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Leveraging SOA for Distributed Test and Evaluation: ''To SOA or Not to SOA, That Is the Question''

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Can Service-Oriented Architecture (SOA) support distributed Test and Evaluation (T&E)? When will SOAs be suitable to support distributed testing data management requirements? What are the benefits of modernizing instrumentation to use an SOA for testing? Can SOAs improve reliability and composability of distributed T&E capabilities? These are just some of the questions that are being addressed in an ongoing Office of the Secretary of Defense distributed test infrastructure assessment that includes a study called "Applicability of Service-Oriented Architecture (SOA) to Distributed Testing Infrastructure." This article will give an overview of this quantitative/qualitative study and the Community of Interest being formed to support the study. In addition, the article will describe how the Netcentric Systems Test (NST) reference architecture developed under the T&E/Science & Technology NST focus area sponsored by the Test Resource Management Center is being used as a collaboration point to determine which T&E mission processes to consider in developing a use case for the study.

Key words: Community of interest; DoD architectural framework; Global Information Grid; netcentric systems test; netcentric web services; service-oriented architecture.

Testing of netcentric warfare systems requires bringing together a netcentric system under development with all of the interfacing systems in a scenario that represents the mission for the netcentric systems under test. Since the interfacing systems or their representations as hardware and software in the loop emulations are rarely located or available at a single location, a distributed network is required to link together all of the mission platforms at disparate locations together with the test management and evaluation tools. Further, newer netcentric systems are being developed using Community of Interest (COI)–defined warfare services in a service-oriented environment to take advantage of the agility and flexibility demonstrated in commercial Service-Oriented Architecture (SOA) environments. SOA introduces some new testing requirements and challenges that must be addressed.

It is into this environment that SOA might also be applied to facilitate development of common distributed T&E service applications for distributed test events.

Service-orientation describes an architecture that uses loosely coupled services to support the requirements of mission processes and users. Resources on a network in a SOA environment are made available as independent services that can be accessed without knowledge of their underlying platform implementation. These concepts can be applied to military missions, business processes, software, and other types of producer/consumer systems such as testing.

SOA applies to distributed applications and facilitates agility and flexibility by emphasizing *composability*—the ability to combine and recombine individual service applications in different configurations as long as service interfaces are satisfied. SOA uses coordina-

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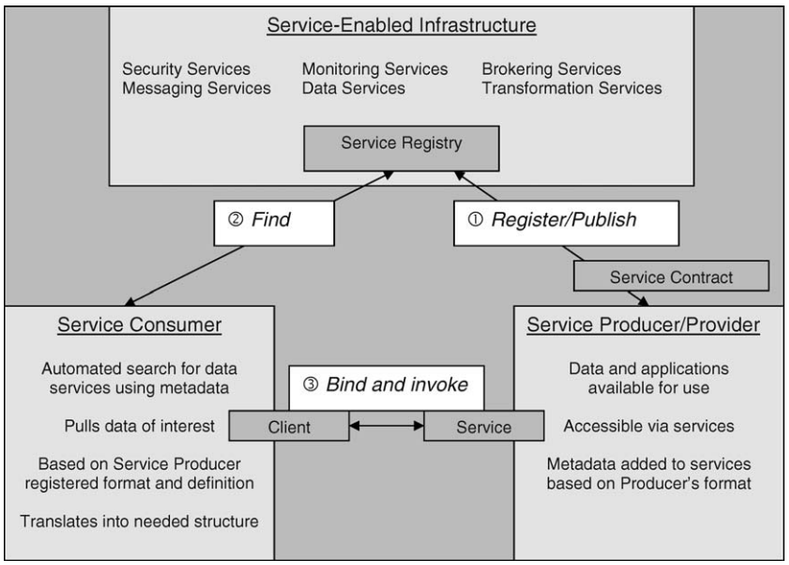

Figure 1. SOA service registration and binding

tion and orchestration services to combine fundamental services into mission activities, transactions, and processes.

The Department of Defense (DoD) Architectural Framework (DoDAF) v1.5 used to define the capability and structure of warfighting systems embraces the IEEE 1003.0 definition of service, *"a distinct part of the functionality that is provided by a system on one side of an interface to a system on the other side of an interface."* The DoDAF extends this definition to include those interfaces that allow execution of a business or mission process, or that exchange information among machines and humans using standard interfaces and specifications without regard for the underlying implementation. Note that while the netcentric guidance provided in DoDAF v1.5 focuses on Web-based services, much of the guidance is applicable to any form of electronic information processing or access service. Services (resources) may be registered by service providers within a registry of registers (itself a service) and made available to a COI with the right access privileges on a distributed network.

Armed with this interface information, clients can bind to service providers to utilize the resources. Across the SOA architecture, enterprise-wide services for registry, binding, access, instrumentation, messaging, security, and so forth can be specified by the architecture. These enterprise-wide services form the backbone upon which the services are built and accessed.

SOA is not a replacement for other software development architectures. Rather, its focus is on defining higher level mission or business process reusable and composable services that are platform and domain independent. Underlying code may be legacy applications or developed using usual methods as long as the SOA design principles and interfaces are met. *Figure 1* illustrates an early simplified SOA registry model demonstrating the potential interactions between a client (Service Consumer) accessing a particular service and the Service Provider offering that service.

In the diagram, step (1) shows the Service Provider registering or publishing the service/resource interface information and making it available for consumption with the Service Registry using a Registration Service. Already included in the registry are examples of Netcentric Core Enterprise Service offered by the Defense Information Systems Agency (DISA) Netcentric Enterprise Services (NCES). The Service Registry holds this information so that a Service Consumer may consult the Service Registry using defined interfaces (and protocols) to enumerate and obtain access to some service resource from the Service Provider. This is shown in the diagram as the (2) Discovery/Find Service. At this stage, it is possible the Service Consumer may not even know the specific Service Provider with which it will ultimately connect. After obtaining the necessary information describing the resource it is attempting to gain access to, the Service Consumer will then (3) bind and invoke the resource by contacting and negotiating access to the Service Interface offered by the Service Provider as specified by the Service Registry.

In practice, many commercial services and applications never used the registry. The registry provides

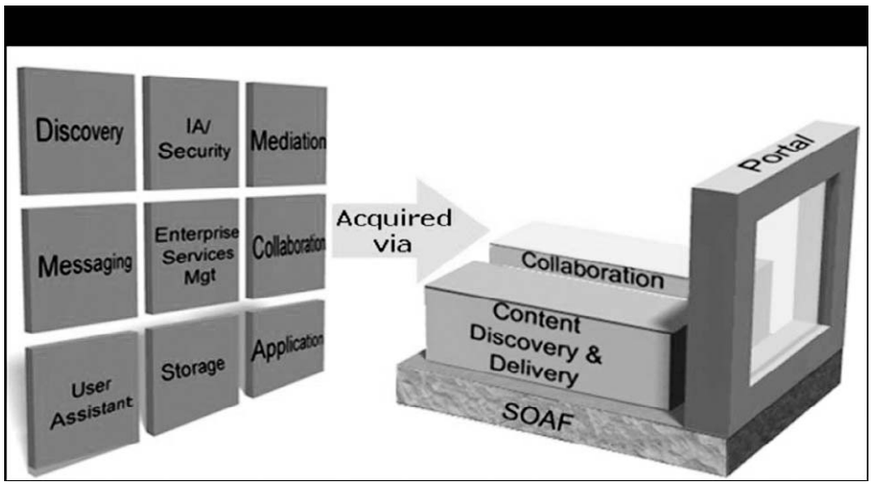

Figure 2. Netcentric Enterprise Services

additional agility and flexibility. A service requestor and/or service endpoint may be a human operator or a human-assisted service. A human reviewer or approval authority may also be an intermediate service. Coordination or Orchestration services may use the registers to compose complex activities using many services in serial and/or parallel processes.

A fundamental aspect of SOA operation is the ability of Service Providers to connect with Service Consumers in possibly unanticipated ways without coordination prior to the Service Consumer's binding and invocation. This is made possible by services designed to be stateless and composable with well-defined interfaces so that the Registration Service and Discovery Service can flexibly locate and bind consumer and provider services as needed to complete a mission activity. The discovery services may also be accessed through a human interface portal as well.

The registry model may imply a simple request response Message Exchange Pattern; however contemporary SOAs support multiple Message Exchange Patterns, defined in evolving standards such as "fire and forget" and "publish and subscribe" that are also supported by the DISA NCES.

Clearly, though not always acknowledged in the literature, there is a potential performance penalty with registry access and with data conversions with loose coupling. SOA may be limited in hard real-time environments and may not be appropriate for every application.

SOA is the principle distributed architectural pattern used by the Global Information Grid (GIG) to support netcentric warfare and facilitates the secure and controlled sharing of data and services among warfighter applications over distributed networks. The DoD is relying on NCES to provision the GIG with SOA capabilities called Core Enterprise Services. NCES is composed of nine services grouped into four product lines (*Figure 2*).

In response to a Joint Capabilities Board Preliminary Review of Assessment (July 2007), the Joint Training Functional Capabilities Board, in coordination with service advisory members of the T&E community, recommended a Joint Distributed Test Infrastructure Capabilities Based Assessment (CBA) (Joint Requirements Oversight Council Memorandum 279-07, 10 Dec 2007) that focused on three potential gaps:

- Service Transition to Internet Protocol version 6;
- Applicability of Service-Oriented Architectures (SOA) to Distributed Testing Infrastructure;
- Transition to Distributed Testing using the Global Information Grid.

Responsibility for this CBA was then transferred to the Network-Centric Functional Capabilities Board (NC FCB), and the assessment is to be directed by the Office of the Secretary of Defense Test Resource Management Center (TRMC). This article will focus on the second component study of this CBA, the Applicability of Service-Oriented Architectures in Distributed Testing, which was initiated in March 2008.

Study objective

The primary objective of the "Applicability of Service-Oriented Architectures (SOA) to Distributed Testing Infrastructure" study is to determine what testing activities of netcentric systems test (NST), particularly distributed tests, can be beneficially and economically developed as reusable and composable test services and which activities would not be beneficially developed as SOA services.

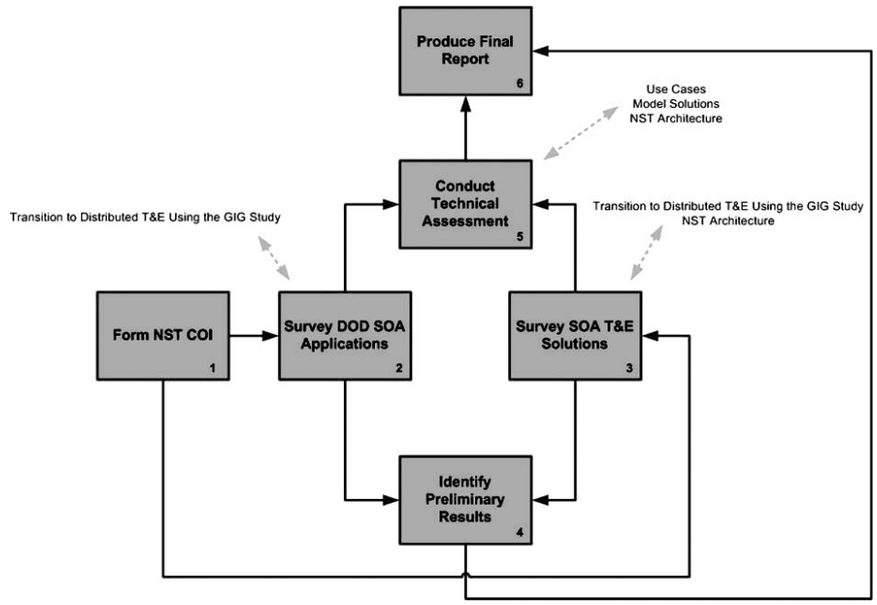

Figure 3. Study task relationships. Each box represents a large task described in this section, the small numbers in each box demonstrate rough sequencing of task execution, and the arrows demonstrate data relationships within internal (solid lines) tasks and external (dash lines) entities.

Study approach/methodology

In the context of the "testing and evaluation business process" for a distributed mission thread test, the study will identify potential SOA-based test tools in the areas of test control, synthetic battlespace environment, data analysis, and collection. It will survey commercial, joint services, and agency ongoing SOA activities; perform a technical assessment of these efforts; and then report on these findings. During the period of the study, preliminary and ongoing status will be briefed to relevant user groups (e.g., Joint Mission Environment Test Capability [JMETC] Users Group, Air Force SOA Symposium). *Figure 3* shows the work breakdown demonstrating task interrelationships and sequencing.

Form NST COI task

A COI representing distributed Netcentric System T&E will be formed and called the NST COI. This COI will collaborate across three portals: (a) Defense Architecture Repository System (DARS) https://dars1.army.mil, (b) Defense Knowledge Online (DKO) https://www.us.army.mil, and (c) TRMC www.trmc-test.org. The NST reference architecture developed as part of the NST Architecture and Technology Insertion Environment (NSTATIE) will be uploaded to both DARS and DKO for reference by the COI. The NSTATIE project will be described in more detail below. The COI will use the architecture to form research teams for evaluation of architecture operational activities (functions) for potential implementation as distributed T&E Services. They will also initially establish the potential benefits or problems of adopting or developing distributed services to implement each of the architecture functions.

The COI will leverage TRMC's new portal area called the Distributed Test Infrastructure Assessment collaborative environment to track status, act on items, and communicate information, including meeting information. Accounts may be established with all three portals to be formally part of the COI. However, one does not need to be a formal COI member to review documents, except on the DARS. For DARS, you must register for the netcentric system test area when requesting an account, located under the DoD portion of the directory. The netcentric system test COI already exists on the DARS. Once registered, you can request to join the COI in order to have access to the information published. For DKO, register at the site and then send an e-mail to Gil Torres (gilbert.a.torres@navy.mil) with your login ID to request access to the reference architecture. When registering for the TRMC portal, indicate that the project you support is the "Joint Distributed Test Infrastructure Capabilities Based Assessment project."

The COI is divided into the Core COI and extended COI membership. The Core COI and extended COI membership will be identified, and invitations for representatives from government and industry will be sent to form these teams. It is anticipated that periodic telecons will occur during the duration of the study, which is projected to end May 2009. These telecons, when required, may include the Joint Distributed Test Infrastructure CBA other two study tasks.

Throughout the study, the COI will brief key user communities on a regular basis, including each JMETC Users Group held during the duration of the study and the planned SOA/GIG Summit.

Survey current SOA applications task

The study will survey current ongoing SOA solutions sponsored by any of the DoD services or agencies that will need testing in a netcentric, distributed test environment. The survey questionnaire will be constructed to facilitate the collection of data from service and agency representatives of any SOA test tool efforts. The survey results will summarize any issues identified by DoD services and agencies regarding the use of SOA for T&E. Based on the survey and NST reference architecture, a use case will be defined for further investigation. This use case will identify potential SOA-based test services. The use case will also represent a joint mission thread test and identify potential areas where SOA-based tools might be applicable.

Survey current SOA T&E solutions task

The study will survey DoD test organizations to identify any service or agency T&E functions being developed as T&E services. Additionally, commercial vendors will be surveyed to identify any commercial T&E services that might be used.

These test services candidates will be initially identified using the NSTATIE architecture, and existing solutions will be compared to the candidate service requirements. The use case will be refined in this task, and qualitative measures will be determined to define testing in the NSTATIE Technology Insertion Environment laboratory.

Identify preliminary results task

This task is divided into three efforts: define initial evaluation criteria, conduct technical assessment, and produce draft report of preliminary results. Preliminary results for each area of research will be drafted into an agreed-upon format and presented to the COI. Publicly, these preliminary results may be presented to an interested external party such as the other GIG study. These preliminary results will be generated via ongoing technical research. The areas for research are initially identified with aid of the NST reference architecture and use case. The research will identify criteria for technical and performance evaluation of identified potential SOA services.

Conduct technical assessment task

After the preliminary survey results have been determined, a detailed technical assessment will be performed by each sub-working group defined in the study to identify and produce technical/performance measures for each area of research.

More specifically, this task is divided into five efforts: (a) model use case, (b) select candidate T&E SOA solutions, (c) define qualitative evaluation criteria and measures of effectiveness and measures of performance for prototype SOA solution experiments, (d) qualitatively evaluate the feasibility and effectiveness of the T&E services applied to the use case, and (e) conduct experiments of critical areas of the use case using available SOA services and prototyped applications. This activity is currently being finalized. The following are some of the metrics being considered:

- *Service time*: response time for synchronous services and delivery time for asynchronous services.
- *Scalability*: examples are user load and number of requests per second.
- *Availability*: includes planned maintenance and unplanned down time.
- *Reliability*: due to defects, rejected requests, message loss, etc (Lau, 2007).

To support this effort, the mission thread use case will be refined to identify candidate high-level T&E mission services to be evaluated for feasibility and benefit as SOA services that implement reference architecture operational activies. Using these inputs, candidate T&E services are identified from the survey for adoption or as candidates at a lower level for future implementation by the NST or Central Test and Evaluation Investment Program (CTEIP) projects. Some T&E services identified will be selected for prototype and experimentation in the Technology Insertion Environment laboratory during the study to collect quantitative results of the performance of these SOA-based services. These results will be compiled and presented to the COI in a draft report.

Produce final report task

Within two months of the preliminary report being presented to the COI, the final report will be generated. The final report will contain data and findings from the SOA experiments conducted. The final report and presentation will be vetted with the COI and service subject matter experts, then delivered to TRMC for further distribution across DoD via coordination with the senior advisory group.

NSTATIE project overview

The NSTATIE T&E/S&T NST Focus Area project depicted in *Figure 4* has two components that will be utilized in this study: NST reference architecture for use case development and qualitative parts of

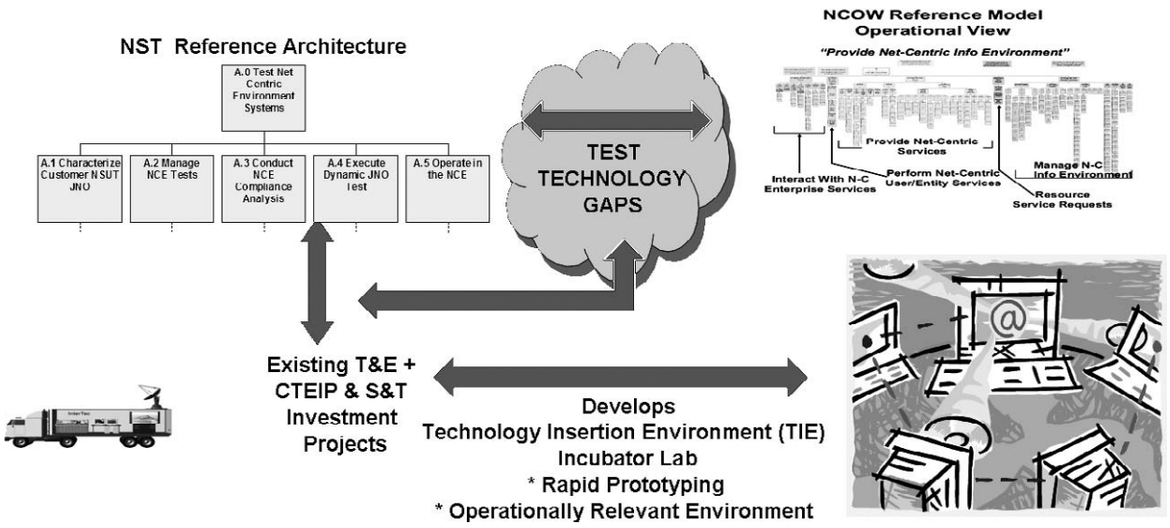

Figure 4. NST Architecture and Technology Insertion Environment (NSTATIE)

the study, and technology insertion environment for the quantitative parts of the study. The NSTATIE project is addressing technologies needed to define an NST architecture that stays lockstepped with the evolving Joint Netcentric Operations architecture. The prototype capability to accurately depict and organize NST technology gaps for current network-centric warfare systems and emerging Net-Centric Operations Warfare reference model compliant systems is being applied within the NST focus area for NST projects. The NSTATIE project is researching and developing the capability for NST S&T projects to perform R&D in a higher-fidelity and more relevant environment. The end product will be a prototype of a system available to all S&T projects to utilize as they mature through Technology Readiness Levels 5 and 6. In essence, this project becomes a technology sandbox and incubator for all T&E/S&T projects as they mature.

Current study accomplishments and status

The study team initiated the formation of the COI and solicited inputs on how to structure the study. Based on those inputs, a draft version of the Terms of Reference that describes how the study will be conducted was generated, released, and is currently under review. The Terms of Reference were presented at the first COI meeting held at the JMETC Users Group Conference held in May 2008. There was an entire track at the conference dedicated to SOA and test infrastructure. The JMETC track met in Charleston, South Carolina, with strong participation from industry, military service T&E, NASA, and DoD agencies. The presentation from this track can be found at www.trmc-test.org.

The study makes use of recent NST focus project outputs, in particular an NST reference architecture and Technology Insertion lab. In addition, the NST reference architecture was briefed at the SOA and Test Infrastructure JMETC Users Group track. Based on inputs from that meeting, the architecture was refined and then the first version was uploaded onto DARS. A survey was generated specifically to query all 18 of the T&E/S&T NST focus areas projects to determine in what ways, if any, they use SOA in the development of the technology for their project. The study team is currently compiling a report to summarize the results of the survey.

Summary

The "Applicability of Service-oriented Architecture (SOA) to Distributed Testing Infrastructure" study is under way and will involve both qualitative and quantitative measures. The COI is now requesting additional participation for the review and comment of the products produced by the core study group and COI. In general, acceptance by the larger netcentric test community is key to the success of the study, especially during the qualitative aspects of the study. The NST reference architecture will be used as a guide with the use case developed to identify candidate T&E services and as a collaboration point for discussions. The NST technology insertion environment will be used during the quantitative phase of the study to make actual measurements on current SOA technology as

part of the technical assessment. Again, the goal of the study is to determine if SOA can improve the distributed testing infrastructure so that more thoroughly tested and timely capabilities are put in the hands of the warfighter. ❑

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