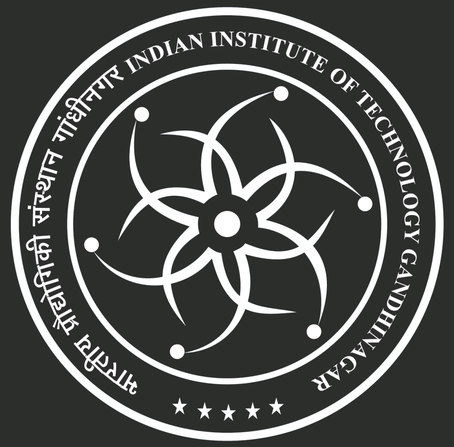

Automating Audit with Policy Inference

Abhishek Bichhawat (IIT Gandhinagar),
Matt Fredrikson (CMU),
and Jean Yang (Akita Software)

Organizational Data Security

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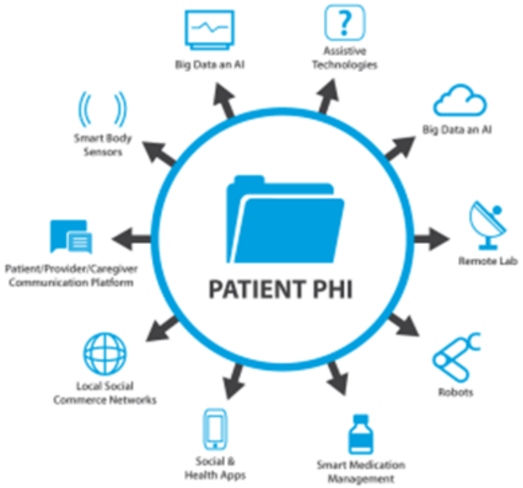

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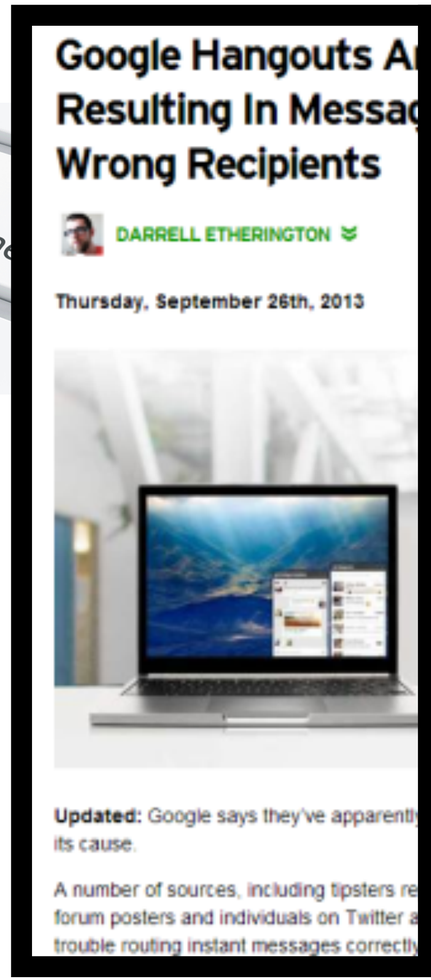
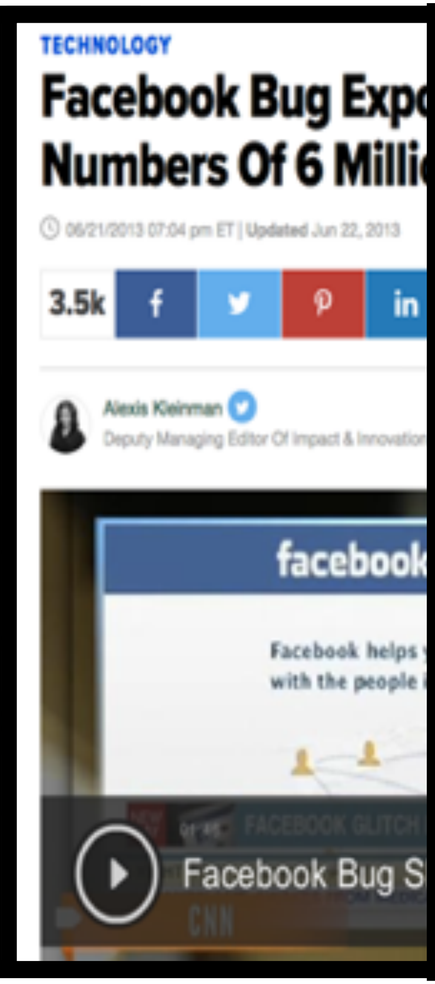
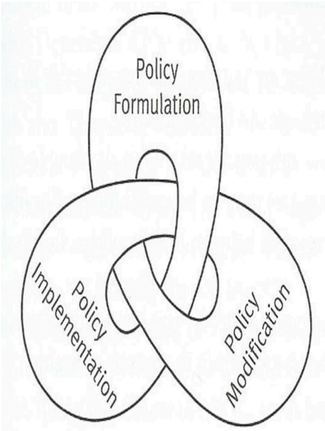
Organizational Data Security



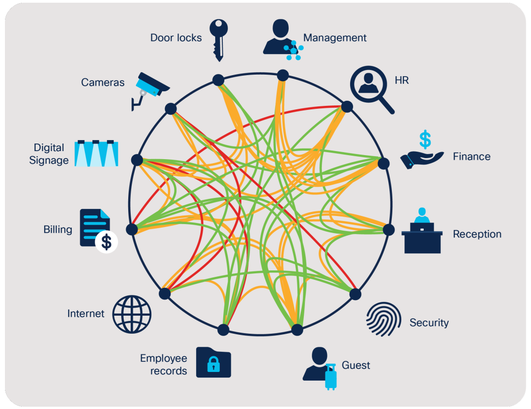


Factors Affecting Policy Enforcement

Constant policy modification

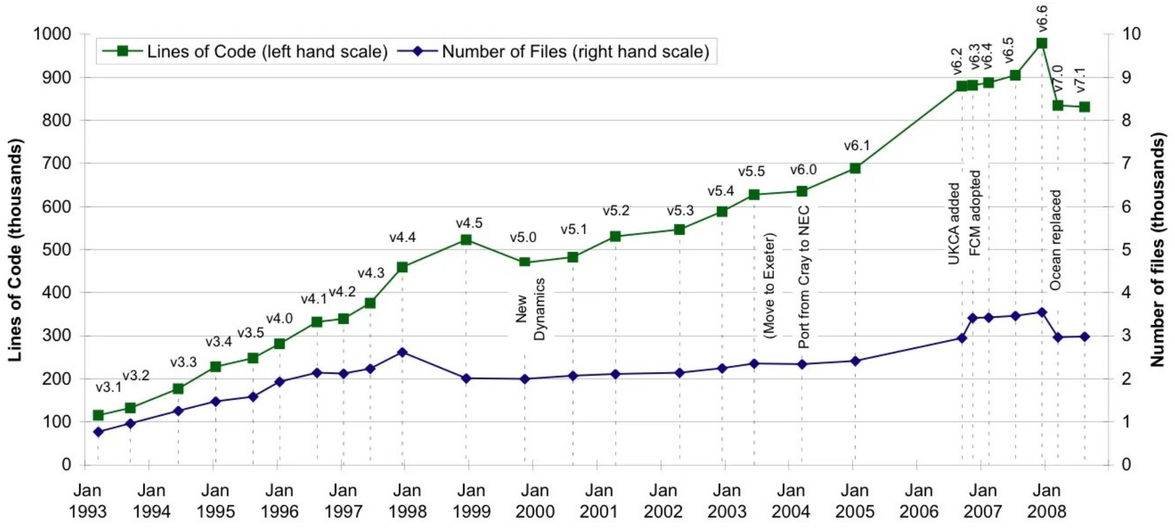


Complexity of policy



Size of the codebase

Evolution of code



Factors Affecting Policy Enforcement

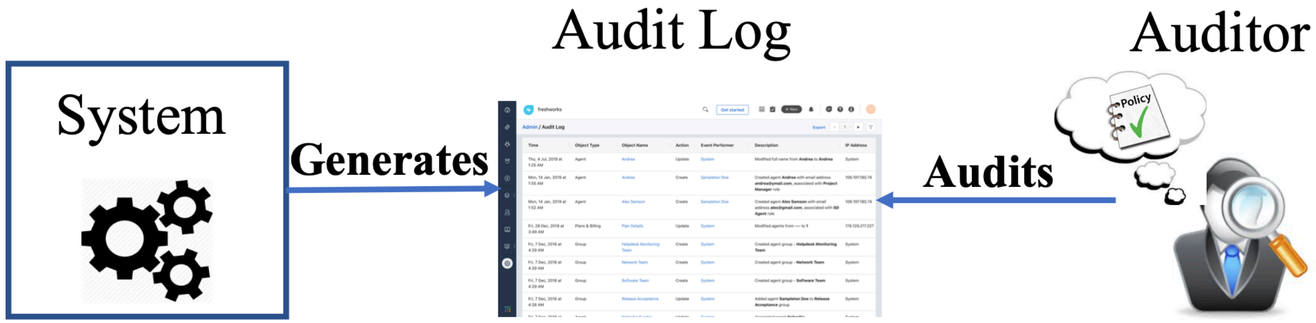
- Organizations may lack explicit, mechanized policy specification

- Inline checks are error-prone; introduce bugs

```
if (in_array($limit, ["a", "r", "ar", "rout", "vis"], true)
    || ($user->privChair && in_array($limit, ["all", "unsub", "unm"], true))
    || ($user->isPC && in_array($limit, ["acc", "reqrevs", "req", "lead", "rable",
                                         "editpref", "manager", "und"], true)))
    /* ok */;
else if ($user->privChair && !$limit && $this->conf->timeUpdatePaper())
    $limit = "all";
else if (($user->privChair && $limit === "act")
         || ($user->isPC
             && in_array($limit, ["", "act", "all", "unm"], true)
             && $this->conf->can_pc_see_active_submissions()))
    $limit = "act";
else if ($user->isPC && in_array($limit, ["", "s", "unm"], true))
    $limit = "s";
else if ($limit === "rable")
    $limit = "r";
else if (!$user->is_reviewer())
    $limit = "a";
else if (!$user->is_author())
    $limit = "r";
else
    $limit = "ar";
```

Auditing Logs for Privacy Compliance

- Organizations audit transactions
  - Log transactions
  - After-the-fact validation of logs
  - Employ human auditor to identify violations of organizational policy



Our Approach - Insight and Overview

Audit logs combined with auditor-decisions, are sufficient to reconstruct a correct mechanized policy, which can be used to reduce the cost of manually auditing logs

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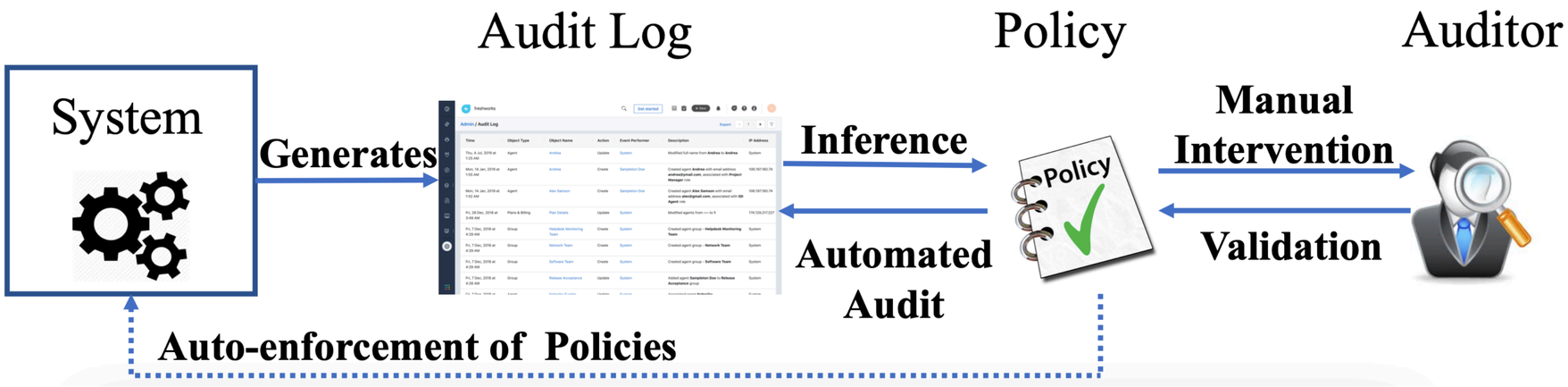
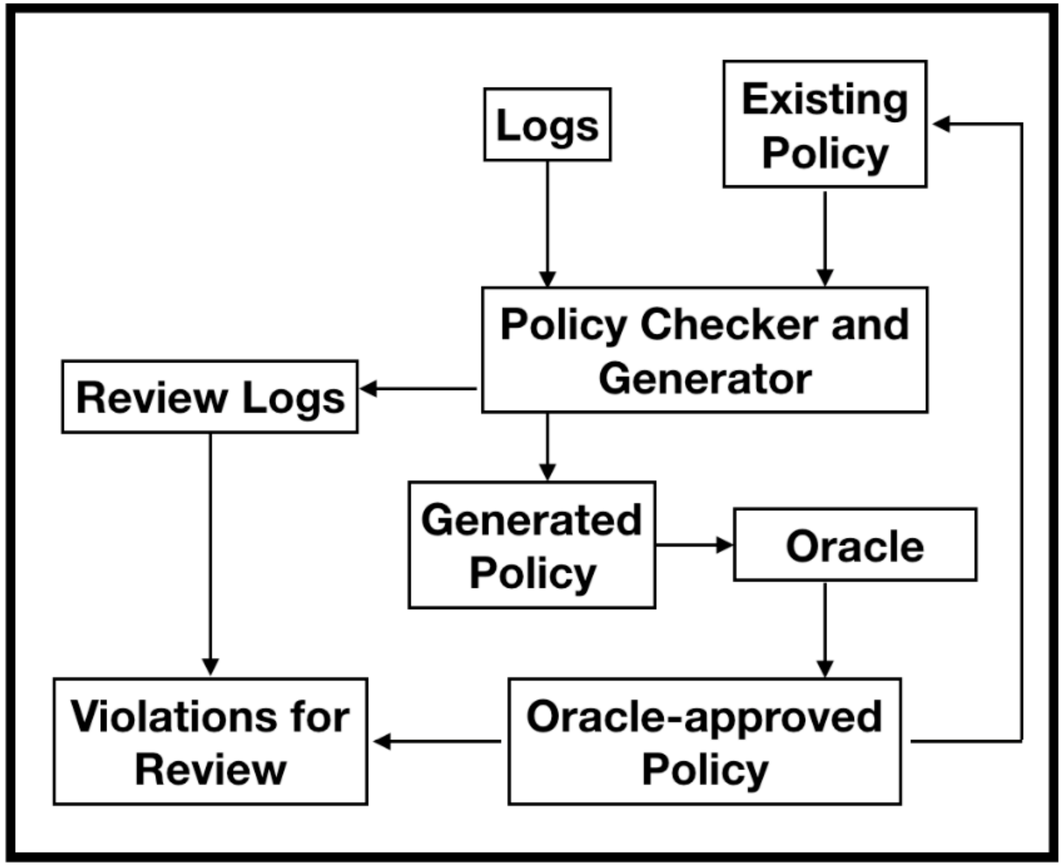


Policy Inference and Audit Framework



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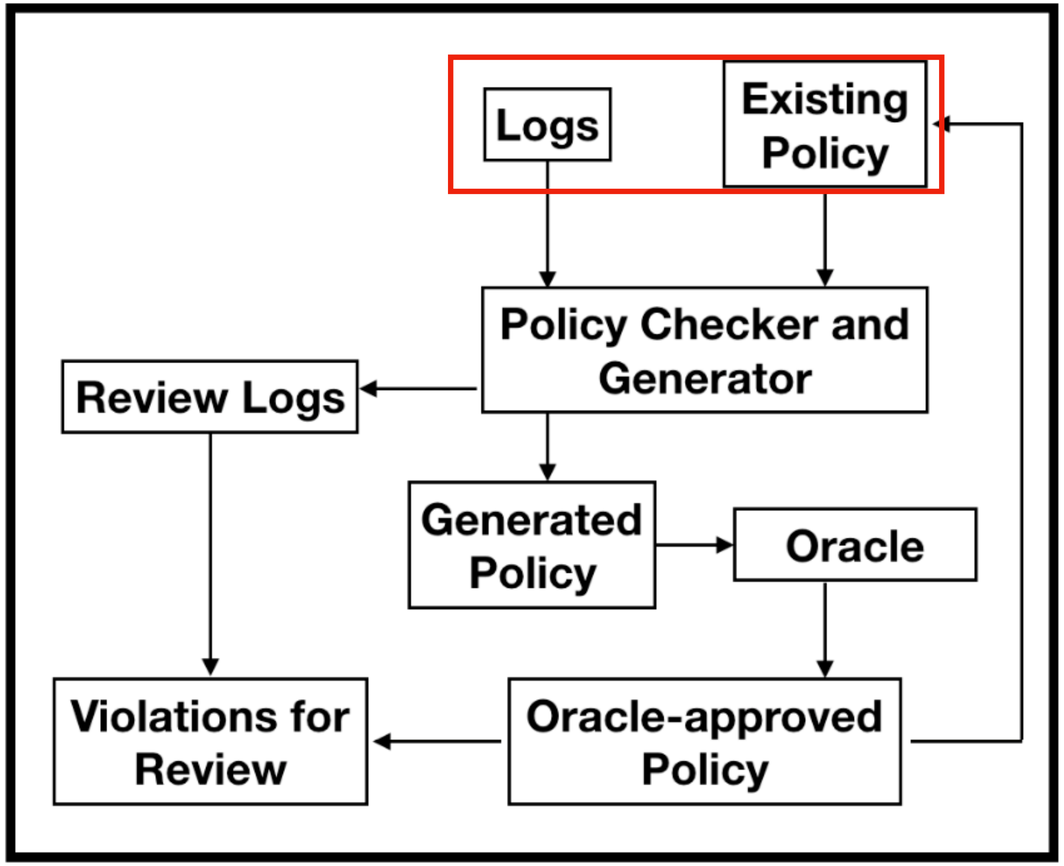

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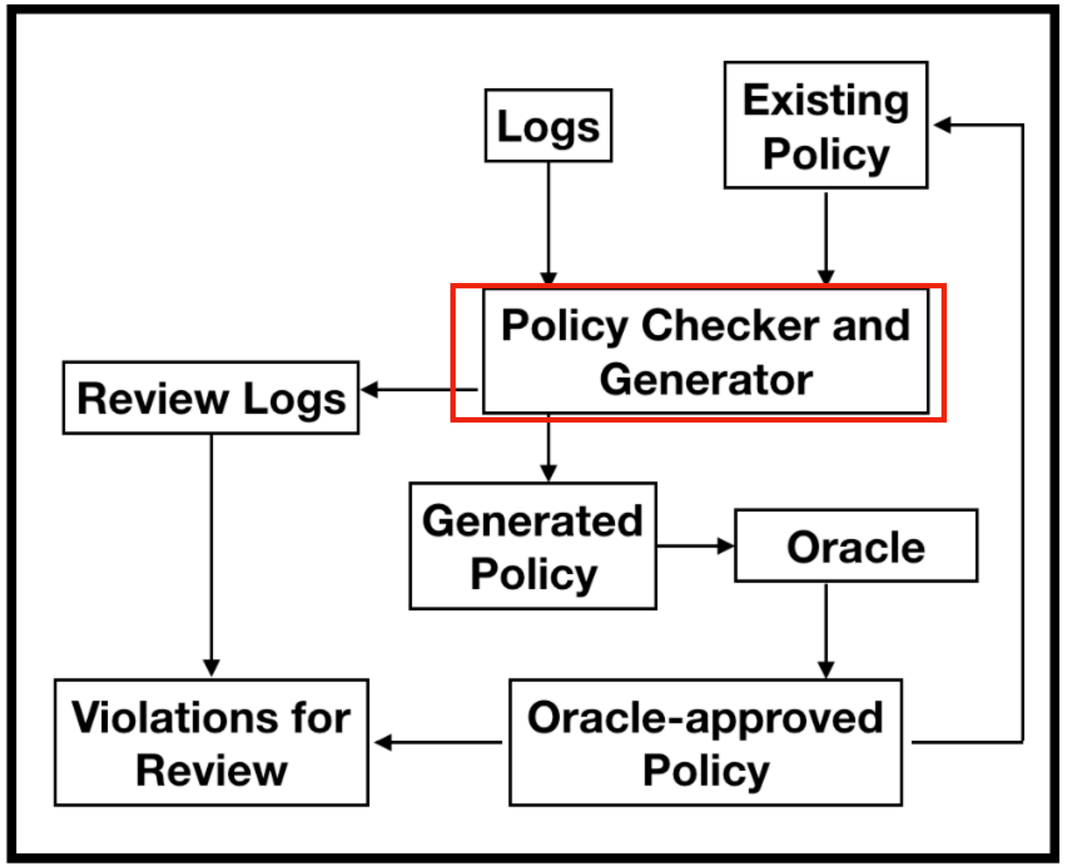

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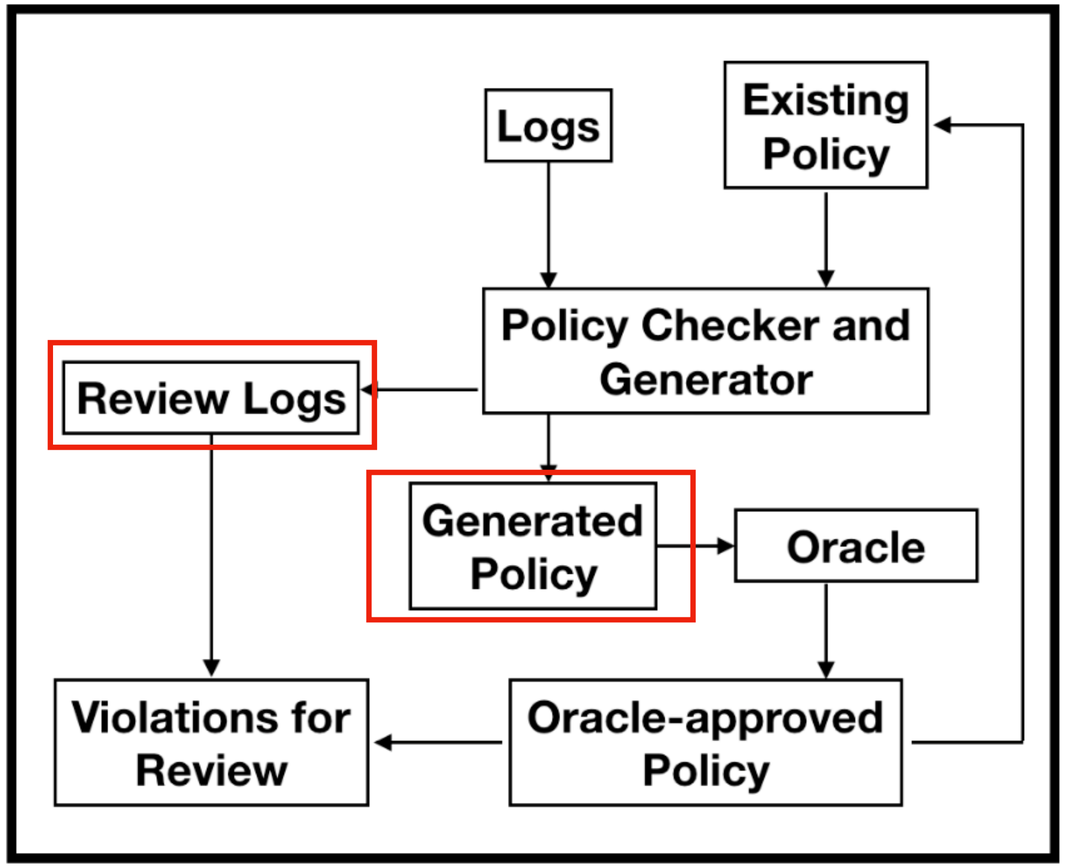

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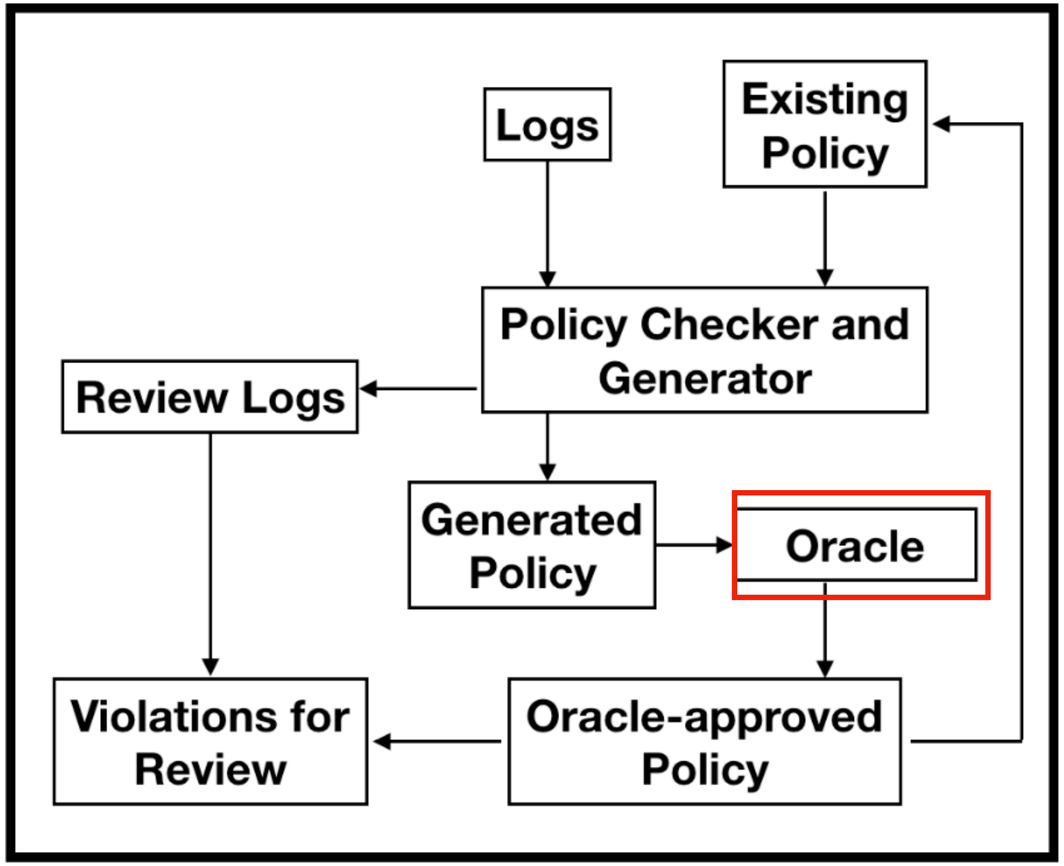

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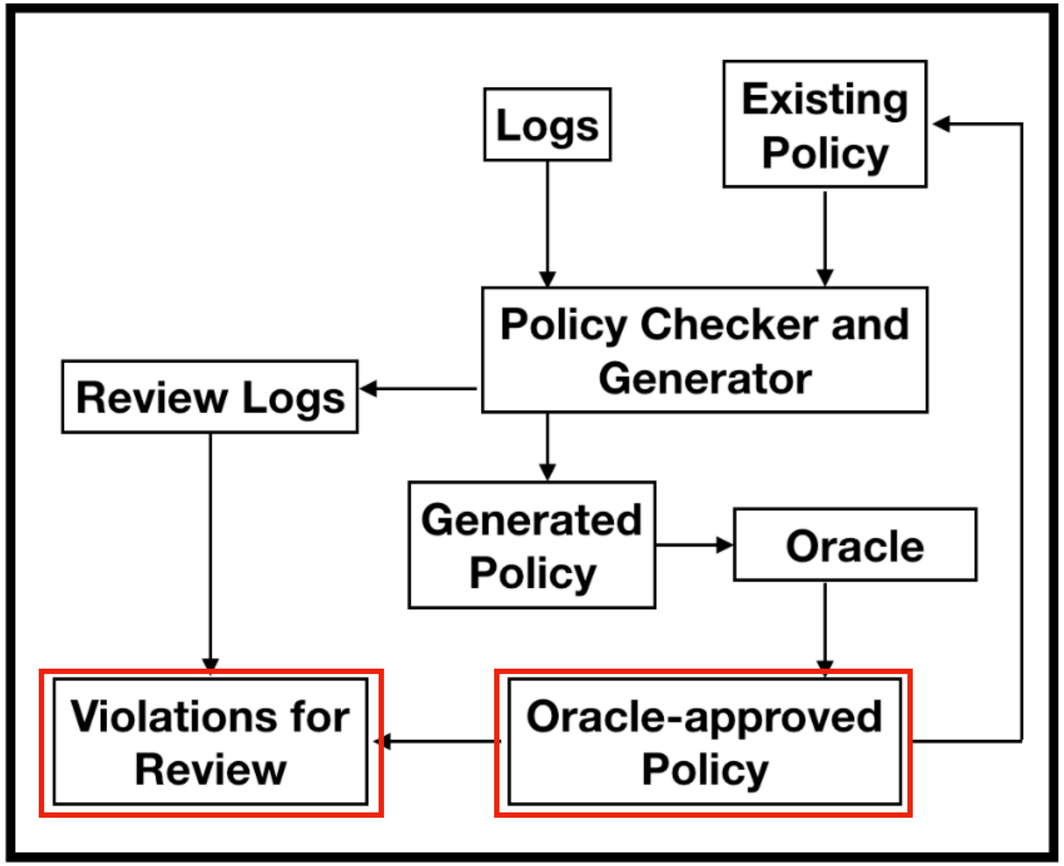

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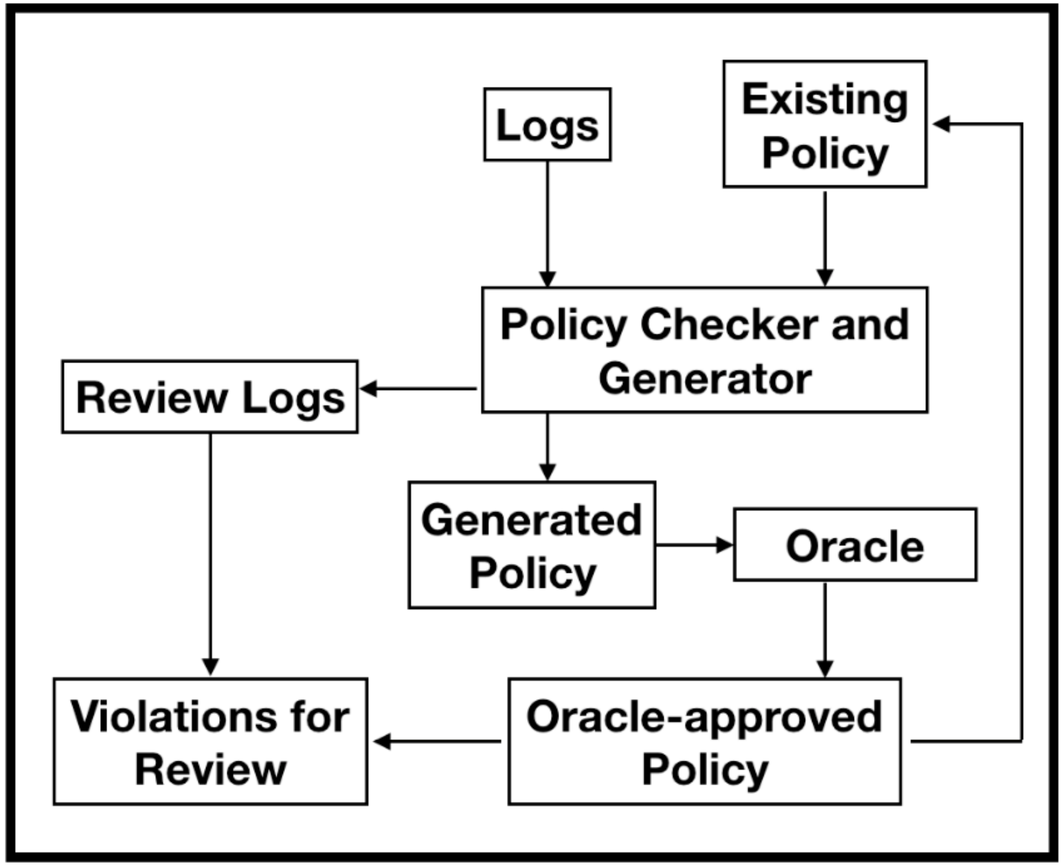

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Output: φ_n - inferred policy
M - map from formula to set of formulas
Function Generate ($\mathcal{L}$, φ_o, Σ, R) **:**

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2   | foreach s_i ∈ φ_o do
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foreach $s_i \in \varphi_o$ **do**
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2   foreach s_i ∈ φ_o do
3       foreach s_j ∈ φ_o \ {s_i} do
4           if reduce(s_i, s_j, Σ) then
5               φ_n ← φ_n \ s_j;
6               M ← appendMap(M, s_i, s_j);
7           else if reduce(s_j, s_i, Σ) then
8               φ_n ← φ_n \ s_i;
9               M ← appendMap(M, s_j, s_i);
10              break;
11          end
12      end
13  end
```

End Function

Input: φ - policy
M - map of formulas to list of formulas
Output: φ_a - approved policy
Function oracle $(\varphi,\ M)$ **:**

```
1   φ_a ← {}; φ_m ← {};
2   foreach s ∈ φ do
3       if isValid(s) then
4           φ_a ← {s} ∪ φ_a;
5       else
6           φ_s ← M(s) ∪ φ_s;
7       end
8   end
9   foreach s ∈ φ_s do
10      if isValid(s) then
11          φ_a ← {s} ∪ φ_a;
12      end
13  end
```

End Function

Properties of Inference

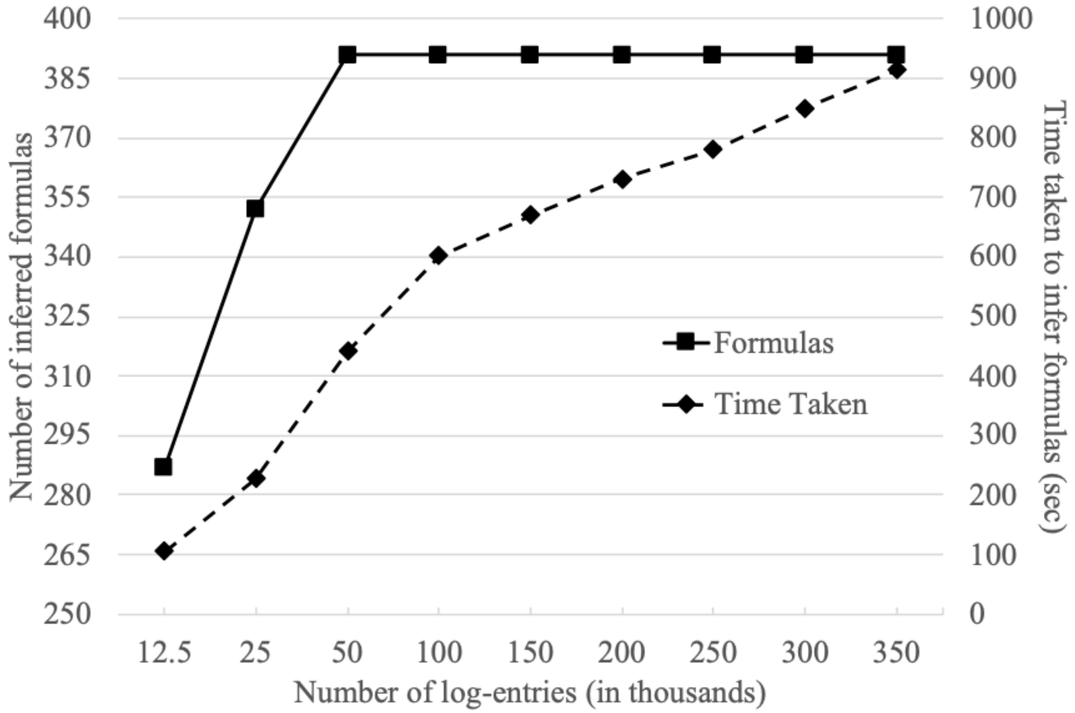
- Monotonicity
  - For a fixed set of relations, adding more entries to a log with an inferred policy results in a more or equally permissive policy.
- Termination
  - Each iteration of the algorithm terminates.
- Soundness
  - The log from which our algorithm infers a policy satisfies the inferred policy.
- Minimality
  - The policy inferred by our algorithm is the most restrictive policy (that can be inferred by our algorithm) that the log satisfies.

Prototype Evaluation

- Implemented the algorithm in Python
  - Log is a table in the database along with the different attributes of data
  - Assumes only one resource is accessed per entry
  - Fixed attributes and relationships between data and principals
  - Employ human oracle for validation
- Generate simulated logs for healthcare organization
  - Based on HIPAA (prior work by Garg et al. [CCS ’11])

Prototype Evaluation

- Time taken and the number of formulas inferred for different no. of log entries



Summary - Automating Audit with Policy Inference

- Infer policies from logs and audit policies
  - Reduce number of entries to audit
  - Reuse policies for enforcement