The VACCINE Framework for Building DLP Systems

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Aimed at prevent an accidental or unintentional distribution of private or sensitive data to an unauthorized entity.
1. Admin self interpreting policies from handbooks to specify rules (which is error-prone)

2. Conflating extraction sensitive data (regular expressions templates, keywords, or patterns) and enforcement of policies
VACCINE: Verifiable and ACtionable Contextual Integrity Norms Engine

- Uses Contextual Integrity to model the information flows and the notion of information leakage
  - A flow represents an atomic unit of an information exchange
    \[
    \langle \text{sender}, \text{recipient}, \text{subject}, \text{attribute} \rangle
    \]
  - Contextual Informational Norms specify what flows are allowed in a given privacy context constrained by transmission principles.
    \[
    \langle \text{Sender}, \text{Recipient}, \text{Subject}, \text{Attribute}, \text{Transmission principle} \rangle
    \]
- Norm violation serves as the definition of information leakage.
VACCINE Architecture

The system allows exactly those flows that adhere to the given contextual information norms.
Privacy Logic

• **Actionable norms:** specify the operational rules that define the runtime behavior of the system
  
  • Example: Professor may not disclose student's educational record to parents without the student’s permission.
  
  • allowed (FERPA_{ctx}, Professor_{sndr}, ER_{attr}, Student_{subj}, Parents_{rcp})
    
    explicit_permission (Student_{subj}, PO_{attr}, Agent_{rcp})
  
• **Non-actionable norms:** define auxiliary properties that must be guaranteed by the actionable norms e.g., *Implicit Norms, Blocking Norms*.
  
  • Example (implicit norm): *A student should be able to send herself a message containing her own personal data.*
VACCINE Architecture
Extracting Privacy Logic

- Extracts the privacy logic in the form of actionable and non-actionable norms from a privacy handbook and checking their consistency
  - ie., make sure actionable norms don’t violate non-actionable ones
- Norms are translated into operational rules that can be enforced by an engine
Evaluation Questions

- How formal methods can assist in the creation of a consistent set of privacy rules?
  - Manually extracted privacy norms from the FERPA summary actionable and non-actionable norms
    - It took three iterations of the check-refine loop to obtain a consistent set of actionable norms
  - If a particular non-actionable norm is violated, the theorem prover (Z3) will produce a model describing a sequence of information flows that respects the rules but violates the norm.
    - Using this model, we can then identify the rules that are responsible for the violation.
Evaluation Questions

• How efficiently can CI flows be checked against the privacy rules?
  • Checking whether a flow complies with the privacy logic amounts to performing a single query of the *allowed* predicate.

• How effective is the VACCINE framework in preventing potentially unauthorized flows in a real-world emulated context?
  • We created 43 Enron privacy rules that focus on access and disclosure of PII in a corporate setting.
Lessons & Future Work

• Lessons
  - Privacy regulations are not written with CI in mind e.g., lots of assumption about implicit flows
  - CI is not well understood outside the legal and privacy scholars communities

• Future work
  - Automate privacy logic extraction