Structural improvements for SDLs

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OWASP Belgian Chapter Meeting

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Background

- DistriNet research group, K.U.Leuven
  - Secdam taskforce on software development and middleware for security
  - Research on SDLs, security architectures & middleware, security metrics, SSE techniques incl. MDA, aspect-oriented programming, ...

- SDLs:
  - Increased attention over the last years
  - Many exist: SDL, CLASP, TP, TSPSecure, CbyC, SP800-64, (SSE-CMM), ...
  - How do they compare? How can they be improved?
In-depth process comparison

<table>
<thead>
<tr>
<th>Detailed Design</th>
<th>SDL</th>
<th>CLASP</th>
<th>TP</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1. Assess the privacy impact rating of the project</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>5.2. Software attack surface reduction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.2.1. Remove unimportant features</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>5.2.2. Determine who needs access from where</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>5.2.3. Reduce privileges</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>5.2.4. Identify system entry points</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>5.2.5. Map roles to entry points</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>5.2.6. Map resources to entry points</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>5.2.7. Scrub attack-surface</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>5.3. Class design annotation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.3.1. Map data elements to resources and capabilities</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>5.3.2. Annotate fields with policy information</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>5.3.3. Annotate methods with policy data</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>5.4. Database security configuration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.4.1. Identify candidate configuration</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>5.4.2. Validate configuration</td>
<td>x</td>
<td>✓</td>
<td>x</td>
</tr>
<tr>
<td>5.5. Make your product updatable</td>
<td>✓</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>


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What constitutes a process?

- A process consists of a temporally ordered sequence of steps (or activities) that, starting from an input state, lead to an outcome by using a set of resources like time or expertise

- The main goal of a process should be to increase systematicity, predictability and coverage.
  - In particular for secure software

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Outline

- Background
- SDL improvements
- Principled process
  - Analysis of support in CLASP
  - Least Privilege in Software Architecture

Quality of Process Definition (micro)

- Activity semantics:
  - Method: not what to do, but how to do it
    - Guidelines vs. activities
  - Systematic (no 100% security, but know what you’re doing)

- Activity description:
  - In general: input — method — output + resources
  - Clear added value and visible impact of an activity in terms of input and output
    - for CLASP only few activities specify output artefacts
  - Clearly, a process description should not be fully self-contained. However, for some activities it is not really clear how to proceed.
Quality of Process Definition (macro)

• Useful guidelines
  — \( \forall \text{ activity } X, \exists \text{ activity } Y: \text{ output}(X) = \text{ input}(Y) \)
  — Good mix of construction — verification — management activities
  — Constructive activities should be checked by verification activities

Coverage gaps

• Good coverage for requirements analysis, threat analysis and testing
• Little support available for:
  — Architecture level design activities
    • Could include for instance architectural trade-offs
  — Deployment:
    • Mostly packaging and support
    • Could be extended to operational procedures, product monitoring, ...
Security in Context

• Activity selection
  — Operational environments are constrained by cost
    • Currently difficult to link to process activities
  — Guide the selection of activities
    • Priority
    • Risk of omitting
    • Dependencies between activities
  — A CMM-like approach for processes could be useful, and might drive the software assurance process later on

• Processes must be integrate-able into different environments
  — High-profile, rigid and possibly certified (a la UP, ISO)
  — Small-scale, flexible and state-of-the-art (a la XP)

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Verification

• Small security flaws can have serious consequences
  — Correctness is important

• Security is a negatively spaced problem
  — Verification is more difficult

• Currently, verification is mostly based on selective testing

• We should introduce ways to verify correctness of output:
  — for single activities
  — spanning multiple activities

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Metrics

• Extension and improvement of the use of metrics within SSE
  — Activity-wise
    • Metrics as acceptance criteria for output (every activity !)
    • To identify criticalities early on
  — Process-wise
    • Process impact on product quality
    • Process impact on resource usage (time and personnel)

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Principled process

• Security principles are included in most processes. However, often:
  — Guidelines, rather than methods
  — Implicit support
• This situation should be improved:
  — more explicit and systematic integration of principles into the process
  — both in construction and verification activities

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Process support for moving targets

- Security operates on moving targets:
  - Applications change
  - Environments change
  - Attackers change
  - New types of vulnerabilities are found
- How to support this within a process?
  - Support after release
  - Process 'backtracking' (iterations, feedback loops, ...)
  - Minimize ripple effects of (functional) changes
  - Support traceability of results and decisions

Outline

- Background
- SDL improvements
- Principled process
  - Analysis of support in CLASP
  - Least Privilege in Software Architecture
Methodology

Sources?

NIST
OWASP
Saltzer
McGraw

Flat list

17

• Least privilege
• Keep security simple
• Secure defaults

114

Remove overlaps

49

• Least privilege
• Keep security simple
• Secure defaults
• Ethics in secure software development

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• Least privilege
• Keep security simple
• Secure defaults
• Ethics in secure software development

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Principle

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Least privilege</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>Keep security simple</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Reluctant to trust</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Fail securely</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Open design</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>All classes of attack</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Complete mediation</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Compartamentalize</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Comprise recording</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Multiple layers</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Positive security model</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Separation of privilege</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Least common mechanism</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Input Validation</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Relationships

- Support for principles is substantial
  - 85 elementary activities in CLASP
  - 30 mention a principle explicit
  - 9 are ancillary
  - 9 are implicit
  - \( \Rightarrow \) 35% of the activities is explicitly connected to principles

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Relationships

- Early phases are best connected to security principles

![Bar chart showing connections between phases and explicit, ancillary, and implicit activities. Project inception and requirements and analysis have the highest connections.]

Work by Koen Buyens, Riccardo Scandariato and Wouter Joosen

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### Relationships
- Established principles are more covered
- Some important principles are not supported at all

![Relationships Diagram]

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### Quality
- Guidance provided by principled activities is limited
  - Low: barely mentioned
  - Medium: information provided to implement it
  - High: extensive guidance, possibly step-by-step and (counter)examples provided

![Quality Diagram]

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Our longer term goals

- Materialize security principles within SDL: make them concrete in different activities
  - Different activities, different viewpoints
  - Security optimization vs. cost optimization

Least Privilege as an example

<table>
<thead>
<tr>
<th>Global security policy</th>
<th>determine the project-wide goals wrt. LP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Map roles to capabilities</td>
<td>analyze for 'over-assignment'; introduce new roles if necessary</td>
</tr>
<tr>
<td>Threat modeling</td>
<td>spot LP threats in (M)UCs; categorize UCs according to sensitivity</td>
</tr>
<tr>
<td>Requirements specification</td>
<td>include specific LP constraints</td>
</tr>
<tr>
<td>Architectural design</td>
<td>massage architecture (e.g., by splitting components)</td>
</tr>
<tr>
<td>Arch. threat modeling</td>
<td>spot LP threats in architecture</td>
</tr>
<tr>
<td>Attack surface reduction</td>
<td>reduce privileges in entry points (explicit in SDL)</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
**LP @ architecture level**

- **Available information:**
  - Component and Connector diagram
  - Collaboration diagram (UC)

- **Idea:** transform SW architecture into an artifact that is ‘better geared towards’ enforcing least privilege
  - Architectural structure vs. architectural policy

- **Different strategies:** splitting, rewiring, introduce established components, ...

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**Basic rules**

**Splitting interfaces**

**Splitting components**

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Discussion

- Early work in progress, but first results seem promising
- Major challenge is the lack of semantically meaningful information @ architectural level
- Many remaining issues
  - Identify alternative rules
  - Order of rule application
  - Minimize impact on SW architecture (not necessarily full solution at this level)

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Conclusion

- Current SSE processes such as SDL, CLASP or TP are a good step towards improved construction of secure software
- Given the brittleness of security, however, these processes might benefit from a number of structural improvements
  - Quality of description
  - Support for moving targets
  - ...
- Security principles are an interesting candidate to address more structurally, in every activity