigorous SOA ESB for C4I architecture framework” is at top of the hierarchy. The criteria and sub-criteria are shown in the middle. The alternatives are at bottom of the hierarchy but these are not shown due complexity in the diagram.

5.5 Assignment of Priorities. The assignment of priorities is based on the information obtained from previous works [10-14]. The scale used for pairwise comparison is nine points scale as shown as Table 1.

5.6 Calculation of Weights. The weights of each node (criteria, and sub-criteria) are calculated on the bases of assigned priorities as shown in Table 1.

5.7 Consistency Test. The consistency ratio is calculated based on the weights. If the consistency ratio is less than 10 percent, the inconsistency is acceptable. Otherwise, we need to revise the subjective judgment

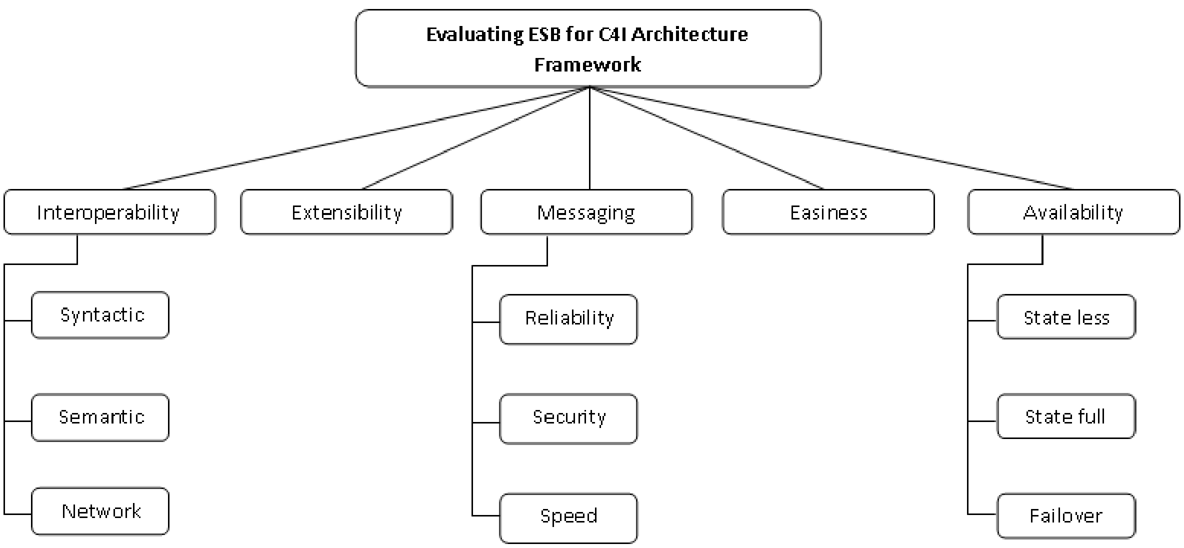

FIGURE 2: Hierarchy consist of goal, criteria and sub-criteria

TABLE 1. Weights of Main criteria and sub-criteria

Weights	Interoperability	Extensibility	Messaging	Easiness	Availability	Total
Local	0.38	0.09	0.23	0.12	0.18	1.00
Global	0.38	0.09	0.23	0.12	0.18	1.00
Interoperability sub-criteria weights						
Weights	Syntactic	Semantic	Network	Total		
Local	0.33	0.33	0.34	1.00		
Global	0.12	0.12	0.14	0.38		

Messaging sub-criteria weights				
Weights	Reliability	Security	Speed	Total
Local	0.32	0.21	0.47	1.00
Global	0.07	0.05	0.11	0.23
Availability sub-criteria weights				
Weights	State less	Sate full	Failover	Total
Local	0.33	0.33	0.34	1.00
Global	0.06	0.06	0.06	0.18

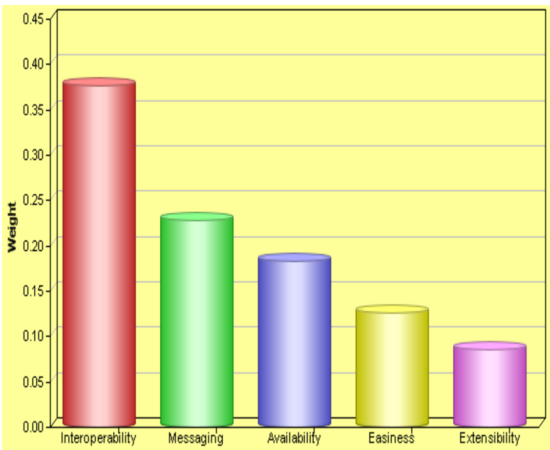

Figure 2. Criteia's Ranking

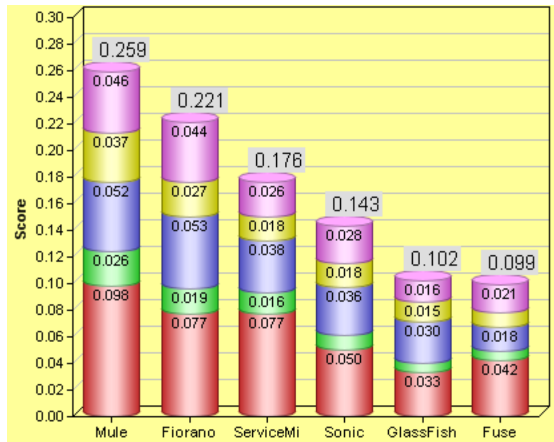

Figure 4: Alternative Ranking

6. Results. Table 1 explains weights of main criteria and sub-criteria like interoperability, messaging and availability. Figure 3 illustrates criteria ranking such as interoperability, messaging, availability, easiness and extensibility. Figure 4 demonstrate ranking between six different alternatives such as Mule, Fiorano, ServiceMix, Sonic, GlassFish and Fuse. Mule is rated as best ESB in the application of C4I architecture framework. The Fiorano is rated as second, ServiceMix as third, Sonic as fourth, GlassFish as fifth, and Fuse as sixth in this work.

7. Conclusions. The MCDM technique is used to evaluate six ESBs such as Mule, Fiorano, ServiceMix, Sonic, GlassFish and Fuse. This evaluation based on main criteria and sub-criteria. According to our study, we have concluded that among all the ESBs, the Mule and Fiorano are more suitable to tackle the current issues of C4I architecture framework such as interoperability, messaging, availability, and easiness.

Acknowledgment. This work is supported by Department of Software Engineering, College of Computer and Information Sciences, King Saud University, Riyadh, Saudi Arabia.

REFERENCES

[1] Lean Weng YEOH, Ming Chun NG, *Architecting C4I Systems*, Second International Symposium on engineering Systems MIT, Cambridge, Massachusetts, June 15-17, 2009.

[2] Luis Garces-Erice, *Building an Enterprise Service Bus for Real-Time SOA: A Messaging Middleware Stack*, 33rd IEEE International Computer Software and Applications Conference, pp. 79-84, 2009.

[3] Saurabh Mittal, Bernard Zeigler, Jose L. Risco Martin, Ferat Sahin and Mo Jamshidi, *Modeling and Simulation for systems of systems Engineering*, Chap 5, Wiley [Imprint], Inc. 2008. http://acims.arizona.edu/PUBLICATIONS/PDF/Mo_Chapt_5_MittalZeiglerJoseFeratV4.pdf

[4] Robert Woolley, *Enterprise Service Bus (ESB) Product Evaluation Comparisons*, Utah Department of Technology Services, Oct 18, 2006; Webpage accessed on Dec 15, 2009. http://dts.utah.gov/techresearch/researchservices/researchanalysis/resources/esbCompare061018.pdf.

[5] Stein. Desmet, Bruno Volckaert, Steven Van Assche, Dietrich Van Der Weken, Bart Dhoedt, Filip De Turck, *Throughput Evaluation of Different Enterprise Service Bus Approaches*, Conference on Software Engineering Research and Practice, ISBN: 1-60132-033-7, pp. 378-384, Jun 25-28, 2007.

[6] Ken Vollmer and Mike Gilpin, *The Forrester Wave: Enterprise Service Bus, Q2 2006*, BEA Systems, Nov 17, 2006, http://whitepapers.zdnet.co.uk/0,1000000651,260256988p,00.htm

[7] Lori MacVittie, *Review: ESB Suites*, Networking Computing, CMP Media LLC, March 10, 2006. http://www.networkcomputing.com/wireless/review-esb-suites.php.

[8] Abdullah S. Alghamdi, *Evaluating Defense Architecture Framework for C4I System using Analytic Hierarchy Process*, Journal of Computer Science 5(12), pp. 1075-1081, 2009.

[9] Abdullah S Alghamdi, Iftikhar Ahmad, Muhammad Nasir, *Evaluating ESB for C4I Architecture Framework Using Analytic Hierarchy Process*, 9th International Conference on Software Engineering Research and Practice (SERP10), Las vegas,Nevada, USA, in press.

[10] Vasiliev and Yuli, *Beginning Database-Driven Application Development in Java EE Using GlassFish*, ISBN: 978-1-4302-0964-5 (Online), Springer Link: Apr 21, 2009.

[11] Adam Badura, Bartosz Sakowicz and Dariusz Makowski, *Integration of Management protocols based* on Apache ServiceMix JBI platform, CADSM 2009. 10th International Conference, pp. 381-384, Feb 2009.

[12] Sonic ESB, *Delivering an Integration Framework for the OpenEdge Enterprise*, Progress Software, 2006. http://www.progress.com.tr/openedge/urunler/verisayfasi/sonic_esb.pdf

[13] FU Ning, ZHOU Xingshe, WANG Kaibo, ZHAN Tao, *Distributed Enterprise Service Bus on JBI*, The 3rd International Conference on Grid and Pervasive Computing – Workshops, IEEE Computer Society Washington, DC, USA, ISBN: 978-0-7695-3177-9, pp. 292-297, 2008.

[14] Konstantinos Kotsopoulos, Pouwan Lei, Yim Fun Hu, *A SOA-based Information Management Model for Next-Generation Network*, Proceedings of the International Conference on Computer and Communication Engineering 2008, ISBN: 978-1-4244-1691-2, pp. 1057-1062, July 2008.

[15] Chien-Chang Chou, *A Combined MCDM and Fuzzy MCDM Approach to Selecting the Location of the Distribution Center in the Hub Port: An Empirical Study on Hong Kong, Shanghai and Kaohsiung*, International Journal of Innovative International Journal of Innovative, Volume 6, Number 7, July 2010, ISSN 1349-4198, pp. 3037-3051.

[16] Kunio Shibata, Junzo Watada and Yoshiyuki Yabuuchi, *Fuzzy AHP Approach to Comparison of Grant Aid for ODA in Japan*, International Journal of Innovative Computing, Information and Control, Volume 5, Number 6, June 2009, ISSN 1349-4198, pp. 1539-1546.