Engineering Improvement in Software Assurance: A Landscape Framework

Lisa Brownsword (presenter)
Carol C. Woody, PhD
Christopher J. Alberts
Andrew P. Moore
Agenda

Assurance Terminology

Problem Scope

Modeling Framework Overview

Selected Elements of the Framework Pilot

Summary and Next Steps
Assurance

System assurance

• The **justified confidence** that a system **functions as intended** and is free of exploitable vulnerabilities, either intentionally or unintentionally designed or inserted as part of the system at any time during the life cycle*

Software assurance

• Software’s contribution to system and system of systems (SoS) assurance
  – Software assurance in the context of a system’s and SoS mission and use

*Justified confidence*: rational basis for deciding about SoS readiness for use

*Functions as intended*: involves user expectations, which change over time

*Environment of use*

• Actual environment of use (not just the expected environment of use)
• Means evaluating robustness against *unexpected* use, threats, and changes in the environment

Problem Scope

Numerous assurance solutions (i.e., technologies, policies, and practices) are available

- A large number of organizations produce, fund, or use these assurance solutions
- How these assurance solutions contribute to operational assurance is often unclear

Operational environments are plagued with undiscovered defects and escalating numbers of known vulnerabilities

- Where should resources be invested to gain the most benefit?
- Where are the critical gaps in available assurance solutions?
- What additional assurance solutions are needed?
- Are the incentives for routinely applying assurance solutions effective?
A Solution Approach

Goal – longer-term

- Identify gaps, barriers, and incentives to the formation, adoption, and application of assurance solutions (i.e., technologies, policies, practices) to improve operational assurance
- Exploit this knowledge to accelerate the formation, adoption, and application of appropriate assurance solutions

Near-term approach

- Build a modeling framework that
  - Characterizes the current portfolio of organizations working in assurance, available assurance solutions, and how they work together to improve operational assurance
  - Characterizes the gaps, barriers, and incentives related to the adoption and application in operational environments of assurance solutions
- Leverage (or adapt) existing modeling and analysis methods
Where might we start?

<table>
<thead>
<tr>
<th>Key Information for a Modeling Framework to Address</th>
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<tbody>
<tr>
<td>1. How is software assurance value defined for a selected context?</td>
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<td>2. Who/what are the participating organizations and assurance solutions?</td>
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<td>3. What are the elements of value exchanged among participants?</td>
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<td>4. How do participating organizations and assurance solutions work together to achieve operational assurance?</td>
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<td>5. What are the drivers and motivations of participating organizations?</td>
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<td>6. What are the critical usage scenarios and behaviors among the participating organizations and assurance solutions?</td>
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<td>7. What are the adoption and operational usage mechanisms used for assurance solutions?</td>
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<td>8. How are the adoption and operational usage mechanisms aligned with organizational context and need?</td>
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<td>9. What is the impact of future trends and events on participating organizations and assurance solutions?</td>
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<td>10. What patterns of possible inefficiencies can be identified?</td>
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<td>11. What are candidates for improvements? What could be the impact, if implemented?</td>
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Conceptual Context of Assurance Modeling Framework

- Assurance Capability Area
- assurance ecosystem
- Assurance Modeling Framework
- Assurance Capability Area Profile

- selected assurance capability area for analysis
- assurance capabilities drawn from assurance ecosystem to support assurance properties
- facilitates creation of a profile of the selected assurance capability area that includes the important aspects/elements of the assurance ecosystem
- describes the landscape of the assurance ecosystem for the selected assurance capability area to better inform resource decisions
- includes decision makers, technologies, practices, people, and their relationships
Our modeling framework is comprised of multiple *categories of activities* necessary to produce an assurance capability area profile.

Each activity category focuses on developing insights on one or more of the framework information questions and produces one or more *views*.

Each view is formed using one or more *methods*.

A *profile* is a set of views that collectively describe an assurance landscape.
Assurance Modeling Framework

1. Determine Context and Scope
   - Q1, 2

2. Characterize Current State: Participants Relationships
   - Q2 - 6
     - Principal Participants & Influences
     - Value Exchanged
     - Potential Assurance Results
     - Motivations
     - Critical Behaviors

3. Characterize Current State: Asset Maturation and Adoption
   - Q7, 8
     - Adoption of Products
     - System Dynamics

4. Determine Future Factors
   - Q9
     - Critical Context Analysis
     - Value Mapping
     - Driver Identification & Analysis
     - Technology Development & Transition Analysis
     - Strategic Alternatives Analysis

5. Identify Candidate Improvements
   - Q10, 11
     - Future Drivers
     - Inefficiencies
     - Prioritized Improvements

Assurance Capability Area Profile

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Pilot Use of the Assurance Modeling Framework

Assurance Capability Area

assurance capabilities drawn from software ecosystem to support assurance properties

security as the assurance property

vulnerability management selected as the Assurance Capability Area

assurance ecosystem

selected assurance capability area for analysis
Assurance Modeling Framework

Determine Context and Scope

Characterize Current State: Participants Relationships

Characterize Current State: Asset Maturation and Adoption

Determine Future Factors

Identify Candidate Improvements

Critical Context Analysis

Value Mapping

SoS Focus Analysis

Driver Identification & Analysis

System Dynamics

Technology Development & Transition Analysis

Strategic Alternatives Analysis

Assurance Capability Area Profile

Principal Participants & Influences

Value Exchanged

Potential Assurance Results

Motivations

Critical Behaviors

Adoption of Products

Future Drivers

Inefficiencies

Prioritized Improvements
View: Value Exchanged (Q2, 3, 4)

Method: Value Mapping

- Shows static relationships among principal participants (organizations and assurance solutions)
- Shows primary elements of value exchanged between two participants

Selected insights

- One organization or technology by itself does not mean a great deal; its relationship to other organizations and technologies has meaning
  - An organization may play several roles in the assurance ecosystem
- Values identified in value exchanges may have only an indirect effect on operational assurance and is often difficult to determine
- The models provide an effective way for assurance solution owners to describe and better understand the key relationships associated with their solution
Sample CVE Value Map -1
An organization may play multiple roles with different values exchanged.

CVE – Common Vulnerability Enumeration
NVD – National Vulnerability Database
View: Potential Assurance Results (Q2, 4)

Method: SoS Focus Analysis

- Produces a model for alignment of services between suppliers of assurance solutions to what operational users do to achieve operational assurance
- Oriented to defining collaborations within complex, socio-technical systems (of systems) domains

Selected insights

- The effect an assurance solution has on achieving operational assurance is often not direct
  - It is a network of relationships among organizations and assurance solutions that must be understood within their operational context
- The models surface potential areas of inefficiencies for further analysis
SoS Focus Analysis with CVE

What Vendors

Demand-Side
- Addressing known vulnerabilities
- Disseminating vulnerabilities and patches
- Maintaining current knowledge of vulnerabilities and patches

Supply-Side
- Building, testing, issuing patches
- Registering
- Monitoring

How CVE, NVD

Who Security analysts
- Maintaining current knowledge of available patches & site configurations; forming site solutions
- Tracking, analyzing, forming solutions

Who Computer installations & operations
- Maintaining awareness of risks and effectiveness of solutions
- Installing solutions, monitoring effectiveness

Why User environments
- Operational assurance in the context of use
- Operational availability and integrity

Potential inefficiencies:
- where tacit knowledge is held
- where people manually synthesize significant information from multiple sources
View: Critical Behaviors (Q6)

Method: System Dynamics

- Produces a model for analyzing critical behaviors within complex socio-technical system of system domains
- Identifies primary positive and negative feedback loops driving critical behaviors

Selected insights

- There is a tension in the vendor community between resources for proactive software vulnerability prevention practices and reactive patch generation and release practices
  - Urgency of response has historically promoted reactive practices
  - CVE-induced market pressures are beginning to promote proactive practices
- The models provide a structured way to approach discussions among technology representatives and other affected stakeholders
1. Vendors must decide how to split resources between reactive and proactive responses to product vulnerabilities to balance the need for an immediate response with the need for a proactive solution that prevents product vulnerabilities.

2. The reactive approach patches product vulnerabilities based on CVE information. The development of patches is prioritized based, in part, on the impact a given vulnerability is having on the operational community.

3. The proactive approach focuses on a strategy of vulnerability prevention based on applying CWE information within the vendor community to developed software that prevents vulnerabilities.

4. If vendors feel the need to devote more resources to vulnerability patching and less to vulnerability prevention, then this leads to a downward spiral of increasingly vulnerable products and ever increasing assurance problems.
Summary

Assurance modeling framework lays important groundwork by providing a multi-dimensional approach to

- Better understand relationships between organizations and assurance solutions and how these relationships contribute to operational assurance
- Begin identifying potential areas of inefficiencies across a spectrum of technical and organizational areas

Status of SoS software assurance modeling framework project

- Completed initial version of the assurance modeling framework and validated it through the pilot on vulnerability management as a selected assurance capability area
- Finishing up a report on the modeling framework and its pilot use
Next Steps

- Expand modeling of future trends and technology formation and adoption
- Review the behavioral system dynamics models with community representatives
- Review usage scenarios of the pilot profile with community representatives
- Expand the use of the framework to another aspect of software assurance
Contact Information

Lisa Brownsword  
Senior Member, Technical Staff  
Research, Technology, and System Solutions (RTSS) Program  
+1 703-908-8203  
llb@sei.cmu.edu

Carol C. Woody, PhD.  
Senior Member, Technical Staff  
Networked Systems Survivability (NSS) Program  
+1 412-268-9137  
cwoody@cert.org

Christopher J. Alberts  
Senior Member, Technical Staff  
Acquisition Support Program (ASP)  
+1 412-268-3045  
cja@sei.cmu.edu

Andrew P. Moore  
Senior Member, Technical Staff  
Networked Systems Survivability (NSS) Program  
+1 412-268-5465  
apm@cert.org
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