Towards Generalized Security & Compliance Assessment of Programs

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Motivation

- Automated analyses are hard to get right and writing them is cumbersome
- Typically, analyses are adapted to different programming languages
- Each programming language has different types, programming paradigms, operations, syntax, behavior of similar concepts, evaluation order, ...

⇒ Abstract from the programming language with minimal information loss

- Standards and regulations have to be met by the developers
- Challenges of automated compliance analysis:
  - Interpreting the high-level text in standard requires expert knowledge
  - Text cannot be interpreted ⇒ Translate to formalized rules
  - Changes in requirements ⇒ Rewrite all rules?

Research-Landscape at Fraunhofer AISEC

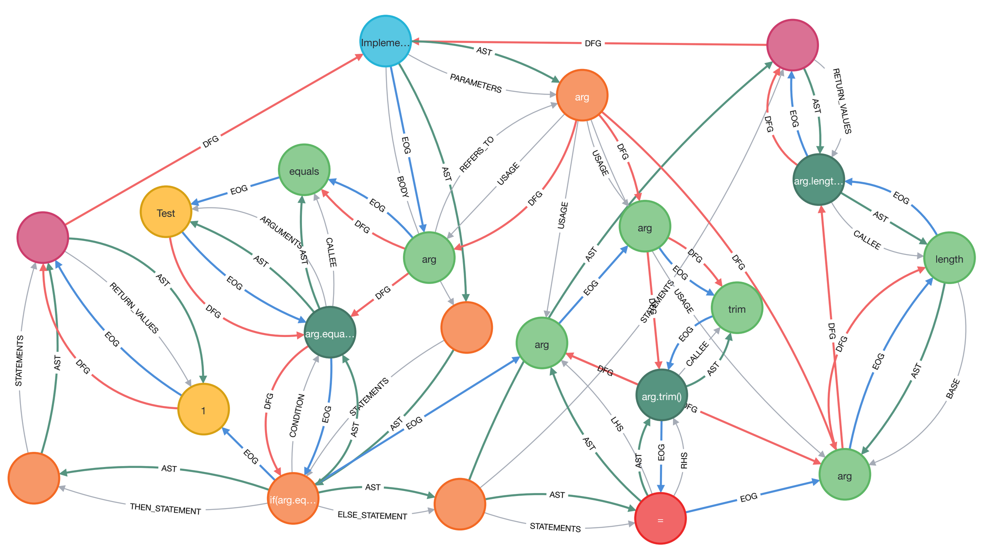
Unified Code Representation

Code Property Graph (CPG)

Generalized representation of code combining

- Abstract Syntax Tree (AST)
- Evaluation Order Graph (EOG)
- Data-Flow Graph (DFG)
- Control & Program Dependence Graph (CDG, PDG)

This is enough information to conduct almost every analysis



Language-Agnostic Representation

- The graph serves as a way to represent and traverse the code
- But how to include the subtle differences between languages?
  - ⇒ *Language traits*: Frequently occurring concepts of programming languages
  - ⇒ Customizable *passes*: deviate from "default" behavior depending on the language
- Extensibility is achieved through a plug-in-like system

Supported Languages

Java, C/C++, Go, Python, TypeScript, LLVM-IR

Built-In Analyses

Dataflow Analysis, Reachability Analysis, Constant Propagation, Intraprocedural Order Evaluation of Statements

Accessing the graph

- Graph DB **neo4j**: Cypher queries and visualization
- **Library**: Integration in other projects
- **Interactive CLI**: Manual exploration
- **Query API**: Built-in analyses and custom queries

Handling incomplete code

Fuzzy parsers: Analyze code with missing dependencies or code fragments

Extensions

- Analysis of cloud applications
- Privacy assessment
- Holistic analysis of quantum programs
- Analysis of Ethereum smart contracts

Abstract Hierarchical Requirements Definition

Codyze

- Defines a set of rules
- Abstracts from concrete implementations
- Parametrizes and runs analyses in the CPG

Correct API Rule Usage

Source of mistakes: Violating conditions when interacting with libraries or APIs, e.g.,

- Input validation
- Typestate: Correct order of operations to bring objects in a specific state
- The choice of arguments might change the security properties

This is specific to a concrete library ⇒ Define library-specific rules.

Use-Case-Specific Standards & Recommendations

- Define what is considered secure today in one area (e.g. cryptography)

⇒ Parametrization of specific API rules (e.g. cipher, mode, keylength, ...)

⇒ Further pre-conditions of parameters (e.g. "key must come from a good RNG")

MARK/CoKo: Language to model such requirements

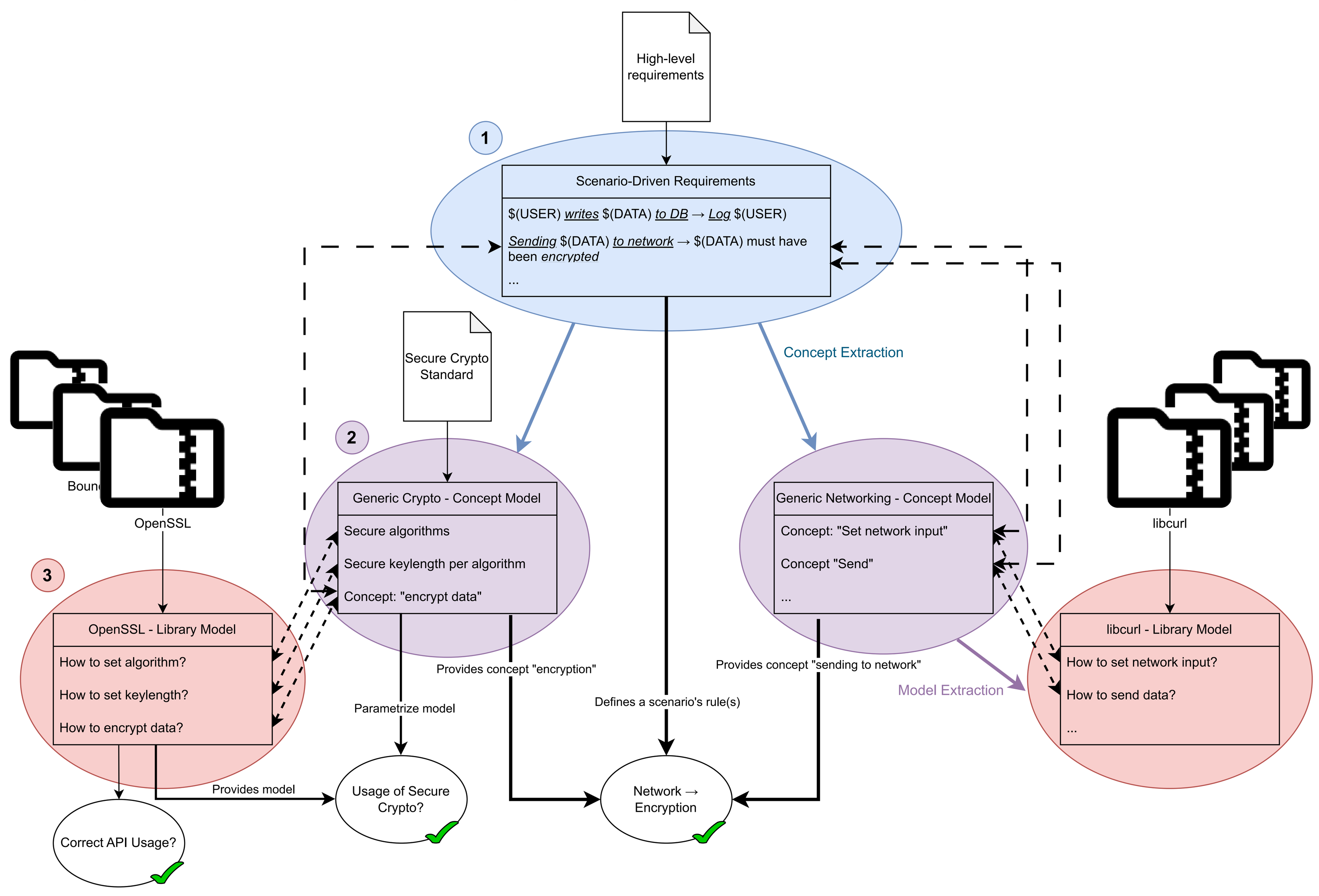
From Specific Libraries to Abstract Concepts

- Other high-level standards use abstract concepts to define scenarios (e.g. "network traffic must be encrypted")
- Can require multiple use-cases or libraries

Conceptualized Analysis of Compliance to Regulations

Goal: Construct a hierarchy of requirements with placeholders:
generic scenarios ① — concepts & requirements ② — implementation ③

- The depth of the hierarchy/tree depends on the use-case to allow maximal flexibility.
- Layer ③ is chosen automatically depending on the code under analysis.
- Layer ② should be customizable e.g. in case of different national standards.



Publications

[1] Christian Banse, Immanuel Kunz, Angelika Schneider, and Konrad Weiss. Cloud Property Graph: Connecting Cloud Security Assessments with Static Code Analysis. In *2021 IEEE 14th International Conference on Cloud Computing*, Chicago, IL, USA, 2021. IEEE.

[2] Maximilian Kaul, Alexander Küchler, and Christian Banse. A Uniform Representation of Classical and Quantum Source Code for Static Code Analysis. In *2023 IEEE International Conference on Quantum Computing and Engineering*, QCE, Bellevue, WA, USA, 2023. IEEE.

[3] Alexander Küchler and Christian Banse. Representing LLVM-IR in a Code Property Graph. In *25th Information Security Conference*, ISC, Bali, Indonesia, 2022. Springer.

[4] Alexander Küchler, Leon Wenning, and Florian Wendland. AbsIntIO: Towards Showing the Absence of Integer Overflows in Binaries using Abstract Interpretation. In *ACM ASIA Conference on Computer and Communications Security*, Asia CCS, Melbourne, VIC, Australia, 2023. ACM.

[5] Konrad Weiss and Christian Banse. A Language-Independent Analysis Platform for Source Code, 2022.

Research Interests & Opportunities

- Enhance analysis capabilities
- Improve/Show the correctness of the representation
- Explore novel use-cases
- Analysis across applications/components
- Modeling standards and libraries
- Identifing concepts and generalizations

More Info

- CPG: https://github.com/Fraunhofer-AISEC/cpg
- Codyze: https://codyze.io
- Fraunhofer AISEC: https://www.aisec.fraunhofer.de

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