

Problem & Motivation

The software testing process represents an **attractive attack target**:

- ▶ Risk of software piracy & theft of IP
- ▶ Covert attacks based on know-how gained via stolen artifacts (cf. Stuxnet)
- ▶ Means to conceal injected malicious code
- ▶ Potential damages to physical systems during test execution

Conducting security analyses (e.g., as per the VDI/VDE 2182 [7] guideline) of the testing process is **challenging**:

- ▶ Requires expert security know-how
- ▶ Is complex and effortful to perform
- ▶ Insufficient tool support available

Need: Framework to (semi-)automate security risk assessments with flexible assessment scope

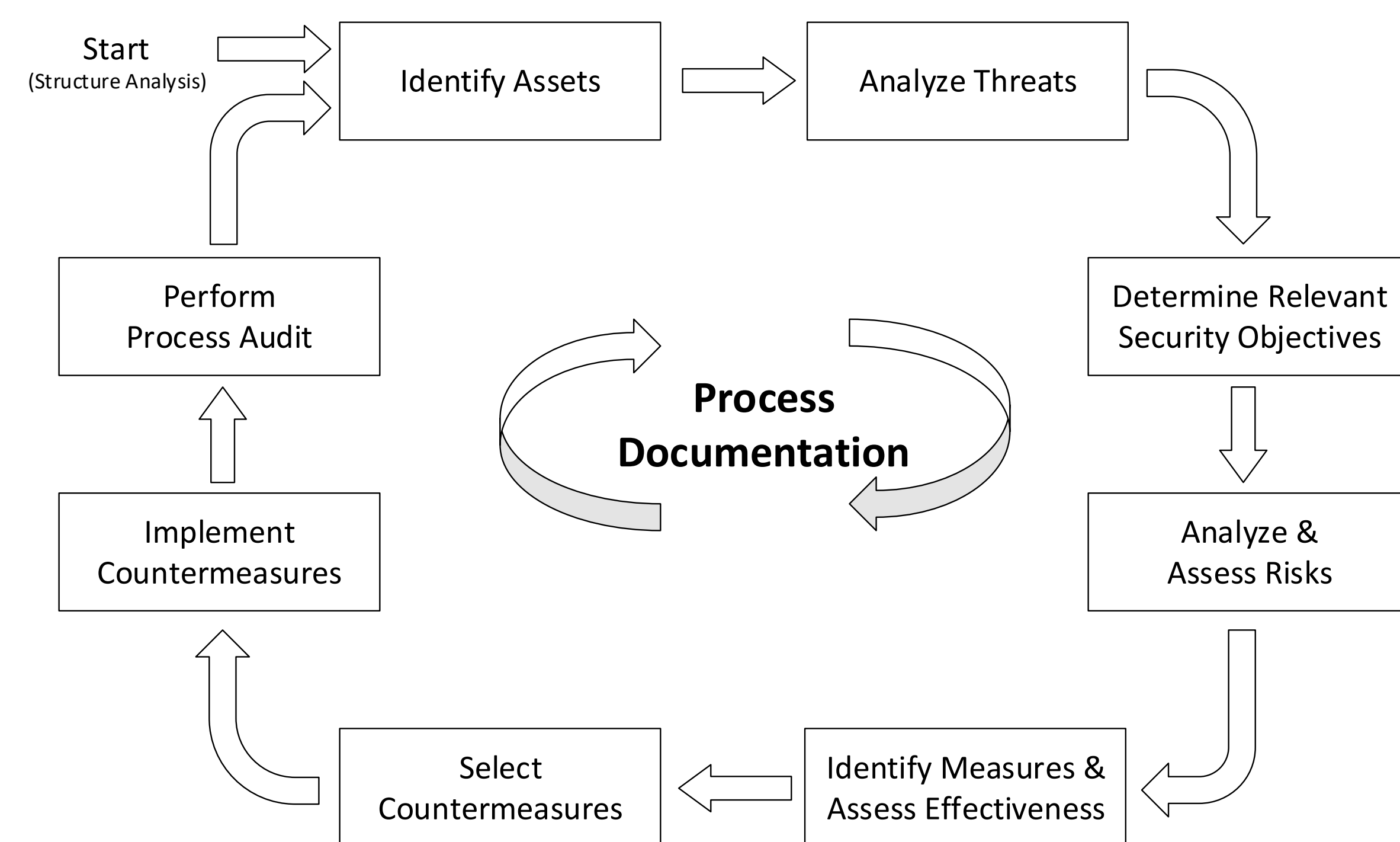


Figure 1: The procedural method according to the VDI/VDE 2182 [7] guideline.

Semi-Automated Security Analysis Framework

Contribution [1]: Provides the capabilities to conduct security analyses of an organization's software testing process for industrial automation software in a semi-automated manner.

Generic Software Testing Process as the Target of Inspection

- ▶ Investigated state of practice
- ▶ Performed unstructured interviews with employees of an Austrian-based systems integrator to design a generic testing process
- ▶ Reviewed the process together with a software quality consultancy
- ▶ Aligned the process to the ISO/IEC/IEEE 29119 [2] series of standards

Overview

- ▶ Framework supports the VDI/VDE 2182 [7] guideline
- ▶ Ontological modeling approach
- ▶ Flexible assessment (scope)
- ▶ Combination of STRIDE [6] and attack-defense trees (ADTrees) [4]
- ▶ Automated generation of ADTrees
- ▶ Open-source prototype: <https://github.com/sbaresearch/adtgenerator>

Security Modeling Approach

- ▶ STRIDE: 6 categories of security threats used to build threat trees [6] that are included in the knowledge base
- ▶ ADTrees [4]: Attack trees extended by defense measures
- ▶ Description and formalization of various threat scenarios
- ▶ Automated generation of ADTrees, which can be imported into ADTool [3]
- ▶ Development of SPARQL queries to extract valuable security information from knowledge base (e.g., STRIDE threats to assets)

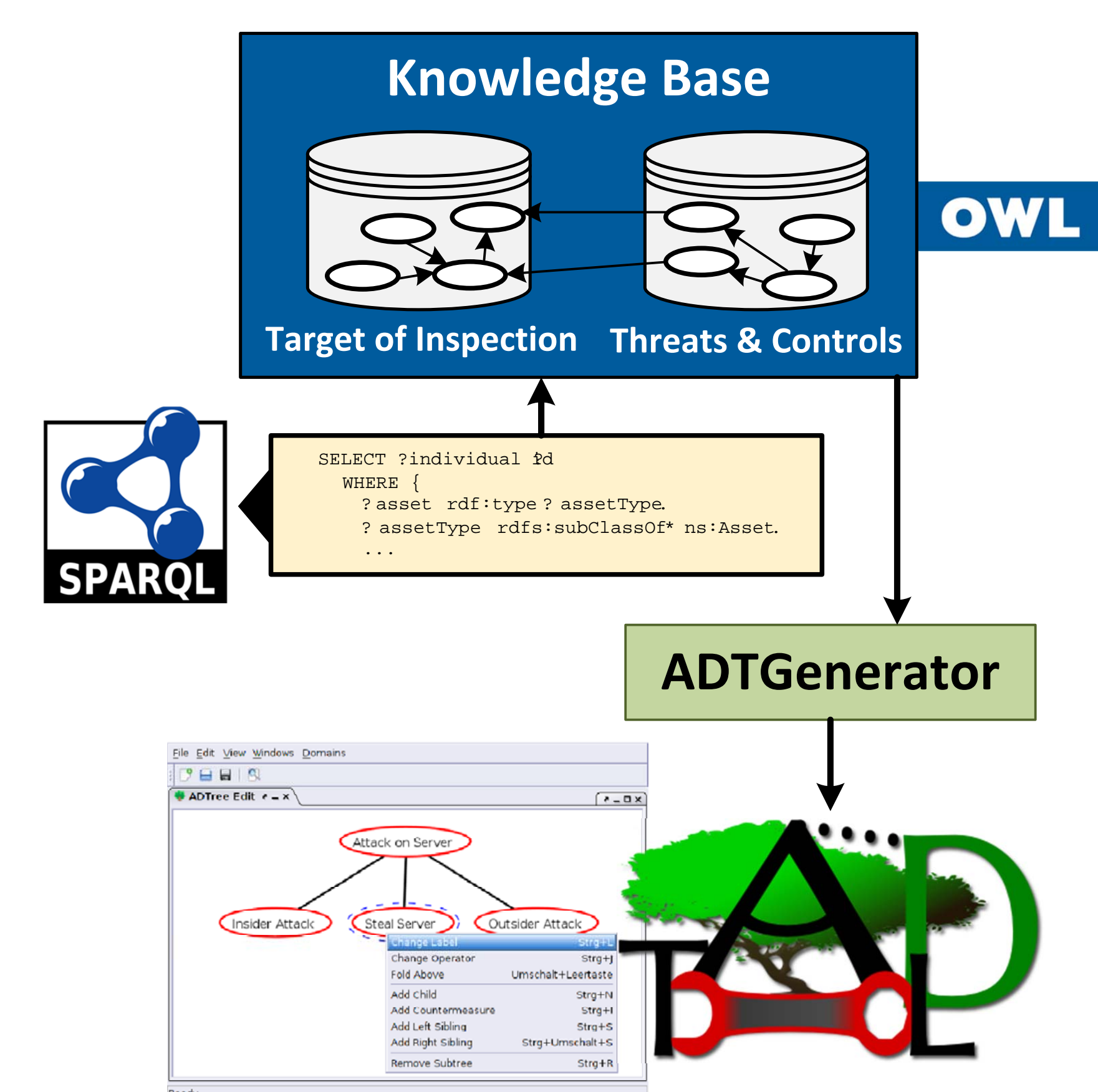


Figure 2: High-level overview of analyzing security risks in a semi-automated manner (ADTool illustrations taken from [3]).

Evaluation

- ▶ Two-step process: Tool selection step according to [5] and tool evaluation
- ▶ Considered 10 tools, two of which were extensively evaluated
- ▶ **Results:** Provides valuable support for security analyses, but needs to be improved to facilitate the structure analysis

Conclusion

- ▶ Designed a **generic software testing process for industrial automation applications** to define the target of inspection
- ▶ Proposed a framework that enables a **flexible, semi-automated security analyses**
- ▶ Adaptation to other engineering activities possible
- ▶ Developed a **prototype: ADTGenerator** (generation of ADTrees)
- ▶ SPARQL queries and ADTool [3] further support the analysis

Outlook

- ▶ **Automating risk identification** based on engineering data
- ▶ **Security modeling** extension for AutomationML (AMLsec)
- ▶ Detection of **vulnerabilities in plant structure** (e.g., attack graph generation), **consequences** of potential attacks, **business impact** analysis
- ▶ **Dynamic security risk analysis** methods for CPSs
- ▶ **Digital-twin-based attack simulation** for risk analysis

[1] M. Eckhart, K. Meixner, D. Winkler, and A. Ekelhart. Securing the testing process for industrial automation software. *Computers & Security*, 85:156 – 180, 2019.

[2] ISO/IEC/IEEE 29119-1. Software and systems engineering – software testing – part 1: Concepts and definitions, 2013.

[3] B. Kordy, P. Kordy, S. Mauw, and P. Schweitzer. ADTool: Security analysis with attack-defense trees. In K. Joshi, M. Siegle, M. Stoelinga, and P. R. D'Argenio, editors, *Quantitative Evaluation of Systems*, pages 173–176. Berlin, Heidelberg, 2013. Springer Berlin Heidelberg.

[4] B. Kordy, S. Mauw, S. Radomirović, and P. Schweitzer. Foundations of attack-defense trees. In P. Degano, S. Etalle, and J. Guttman, editors, *Formal Aspects of Security and Trust*, pages 80–95. Berlin, Heidelberg, 2011. Springer Berlin Heidelberg.

[5] R. M. Poston and M. P. Sexton. Evaluating and selecting testing tools. *IEEE Software*, 9(3):33–42, May 1992.

[6] A. Shostack. *Threat Modeling: Designing for Security*. Wiley Publishing, 1st edition, 2014.

[7] VDI/VDE 2182-1. Sheet 1: IT-security for industrial automation - general model, 2011.