Formal Analysis of ReBAC Policy Mining Feasibility

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Access Control

Can we access resource?

Legitimate users get legitimate access only i.e., Role-Based Access Control (RBAC), Attribute-Based Access Control (ABAC)
ReBAC ≡ Relationship-Based Access Control

- ReBAC expresses authorization in terms of various direct and indirect relationships amongst entities, most commonly between users
  - Access conditions are usually based on type, depth, or strength of relationships

Assumption

- Relationship Graph (RG) where users(node) are connected(edge) by social relationships(edge label). Each edge in the RG is labeled with a relation type
  - Only user-to-user relationships are considered
Problem: migration from an existing access control model to another one

New access control

Switch to existing better one

Organization size changes

Changing mode of operation

Manual effort often error-prone, time consuming and costly

Is automation possible?
Policy Mining Cont.

Access Control List / Log / RBAC + Supporting attribute data $\rightarrow$ ABAC policy mining

Access Control List + Supporting Relationship data $\rightarrow$ ReBAC policy mining

Given an access control system + Supporting data $\rightarrow$ Another access control model

Mining is partially automated so far...
The feasibility analysis of the ReBAC policy mining problem studies whether the migration process from a given authorization set to ReBAC policy is feasible or not under the set of imposed criteria:

- Relationship Graph (RG) is given
- ReBAC rule structure is given
- Use of entity ID is not allowed
  - Existing literature allows ID
- Equivalent set of ReBAC rules are required

- Solution is guaranteed even if inconsistency arises
  - Infeasibility problem
Contributions

- Feasibility analysis on ReBAC policy mining for the first time
- Developing feasibility analysis algorithms for the given set of criteria with complexity analysis
  - Variety of ReBAC rule structures are considered
- In case of infeasibility, solution algorithms are presented to make it feasible under given criteria
  - Varieties available
- Demonstrate the generated algorithms with cases and show the effectiveness beyond complexity analysis
- Future scopes
ReBAC Rule Structure

\[
\begin{align*}
\text{Rule}_{op} &: \equiv \text{Rule}_{op} \lor \text{Rule}_{op} \mid \text{pathRuleExpr} \\
\text{pathRuleExpr} &: \equiv \text{pathRuleExpr} \land \\
& \quad \text{pathRuleExpr} \mid \text{pathLabelExpr} \\
\text{pathLabelExpr} &: \equiv \text{pathLabelExpr}.\text{pathLabelExpr} \mid \text{edgeLabel} \\
\text{edgeLabel} &: \equiv \sigma, \sigma \in \Sigma
\end{align*}
\]

- Evaluation of access request (a, b, op)
  - for each pathLabelExpr in \( \text{Rule}_{op} \) substitute True if there exists a simple path \( p \) from \( a \) to \( b \) in RG with path label pathLabelExpr, otherwise substitute False
  - the resulting boolean expression evaluates true \( \rightarrow \) grant, deny otherwise

RREP(ReBAC Ruleset Existence Problem)-0
Feasibility Detection

Input:
- Authorizations
- RG
- ReBAC rule structure

RG is directed

Feasibility detection Algorithm

Output:
- Feasible / Infeasible Status

Failed authorization list is returned

Complexity !!
RG Example

Feasible

- (Bob, Cathy, op)
- (Ray, Cathy, op)

Rule\textsubscript{op} = F

Infeasible

i) (Bob, Cathy, op)
ii) (Cathy, Ray, op)
Solution 1

Infeasible

i) (Bob, Cathy, op)
ii) (Cathy, Ray, op)

Rule_{op} = op
Solution 1

Infeasible

i) (Bob, Cathy, op)
ii) (Cathy, Ray, op)

Rule_{op} = op

Simple

Operation ∩ Relationship types={}

Minimal edges not guaranteed

|Authorization| edges at worst!
Path Variations

- Simple Path (SP)
- Simple Complementary Path (SCP)
- Simple Permissive Path (SPP)
- Simple Complementary Permissive Path (SCPP)

Table represents path variations with original, non-relationship, inverse and non-relationship inverse edges (row 1, 2, 3, and 4, respectively).

- $a,b$: users, $E$ and $\Sigma$ are the sets of edges and relationship type specifiers
Path Variations Cont.

Original edge (i)

Alice \rightarrow Bob \rightarrow Cathy

Inverse edge (ii)

Ray \rightarrow Cathy \rightarrow Ray
Path Variations Cont.

Non-relationship edge (iii) Non-relationship inverse edge (iv)
Rule minimization techniques are described in the paper.

RREP Variations

- RREP-0 → SP (i)
- RREP-1 → SCP (i + iii)
- RREP-2 → SPP (i + ii)
- RREP-3 → SCPP (i + ii + iii + iv)
Future Enhancement

- Complexity
- Inexact solution
- More path variations
- Cope up with changes in rule structures!
- Other infeasibility solutions
- Extend beyond user-user context

!! Just the beginning !!
Acknowledgement

- This work is partially supported by NSF CREST Grant HRD-1736209

- Question/ Feedback