Service Oriented Architecture in Education Sector

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Summary
The adoption of SOA (Service Oriented Architecture) has gained momentum in the past few years, and the predictions are for further rapid uptake of SOA and Web Services. This was mainly driven by high demand in business agility, business process efficiency and cost optimization. The obsolete legacy systems are interfering with these key business success factors, making it unnecessarily difficult to implement university-wide best practices. Web services built on SOA promise to integrate systems seamlessly, while also offering campus stakeholders easily customizable solutions and real-time information from a "single source of truth." SOA trends could be predicted from different aspects including business, research areas technology and standards. This paper focuses on SOA trends with respect to three important service orientation quality factors namely interoperability, performance and security. These factors are highly impacting the SOA trends in all aspects. The analysis, examples and discussion provided in the paper are primarily focus on SOA adoption in the Education sector.

Key words:
Service Oriented Architecture, e-Education, Web service, SOA Quality factors.

1. Introduction

Universities around the world are competing to create the ideal digital campuses to leverage a richer electronic environment for students, faculty and alumni. They are opting to deploy a single point of entry for communication, registration, class and content management, collaboration and research, in order to

- Empower Students and Faculty: Virtual classrooms encourage real-time collaboration by allowing students to conduct research and exchange ideas. Faculty has a forum for disseminating and collecting classroom documents, conducting polls and posting grades.
- Lower Administration Costs: Higher education portals streamline course scheduling and management, and enable students to register for classes, manage financial aid and track tuition payments. These portals help institutions save cost of printing and distribution.
- Have better Information visibility: instant access to students, faculty and department progress reports for early intervention, access to national and international data for collaboration and resources sharing to improve service quality and contribute to students and researchers recruitment and retention
- Achieve Business agility: be ready for regulation changes, merging/splitting of departments and colleges. Meet challenges from competitors, partners and even vendors for activities such as sharing research resources and outcomes, vocational training for students, student and faculty exchange programs that stipulate profiles and credits exchange.

SOA, Service Oriented Architecture, is looked at as the way to bind loosely coupled services or software components from different legacy or open standard applications to empower business agility and facilitate the reusability of software assets (Erl, 2008). This will enable educational institutions to reduce cost and bring their services to market more swiftly.

SOA is predicted to remain as a fundamental IT paradigm although it is still considered as a vendor push and lakes maturity in standardization. (SUNGARD, 2007) Universities such as Wisconsin, Embry-Riddle Aeronautical and Cornell demonstrated that through the appropriate definition and use of small number of simple services one can enable disciplined application development agility and get best use of services orientation. (Eduventures, 2006)

Trends of SOA can be looked at from different aspects including business, research areas, technology and standards.

In Business, the market forecast anticipate to exceed $15 billion by 2013. (Wintergreen Research, 2007) It is also predicted that it will be difficult to differentiate major SOA software vendor's offering. Consequently, this will

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drive down software cost especially with penetration of open source SOA applications and tools.

In research, Non vendor based groups and consortiums are unifying the efforts and setting clear campus direction for SOA challenges and opened area research projects (Ibrahim, Michelson, Holley, Thomas, Josuttis, & Vadoss, 2007).

Although some technologies such as BPEL and BPMN implementation failed to reach the expectations, the prediction is in favour of cross-platform, cross-applications and cross-tools and SOA-Aware network infrastructures adoption (Dan, Johnson, & Carrato, 2008). With regards to standards Open Group, W3C and major vendors such as IBM, Microsoft and Oracle are setting standards to achieve systematic procedures and policies (Lucca & Fasolino, 2006).

In this paper we show that service quality attributes such as Interoperability, Performance and Security are directly impacting the trends of SOA adoption and its future direction.

The paper is organized as follows: In the second section we present main development in SOA arena. In the third section we outline SOA models and challenges. In the fourth section we present quality attribute for successful SOA implementation. In the fifth section we outline the trends prediction and the final section we provide summary and conclusion.

2. Development in SOA arena

There are a range of standards used in the development of the IT services used by organisations and any organisation may be tied to whichever vendor makes the development tools for that particular standard. These standards apply to the interactions of the end user, the application being used, the technology that applies and the external entities that may be involved. Most of these are standards like HTTP, HTML and SMTP which lie at the core of Internet usage. Beyond these key standards are developing ones being evolved by companies like Microsoft and IBM who make some of the development tools. According to (Boehm, 2006), these evolutions by the different companies are creating a range of separate user groups each with its own adopted tools and application standards.

2.1 Web services evolution

Early in this decade Web services became popular as pieces of software that can communicate with another application over a network by using a specific set of standard protocols. This includes Simple Object Access Protocol (SOAP), the Universal Description, Discovery, and Integration (UDDI) framework, and the Web Services Description Language (WSDL). This new set of tools and standards allow the known concept of Client/Server computing to be extended beyond a fixed set of computers to include multiple sets of services provided by servers and orchestrated by other computers. (Breedlove, 2008)

2.2 SOA evolution

The orchestration between applications is also evolving. Furthermore, a demand for dynamic integration between systems in a changing business environment is rising. This has derived a need for a new computing concept. The new concept should not be limited to the technology standards and tools. It should rather extend to cater for business agility, federation, intrinsic interoperability, business to IT alignment and services level agreements to define and preserve security, availability and performance. It should also facilitate the use of capabilities of computing components located in a distributed computing to provide services to a requester autonomously. This concept is commonly referred to as service-oriented architecture (SOA), SOA-based systems, or service-oriented systems.

2.3 Maturing SOA

Currently all primary software vendors that officially support SOA seem genuinely committed to advancing their product platforms to provide increasingly sophisticated implementation technology capable of realizing service-orientation on a broad level. Gartner sees that mature SOA products are available but technologies are still evolving (Gartner, 2008). Leaders and visionaries vendors according to Gartner's magic quadrant are predicted to retain their status for the coming few years although landscape is changing.

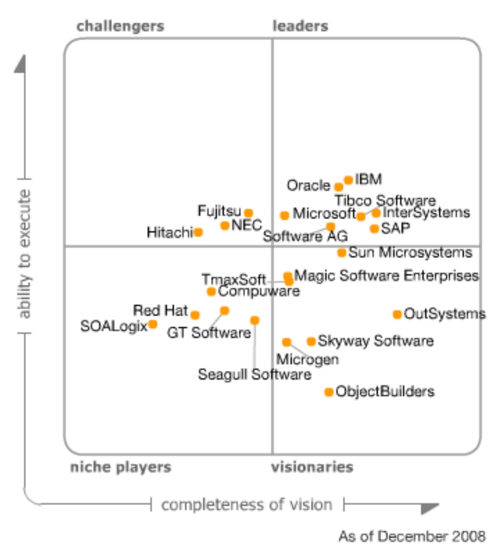

Fig 1: Magic Quadrant for Application Infrastructure for SOA Composite Application Projects (Gartner, 2008)

Gartner has also estimated that SOA will be used in more than 80% of new, mission-critical applications designed by 2010 (Gartner, 2008).

3. Models and Challenges

Over the years, a few organizations have published "SOA Reference Models", each with its own unique qualified rendering of what an SOA looks like. There are models that come from many different aspects: logical architecture, interface architecture, standards architecture, etc. (SOALogix, 2007). It is at least agreed that SOA is a design philosophy that is independent of any vendor, product, and technology or industry trend.

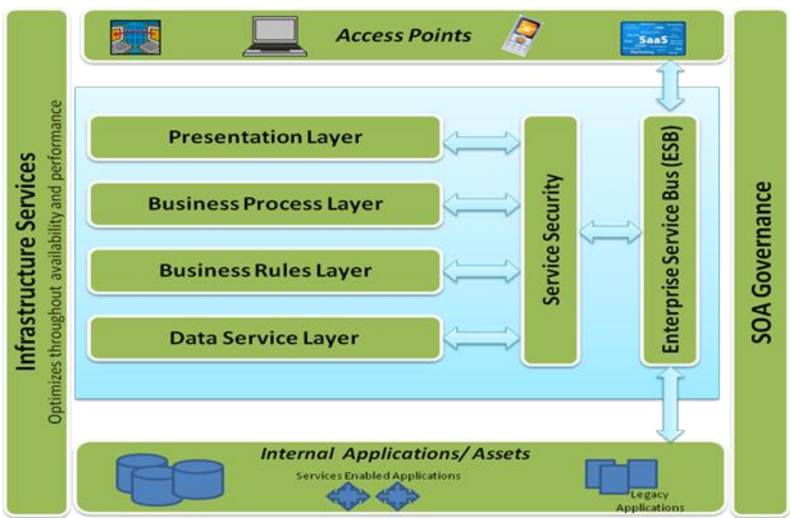

Fig 2: SOA Reference Model

No vendor will ever offer a "complete" SOA "stack" because SOA needs vary from one organization to another. Hence it would not be possible to define a reference Model that fits all SOA implementations. We can rather accept an abstract model as a guideline for best practice adoption of SOA projects. An example of such reference modules is shown in Fig 2.

This reference model is built on top of the existing organizational asst of legacy systems, services enabled applications and other internal applications. This model uses separate layers for data service, business process and business rules to allow better business agility and enhance performance. The data service layer act as a single entry point to all enterprise data stores. This allows data access to be performed in a centralized manner. Hence, issues such as optimization and transformation can be addressed while ensuring data integrity and security.

The Business Rules layer handles the abstraction of the policies and practices of the organization. These business rules are in a language that business and IT can both understand. They describe the operations, definitions and constraints that apply to an organization in achieving its goals. For example, a business rule might state that "Native speaking students are exempted from taking language placement test". Another rule might be "allowing outstanding students to register for extra credit hours. These business rules are used by – but not embedded in – services to allow greater flexibility for architected services to adapt to changes in business rules and continue providing its designed function while adhering to the new business rules. For example:

- A service might need to allow each faculty to set different grading scheme based on their own observation of students' progress.
- A service for assessing the current status of a student might have to be changed after midterm exams.

Business process layer is a unit of application logic that controls sequences and enforces business rules. It also performs transactional integrity of an application's operations. Unlike other published models, this model added an external access points layer to allow for a wide variety of interpretations for presentation and activity implementations beyond the "corporate portal". Cell phones, mash-ups, streaming clients are examples of this representation beyond the portals.

Implementing a standardised SOA at the education sector might even be more complex. Universities for instance have been traditionally operated as highly decentralized enterprises, with faculty and business units allowed considerable autonomy to choose their computing systems, business rules, and operating practices (Liu & Yang, 2008). With this complex nature of a university identity portfolio to be translated into a situation of a single sign-on, scalable, real-time and where system components could be reconfigured in an autonomic and ad-hoc manner sort of environment is quite a challenging task.

4. Quality attributes for SOA & Trends

The use of SOA for implementing distributed systems is a critical architecture decision. This is due to the fact that quality attributes for a system are impacted by that decision. While there are significant benefits with respect to interoperability, modifiability, and reusability other qualities attributes such as performance, security and testability are concerns. (Nicolás López, 2007)
Attributes such as security, performance and availability have even hold back the wide adoption of SOA in the early stages as it would limit the capabilities of SOA architected applications. Organizations responsible for setting standards such as OASIS, W3C and WS-I are working towards leveraging unified standards to maintain systems development quality (Maurizio, Sager, Jones, Corbitt, & Girolami, 2008). In this paper we discuss interoperability as the most prominent benefit of SOA, especially when we consider Web services technology. Idealistically, the aim is to reach to cross-vendor and cross-platform interoperability. On the other side we discuss performance and security as a challenge to adopting SOA especially for mission-critical and real time environment.
Other attributes such as reliability, testability, reusability and scalability are also important and need further research to study their impact in predicting the SOA trends in future.

4.1. Interoperability

Achieving interoperability is a key requirement for service orchestration and composition. That is the ability of a collection of communicating entities to share specific information and operate on it according to an agreed-upon operational semantics (O'Brien, Merson, & Bass, Quality Attributes for Service-Oriented Architectures, 2007). During the last few years the industry has produced several standards and technologies for service orchestration and composition such as Web Services Business Process Execution Language (WS-BPEL), Service Component Architecture (SCA), and the Web Services Choreography Description Language (WS-CDL). All of those standards are based on coordinated interactions between different Web Services endpoints. However, Business Processes and Composite Services are only as good as their capacity for interacting with different services developed on different technologies according to (Rodriguez & Mariscal, 2007) which we agree with.
Implementing interoperable services should guaranty that those services can be used as part of orchestrations, choreographies, or composite services to address more complex scenarios. Monitoring of students progress for example requires sharing students' results data that are locked by a virtual learning environment with the management system that is tracking progression against funding in order to address the motivation and commitment of struggling students. Freeing up data through interoperable set of services could allow early intervention to retaining students and maximize funding.
However, interoperability cannot be guaranteed due to various reasons like differences in the versions of Web Service standards and specifications supported, differences in error handling mechanisms, differences in protocol support etc. Tools like the one defined by (Kuppuraju, Kumar, & Kumari, 2007) may act as interoperability gateway for SOA, which generates a report of interoperability issues, given the WSDL files and the products used in the SOA stack. Such tools will contribute in directing the trends for the evolving development of interoperability services and standards.

4.2. Performance

The ability to make services on different platforms interoperate seamlessly has a performance (response time) cost. Depending on the SOA technology or framework being used, stubs, skeletons, SOAP engines, proxies, ESBs, and other kinds of intermediaries' elements cause performance overhead such as delivery, parsing, validation and serialization. Today's technology still cannot guarantee performance quality in distributed application. Performance is mostly found in practical to be lower than customers' expectation. For example, there are SLAs which promise a sub-second response time, whereas in practice response time ranged from 1 to 48 seconds. (O'Brien, Brebner, & Gray, Business Transformation to SOA: Aspects of the Migration and Performance and QoS Issues, 2008). One of the obvious issues that directly affecting the performance is the use of a standard messaging format which increases the time needed to process a request. For example, in the Web Services technology, the use of XML has a great impact on performance. XML is text-based and messages can be 10 to 20 times larger than the equivalent binary representation, so transmitting them over a network takes longer. (Sankarasetty, Mobley, Foster, Hammer, & Calderone, 2007).

In the e-Education area observation shows that there is increased dependency between services across university units. Compositions of these services are offered and reused across all level of university units, academic and non academic. The ability to architect applications with well known performance characteristics is critical, but becomes harder because of the dependencies between services, and the possibility of large numbers of users accessing applications during periods of peak demand (e.g. to meet deadlines for submission of information during semester ends and exam periods). The trend is to architect SOA based systems with performance in mind. To do this it is necessary to be able to understand the performance characteristics of the architecture and investigate alternatives early on in the development lifecycle (Brebner, O'Brien, & Gray, 2008). This would require developing methods and tool to support for early lifecycle performance modelling of SOA-based systems.

4.3. Security

Security is a major concern for SOA and Web services. It is associated with four principles: *(a)* confidentiality, which ensures that access to information/services is granted only to authorized subjects; *(b)* authenticity, which is related to trust that the indicated author/sender is the one responsible for the information; *(c)* integrity, which guarantees that information is not corrupted; and *(d)* availability, which ensures that the service is available in a timely manner. (O'Brien, Merson, & Bass, Quality Attributes for Service-Oriented Architectures, 2007)

Existing Solutions and Challenges.

Web services solutions have been addressing some of the security concerns at the network infrastructure level. For example, Web servers that host Web services can be configured to use Secure Sockets Layer (SSL) and digital certificates to encrypt data transmission and authenticate the communicating parties. (Rahaman, Schaad, & Rits, 2006) gives an example of Kerberos as an authenticity option in intranet solutions, where users receive a ticket for access to each Web service they have permission to use. However, these solutions merely help to protect point-to-point interaction and hence a comprehensive mechanism that covers end-to-end security is still not achieved.

Better Solutions

In 2002, IBM, Microsoft, and VeriSign proposed Web Services Security as a comprehensive security model for Web services. Besides the core WS-Security policy for message protection, the original proposal contained a roadmap of complementary security specifications. These specifications (WS-Authorization, WS-Privacy, WS-Trust, WS-Federation, WS-Policy, and WS-Secure Conversation) are gradually developing into standards. The WS-Security specification was submitted to OASIS, and the first version was approved in 2004 (O'Brien, Merson, & Bass, Quality Attributes for Service-Oriented Architectures, 2007). WS-Security defines a standard set of SOAP extensions that can be used to provide message content integrity and confidentiality. It accommodates a variety of security models and encryption technologies and is extensible to support multiple security token formats.

More promising solutions

Two other proposed standards relevant to Web services security are Security Assertions Markup Language (SAML) and eXtensible Access Control Markup Language (XACML). SAML provides a standard, XML-based format to exchange security information between different security agents over the Internet. It allows services to exchange authentication, authorization, and attribute information without organizations and their partners having to modify their current security solutions. XACML complements SAML by providing a language to specify role-based, access control rules in a declarative format (Chmielewski, Brinkman, & Hoepman, 2008).

Security against quality factors

As we have explained, existing security mechanisms may have a negative impact on performance, modifiability and interoperability. Nevertheless, adherence to security standards is important to preserve interoperability. WS-I has been working on a basic security profile that will ensure interoperability of security features among compliant vendors.

The architect should also look into the network configuration required by the chosen SOA technology. For example, if a service user interacts with a remote provider via the Internet using CORBA, then the firewall on both ends probably needs to permit Internet Inter-ORB Protocol (IIOP) communication (Arsanjani, Ghosh, Allam, Abdollah, Ganapathy, & Holley, Nov 2008). On the other hand, in a Web services solution, firewall rules don't need to change because the SOAP interaction is over a protocol that is normally open (e.g., HTTP or SMTP).

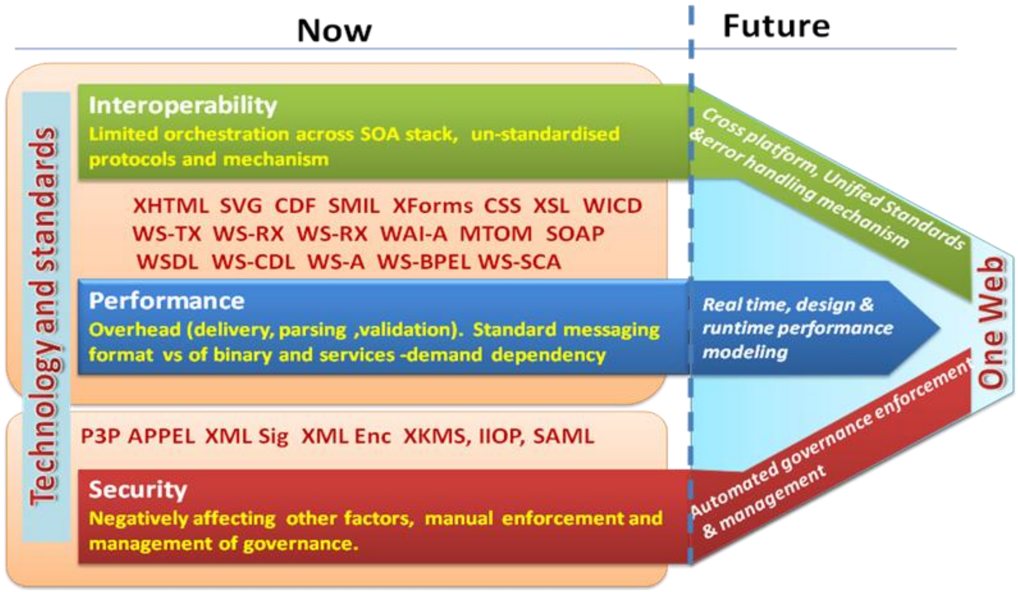

Fig 3: Key-trends in the concerned SOA quality factors

Governance

Organizations are striving to accomplish the security in terms confidentiality of data, integrity and authenticity as well as handling threats and malware issues if applications are deployed on the public Internet. In a highly dynamic and a highly distributed environment, the trend is to apply security solutions in a holistic approach.

This could be addressed by governance which refers to the broad combination of security policy, provisioning, message-level security, corporate IT policies, human resources (HR) policies, compliance, and other administrative aspects of managing enterprise IT (Giblin, 2005). Governance affects many areas of IT, and with SOA, governance has particular relevance for security.

According to a recent survey, SOA trends in governance reveal that a majority of companies are manually enforcing their SOA security, compliance, and business policies. This is raising a concern to large enterprises and hence they are urged to take an immediate step forward to deploy automated governance methods to insure higher level of confidence in their security solutions.

4.4. Key-trends in SOA Quality factors at a glance

As SOA adoption continues, we predict a further convergence of SOA quality factors towards interoperable, real time performing and secure services oriented enterprise applications.

Figure-3 show the move from current limited orchestration across SOA stack with different standards, mechanisms and protocols used for communication, messaging and error handling to go to a cross-platform interoperability with unified standards, mechanisms and protocols. Future architecture is also predicted to reveal a real time performance and automated security enforcement and management.

Ball state university and its students have both benefited from their newly adopted smart SOA solution that allows them cross platform interoperability. Students have near real-time information regarding the availability of and requirements for online courses, enabling them to quickly and easily make right decisions on how to progress their studies. (IBM, March 2009)
City University London shows another example that confirms our future prediction towards cross-platform interoperability and real time performance. “City–2012”, the university’s five-year strategic plan has revealed an accurate flow of information from student records to the Virtual Learning Environment (VLE) in near real-time. This would not have been possible without using a services-based infrastructure that in turn allows changes to the student records system to cause an event trigger process for new information to be automatically transferred, via the Enterprise Service Bus (ESB) through to the VLE. (JISC, October 2008)

Queensland University of Technology (QUT) new SOA-based environment allows them to present a unified interface to their intranet business functions with an inbuilt security mechanism and a single sign-on process across 25 external systems as well as the core student management system and other mission-critical applications. The new environment is developed with SOA governance, standards and processes to insure managing interoperability

between the student management system and other core systems, including human resources, financials, and the new online learning system. (Oracle, April 2008)

5. Conclusion

Predicting trends for evolving technology is quite challenging task. Nonetheless, the evidence presented makes it clear that SOA adoption in mission critical application is increasing. Moreover, technologies supporting this architecture are also going forward towards standard based processing and methodologies. In this paper we have discussed the current status and developments in SOA arena and clearly stated the challenges in defining a reference model that fits all SOA implementation. The main conclusion is that SOA quality attributes such as interoperability, performance and security are directly impacting the future progress of SOA adoption. These three attributes are currently the main concern for wide acceptance and adoption of SOA based systems. The trend is going towards agreed upon standards in the next five years at least on the discussed SOA quality attributes. This will eventually leverage wider adoption of SOA based system irrespective of the existing economy crises.

Further research is required to cover other quality attributes to investigate its future trends and their affect to SOA projects. More work is also required to refine a framework for Universities and large schools that leverage better interoperability, performance and security.

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