Formal Analysis of ReBAC Policy Mining Feasibility

Shuvra Chakraborty and Ravi Sandhu

Dept. of Computer Science
Institute for Cyber Security
University of Texas at San Antonio, TX 78249, USA

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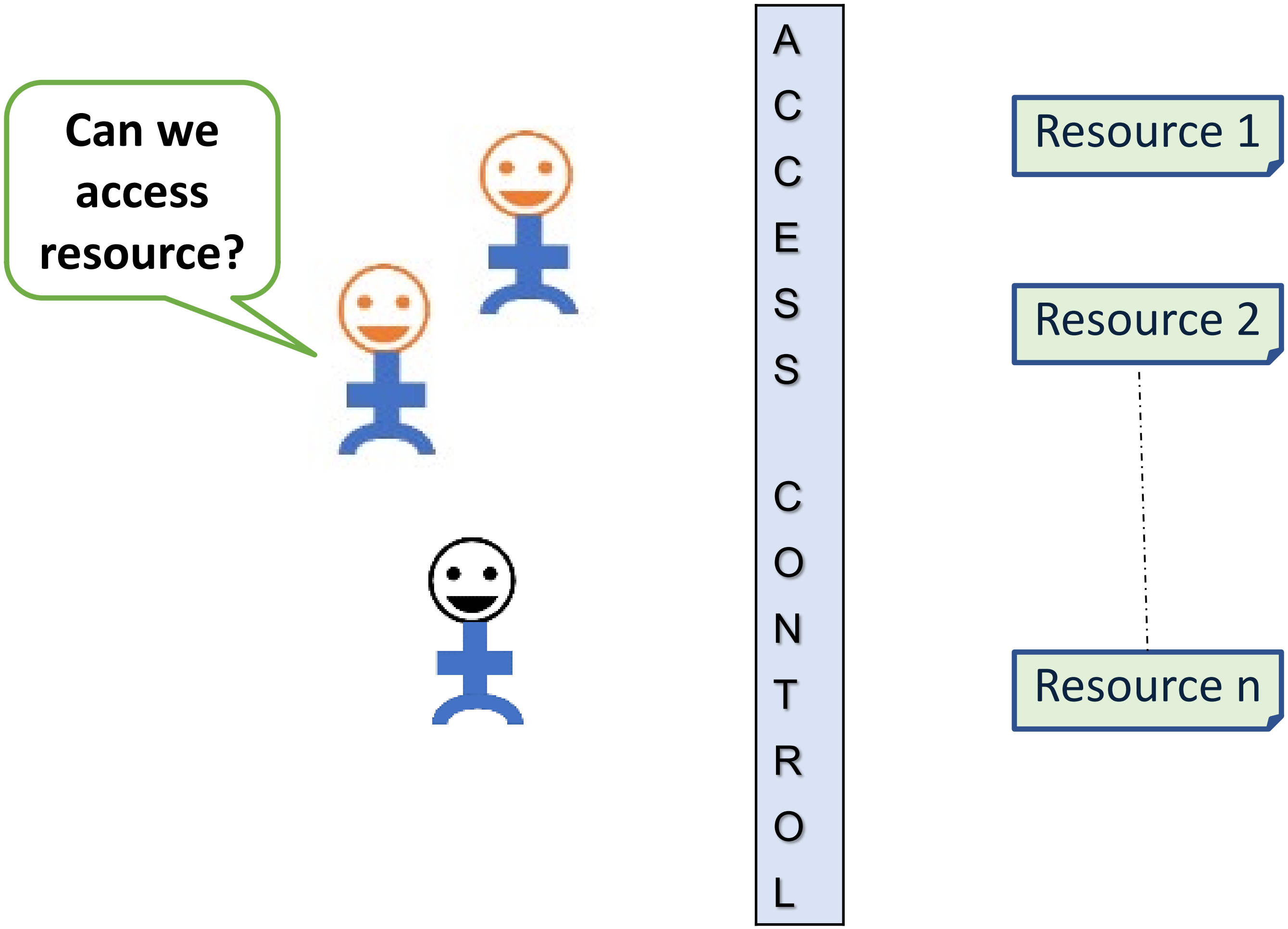
Access Control



Legitimate users get legitimate access only

i.e., Role-Based Access Control (RBAC), Attribute-Based Access Control (ABAC)

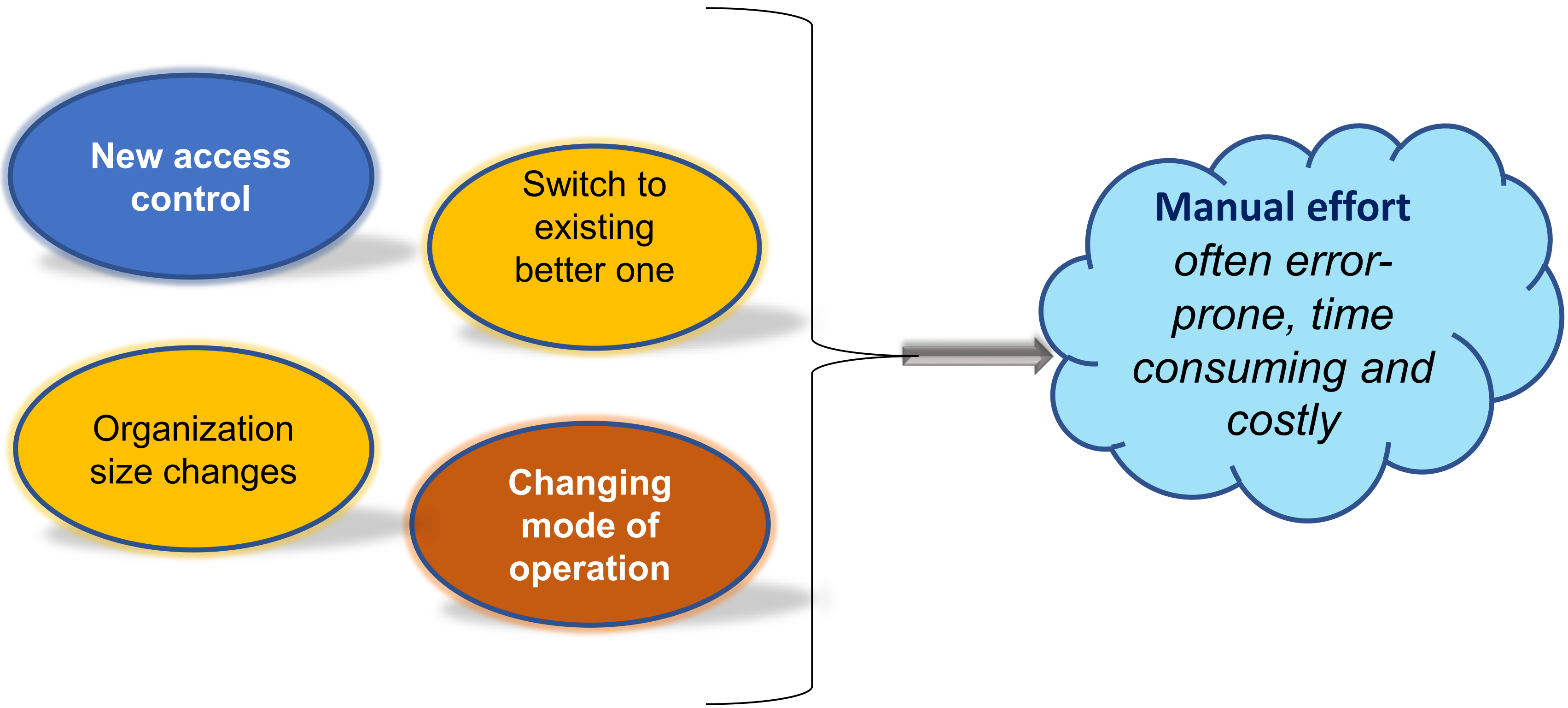
ReBAC

- *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

Policy Mining

- **Problem:** migration from an existing access control model to another one



Is automation possible?

Policy Mining Cont.

Access Control List / Log / RBAC + Supporting attribute data → ABAC policy mining

Access Control List + Supporting Relationship data → ReBAC policy mining

Given an access control system + Supporting data → Another access control model

Mining is partially automated so far…

Problem Statement

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
- <u>Use of entity ID is not allowed</u>
  - <u>Existing literature allows ID</u>
- Equivalent set of ReBAC rules are required

- <u>Solution is guaranteed even if inconsistency arises</u>
  - <u>Infeasibility problem</u>

Contributions

- Feasibility analysis on ReBAC policy mining for the <u>first time</u>
- 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

$$Rule_{op} ::= Rule_{op} \vee Rule_{op} \mid pathRuleExpr$$
$$pathRuleExpr ::= pathRuleExpr \wedge pathRuleExpr \mid pathLabelExpr$$
$$pathLabelExpr ::= pathLabelExpr.pathLabelExpr \mid edgeLabel$$
$$edgeLabel ::= \sigma, \sigma \in \Sigma$$

- Evaluation of access request (a, b, op)
  - for each pathLabelExpr in $Rule_{op}$ 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 evalutes true → grant, deny otherwise

Feasibility Detection

Input:
Authorizations
RG
ReBAC rule structure

RG is directed

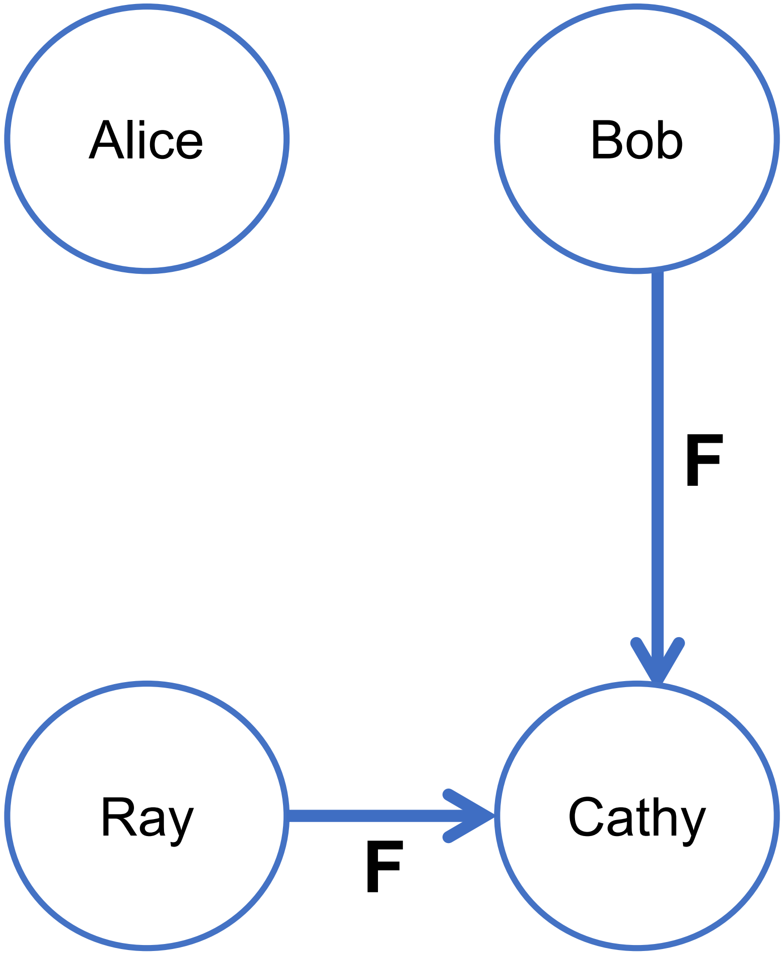
Feasibility detection Algorithm

Complexity !!

Output:
Feasible / Infeasible Status

Failed authorization list is returned

RG Example



Feasible

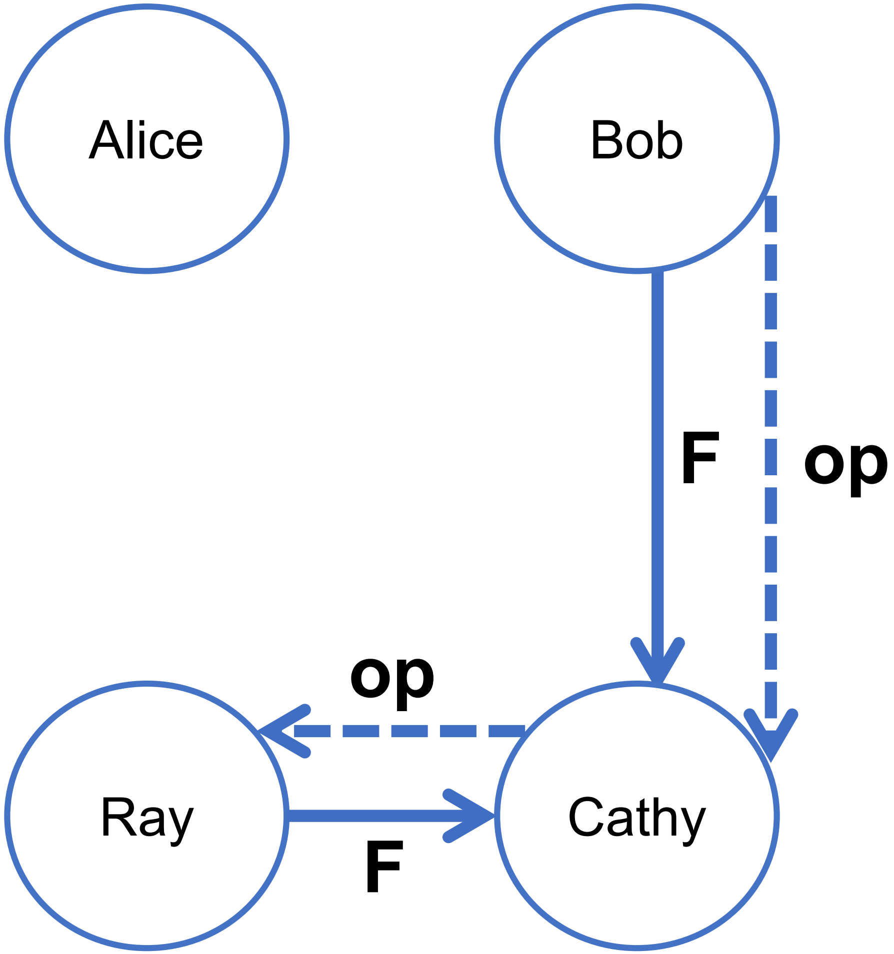
(Bob, Cathy, op)
(Ray, Cathy, op)

$Rule_{op}$ = F

Infeasible

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

Solution 1

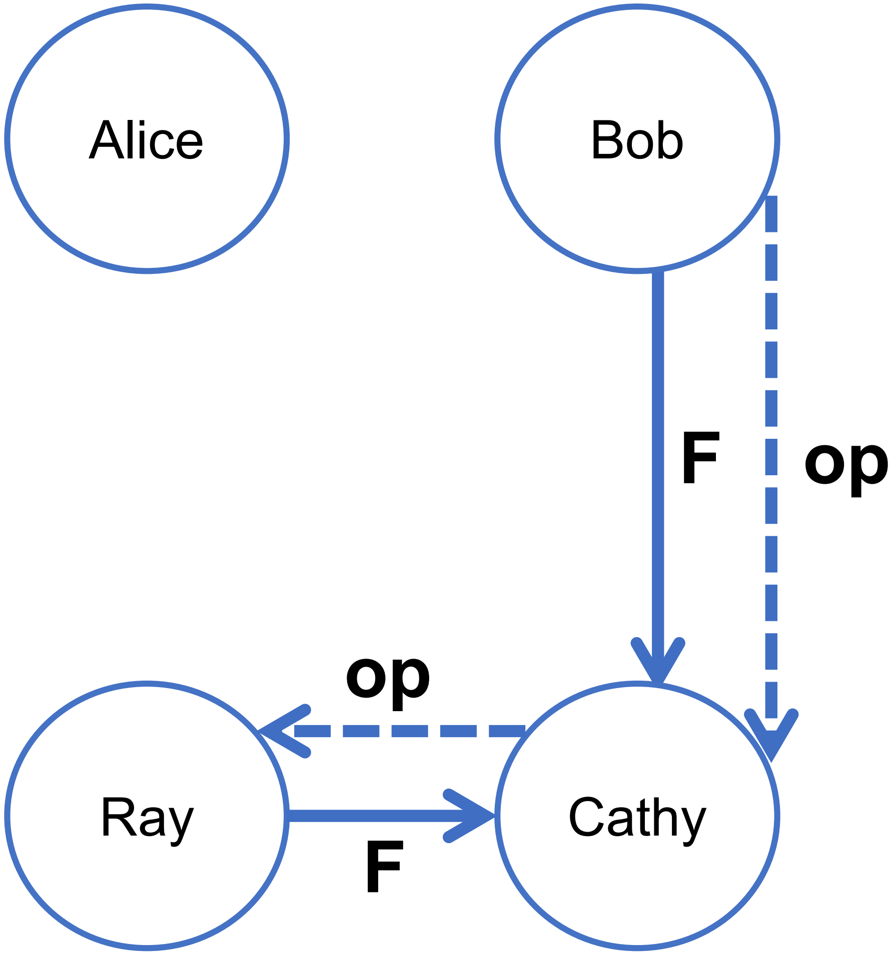


Infeasible

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)

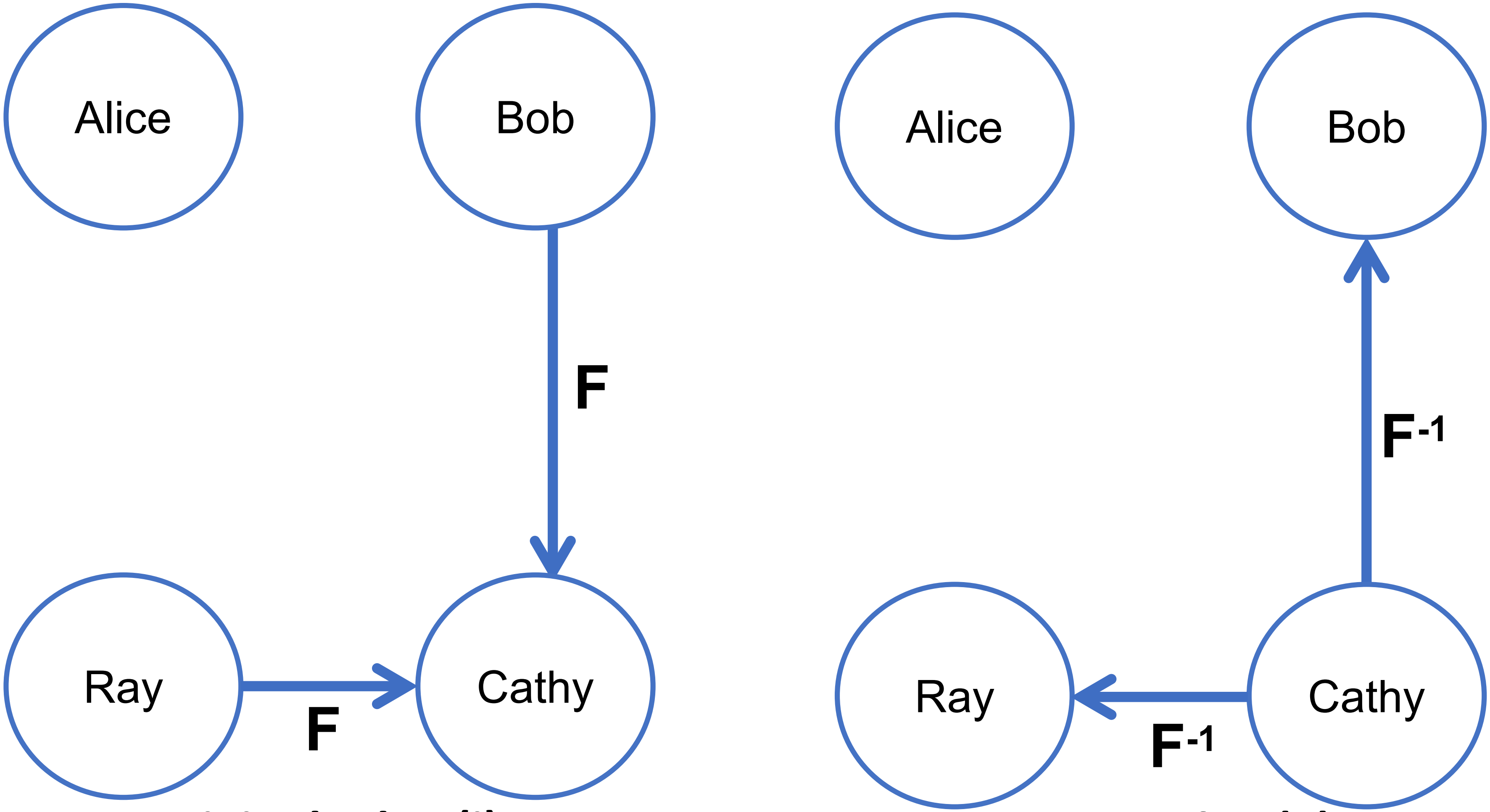
Simple Complementary Permissive Path (SCPP)

Characteristics	SCP	SPP	SCPP
$(a, b, \sigma) \rightarrow (a, b, \sigma) \in E, \sigma \in \Sigma$	✓	✓	✓
$(a, b, \overline{\sigma}) \rightarrow (a, b, \sigma) \notin E, \overline{\sigma} \in \overline{\Sigma}$	✓		✓
$(a, b, \sigma^{-1}) \rightarrow (b, a, \sigma) \in E, \sigma^{-1} \in \Sigma^{-1}$		✓	✓
$(a, b, \overline{\sigma}^{-1}) \rightarrow (b, a, \sigma) \notin E, \overline{\sigma}^{-1} \in \overline{\Sigma}^{-1}$			✓

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 ∑ are the sets of edges and relationship type specifiers

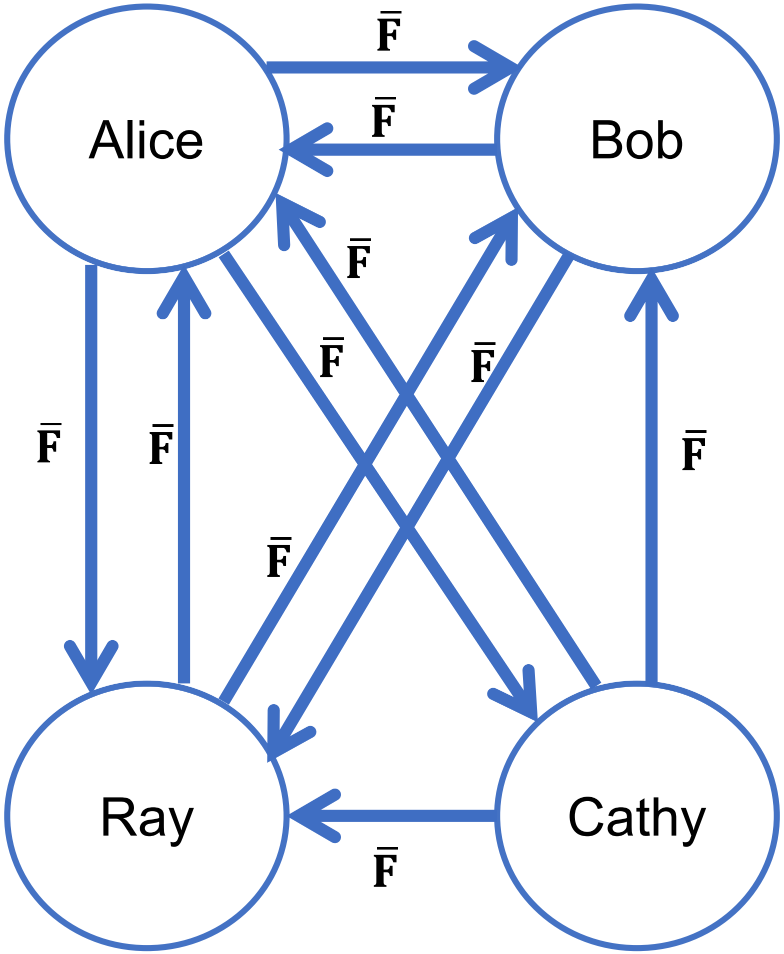
Path Variations Cont.



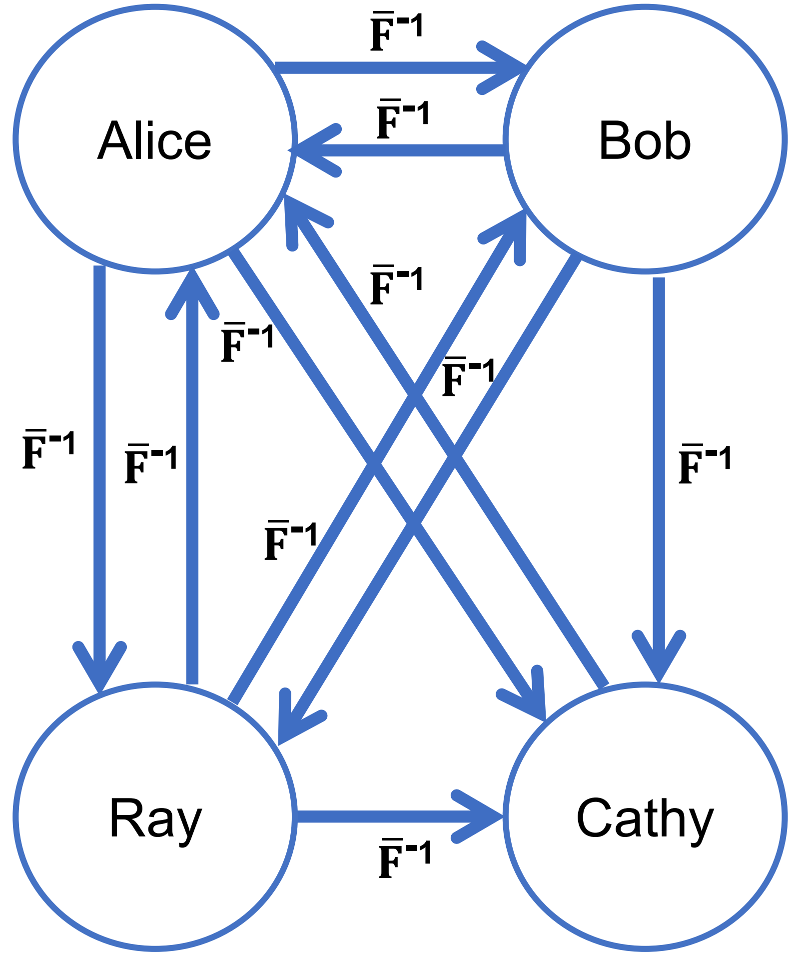
Original edge (i)

Inverse edge (ii)

Path Variations Cont.



Non-relationship edge (iii)



Non-relationship inverse edge (iv)

RREP Variations

RREP-0 → SP (i)

RREP-1 → SCP (i + iii)

RREP-2 → SPP (i + ii)

RREP-3 → SCPP (i + ii + iii + iv)

Rule minimization techniques are described in the paper

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

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❖ Question/ Feedback