Governance of Data Initialization for Service Oriented Architecture-based Military Simulation and Command & Control Federations

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Abstract
Military simulation and command and control federations have become large, complex distributed systems that integrate with a variety of legacy and current simulations, and real command and control systems locally as well as globally. As these systems continue to become increasingly more complex so does the data that initializes them. This increased complexity has introduced a major problem in data initialization coordination which has been handled by many organizations in various ways. Service-oriented architecture solutions have been introduced to promote easier data interoperability through the use of standards-based reusable services and common infrastructure. However, current SOA-based solutions do not incorporate formal governance techniques to drive the architecture in providing reliable, consistent, and timely information exchange. This article identifies the need to establish governance for data service development oversight, presents current research and applicable solutions that address some aspects of SOA-based federation data service governance, and proposes a conceptual governance reference model for initialization of data in SOA-based simulation, and command and control federations.

Keywords: service-oriented architecture, governance, data initialization, net centricity, web services, data services, simulation federation, command and control

1. Introduction

Military "transformation" is inevitable as technology and warfare change over time. As advanced technology improves communication and information sharing, policies are updated to reflect modernization. Thomas McNaugher, Director of Army Research Division at the Rand Corporation, wrote in *Foreign Affairs* about the idea of a "revolution in military affairs" (RMA) based on new information technology. McNaugher explains that though "transformation" can be difficult, time consuming, and expensive, it is also critical to a military's success [1]. The notion of RMA and "transformation" is equally important in military training and tactical systems. Military services use constructive simulation augmented with command and control (C2) systems, collectively known as a federation, to effectively train warfighters in tactics and operations for the battlefield. Current simulation and C2 federations offer a wide array of training services based on policy. However, to execute a capable simulation and C2 federation training event, the federation data must be properly initialized.

The Department of Defense (DoD) vision for a data initialization capability in simulation and (C2) federations is to transition from the current manual stove pipe legacy process to an automated, over the network, service-oriented architecture (SOA). In 2006, the DoD Chief Information Officer published the "Net-Centric Services Strategy" to provide guidance for evolving the DoD net-centric environment to a SOA. In the document, the DoD states that:

> *"As the threats facing the DoD evolve, and as new threats begin to emerge, a new level of responsiveness and agility is required from our forces. The DoD cannot transform its operations to support a net-centric force by merely maintaining and expanding the status quo. Patching stovepipes together is a temporary solution; however, this leads to a fragile environment, which will eventually crumble under the high demands and unpredictable needs of the users. The current DoD network consists of information silos that cannot communicate with each other unless they are pre-wired to do so. In addition, these silos cannot scale to accommodate the levels of interaction that will exist. The DoD's current stovepipe-based information environment must shift to a more robust and agile information environment that can support and enable net-centric operations."* [2].

The scope of this vision encompasses initialization of information systems, common information services, and communications networks [2, 3, 4, 5]. Upon implementation, this capability will potentially support global use, use certified and synchronized authoritative data sources, provide initialization data sets [5] to support modular force deployments, and be expansible to new units and systems including Joint, Interagency, Intergovernmental, and Multinational forces [2, 6].

Asit, et al. [7] describe an SOA as a new approach to the development of service-based enterprise-wide environments and solutions. Asit, et al. claim that SOA will lead to better alignment of business and IT goals within an enterprise. They continue to explain that SOA promotes greater agility of loosely-coupled applications; as well as, provides opportunities for effective reuse and governance of cross-organizational activities. Since current methods and tools that support SOA development activities have focused primarily on supporting business process and business logic, the authors currently investigate the application of SOA principles to enable the utilization of data as a service. Dorn, et al. [8] describe a shift in the information system paradigm from document-centric transactions of business information to process-centric and service-based data exchange. In addition the authors mention that a lot of work has been accomplished in capturing business models and collaborative business processes of an enterprise. On a technical level, Dorn et al. observe that the focus in software development is moving towards service-oriented architectures. The authors also provide a survey and taxonomy of the most promising models and processes at both the business and technical levels. Thomas Erl [9] mentions in his book that "SOA establishes an architectural model that aims to enhance the efficiency, agility and productivity of an enterprise by positioning services as the primary means through which solution logic is represented in support of the realization of strategic goals associated with Service Oriented Computing". A more formal description of an SOA is provided in the next section.

While the complexity of SOA may be obtuse, there are many simple examples of SOA implementations used every day. One particular common use is online purchasing. For example, a buyer connects to Amazon.com's online catalog and chooses a number of items for purchase. The buyer specifies the order through one service, which communicates with an inventory service to find out if the items requested are available in the specifications needed. The order and shipping details are submitted to another service which calculates the total, provide the buyer with delivery details such as when items should arrive, and furnishes a tracking number that, through another service, will allow the buyer to keep track of the order's status and location en route to its final destination. The entire process, from the initial order to its delivery, is managed by communications between the Web services—programs talking to other programs, all made possible by the underlying framework that SOA provides [9].

SOA governance is a concept used for activities related to exercising control over services in an SOA. SOA governance can be seen as a subset of IT governance which itself is a subset of corporate governance. The focus is on those resources to be leveraged for SOA to deliver value to the organization [9]. SOA needs a solid foundation that is based on standards and includes policies, contracts and service level agreements. The organization is expected to be able to use services to build and change business processes quickly. To do so, a degree of granularity in the available services will be required. Consequently a SOA increases the need for good governance as it will help assign decision-making authorities, roles and responsibilities and bring focus to the organizational capabilities needed to be successful [9, 10].

SOA and SOA governance enable intrinsic interoperability through the use of standards-based reusable services. Thus, SOA has been identified as an enabler for Net-Centricity [10]. SOA has proven itself as a viable approach to achieving services reuse, application integration and information agility while delivering compelling financial benefits [9].

The DoD Modeling and Simulation Coordination Office (M&S CO) also understands the importance of migrating to an SOA and efforts are underway to identify the data services required to support military simulation and C2 systems [11, 12, 13]. Additional efforts are ongoing to identify *new* data services that are required for such systems. Data services supporting these systems need to be governed to ensure that the services can support both the operational and tactical, to ensure interoperability between data services, and to reduce duplication of data services [2, 13].

This article presents the challenges of SOAs, introduces governance, explains the impacts of ungoverned services in a SOA environment for simulation and C2 federations, and describes key components of SOA environments that governance proposes to address (section 2, The Need for SOA Governance). Next, we will propose a conceptual governance reference model for data service development oversight in SOA-based data initialization of simulation and C2 federations (section 3, A Proposed Conceptual SOA Governance Reference Model). Afterwards, we provide a description of relevant work in the area of SOA-based data initialization for federations (section 4, Current Related Effort). Finally, we will summarize how the proposed research will support SOA-based data initialization of simulation and C2 federations (section 5, Summary and Future Work) and the DoD's net-centric enterprise objective.

2. The Need for SOA Governance

The Organization for the Advancement of Structured Information Standards (OASIS), a not-for-profit consortium that drives the development, convergence and adoption of open standards for the global information society, defines SOA as:

> *"A paradigm for organizing and utilizing distributed capabilities that may be under the control of different ownership domains. It provides a uniform means to offer, discover, interact with, and use capabilities to produce desired effects consistent with measurable preconditions and expectations."* [14].

SOA is an architectural and design discipline conceived to achieve the goals of increased interoperability (information exchange, reusability, and composability), increased federation (uniting resources and applications while maintaining their individual autonomy and self-governance), and increased business and technology domain alignment from a set of universally interconnected and interdependent building blocks, called services [9]. A service comprises a stand-alone unit of functionality available only via a formally defined interface [9].

SOA realizes its business and technical benefits through utilizing an analysis and design methodology (i.e. establishing governance) when creating services that ensures they are consistent with the architectural vision and roadmap and adhere to principles of service-orientation [14, 15]. Arguments supporting the business and management aspects from SOA are outlined in various publications [9, 16, 17, 18].

Industry and government sectors implementing SOAs have found that governance is one of the most important topics associated with achieving a successful Network-Centric Environment. An InfoWorld study released in July 2006 (see Figure 1) determined that 42% of the projects examined identified a lack of governance to be the largest factor inhibiting SOA adoption [19].

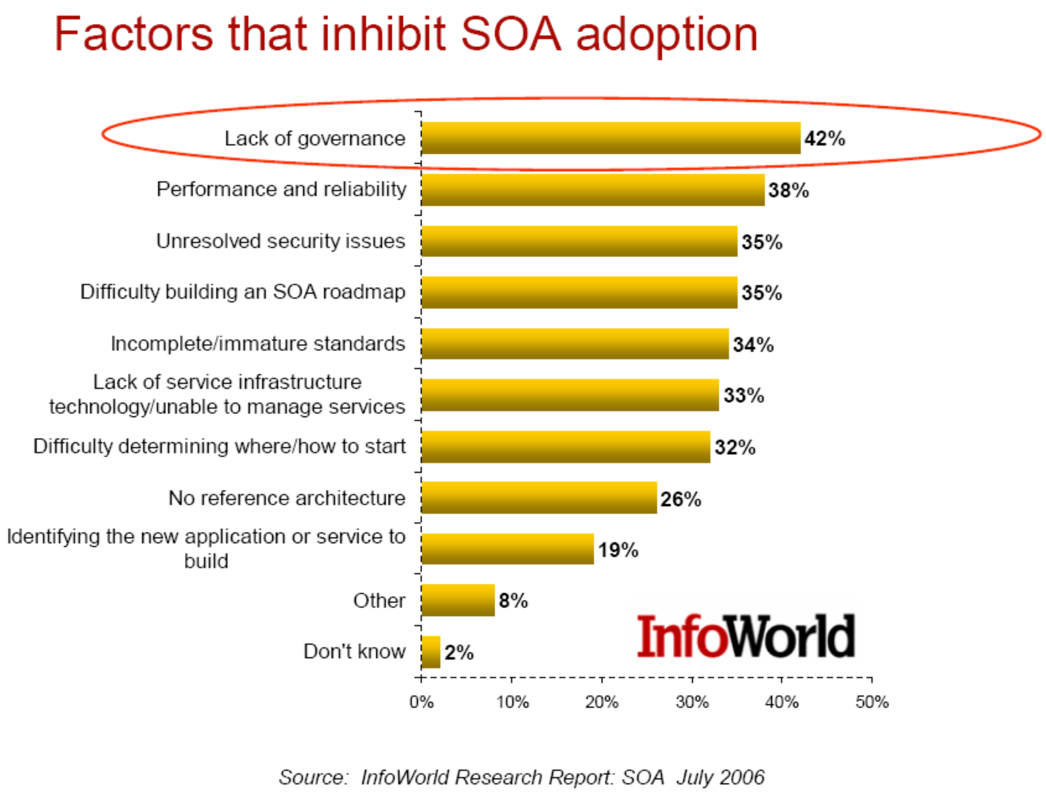

Figure 1. InfoWorld study looking at factors that inhibit SOA adoption

2.1 SOA Governance Challenges

While it may seem obvious that a federation composed of possibly reused, independent and self-governed entities would face governance challenges, most often in practice sufficient governance type mechanisms are not introduced. Governance is the intentional usage of policies, plans, procedures, and organizational structures to make decisions and control an entity to achieve the objectives of the organization [15]. SOA governance focuses on the services that need to be or are created in the realization of an SOA. A major reason to have an SOA is to create business, technical, and information agility [16, 17]. In the context of joint military simulation federations, SOA is a reusable services approach to implementing the operational and tactical strategy using the federation architecture [20]. Creating an environment in which reusable data services flourish and the benefits are fully realized requires a well thought-out, explicit, implemented, and maintained governance plan.

The approach to governance in this document emphasizes incentivizing behaviors, enforcing policies and standards, implementing processes and procedures, managing roles and responsibilities, and monitoring metrics to obtain federation behavior that tends to be (or become) good in the context of the relevant operational and tactical, factors. SOA governance of data services is not a single registry or tool used for management. SOA governance is the management of key assets owned by a federation to promote and enforce their use for maximum enterprise benefit and interoperability.

2.2 SOA Governance Goals and Objectives

The goal of SOA governance is to develop processes and oversight to ensure that services are developed and sustained to promote a flexible and dynamic infrastructure [18]. Though tools exist to assist in governing services, a governance process must be a normal part of the day-to-day operations within any organization to ensure that all of the services are being built and maintained in a manner that promotes interoperability [20].

The objectives of SOA governance include [9, 14, 20]:

- *Encouraging desirable behaviors in SOA* – Services are presented to consumers in a standardized manner allowing them to be quickly consumed.
- *Maintaining consistency and relevance within the SOA life cycle* – Requiring that certain criteria be met before moving to the next cycle ensures that the services being exposed meet a minimum level of maturity.
- *Tracing operational goals and capabilities to services* – Defined capabilities are mapped to candidate services.
- *Measuring the results of those services* – Measuring the results of the services allows for them to be prioritized. This helps to ensure that the most important services are addressed and fielded first.

2.3 SOA Governance Prerequisites

For a successful governance structure to be established, certain prerequisites must be met so simulation federation systems can realize the advantages associated with a network-centric architecture (e.g., adaptability, extensibility, etc.). These prerequisites include [9, 17, 18, 20]:

- *Support and commitment from senior management* – Commitment from senior leadership is required to empower a governance committee. Empowerment from senior leadership ensures participants adhere to a committee decision.
- *Defining an accepted SOA vision (federation architecture*) – Agreed-upon federation architectures ensure participant development towards a common end state. The architecture is a way to identify current and future capabilities.
- *Existing data governance and decision-making frameworks* – A SOA governance committee needs decision-making authority.

2.4 Run-time Governance vs. Design-time Governance

Design-time governance and Run-time governance are essential aspects of SOA governance.

Design-time governance is an IT development function that involves the enforcement of processes and the application of rules for governing the definition, creation, and maintenance of SOA assets such as services and schemas [9, 11]. Policies typically ensure that services are technically correct and valid, and that they conform to relevant organizational and industry standards. Design-time governance includes change management—the act of managing SOA assets through the cycle of change—which is arguably more complex and important in the long term than the design and creation of SOA assets [9, 16]. Design-time governance is used to manage and streamline the design and development of services and other software development assets [17]. For simulation and C2 federations, design-time governance attempts to design an SOA to consistently capture, automatically deliver and apply knowledge across the entire federation.

Governance at run-time consists of defining and enforcing policies for controlling the deployment, utilization, and operation of deployed services. These run-time policies typically relate to non-functional requirements such as trust enablement, QoS management, and compliance validation [9, 17, 20]. Run-time governance also involves service-level agreement (SLA) monitoring and reporting. By tracking the actual performance of a service and comparing it to the requirements specified in the SLA, the system can identify non-compliant services that require prompt action [9]. Run-time governance manages available deployed services, and ensures that the deployed data services (and composite applications built to use those services) are operating effectively with sufficient performance, throughput and security [17, 20] to meet a federation's operational and tactical objectives. A good analogy is Windows registry, which is used to manage the list of installed programs and some of their configuration settings. Run-time governance not only manages access to deployed services, but also gathers and presents information about the performance and availability of those services, typically via integration with Web Services [15, 18]. Run-time governance has mostly been established for many of the available SOA-based data services in simulation federations by implementing Model-Based Data Engineering methods as described by Tolk in [21, 22, 23].

Due to an emerging need to develop new data services, design-time governance has become more necessary [24]. As data services are identified and new data services are developed, there is no control or management for the service development life cycle. Also, one of the driving ideas of web services is that they allow the composition of required functionality "on the fly" by loosely coupled services that provide the contributing capabilities. In order to be composable, design-time guidance is needed to allow the composition, which is a run-time challenge. Thus, there is a need to focus more on the design-time governance of data services for SOA-based data initialization of simulation and C2 federations.

2.5 Impacts of Ungoverned SOA-based Solutions

An ungoverned SOA can become a liability for the federation, adding cost and disrupting processes. The Gartner Group estimates that a lack of working governance mechanisms in mid- to large-size (greater than 50 services) SOA projects is the most common reason for project failure [20]. A key goal of a governance model is minimizing risk by defining a SOA strategy that builds governance into a federation.

Not developing a governance reference model or having a weak governance reference model for a SOA-based simulation federation will negatively affect development and horizontal integration. Effects from weak or missing SOA governance include [16, 17, 18]:

- *A lack of trust in data service offerings, causing consumers to not reuse services because of unpredictable quality and performance issues* – Governance reference models force different federates to interact to meet a common goal. Not having a SOA governance reference model would allow the federate to develop their own specific integrated architectures that do not support the larger federation. The federate-specific integrated architectures, over time, will create stove-piped (but net-centric) environments in which consumers build their own data services. Even though similar data services may be available within another federate or federation, they might not be used because of an impression that those data services could change and adversely affect the SOA.

- *A disruption in operations and processes from publishing data services that fail to assess the impact of a change* – Data services can be changed easily and it is possible for modified data services to disrupt the whole SOA. A set of processes and metrics needs to be in place to ensure that the risks to the SOA from evolving data services are mitigated. A tracking service, for example, can be modified to meet the needs of a subset of users, but adversely affect all of the dependent services because the data model was modified.
- *A lack of interoperability through the creation of data service stovepipes, which perpetuate the challenges of a traditional, tightly coupled architecture* – Data interoperability is required by governance committees to prevent stovepipes. SOA functionality would be adversely affected if ungoverned data services are published into the federation and programs begin developing to the data service. If a program wanted to migrate away, then additional development funds would be required when the data service interface could have been standardized in the beginning.
- *Non-compliance with regulations by failing to associate key policies with data services* – Data services can be developed without adhering to a set of mandates or policies. Not adhering to certain policies may require additional hardware or software by users to support special configurations, thereby raising license and sustainment costs for the project.
- *Security breaches through uncontrolled data service access* – The combined operational and tactical federation may require certain security policies or best-practices be met for specific data services due to classification requirements. In this case, there will not be a committee to ensure that the specific data services meet the standards required.

2.6 Information Agility, Interoperability, and Data Ownership

In the context of SOA governance, information agility is the ability to understand [14], control [17], and leverage the information assets [14, 18] of the organization (federation) in a useable and readily adaptable manner. Information agility tends to be the "redheaded stepchild" of the SOA strategy. This is unfortunate and needs to be corrected by SOA governance, because there is tremendous leverage in a well thought-out and implemented information strategy as part of the federation SOA strategy. It is well known within the DoD M&S community that application integration is a nontrivial problem to solve [25]. Applications have usually been developed without benefit of an enterprise data model. Many simulation and C2 systems come with their own data schema and an implied functional process, which the federation developers must either adapt to or engage in an expensive process of adapting to the current federation activity model [26]. Of course, this is a process that keeps on giving pain. Further adaptation is necessary whenever either a new release of a federate must be implemented or changes to the business operations cause enhancements to the data structure.

The usual solution for simulation and C2 integration has been point-to-point interface solutions. Such solutions, while operationally efficient, result in an ossification of the federation data model [25]. It is expensive and risky to change out one system for another or even make changes to an existing system because of the complex nature of the information and functional model. Changes to one system's interface can result in multiple changes and testing of all the myriad systems that must adapt to this change [26].

More generically, the following are regarded as typical problems that most federations must deal with [3, 25, 26]:

- A multitude of technologies and platforms support the simulation and C2 systems.
- Federation process models include a mixture of people practices, application code, and interactions between people and systems or systems of systems.
- Changes to one system tend to imply ripples of changes at many levels and to many other systems.
- No single, fully functional solution will "talk to" or work with all other functional solutions.
- Deployment of any single, proprietary integration solutions across the federation is complex, costly, and time-consuming.
- No single data, organization, or process reference model spans, much less extends beyond, the federation.

In run-time governance, Tolk and Diallo, describe Model-Based Data Engineering (MBDE) for web services in an SOA for better data management in support of semantic definition in information exchange [23]. MBDE provides some process management through a Common Reference Model (CRM) at run-time; which in the case for simulation federations can be the JC3IEDM [21, 22, 27], C2 Common Core, or Universal Data Core [28].

SOA stresses interoperability as one of its key principles [9]. Interoperability refers to the ability of services deployed using different technologies and platforms to communicate with each other [16]. SOA governance can help drive data initialization by demanding and directing this as part of the SOA journey. Data ownership is another key concern for SOA governance. Many different simulation federates will claim to be the primary user and therefore owner of a particular set of data [9, 17]. SOA design-time governance should seek to identify the owner of each major information area. This will become important in the future as hard decisions need to be made to rationalize this information and enable information agility. Lastly, it should be mentioned that SOA and SOA governance is a mechanism that supports cultural change in existing organization and social boundaries. SOA can provide optimal interoperability but it should not force boundaries to change in support of any specific implementation.

3. A Proposed Conceptual SOA Governance Reference Model

A reference model is an abstract representation of something that embodies the basic goal or idea of something and can then be looked at as a reference for various purposes [14]. It is necessary for a governance plan to have a reference model that is consistently applied to the entities to be governed. The idea of an SOA governance reference model was initially proposed by Norbert Bieberstein as an entity-relationship diagram [17]. He explains that the model has been successfully used in various governance consulting assignments.

Figure 2 below is a proposed variation of the diagram [17] that conceptually illustrates the components that make up a proposed governance reference model for data services in simulation federations. The conceptual governance reference model includes:

- Policies and Standards to enforce
- Processes and Procedures to implement
- Roles and Responsibilities to manage
- Metrics to monitor the data service lifecycle
- Behaviors to incentivize and sustain the process

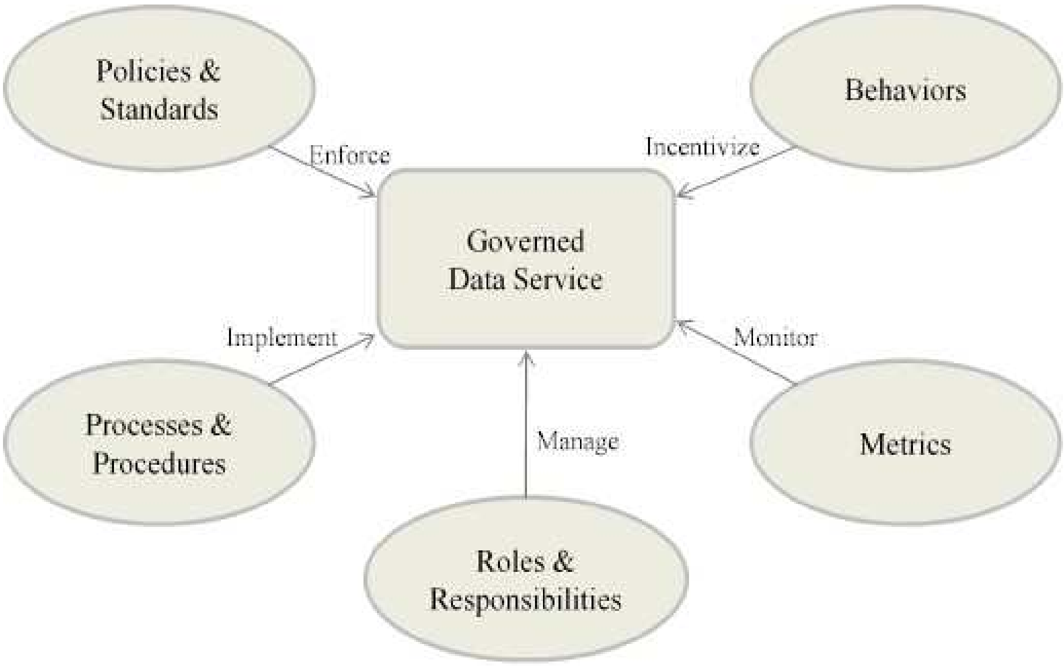

Figure 2. Conceptual Governance Reference Model for data initialization services in simulation federations

The details of the governance reference model need to be extended into a full model with further research. The following sub-sections begin to develop components of the model.

3.1 Policies & Standards

Federation policies are the cornerstone of governance. They are the set of goals by which one directs and measures success [15]. Policies need to be developed based on the federation impact to operations and the reliability required of the data services created. As data services are added and the SOA evolves, new policies need to be created and old policies need to be changed or retired.

Current policies should be collected and made available to service developers [17]. Policies from both the technology and operational and tactical areas defining governance best practices across the federation are required. Relevant areas include:

- Performance [17].
- Security [17].
- Government doctrine and mandates [18].
- Registration process details [20].

Policy management ensures that data service providers are adhering to current operational and tactical guidance documents. This list is not comprehensive but some of these guidance documents include:

- *Net-Centric Enterprise Solutions for Interoperability (NESI)* – NESI is a body of architectural and engineering knowledge that guides the design, implementation, maintenance, evolution, and use of the Information Technology (IT) portion of net-centric solutions for military application. NESI provides specific technical recommendations that an organization can use as references [4].
- *Department Of Defense Architecture Framework (DoDAF)* – The DODAF is a framework guide for developing architectures. All major U.S. Government Department of Defense (DoD) weapons and information technology system procurements must develop an architecture and document that architecture using the set of views prescribed in the DoDAF [4].

Standards are artifacts established by authority, custom, or general consent as a model or example. The governed service must adhere to the agreed standards. For example, current standards for simulation federation interoperability include:

- IEEE 1278 Distributed Interactive Simulation [29].
- IEEE 1516 High Level Architecture [30].

Also, emerging standards for information exchange and data initialization in simulation federations include:

- Joint Command, Control and Consultation Information Exchange Data Model (JC3IEDM) [11].
- Military Scenario Definition Language (MSDL) [31, 32].
- Battle Management Language (BML) [11, 33].

3.2 Processes & Procedures

Processes and procedures describing design, development, testing, implementation, deployment, and sustainment [15, 16] should be in place to ensure that data service implementations conform to the federation's policies.

Strict processes and procedures need to be developed for building and releasing data services that adhere to the agreed-upon policies [20]. Simulation federations need to have a committee with an overarching federation architect to oversee the efforts and reduce potential overlaps. This committee would collaborate with or have representatives from other committees to ensure consistency with other federations. In order to conform to tactical standards, close interaction with C2 entities is required. Figure 3 below illustrates an example how a data service could be submitted to the simulation federation for approval and funding for development. Approving the funding for a data service by a central authority is one important mechanism for ensuring consistency.

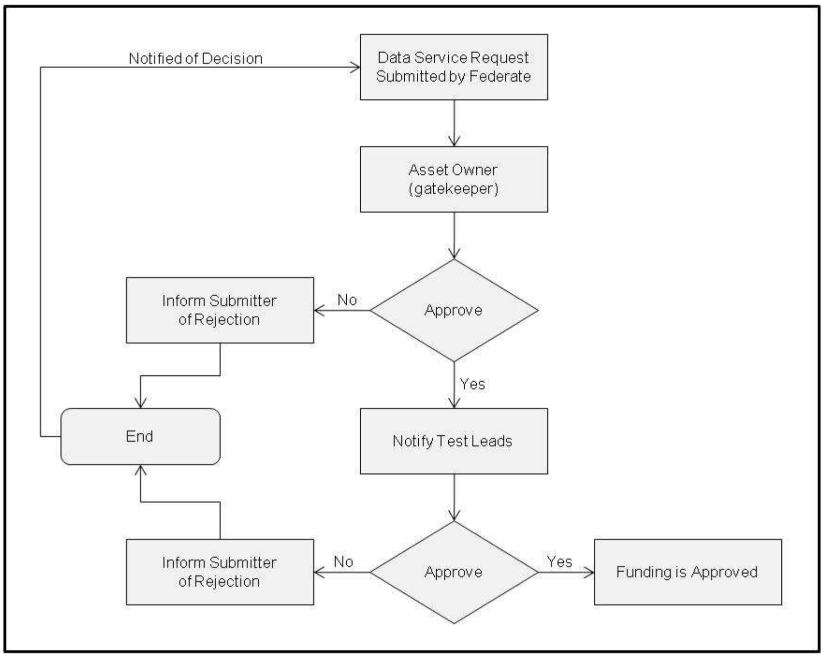

Figure 3. Approval to develop a data service for a simulation federation

Figure 4 describes an example of a high-level process for approving a data service for fielding. Committee approval guarantees data service compliance with the set of imposed standards within the SOA.

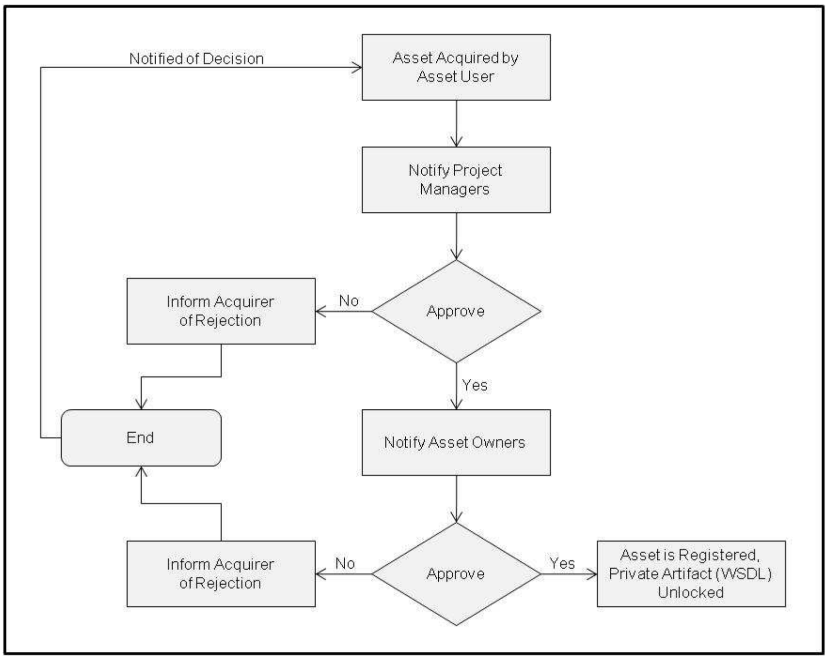

Figure 4. Approval to field a data service for a simulation federation

A process for granting waivers across federations also is required [9, 17]. Granting a waiver by one federation does not guarantee that the policy is supported by any of the other SOA-based simulation federations. Decisions on how and when to grant data service waivers can have a substantial impact when the waived data service is discovered and consumed by a data service from another federation with very different SOA requirements.

3.3 Roles and Responsibilities

The roles and responsibilities of federates within a SOA-based simulation federation need to be defined early. For example, the simulation and C2 communities need to agree about data service boundaries. When a decision cannot be agreed upon by the SOA governance committee, the federation architecture chair or co-chairs will have the responsibility of making the final decision.

A decision brief capturing the charters from relevant groups and committees should be created to help senior leadership identify the best location for a governance committee. Resolving potential operational and technical impacts to the mission is the responsibility of the governance committee. Verification [17] of current policies will have to be reviewed to ensure that current doctrine or mandates are followed among the different federates and federations. Doctrine and mandates can conflict between federations because of the mission.

3.4 Metrics

Metrics provide the technical basis for evaluating the effectiveness of the SOA and determining the order [14] data services should be built as it moves towards the architecture vision. Metrics give ways to prioritize data services and determine the largest return on investment (ROI) within a federation.
Metrics to consider for approving a data service to be developed include:

- Number of potential users leveraging the data service [17, 18].
- Estimated number of users [17, 18].
- Expected average service usage per mission type [20].
- Data service scope [17, 18].
- Underlying operating costs (e.g., sustainment) [15, 17, 20].
- Operational requirement and recommended priority [14, 15].
- Assessed net value of each data service to all consumers [14].

Some additional evaluation criteria include:

- Identification and concurrence of members involved in Service Level Agreements (SLA) for the data service [15].
- Information flows of the existing and future architecture [18].

Although this discussion has revolved around keeping track of the ROI for achieving the SOA vision, some metrics should be used to continually review the effectiveness of the SOA governance. Some examples include:

- Turn-around time for data service submission and deployment [14].
- Number of waivers issued by the committee [14].
- Feedback ratings from data service providers [16].

Auditing and conformance are required for a successful SOA [20]. The design of data services to conform to federation policies should be facilitated with an automated system that provides easy methods to capture requirements, recommendations, and best practices.

The committee needs to define a maturity model [17] to assess the current state of data services and the desired or future states of each involved federation. A maturity model will help to:

- *Assist a federation in determining its architectural strategy when adopting data services to improve flexibility, integration, and reuse* – A list that defines a set of required technologies, mandates, and specifications is needed to determine the level of data service compliance for interoperability. Independent design and architecture reviews should be conducted for key applications and infrastructures.
- *Determine scope, focus, and incremental steps towards realization of the architectural roadmap* – Mapping data services to certain sets of capabilities or requirements helps identify development priorities and helps define the SOA hierarchy of data services.

Tolk et al. describe the Levels of Conceptual Interoperability Model (LCIM) as a layered approach and solution to the challenges of service interoperability among heterogeneous systems [23]. Evaluations based upon the maturity model provide a framework for identifying improvements [34]. The areas of improvement can then be fed back to the SOA governance committee from the data service developers.

3.5 Behaviors

Behavior is important to a governance reference model [14, 17, 18]. Supporting a set of distributed data services requires an increased level of social interaction between the different SOA federation members.

Federates are rewarded on how well they meet cost, schedule, and performance as opposed to how well the program completes a certain capability or how much closer the federation is towards attaining the architectural vision. This paper does not intend to convey that cost, schedule, and performance should be ignored, but instead suggests that additional evaluation criteria be added to help facilitate discussion and interaction. Federates are dependent upon funds to continue; therefore, setting certain incentives, penalties, and rewards for successful "SOA Behavior" would be a possible first step toward achieving optimal simulation and tactical interoperability. Withholding a certain percentage of funding from each federate until a minimum level of SOA behavior is met would be an example.

4. Current Related Effort

This section briefly describes related work in data initialization for simulation and C2 federations. While most work done in this domain is focused on standards development, there is a movement to develop data services (using standards) for SOA-based initialization of federations. As such, this section summarizes the general application and implementation of the topics which provide motivation for establishing governance.

4.1 Objective Initialization Capability

The Objective Initialization Capability (OIC) is a web-based enterprise environment, compatible with the Army Knowledge Online (AKO) Single Sign On initiative to build Web/GIG enabled data products. It uses a SOA, an Army enterprise service bus, and a master initialization capability repository. A series of spirals will be conducted by the Army's Product Manager for Network Operations in 2008 and 2009 to develop the foundation of the OIC SOA framework which can be modified as network systems change, and expanded to initialize other than network systems [3].

4.2 Joint Event Data Initialization Services

The Joint Event Data Initialization Services (JEDIS) project was sponsored by Joint Rapid Scenario Generation (JRSG), and developed by the Virginia Modeling and Simulation Center, and Gestalt LLC. JEDIS provides a common interchange model for four data initialization systems to integrate data from a common repository based on the JC3IEDM [11]. JEDIS provides a set of web services that allow access to integrated joint event data sets for use in select federations. Also, JEDIS provides a SOA-based implementation of data initialization services for simulation and C2 federations. JEDIS became part of the Joint Training Data Services (JTDS) and was used to set up a portal solution in support of U.S. Joint Forces Command exercises providing unit-of-order initialization data to the participating system **[11]**. Run-time governance is established in JEDIS based on MBDE methods [21, 22], JC3IEDM common reference model, and ISO/IEC 1179 standard. However, design-time governance will need to be established upon creating additional data services that will interoperate with JEDIS in a federation [11].

4.3 Military Scenario Definition Language

The Military Scenario Definition Language (MSDL) intends to serve the international command and control and simulation domains with data representation and file transmittal format standards to define military scenario information that can be populated by MSDL-compliant scenario planning tools, including command and control planning applications, and read by MSDL-compliant live, virtual, and constructive simulations [31, 32, 35], including DIS [29] or HLA-based federations [30]. MSDL is now a standard, andcan be downloaded from the Simulation Interoperability Standards Organization product website [32].

4.4 Battle Management Language

The Battle Management Language (BML) enables direct communications between BC systems and simulations [33]. BML's goal is to enable automatic and rapid unambiguous tasking and reporting between C2 and M&S systems [11]. The emergence of these two new standards, MSDL for simulation initialization [31, 32] and BML for battle command and simulation initialization [11], both using JC3IEDM data exchange, provides an opportunity for the initialization community to move towards standardized initialization formats for battle command and simulations. These standards provide run-time governance, but need to be identified and established in design-time governance when developing or composing new data services in a SOA-based simulation and C2 federation.

4.5 Semantic Web Services

The mainstream XML standards for interoperation of web services specify only syntactic interoperability, not the semantic meaning of messages. For example, the Web Services Description Language (WSDL) can specify the operations available through a web service and the structure of data sent and received but cannot specify semantic meaning of the data or semantic constraints on the data. This requires programmers to reach specific agreements on the interaction of web services and makes automatic web service composition difficult. Semantic web services are built around universal standards for the interchange of semantic data [36], which makes it easy for programmers to combine data from different sources and services without losing meaning. Web services can be activated "behind the scenes" when a web browser makes a request to a web server, which then uses various web services to construct a more sophisticated reply than it would have been able to do on its own. Semantic web services can also be used by automatic programs that run without any connection to a web browser [36].

4.6 Non Defense SOA Governance Communities

While formal governance is immature in SOA-based data initialization of military simulation and C2 federations, there are many examples of non-defense related research and products that promote and implement rigorous SOA governance techniques. Organizations such as IBM [15], Hewlett Packard [37], Oracle [38], AgilePath [39], LogicLibrary [40], Gartner [20], and ZapThink [41] are just a few that offer well-defined SOA governance reference products and frameworks. Although many of the aforementioned organizations are commercial and provide mainly proprietary solutions, there are open-source organizations that offer resources. OASIS defined a generic SOA governance reference model that can be customized to fit any organization's needs [14]. Furthermore, WS02 [42] offers a fully open-source SOA platform with governance infrastructure that can be downloaded and configured to specification. Thus, there are many documented case studies whereby best practices can be extracted and applied to a governance reference model for data initialization services in a SOA-based simulation and C2 federation.

5. Summary and Future Work

SOA-based solutions for data initialization in simulation and C2 federations are the new strategy for joint data services development and reuse [3, 26, 43, 44, 45]. However, implementation of an SOA would require creating a governance reference model from the ground up, incorporating the best practices of current solutions described earlier, that would have the ability to meet the goals and constraints of the various federations. The governance reference model would provide a generic, common platform to support data initialization of federation simulations and command and control systems. Specifically, a governance reference model will potentially:

- provide a common reference to promote data services that initialize common data products from various authoritative data sources,
- support reusable policies, standards, and processes across varying simulations and inter-service domains,
- provide greater common data consistency, verification, validation, and re-use,
- allow sharing of common data assets,

- provide easier common data migration & change management, and
- provide improved definition of policies and agreements for common data assets across the federation.

A governance reference model in developing SOA-based data initialization services for joint military federation simulation and C2 systems would address many of the weaknesses to previous SOA-based strategies. It has the potential to allow full interoperability of common initialization data and tools across a federation. While there would be an initial implementation cost, the reference model would have a low lifetime cost because of the savings gained from faster data service development, faster initialization of common data and interoperability, and reusable policies, services, processes, and policies. Because the governance reference model will have been created to address common data services for joint military training objectives, it could be used as a framework across all DoD organizations and their respective simulation systems. This could be done without the re-engineering effort currently required to initialize common data from one military service to the other. Furthermore, a governance reference model will further allow SOA-based solutions to satisfy the DoD requirement for systems to meet the Net-centric Enterprise Service objective [4].

This paper presents an overview of the current research in SOA-based data initialization for simulation and C2 federations, and best practices in SOA governance. As such, a conceptual governance reference model was proposed that integrates governance best practices and SOA-based data service development. Further research is needed to fully extend the conceptual governance reference model, and integrate design-time and run-time governance for an SOA-based military simulation and C2 federation-specific domain.

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