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Towards Automated Learning of Access Control Policies Enforced by Web Applications

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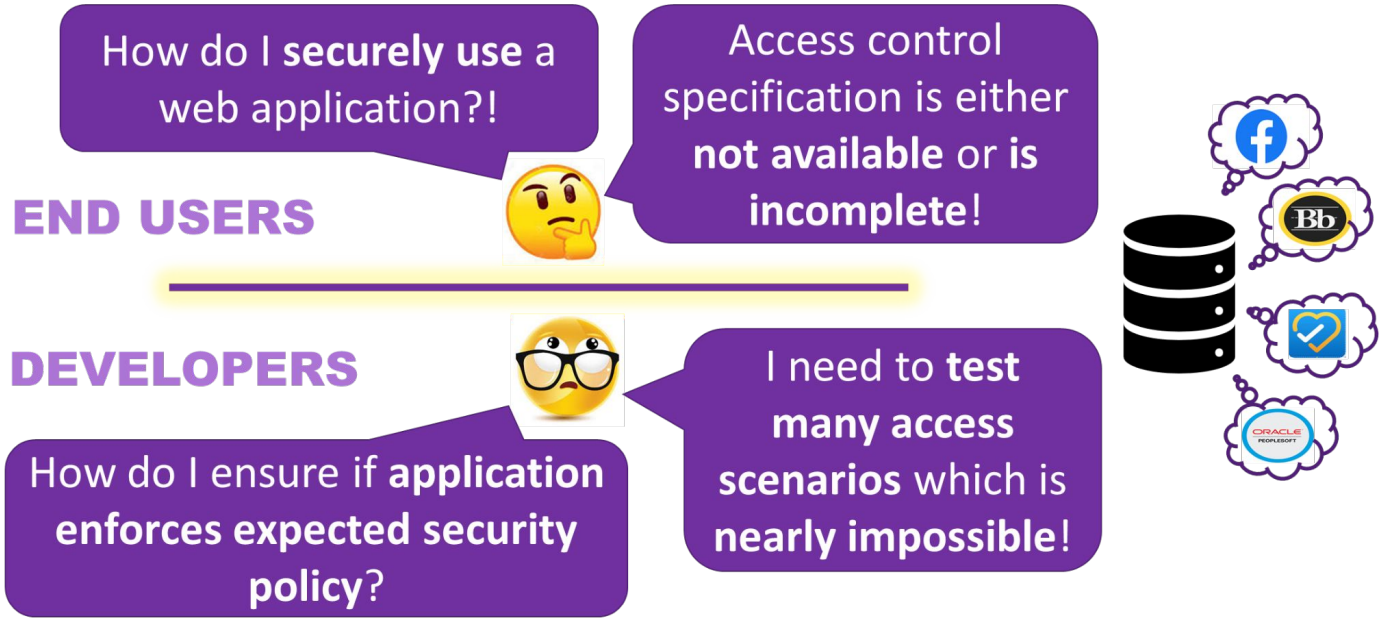
Have you ever been overwhelmed with…



Our strategy to tackle such security/privacy concerns:

- Systematically infer access control policies enforced in web applications
- Inferred access control policies can be utilized by:
  - End users for understanding application's security behavior
  - Developers for validating implementation vs. specification

Previous works have …

- Focused on developing efficient algorithms for mining correct and concise access control policies
- Considered abstract systems with availability of inputs – low-level authorizations & application's data model

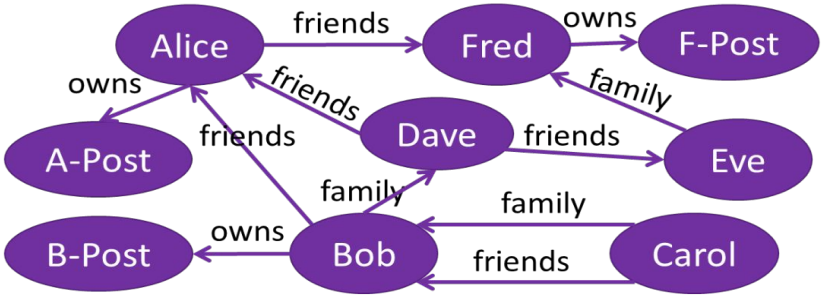
Relationship-Based Access Control Policy Mining

Low-level authorizations: Which user can access what resource

User	Resource	Decision
Alice	F-Post	Permit
Bob	A-Post	Permit
Carol	B-Post	Permit
Dave	F-Post	Deny
Eve	B-Post	Deny

+

Application's data model: System graph connecting users and resources



Policy Miner Algorithm →

- ✓ Users can access their own posts
- ✓ Users can access posts owned by their friends

Access Control Policy

High-level rules based on relationships between users and resources

Motivation

- Policy mining must be applicable to real-world systems
- Two inputs to mining process not readily available in real systems
- Need to infer the two mining inputs themselves

Challenges with concretizing policy mining

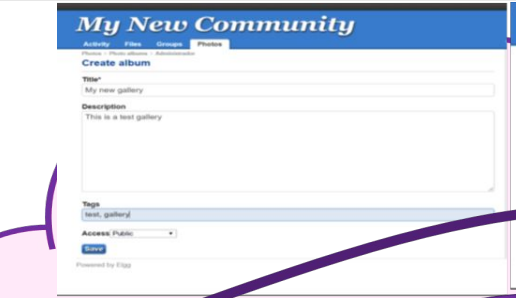
- Many real-world applications handle large amount and variety of data objects
  - *e.g., social networks support posts, comments, likes, and various content types like image and video*
- Different types of data objects may have different applicable policies
  - *Friends can see and comment on my posts*
  - *Friends of friends can only see my posts if they are also colleagues*

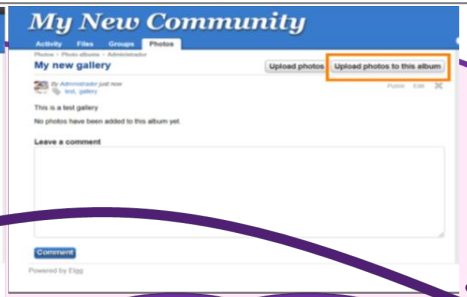
Contributions

- Inferring data model and low-level authorizations
  - Automating and observing user interactions with a web application
- Black-box view of application lets us observe its access control behavior as a whole
  - Helps overcome application's design complexities

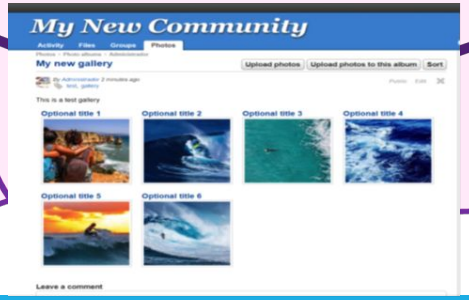
Our black-box inference strategy

By **observing client-server communications**, we can **identify information** about application users/resources…

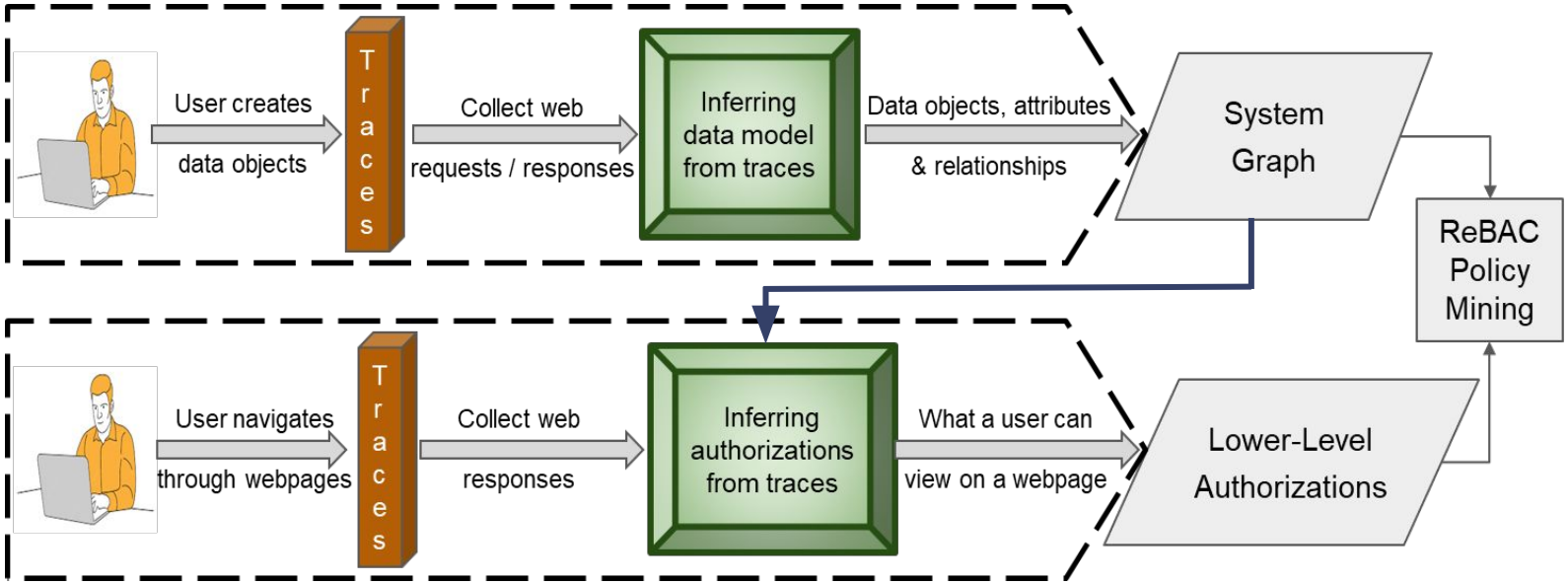




Client creates a photo album and server responds with page containing album's details



Applying ReBAC Mining to Infer Policies from Web Applications



Two-fold approach

Infer application's data model

Infer low-level authorizations using inferred data model

Two-fold approach - Infer Data Model

Infer application's data model

Identify object properties from client-server interactions

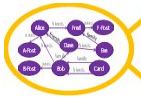
Cluster identified properties to prune spurious properties

Infer object relations using their distinguishing properties

Prune redundant object relationships using heuristics

Infer low-level authorizations using inferred data model

Two-fold approach - Infer Authorizations



Infer application's data model

Infer low-level authorizations using inferred data model

- Identify inferred data objects present in client-server interactions
- User permitted to view data model object & its properties if (s)he can view that object on any page of application; otherwise denied

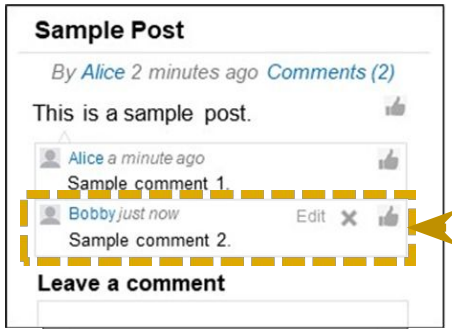
Inferring authorizations is not trivial!

A major challenge being Object-Reidentification!

- That is, how to correlate data elements viewed on a web page to data objects in inferred data model
- No abstract notion as data object; data objects usually characterized in terms of its corresponding attributes

Reidentifying Objects from Inferred Data Model

- Utilize unique properties of data objects to identify corresponding web page data with all those properties

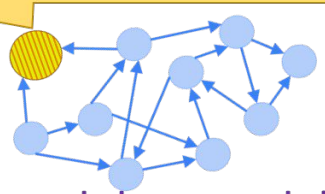


Carol views page corresponding to Alice's post

Re-identifying inferred data objects in page content viewed by Carol

Highlighted data object corresponds to second comment on current page

Inferred comment-object attributes:
Text = Sample comment 2.
Edit-URL = http://localhost/comment/edit/151
…



Inferred data model

Output Format

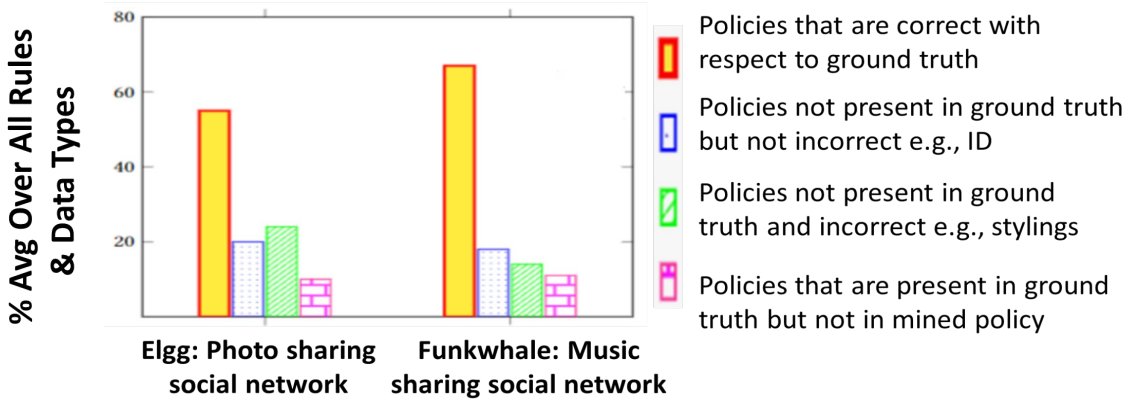
Object-Level Policy: Authorizations specified on data objects like posts and comments

- *e.g., users can access their own and their friends' posts*

Attribute-Level Policy: Authorizations specified on attributes of data objects like date-time, location, title

- *e.g., only users who own a post can see its location*

Experimental observations for mined attribute-level rules



- Ground truth based on what different users can see on their interfaces
- Able to mine most attribute-level policies in both applications
  - Failed in cases such as dates shown as “2 days ago” instead of absolute values
- Also mined policies for hidden attributes used by application to describe a data object
  - e.g., object-id present in the raw HTML to reference a post or a comment

Observations for mined attribute-level rules based on relationship patterns and data types

Application	Rule	Data Type	Mined	Ground-Truth (visible atts.)	$\|\Updownarrow\|$	$\|\Uparrow\|$	$\|\nearrow\|$	$\|\Downarrow\|$
Elgg	$[p]$	Post	27	19	16	6	5	3
	$[f, p]$	Post	23	15	12	6	5	3
	$[p, -b]$	Comment	20	12	11	3	6	1
	$[c]$	Comment	24	16	15	3	6	1
	$[f, p, -b] \wedge [f, c]$	Comment	20	12	11	3	6	1
Funkwhale	$[o, -i]$	Audio file	35	28	24	6	5	4
	$[w, -i]$	Audio file	29	23	20	6	3	3

Meaning of Relationships in Rules: b=belongs-to-post, c=owns-comment, f =friends-with, i=in-library, o=owns-library, p=owns-post, w=follows-library

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Mined object-level rules

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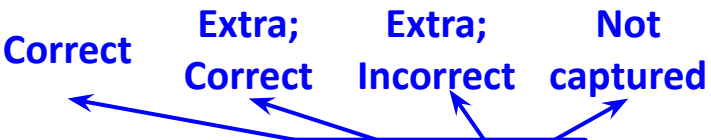

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Observations for mined attribute-level rules based on relationship patterns and data types

Visible attributes of certain data object type to users satisfying the given object-level rule

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Conclusion and Future Work

- Concretizing ReBAC mining to web applications
- Inferring data model and low-level authorizations by observing client-server interactions
- Experimented on two applications to show feasibility
- Future plans include:
  - Investigating further automation of trace generation
  - Experimenting on wider set of real-world applications