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Streamlining the Process of Acquiring Secure Open Architecture Software Systems

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14. ABSTRACT

We present results from our ongoing investigation of how best to acquire secure open architecture (OA) software systems. These systems incorporate software product line (SPL) practices that include closed source proprietary software and open source software (OSS) components, where such components and overall system configurations are subject to different security requirements. The combination of SPLs and OSS components within secure OA systems represents a significant opportunity for reducing the acquisition costs of software-intensive systems. We seek to make this a simpler, more transparent, and more tractable process. Such a process must be easy to reuse, adapt, and streamline for different system application domains in order to realize cost reductions and improve acquisition workforce capabilities. Further, such a process should be aligned with Better Buying Power initiatives addressing OA systems, improved competition, defense affordability, and acquisition workforce improvements. We identify different ways and means for how to streamline the acquisition process for secure OA software systems through a focus on doing more with limited resources. Along the way, we pay particular attention to revealing how software licensing practices can affect cost in ways that hamper or better the buying power of acquisition programs.

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Preface & Acknowledgements

Welcome to our Tenth Annual Acquisition Research Symposium! We regret that this year it will be a "paper only" event. The double whammy of sequestration and a continuing resolution, with the attendant restrictions on travel and conferences, created too much uncertainty to properly stage the event. We will miss the dialogue with our acquisition colleagues and the opportunity for all our researchers to present their work. However, we intend to simulate the symposium as best we can, and these *Proceedings* present an opportunity for the papers to be published just as if they had been delivered. In any case, we will have a rich store of papers to draw from for next year's event scheduled for May 14–15, 2014!

Despite these temporary setbacks, our Acquisition Research Program (ARP) here at the Naval Postgraduate School (NPS) continues at a normal pace. Since the ARP's founding in 2003, over 1,200 original research reports have been added to the acquisition body of knowledge. We continue to add to that library, located online at www.acquisitionresearch.net, at a rate of roughly 140 reports per year. This activity has engaged researchers at over 70 universities and other institutions, greatly enhancing the diversity of thought brought to bear on the business activities of the DoD.

We generate this level of activity in three ways. First, we solicit research topics from academia and other institutions through an annual Broad Agency Announcement, sponsored by the USD(AT&L). Second, we issue an annual internal call for proposals to seek NPS faculty research supporting the interests of our program sponsors. Finally, we serve as a "broker" to market specific research topics identified by our sponsors to NPS graduate students. This three-pronged approach provides for a rich and broad diversity of scholarly rigor mixed with a good blend of practitioner experience in the field of acquisition. We are grateful to those of you who have contributed to our research program in the past and encourage your future participation.

Unfortunately, what will be missing this year is the active participation and networking that has been the hallmark of previous symposia. By purposely limiting attendance to 350 people, we encourage just that. This forum remains unique in its effort to bring scholars and practitioners together around acquisition research that is both relevant in application and rigorous in method. It provides the opportunity to interact with many top DoD acquisition officials and acquisition researchers. We encourage dialogue both in the formal panel sessions and in the many opportunities we make available at meals, breaks, and the day-ending socials. Many of our researchers use these occasions to establish new teaming arrangements for future research work. Despite the fact that we will not be gathered together to reap the above-listed benefits, the ARP will endeavor to stimulate this dialogue through various means throughout the year as we interact with our researchers and DoD officials.

Affordability remains a major focus in the DoD acquisition world and will no doubt get even more attention as the sequestration outcomes unfold. It is a central tenet of the DoD's Better Buying Power initiatives, which continue to evolve as the DoD finds which of them work and which do not. This suggests that research with a focus on affordability will be of great interest to the DoD leadership in the year to come. Whether you're a practitioner or scholar, we invite you to participate in that research.

We gratefully acknowledge the ongoing support and leadership of our sponsors, whose foresight and vision have assured the continuing success of the ARP:

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Streamlining the Process of Acquiring Secure Open Architecture Software Systems

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Streamlining the Process of Acquiring Secure Open Architecture Software Systems

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Abstract

We present results from our ongoing investigation of how best to acquire secure open architecture (OA) software systems. These systems incorporate software product line (SPL) practices that include closed source proprietary software and open source software (OSS) components, where such components and overall system configurations are subject to different security requirements. The combination of SPLs and OSS components within secure OA systems represents a significant opportunity for reducing the acquisition costs of software-intensive systems. We seek to make this a simpler, more transparent, and more tractable process. Such a process must be easy to reuse, adapt, and streamline for different system application domains in order to realize cost reductions and improve acquisition workforce capabilities. Further, such a process should be aligned with Better Buying Power initiatives addressing OA systems, improved competition, defense affordability, and acquisition workforce improvements. We identify different ways and means for how to streamline the acquisition process for secure OA software systems through a focus on doing more with limited resources. Along the way, we pay particular attention to revealing how software licensing practices can affect cost in ways that hamper or better the buying power of acquisition programs.

Introduction

Our focus in this effort is to identify ways and means for streamlining the acquisition process for secure open architecture (OA) systems. These OA systems often rely on the integration of components that are independently developed by different software producers and made available as either open source software (OSS) or proprietary closed source software executables. Program managers, acquisition officers, and contract managers will increasingly be called on to review and approve security measures employed during the design, implementation, and deployment of OA systems (Department of Defense [DoD] Open System Architecture [OSA], 2011). Our effort builds on both our prior acquisition research (e.g., Scacchi & Alspaugh, 2008, 2011, 2012a) and related acquisition research efforts at the Program Executive Office (PEO) Integrated Warfare Systems (IWS; Guertin & Clements, 2010; Guertin & Womble, 2012; Womble, Schmidt, Arendt, & Fain, 2011), the Department of the Navy (Mactal & Spruill, 2012), and the Software Engineering Institute (SEI) that address software product lines (SPLs; Bergey & Jones, 2010; Jones & Bergey, 2011; Northrop & Clements, 2007). It is also influenced by related research in the DoD community addressing OSS (Defense Information Systems Agency [DISA], 2012; Hissam,

Weinstock, & Bass, 2010; Kenyon, 2012; Martin & Lippold, 2011], component-based software ecosystems (Scacchi & Alspaugh, 2012b; Reed, Benito, Collens, & Stein, 2012), and Better Buying Power (BBP) initiatives (Defense Acquisition University [DAU], 2012).

OSS represents an integrated web of people, processes, and organizations, including project teams operating as virtual organizations (Scacchi, 2007, 2009, 2010). There is a basic need to understand how to identify an optimal mix of OSS within OA systems as products, production processes, practices, community activities, and multi-project (or multi-organization) software ecosystems. However, the relationship among OA, OSS, security requirements, and acquisition is poorly understood [cf. Scacchi, 2009, 2010; Scacchi & Alspaugh, 2011, 2012b; Naegle & Petross, 2007]. Subsequently, from 2007–2008, we began by examining how different OSS licenses can encumber software systems with OA, which therefore give rise to new requirements for how best to acquire software-intensive systems with OA and OSS elements (Scacchi & Alspaugh, 2008).

As a result of our recent acquisition research efforts, we have been able to demonstrate that it is both possible and feasible to develop OA systems that incorporate best-of-breed software components, whether proprietary or OSS, in ways that can reduce the initial and sustaining acquisition costs of such systems.

We believe that such results are applicable to both enterprise information systems, which are widespread throughout the DoD and the U.S. government, as well as command and control (C2; e.g., Reed et al., 2012; Scacchi, Brown, & Nies, 2012; Scacchi & Alspaugh, 2013b) and other defense systems. Doing so, however, requires new guidance, and ideally automated tools, for explicitly modeling and analyzing the architecture of an OA system during its development and evolution, along with modeling and annotating the architecture with software component license rights and obligations. Our results thus demonstrate a major technological advance in the acquisition and development of OA systems, as a breakthrough in simplifying software license analyses throughout the contracting activities. Creating similar advances for streamlining the acquisition process, while reducing the costs of secure OA systems, is the next breakthrough that is needed.

In this paper, we describe ways and means for how to articulate, tailor, and streamline the process for how to simply and transparently specify and assess OA system security when acquiring different kinds of OA systems, and to do so in ways that highlight opportunities for cost reduction through system security requirements specification and OA system acquisition process streamlining. We provide examples of complex software elements that are applicable to many kinds of software-intensive systems within the DoD as well as within other government agencies and industrial firms. But we start in the next section by reiterating BBP principles and initiatives that guide this research by focusing on how to promote competition in the acquisition and development of secure OA systems.

Open Architecture and Better Buying Power

BBP (see http://bbp.dau.mil/) is part of the DoD's mandate to do more without more by implementing best practices in acquisition. BBP identifies seven areas of focus that group a larger set of 36 initiatives that offer the potential to restore affordability in defense procurement and improve defense industry productivity. One of the seven areas focuses on promoting competition, and this area includes an initiative to "enforce open system architectures and effectively manage technical data rights" (DAU, 2012). Technical data rights pertain to two categories of intellectual property (IP): they refer to the government's rights to (a) technical data (TD; e.g., product design data, computer databases, computer software documentation) and (b) computer software (CS; e.g., source code, executable code, design details, processes, and related materials). These rights are realized through IP

licenses provided by system product or service providers (e.g., software producers) to the government customer, so long as the customer fulfills the obligations stipulated in the license agreement (e.g., to indicate how many software users are authorized to use the licensed product or service according to a fee paid). As already noted, our acquisition research has focused on issues addressing OA systems and IP licenses since 2008 (Scacchi & Alspaugh, 2008).

OA software systems offer the potential to improve acquisition by providing new ways and means to acquire, develop, deploy, and sustain software-intensive systems. These new ways and means in turn may transform how the DoD acquires complex systems by moving away from long-duration, proprietary (closed) system architecture, and the difficult-to-control cost of system development efforts, towards systems that may be more rapidly assembled/integrated in an OA manner with more transparent costs. Such a transformation may in turn reduce vendor lock-ins that oftentimes are associated with rising costs to sustained deployed systems that are inaccessible to competing vendors. So closed architecture legacy systems are often subject to IP licenses whose consequence is to reduce competition while increasing system sustainability costs. Our research on OA systems dating many years back (Scacchi & Alspaugh, 2008) has consistently been aligned with efforts for improving competition in software system development and evolution through an investigation of innovative ways and means to acquire/develop component-based OA software systems that are subject to diverse, heterogeneous IP licenses (Alspaugh, Scacchi, & Asuncion, 2010). But there is more to do to improve competition and defense affordability while effectively managing technical data rights when addressing the acquisition of secure OA systems. In particular, this includes understanding that the processes for acquiring such systems are facilitated or constrained in light of overall BBP guidance and best practices as well as how best to improve and streamline these processes. These topics are our focus in the remainder of this paper.

How Better Buying Power Impacts the Processes for Acquiring OA Systems

The move to OA systems represents a transition from the acquisition of monolithic systems to the acquisition of reusable system components that can be integrated to realize different configurations of a software product family for a specific application domain (Bergey & Jones, 2010; Guertin & Clements, 2010; Jones & Bergey, 2011; Reed et al., 2012; Scacchi & Alspaugh, 2012b; Northrop & Clements, 2007; Womble et al., 2011). These components are acquired within a software ecosystem that is evolving towards component provisioning within open repositories, where components from different producers are available for selection, evaluation, and system integration (Guertin & Womble, 2012; Martin & Lippold, 2011; Reed et al., 2012; Scacchi, 2007; Scacchi & Alspaugh, 2012a, 2013b). Figure 1 provides a graphic view of how such an ecosystem spans from a sample of software producers and components through system integrators to software consumers/users.

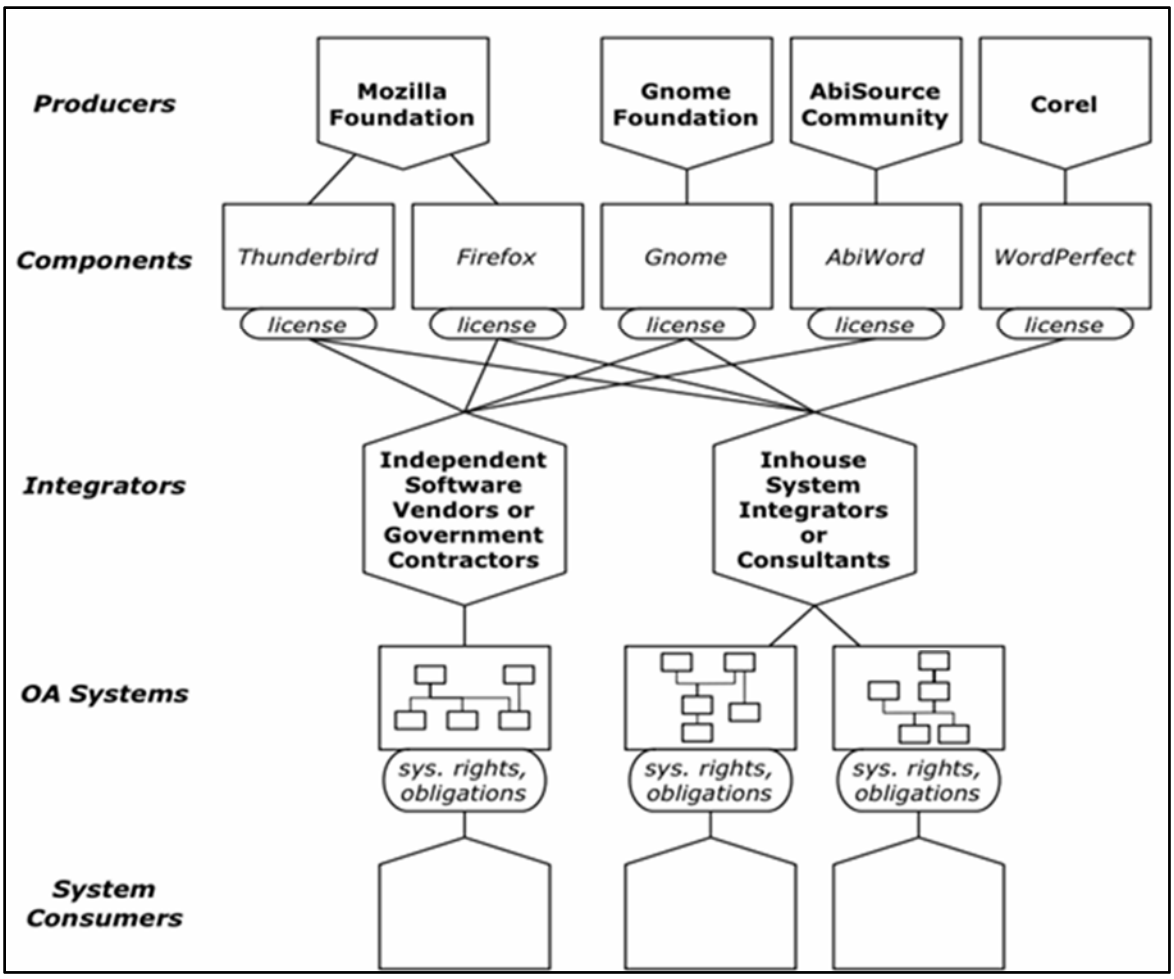

Figure 1. A Sample Software Ecosystem of Producers, Components, Integrators, Alternative OA Systems, and Consumers/Users
(Scacchi & Alspaugh, 2012b)

Figure 2 provides a view of a sample of lightweight software components ("widgets" targeted for software developers or integrators in this example) for download and installation within a Web browser. These widgets, made by different producers, are available for acquisition from Google's Chrome Web Store.

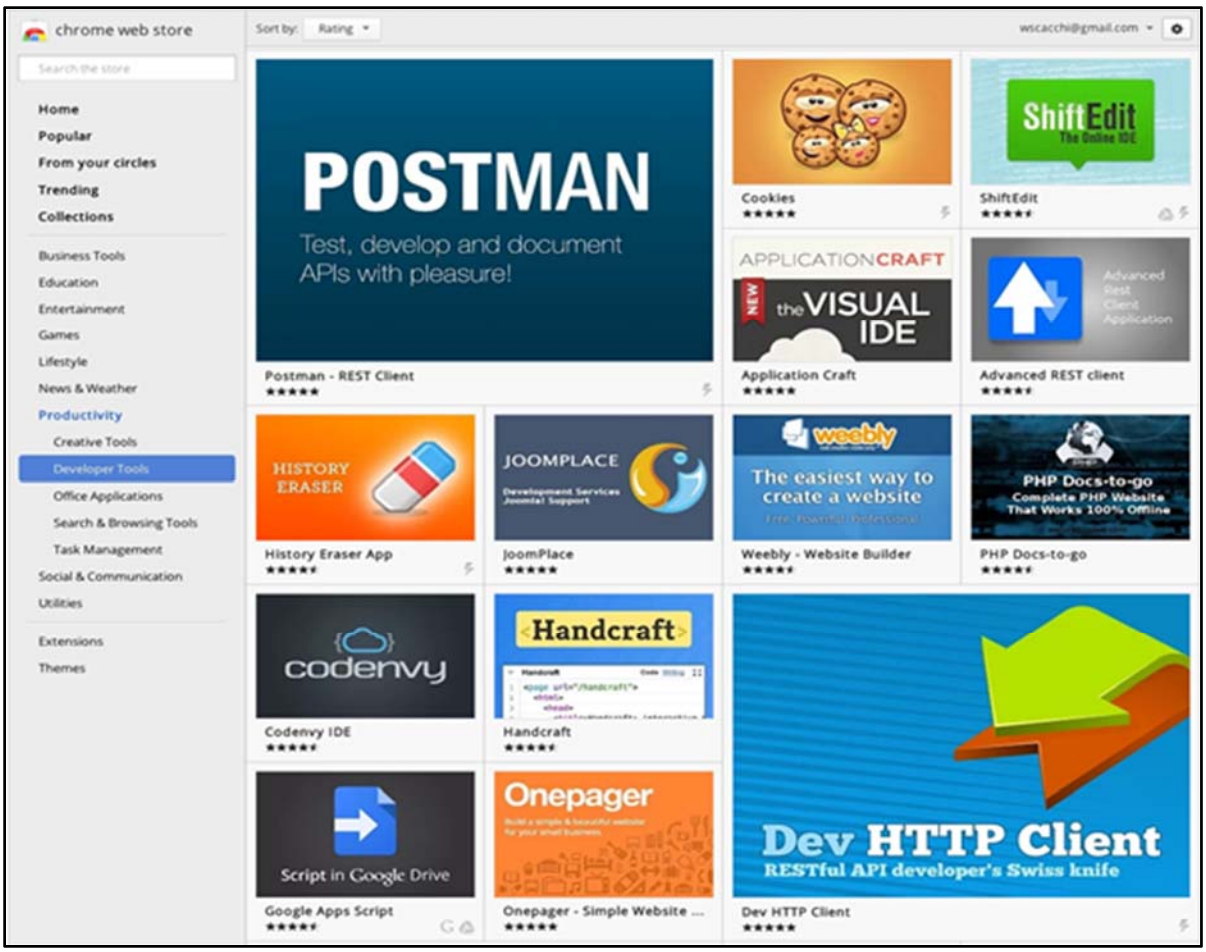

Figure 2. A Sample View of Lightweight Software Components ("Widgets") That Can Be Readily Acquired for Evaluation or Integration From Google's Chrome Web Store

Such an online store serves as a marketplace that provides access to ready-to-run, closed source software executables from within an online software repository that can be navigated using the menu on the left side, browsed by scrolling, or accessed by entry of a search term/phrase in the upper-left corner (see Figure 2).

Software components in an online marketplace like this are rated or recommended by other consumers, but the IP licenses for the TD and CS are hidden away with each component and may be challenging to locate prior to installation. Google Play for Android Apps and the Apple App Store also offer software (widget) components for their respective computing platforms (Android and iPhone smartphones, or Nexus and iPad mobile tablet computers).

Figure 3 provides a view of a different online repository that exclusively features OSS components found at SourceForge.net (similar to Forge.mil [DISA, 2012; Martin & Lippold, 2011]), where the IP licenses for each software component are prominently displayed when one selects to look more closely into the details and development status of a component of interest. In contrast to the Web-browser-specific software widgets available at the Chrome Web Store, the OSS components at SourceForge.net represent more substantial, production-oriented software tools or utilities that can operate as stand-alone application

programs. Forge.mil may be envisioned to provide support for accessing pre-tested and certified software components, whether lightweight widgets or more substantial application systems, in OSS code and ready-to-run executable forms with technical data rights designed for government purposes. Thus overall, what we see is that if we want to improve competition through the acquisition of component-based software systems, our choice of which online repository or marketplace to use leads to different kinds of software components with different IP license schemes.

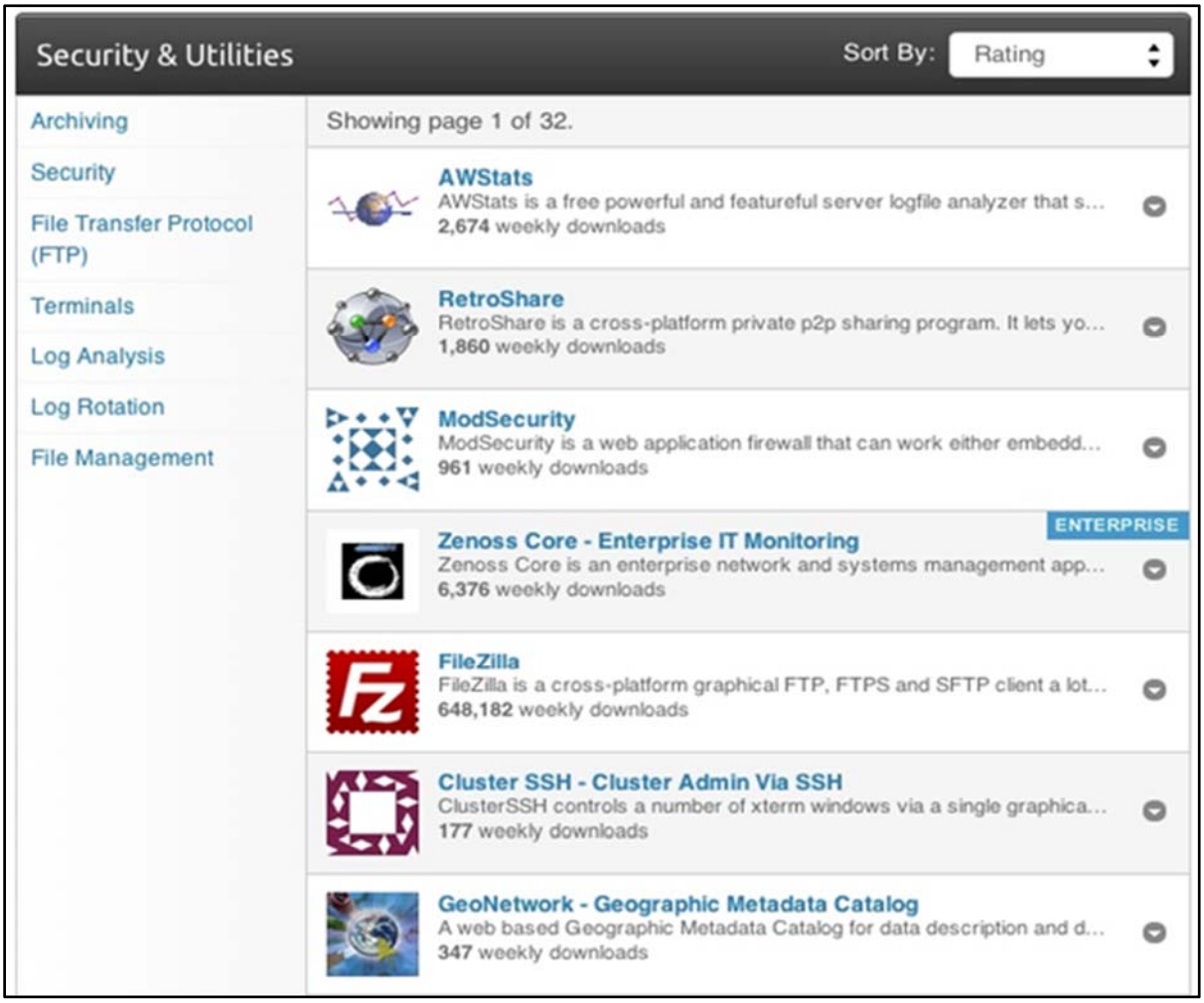

Figure 3. Sample of OSS Security/Utility Components Found at SourceForge.net

Next, we encounter challenges in the development of integrated OA systems that are configured from different software components. Figure 4 provides a visual representation showing that different software producers can develop different kinds of software components (small, medium, or large size/capability), which system integrators can select from in order to create an OA system product line of alternative component configurations.

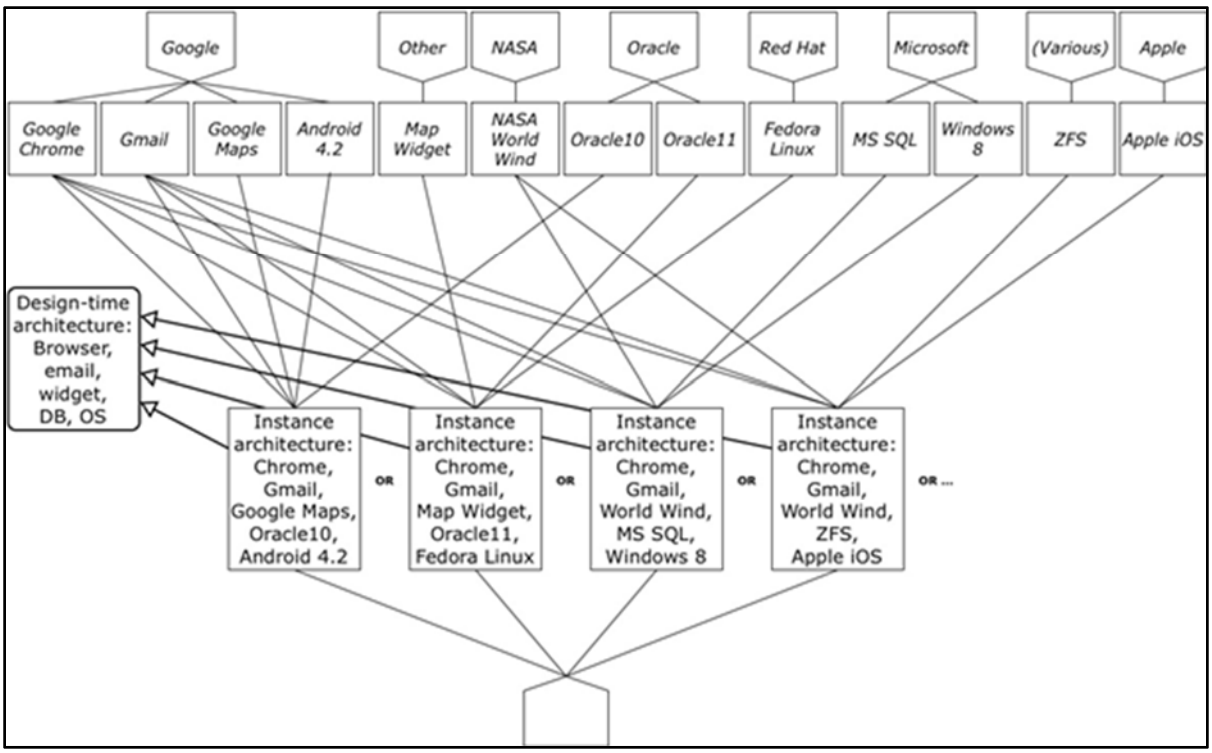

Figure 4. A Component-Based Software Ecosystem That Configures a Product Line of Four Alternative System Configurations, Conforming to an OA System Design in Figure 5

Figure 5 shows a simple OA system design that accommodates alternative software components as applications or infrastructure elements that may be subject to OSS or proprietary licenses. The applications ("apps") may include small, proprietary, and lightweight browser widgets or large components like OSS-based Web browsers. The infrastructure software, which is assumed to serve as an independent foundation for application software, can include proprietary or OSS components like database management systems (or network file systems or other online repositories) and computer operating systems. Figure 6 displays the selection of one set of conforming software components selected from the software ecosystem in Figure 4 that also conforms to the OA system design in Figure 5.

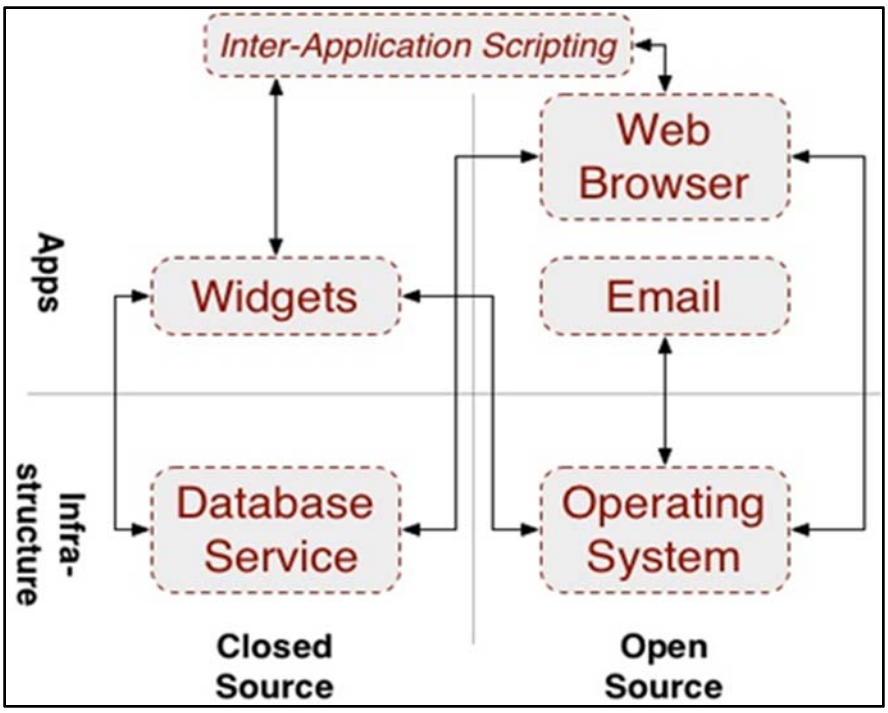

Figure 5. A Simple OA System Design That Accommodates Software Components as Applications or Infrastructure Elements, Shown in Figure 4

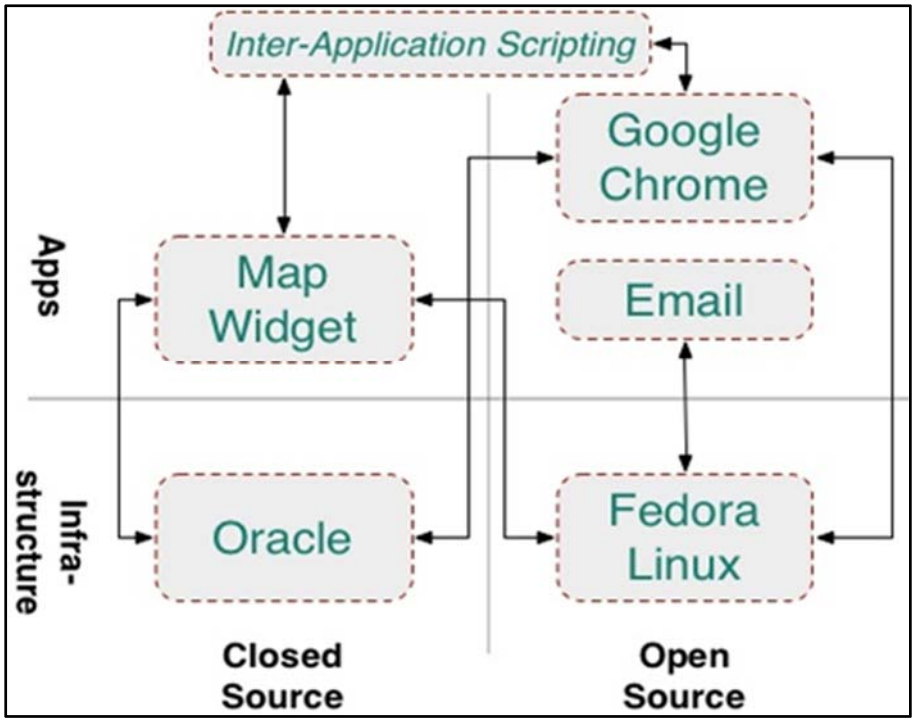

Figure 6. A Selection of Software Components From the Ecosystem in Figure 4 Conforming to the OA System Design in Figure 5

Lightweight software widgets are developed using domain-specific scripting languages, like JavaScript or PHP, which are designed to operate with popular Web

browsers or browser-based integrated system environments. These widgets commonly represent small programs that are often produced with limited resources on short time frames and sometimes constitute only hundreds of lines of scripting source code. More complex integrated capabilities can be constructed by integrating a set of selected widgets using additional scripting code via integration techniques that produce inter-application "mashups." Consequently, there is substantial competition in the widget/app marketplace. However, these lightweight software components often have short-term life cycles, and few updates before their demise.

At present, lightweight software components tend not to be sustained for periods beyond their early availability, widespread adoption, and deployment. Their life cycle may be measured in months, rather than years (or decades). Consequently, these lightweight components are effectively designed to be disposable, low-cost software—acquire it, then use it until something better is available, then repeat. This means that it may be easier for producers of such components to develop new components with new(er) capabilities, technologies, or remote services, rather than trying to sustain the short-lived legacy code. In this regard, producing new components may be less costly than maintaining legacy components that depend on technologies or services that may no longer be available or viable. Lightweight software components with short life cycles in this regard may improve competition, overall system adaptability, and affordability while reducing vendor lock-in to costly legacy software. Updated versions of such components may be provided to repair or replace problematic implementations, but they may also appear simply as an inducement to maintain use of the component until an extended (e.g., "pro") version becomes available for acquisition. Finally, the globally dominant online app stores like those operated by Apple, Blackberry, Google, Microsoft, and others tend to primarily/exclusively distribute small, lightweight software components as proprietary closed source executables on a per-user basis, and with IP licenses that prohibit open access, reuse, modification, and redistribution. But these choices are determined by the business models of the online repository/store operators, rather than on some critical technological dependency or constraint. So new software products like lightweight components from online repositories/stores will likely require more agile acquisition processes, contracting practices, and replacement/upgrade and IP license management regimes.

In contrast, the Web browsers in which these widgets run are themselves substantial multi-million source lines of code software components that are often integrated into larger software-intensive defense systems, like the C2RPC experimentation platform (Garcia, 2010; Gizzi, 2011). These browsers and other integrated software packages are tested and deployed on global scales, which in turn helps to insure their viability, sustainability, and quality within a highly competitive software product ecosystem. Their availability as either proprietary or OSS forms indicates that there is active, ongoing competition among their producers. In addition, these OSS browsers and other integrated software packages based on open standards (e.g., OpenOffice, LibreOffice) mean that commonly used, large-scale software applications and software infrastructure systems are available with IP licenses that offer lower acquisition costs and improved competition, as well as improved defense affordability options.

OSS components found at SourceForge.net or Forge.mil are typically somewhere in between in size, complexity, and functional capability of lightweight widgets and large integrated software packages. However, there is no requirement imposed in OSS repositories about what size, complexity, or capability components can be made available. So many OSS components range in size from thousands to hundreds of thousands of source lines of code, and they vary in terms of their quality and sustainability. OSS

components from online repositories like SourceForge.net are generally available for free or for a low cost and may or may not be designed around open standards. Many OSS-based applications do not rely on any standards, while much OSS-based infrastructure software relies on either open industry standards or de facto standards grounded in proprietary/legacy systems (sometimes referred to as “workalike” or functionally similar [Scacchi & Alspaugh, 2012b] systems). In contrast, the DoD is seeking to make sure that its online OSS repositories like Forge.mil (or others) will only host components that are pre-tested and certified as compliant with relevant standards, quality/reliability indicators, and security policies relevant to their problem domain (DISA, 2012; Kenyon, 2012; Reed et al., 2012].

Software components and online component repositories/stores offer the potential to transform the ways and means for acquiring and developing component-based OA systems. But at present, the size, functional complexity, quality, extensibility, and sustainability of different software components vary in part based on the repository/store from which they are acquired. Although components that can be integrated within a secure OA system offer the potential to increase competition, the acquisition processes need to be updated and the acquisition workforce newly trained in these new ways and means in order to maximize the likelihood for BBP initiatives addressing OA systems.

How Best to Improve and Streamline Acquisition Processes for Secure Open Architecture Systems

The transition to the development, deployment, and sustainment of software-intensive systems based on an OA means that new or revised acquisition processes may be needed. In particular, we believe that such advances call for (a) the adoption of open business models within the DoD and its industry partners, (b) open source approaches to creating Web-based acquisition processes (Scacchi, 2001) that specifically address BBP initiatives, and (c) employing techniques for streamlining these processes (Choi & Scacchi, 2001; Nissen, 1998; Scacchi & Noll, 1997; Scacchi, 2001) for secure OA systems. Each is described in turn in this section.

Encouraging the Adoption of Open (Source) Business Models

One goal of BBP initiatives is to reduce costs by improving competition. Such a situation may be disconcerting to legacy software producers who are long experienced with the long-term development of proprietary, large-scale software systems with closed architectures that are subject to traditional, cumbersome, and costly software product licenses and license management regimes (Anderson, 2012; Konary, 2009). A move towards the agile and adaptive development of secure OA systems based on software components—that can be developed/integrated more rapidly and at a lower cost with more favorable IP licenses—represents a new acquisition strategy (Reed et al., 2012; Scacchi & Alspaugh, 2013b). This suggests the need to incentivize software producers and system integrators so as to insure their ability to effectively produce both proprietary and OSS components that are economically viable yet cost effective to the government over the life of such systems. The overall BBP mandate recognizes this situation but does not specify the means for how best to accomplish it. We believe that one promising candidate is for defense enterprises and program offices to adopt new open business models.

The business models that we have in mind should be rendered in an open source format. Such models should be computer processable (i.e., amenable to automated enactment support) and transparent to participants in the acquisition workforce (e.g., available through Web-based application systems [Scacchi, 2001; Scacchi & Noll, 1997]). They should similarly be open to participants in software producer, system integrator, and

system user enterprises. These models should incorporate a product line of common/reusable open system architectures that can integrate functionally similar software components in order to realize domain-specific system solutions (e.g., for domains like C2, weapon systems, or enterprise computing; Bergey & Jones, 2010; Guertin & Clements, 2010; Jones & Bergey, 2011; Reed et al., 2012; Scacchi & Alspaugh, 2012b; Northrop & Clements, 2007; Womble et al., 2011). These business models should incorporate Web-based computational models of acquisition processes (Nissen, 1998; Scacchi, 2001; Scacchi & Noll, 1997) that manage the system development and support processes that surround the OA product line system models. Finally, these business models should highlight which acquisition or system development processes, or OA system features, require attention to IP licenses.

Prior research has demonstrated that significant cost reductions and process streamlining are possible when open source business process models are utilized (Choi & Scacchi, 2001; Nissen, 1998; Scacchi & Noll, 1997; Scacchi, 2001). These kinds of models can be subjected to performance measurements across multiple acquisition process enactments, continuous improvement, and process redesign by the acquisition workforce (Scacchi, 2001). Now we propose to enhance and extend their value through the incorporation of OA system models. While demonstrating such a capability is beyond the scope of this study, prior research results suggest the plausibility of such an approach. So future acquisition research targeting BBP may be directed to the creation of open business models that can be openly accessed, reused, modified, and redistributed where appropriate.

Open Source Models of Acquisition Processes

As noted, prior research has demonstrated the value and real payoffs of Web-based computational models for defense acquisition processes (Choi & Scacchi, 2001; Nissen, 1998; Scacchi & Noll, 1997; Scacchi, 2001). However, many technological advances, organizational transformations, and shifting defense priorities have occurred since these results were first demonstrated and deployed years ago. Our own studies on the design of secure OA system product lines are an example of technological advances not addressed in our earlier process models. But without explicit, open source process models that can be enacted through Web-based user interfaces (i.e., Web browsers accessing remote application services while tracking process enactment progress and performance parameters), the ability to realize their benefits (like process streamlining and cost reduction) is elusive and difficult to manifest. Among the reasons for why this is so includes overcoming gaps for how best to (a) monitor and measure acquisition process performance without automated enactment support; (b) redesign legacy processes to better accommodate technical advances and to remove ineffective bureaucratic procedures, or that transform acquisition processes in ways that do more with less while also empowering the acquisition workforce; (c) design new acquisition processes like those for acquiring secure, component-based OA software systems subject to multiple IP licenses; and (d) accommodate software IP licenses and license management regimes as acquisition process cost elements. To better understand what gaps exist in these four areas, we now describe techniques for streamlining the acquisition processes for secure OA systems.

Techniques for Streamlining Acquisition Processes for Secure Open Architecture Systems

A goal of this paper is to identify ways and means for streamlining acquisition processes for secure OA systems. In particular, we focus on four kinds of techniques that can be used to streamline such processes in ways that are responsive to the BBP initiative for open system architectures subject to complex IP licenses. These techniques are

illustrative rather than exhaustive since other kinds of techniques in other areas are also expected to exist and be available for practice by the acquisition workforce.

Process Measurement and Assessment

The most direct way to determine the efficiency and effectiveness of acquisition processes is by measuring their structural attributes. Such attributes indicate things such as (a) the length of the longest path of process steps/actions (process length); (b) the number of distinct process paths (process width); (c) the number of sub-process levels (process depth); (d) the total number of process steps (process size); and (e) the process size divided by process length (process parallelism) as well as others metrics (Nissen, 1998). But without an explicit graph-based model of acquisition processes, such measurements are impractical or implausible. Nonetheless, such metrics are a key for where to look for process improvement or process redesign opportunities. One might also recognize that some acquisition processes are underspecified—for example, by not explicitly accounting for where software licenses are negotiated or license trade-off analysis is done. Similarly, because OA systems may include software components subject to different licenses (Alspaugh et al., 2010), how are component-component license interactions assessed or analyzed, if at all? If acquisition processes do not explicitly account for new acquisition or license management activities that emerge due to advances in OA system development, then such processes are underspecified, which means their costs are hidden and difficult to control/minimize. Thus, if the goal of BBP is to help improve the affordability of OA systems within the DoD, then we need to be able to systematically model, measure, and assess our acquisition processes (Scacchi, 2001). Similarly, we need to better understand how to measure and assess open business models for use within the DoD and its industry partners to incentivize and continuously improve competition and defense affordability

Process Redesign and Evolution

Once we have the ability to measure and assess current/emerging acquisition processes for secure component-based OA systems, we can then begin to analyze (or simulate) them in ways that reveal process redesign opportunities and transformation heuristics (Choi & Scacchi, 2001; Nissen, 1998; Scacchi & Noll, 1997; Scacchi, 2001). Among the acquisition process pathologies we seek to identify are those where measured processes reveal sub-processes with low effectiveness (indicating high levels of iterative rework), low efficiency (indicating slow or bureaucratically cumbersome process steps that add marginal value to process completion), and problematic sub-processes (indicating underspecified process steps, steps that generate processing delays due to missing and/or incorrect acquisition data, or inappropriate automated process enactment support). For example, current processes that assume the long-term acquisition of monolithic software systems with proprietary components integrated within a closed architecture are likely not well suited to address the challenges for acquiring secure OA systems that integrate software components from different online repositories. We also place our acquisition workforce at a disadvantage if we do not empower them with the ability to measure, assess, and adaptively redesign their processes as technological advances like component-based OA systems are to be acquired. New software component technologies and software ecosystem niches (Scacchi & Alspaugh, 2012a) are also emerging, which necessitate new continuous development processes and new license management practices and thus the redesign/evolution of acquisition processes (Scacchi & Alspaugh, 2013a; Scacci et al., 2012). These examples all point to new opportunities to redesign, evolve, or otherwise transform existing acquisition processes to better fit the challenges posed by the development, deployment, and support of secure, component-based OA systems. Finally, we can empower the acquisition workforce to realize continuously improved acquisition

processes if we can provide them with the training and resources for modeling, analyzing, and redesigning their acquisition processes in ways that utilize Web-based automated process enactment systems, which also allow them to try out and walk through alternative process redesigns before committing to their use in daily operations.

Design New Acquisition Processes

Across the DoD community, there are many variations in practice for how to specify and model the architecture of a software-intensive system. Some practices focus attention primarily on identification of major components or abstract layers while minimizing (or ignoring) attention to interfaces and interconnections, which are more challenging to identify and manage. However, the BBP initiative for OA systems points to the need for managing explicit interface specifications that identify and reinforce the use of standard interfaces (DAU, 2012). Without such interface and interconnection specifications, it is not possible to determine the scope or potential conflicts/matches between the IP licenses (and thus TD rights) for the overall system architecture. In contrast, we have demonstrated in our prior research that component-based OA systems become tractable and evolvable from IP license management and security perspectives when the system architecture of components, connectors, and interfaces are explicitly modeled (Alspaugh et al., 2010; Scacchi & Alspaugh, 2011, 2012a, 2012b, 2013b). The use of standard interfaces further allows for simpler renderings of OA system structure, and thus simplifies license analysis. Further, once interfaces and interconnections become explicit, software component producers, system integrators, and/or system consumers can determine/negotiate which interfaces should be standardized in order to improve competition and affordability. These standards may then define acceptable data types, relationships between data types, data attribute value ranges, and exceptional data values in ways that are open, sharable, and reusable as well as extensible when appropriate. Such improvements become possible by enabling an agile, adaptive ecosystem for software components of different size and capability relative to OA system product lines for different application domains (Reed et al., 2012; Scacchi & Alspaugh, 2012a, 2013b). Therefore, another important technique for streamlining the acquisition of secure, component-based OA systems, in line with BBP initiatives, is to provide the acquisition workforce with the resources and automated support to design and computationally enact new acquisition processes (i.e., explicitly modeled processes; Choi & Scacchi, 2001; Nissen, 1998; Scacchi & Noll, 1997; Scacchi, 2001), where the processes are open, agile, and adaptive. Such modeled processes may also then be shared, reused, continuously improved, and redistributed across the ecosystem of defense enterprises and program offices.

Cost Management as a Process Design Element

Part of the promise of the move to OA systems stems from their perceived potential to reduce acquisition life cycle costs, improve competition, and improve defense affordability (DAU, 2012). But where and how are the associated cost factors or cost drivers for OA systems identified, tracked, and managed? After all, if we do not know where the cost factors are, or what activities, conditions, or events drive OA system acquisition costs, then we cannot effectively control such costs nor make well-informed system capability/cost trade-offs. For example, people who manage the acquisition of large-scale software systems within various defense enterprises are familiar with the many types of end-user license agreements for proprietary, closed source software systems (Anderson, 2012). In contrast, these people may not know how best to manage the acquisition of OA systems whose software components are jointly subject to different OSS or proprietary licenses.

The acquisition workforce have also learned in practice that software IP licenses are subject to change over time. However, one consequence is that long-lived or widely used

software systems become more costly and much less amenable to technology substitution or vendor replacement, thereby reducing competition due to vendor lock-in. This works against defense affordability. In contrast, emerging online repositories offer different kinds of software components with different functional capabilities (described earlier) along with different IP licenses and end-user licenses (e.g., low-cost, per-user licenses). These repositories of software components represent a means for increased competition and affordability but are subject to different acquisition, development, or integration processes that are just coming to light. Accordingly, we believe that streamlining the acquisition process for secure, component-based OA systems requires that IP license cost obligations (e.g., license fees for end-user agreements) and license management regimes need to be incorporated into process measurement and assessment, process redesign and evolution, and the design of new acquisition processes. This is also a subject for further acquisition research—but one offering practical near-term consequences.

Conclusions

In this paper, we presented our current results from an ongoing investigation of how best to acquire secure OA software systems. These systems incorporate SPL practices that include closed source proprietary software and OSS components, where such components and overall system configurations are subject to different security requirements. The combination of SPLs and OSS components within secure OA systems represents a significant opportunity for reducing the acquisition costs of software-intensive systems by the DoD and other government agencies. Through our research efforts, we seek to make the acquisition of secure, component-based OA systems a simpler, more transparent, and more tractable process. Such a process must be easy to explicitly model, share, reuse, adapt, and streamline for different system application domains. Our goal was to identify ways and means for how to realize cost reductions and improve acquisition workforce capabilities in ways that address BBP initiatives associated with the move to OA systems and licenses (DAU, 2012).

In this paper, we identified different ways and means for how to streamline the acquisition process for secure OA software systems through a focus on doing more with limited resources. Central to our approach was our effort to identify and characterize new ways and means for acquisition process measurement and assessment, process redesign and evolution, the design of new acquisition processes, and the incorporation of cost factors and cost drivers as an element in new acquisition processes. Along the way, we paid particular attention to revealing how licensing practices for emerging online software component marketplaces can affect cost in ways that either hamper or better the buying power of acquisition programs. Consequently, we sought to identify possible next steps for new acquisition research that can further accelerate efforts to improve competition and defense affordability as well as empower the acquisition workforce going forward, in ways aligned with BBP initiatives.

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