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Air Force SOA Enterprise Service Bus Study Using Business Process Management Workflow Orchestration for C4I Systems Integration

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Abstract

Current Air Force (AF) Command, Control, Communication, Computers, and Intelligence (C4I) systems are costly to integrate because they were not initially designed to work together, and many integration efforts still provide point-to-point solutions between tightly coupled systems. The Department of Defense (DoD) is moving toward net-centricity and the AF Air and Space Operations Center (AOC) Enterprise Service Bus (ESB) Risk Reduction Study investigated industry best practices for streamlining the integration process using a service oriented architecture (SOA). The Government study team engaged with three industry vendors and their partners, evaluated ESB interoperability characteristics, explored the business process management workflow orchestration technology, and developed a proof-of-concept prototype for information exchange within the AOC.

1. Introduction

The Air Force (AF) Air and Space Operations Center (AOC) Enterprise Service Bus (ESB) Risk Reduction Study was an investigation into ESB and workflow orchestration characteristics, and their use in integrating heterogeneous systems. The study focused on three objectives:

- How do standards-based ESBs and other SOA technologies, influence the speed of integration?
- How can business process management (BPM) technology orchestrate the AOC services and mission workflows?
- How can ESB mediation and transformation capabilities ease the pains of connecting heterogeneous C4I systems within an environment such as the AOC?

The study provided insight into both the operational and system engineering benefits of applying ESB and SOA technologies. This was accomplished using industry best practices provided by participating vendors and their partners.

For instance, ESB and SOA technologies can provide automated rapid access to information through stacked services and built-in functions. Previously, this would have been accomplished through manual action by the originator.

The study was not a vendor product evaluation exercise. Due to time and resource constraints, we did not explore other ESB capabilities (e.g., security, performance, guarantee of delivery, service discovery) nor investigate some ESB related issues like Universal Description Discovery and Integration (UDDI) registries as well as use of Net-Centric Enterprise Services (NCES) services.

2. Study Background

Like many other AF C4I systems, the AOC Weapon System (WS) program is in the process of migrating to SOA in order to implement the DoD net-centric vision. The goal is to improve information exchange between loosely coupled systems to address the warfighter needs. The AOC WS is considering the enabling of agile integration through use of BPM in combination with a federation strategy that employs SOA at the enterprise level.

The AOC ESB Risk Reduction Study was a proof-of-concept initiative that investigated industry best practices in exploiting SOA related technologies. The Government engaged with three industry ESB vendors and their partners, evaluated ESB interoperability characteristics, explored BPM workflow orchestration capabilities, and developed a prototype system simulating the information exchange within the AOC. The Government and vendor teams successfully integrated

six heterogeneous AF systems of record via three different ESB products. The prototype successfully demonstrated an automated BPM workflow using a notional AOC mission thread.

The AOC mission thread is centered on the production of the Air Tasking Order (ATO). As shown in Figure 1, a sequence of strategy, planning, review, and dissemination activities transforms overall operational concepts into a plan for execution. The focus of this study's mission workflows mainly spans two ATO phases: ATO development and ATO execution.

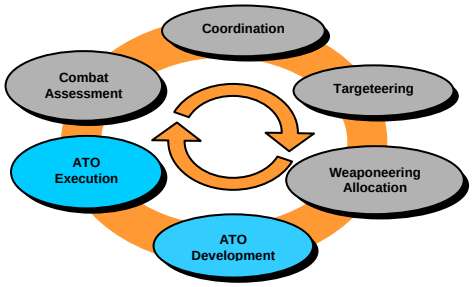

Figure 1. ATO Cycle

3. Study Methodology and Activities

Using ESB and SOA technologies, the study tested the rapid implementation of a proof-of-concept process integrating existing systems. The study sought to determine whether either technologies (ESB or Work-flow Orchestration) provided C4I systems with greater visibility, adaptability, control, and agility.

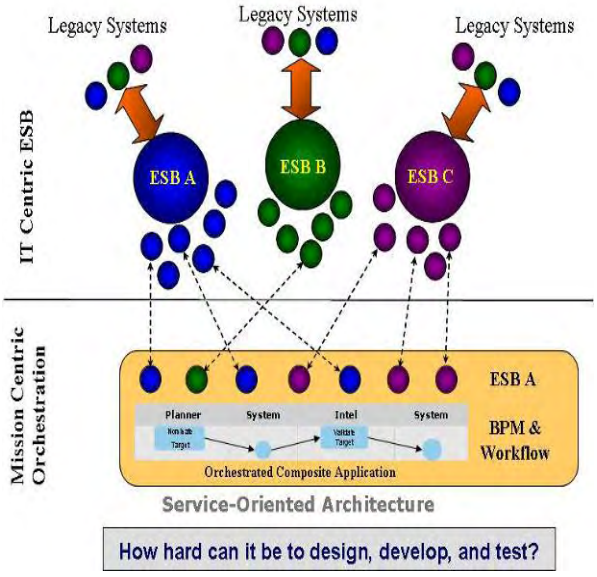

Figure 2. Notional ESB Study Architecture View

As illustrated in Figure 2, three different ESB vendors participated in the study. Each ESB communicated with their assigned AF current systems and other ESB's integration endpoints through emails, SOAP web services, Representational State Transfer (REST)-based RSS services, and legacy flat file data (such as the USMTF ATO).

The ESB products encountered some real-life integration challenges such as legacy systems with hardwired proprietary system configurations and differences in data format and message version. These challenges required the vendors to prove that their built-in ESB messaging, mediation, and transformation capabilities could support the integration of C4I systems. Additionally, the study environment required the vendors to prove the ESB interoperability among different ESB products.

During the study we found that improvements in BPM technology and methodology provided us a level of abstraction of the business logic from the IT centric integration logic and transformational requirements. This also allowed us to provide rapid user experience components that provided greater command and control in a visual manner.

An ESB in conjunction with the use of BPM workflow orchestration offered new integration practices. That included real-time parallel development of small proxy web services to complete the modeling of a business process workflow in the ESB BPM tool. This approach to system integration and business process modeling provided great integration flexibility and could reduce system implementation time. It might improve end-user experiences and allow rapid insight into process and capability changes.

In a short period of time the AOC ESB study team completed at least five iterations of the BPM workflow orchestration development lifecycle. They are process modeling, requirements mapping, system integration, orchestration development, and process monitoring as illustrated in Figure 3.

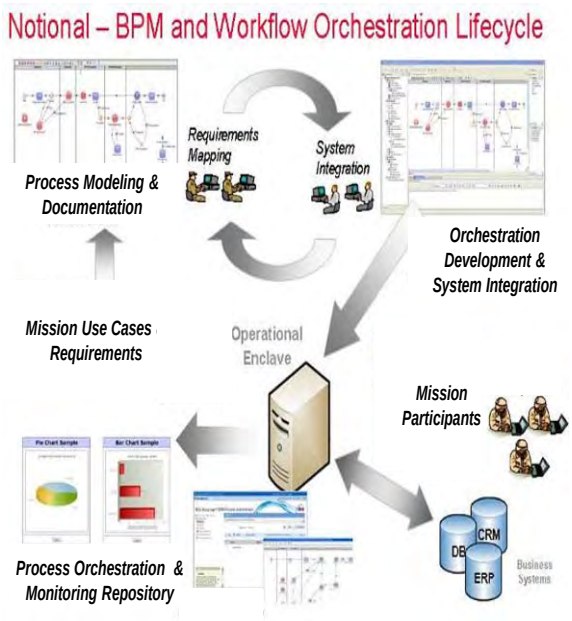

Figure 3. Notional BPM Workflow Orchestration Lifecycle

A notional ATO mission tasking workflow was developed for the ESB study. Illustrated in Figure 4, activities in blue icons are system interactions with the ESB, while activities in red icons are human interactions with real-time forms and reports. Note that systems and swim lanes are redacted. Processes and forms are all notional in nature for the study.

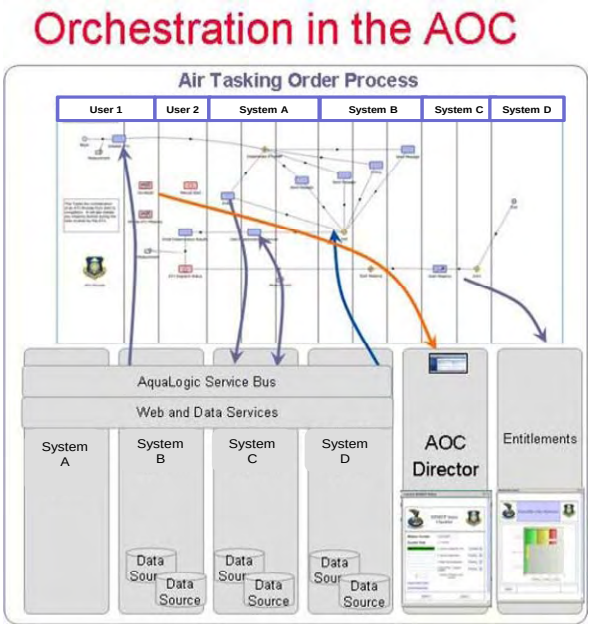

Figure 4. Notional Air Tasking Order Process (redacted)

4. Study Results

Overall the study was successful in producing a working notional system integrated with six AF current systems and three vendor ESBs. The study identified risks and opportunities for SOA interoperability using off-the-shelf ESB products. The advent of BPM and workflow orchestration showed the potential for a more agile and rapid development of capabilities.

The AOC ESB Risk Reduction Study demonstrated the following characteristics:

- Increased operator visibility into AOC mission and business processes
- Improved efficiency by automating notification and providing operational status on acknowledgements
- Aggregation of information sources
- Automated generation of forms and reports
- Need for Service Level Agreements (SLA) and Quality of Service (QoS) guidelines to control and measure how services are being provided and used at both machine and human interaction levels on the ESB.

Some strengths that the ESB study demonstrated in using the ESB and BPM technologies include:

- Adaptability to changes in integration configurations and business processes
- Ability to model, test, and implement orchestration for operational scenarios
- Interoperability across multiple transports, web services, files, email, RSS feeds, and databases
- Capability for monitoring and reporting gained by running all communications on the ESB

Some challenges that we encountered based on a notional mission scenario include:

- Working with a constantly changing lab environment
- Changing business logic as workflow was reviewed and changed.
- Limited development and short integration time
- Standards are still developing or in different versions. Ensuring all technologies are on the same standard is very important. Additionally new technologies may use competing standards. An organization needs to weigh capabilities

against risks for their specific program. Newer capabilities may not interoperate with old standards, but the organization may need capability immediately and accept it on the ground that a new solution has the support of major industry vendors and a large existing customer base. Note that even recognized standards, such as SOAP are still being updated.

- Some established standards, such as the SOAP XML web service standard, require strong typing of the information exchanged. This leads to reduced flexibility in being able to modify the structure of that information at runtime. An evolution towards more flexible standards would be helpful.
- Interoperability is a moot point if there is no oversight of each of the levels (operations, solution, service, and IT asset). For example, the SOAP 1.2 standard may be used but two different versions of the data (schema) are implemented at the IT asset level. A client tries to communicate across both and fails.
- Policy enforcement is the only way to ensure the effectiveness of a governance strategy. For example, if a new capability has side-effects that could cascade through to dependent service consumers, the change must be managed by the people who govern the systems affected.
- Business changes due to mergers and acquisitions of software vendors provide both opportunities as well as risks. In some cases, a merger or acquisition provides more resources and increased scale for product research and development as well as support. However, if there is product overlap, then there is a risk that one or more technologies will either be discontinued or product support will decrease. It is important to establish what the product roadmap is from the vendor. Note that during this study two of the three product vendors were acquired (Cape Clear was acquired by Workday and BEA was acquired by Oracle).

The study result was the creation of two notional mission processes and several forms and reports along with the integration of six AF current systems through the ESBs as illustrated in Figures 5 through 8.

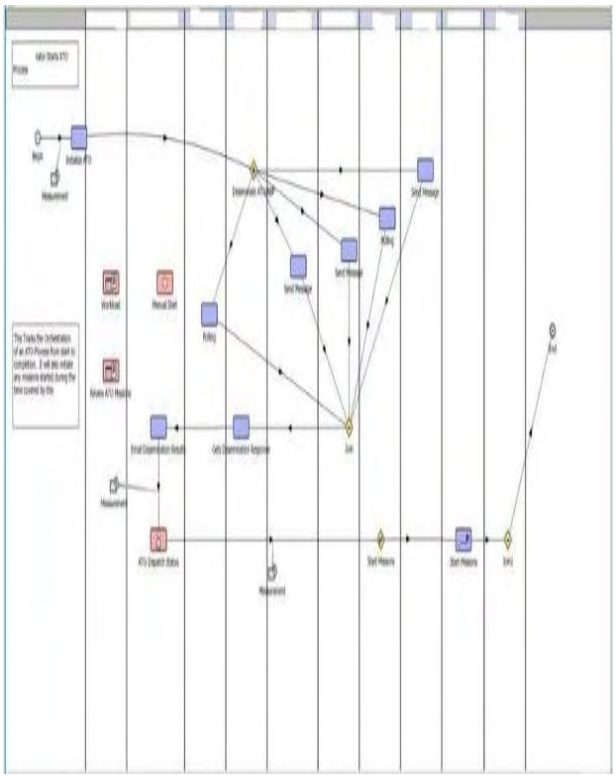

Figure 5. Notional Main Process (redacted)

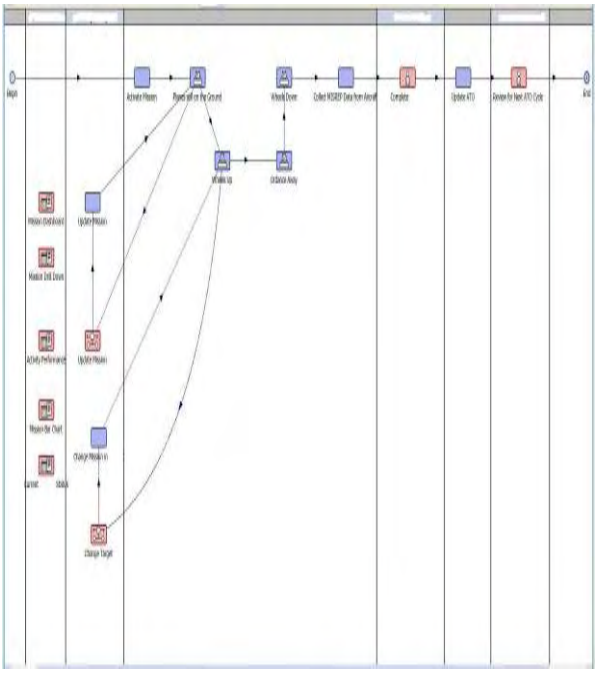

Figure 6. Notional Sub-Process (redacted)

Figure 7. Notional Mission Status Report (Redacted)

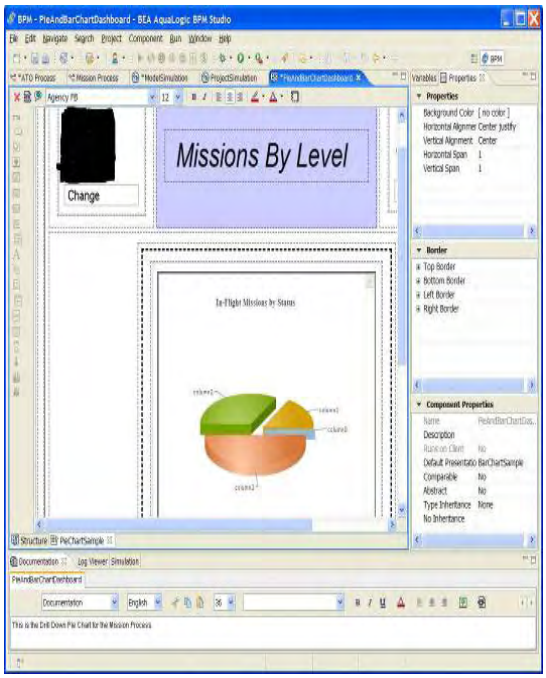

Figure 8. Notional Mission Process Report (Redacted)

5. Conclusion

The three BPM standards used for this study included Business Process Modeling Notation (BPMN), Business Process Execution Language (BPEL), and XML Process Definition Language (XPDL). As BPM matures, convergence and enhanced support of these standards by vendors continue to develop. Currently, risks are low that BPM standards will diverge due to the general market consensus (Gartner, IDC, Forrester, etc.). BPM is one of the fastest growing technology areas.

The study provided insight into the operational and system engineering benefits of applying ESB and SOA technologies. Advances in product capabilities and improvements in the underlying methodologies create opportunities for more rapid solutions. There is reduced risk during implementation because development spirals are shorter and reusability of approved services is increased. It is important to note that regardless of the technologies selected, organizational and cultural walls will always be a threat to solutions. The organizational challenges grow as these new solutions span both IT infrastructures and mission users.

The study showed that using ESB and BPM tool in workflow orchestration can help separate business logic from information providers. Proper separation allows parallel development and integration of ad hoc proxy web services through business process models. This could increase integration flexibility and shorten integration development cycle while reducing risks. (This conclusion comes with the premise of a collective effort between business users with a mission focus and information providers with system data expertise.) The study also showed that with the appropriate selection of technologies, BPM workflow orchestration capability can automate system interactions, as well as allow humans to participate in the workflow.

Most importantly, the study revealed the need to identify critical information resources and expose them through loosely coupled, reusable, and composable services for successful composition into workflows. Without the basic raw material of workflow, the information consumed by the business process, the value of ESB orchestration would be severely limited. Without access to information freed of business process presumptions, the re-combination of information by the orchestration engine in a new process would be difficult to achieve.

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