On the Definition of Role Mining

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link to the paper

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What is role mining?
How should this problem be defined?

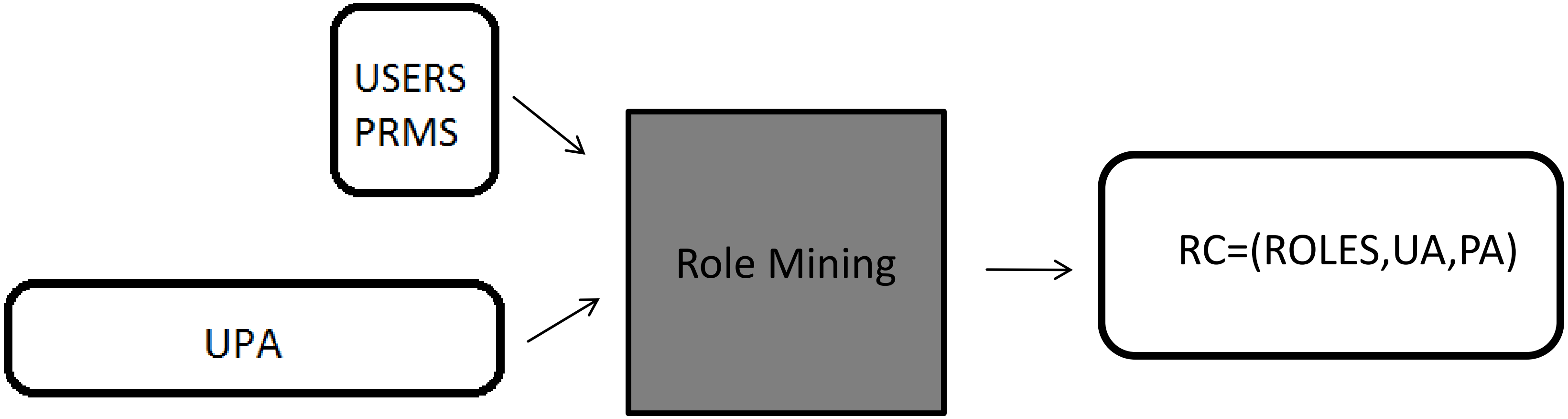
Also:

- How should it be solved?
- How should solutions be evaluated?

Strategy:

- Start with clear parts such as input/output.
- Look at basic requirements for RBAC.
- Define problem such that solutions meet requirements.

Input / Output



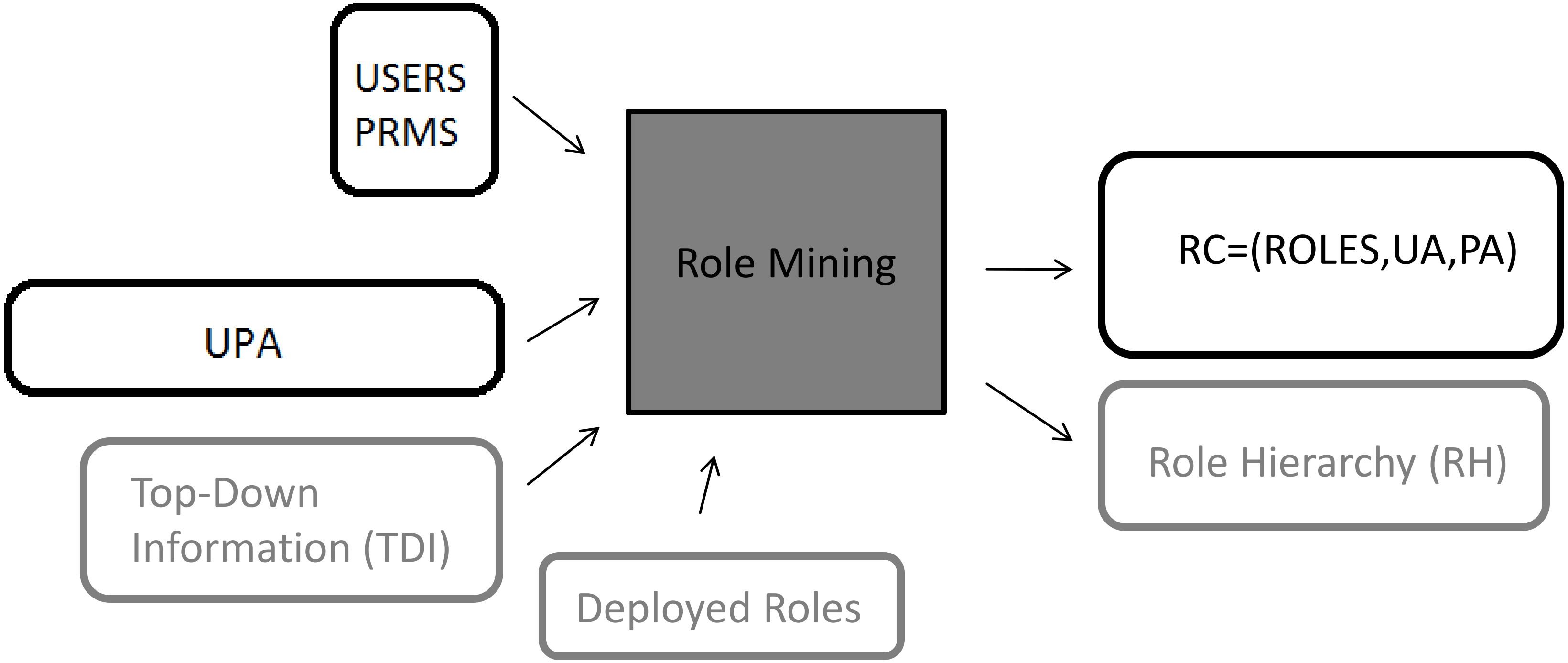
USERS
PRMS

UPA

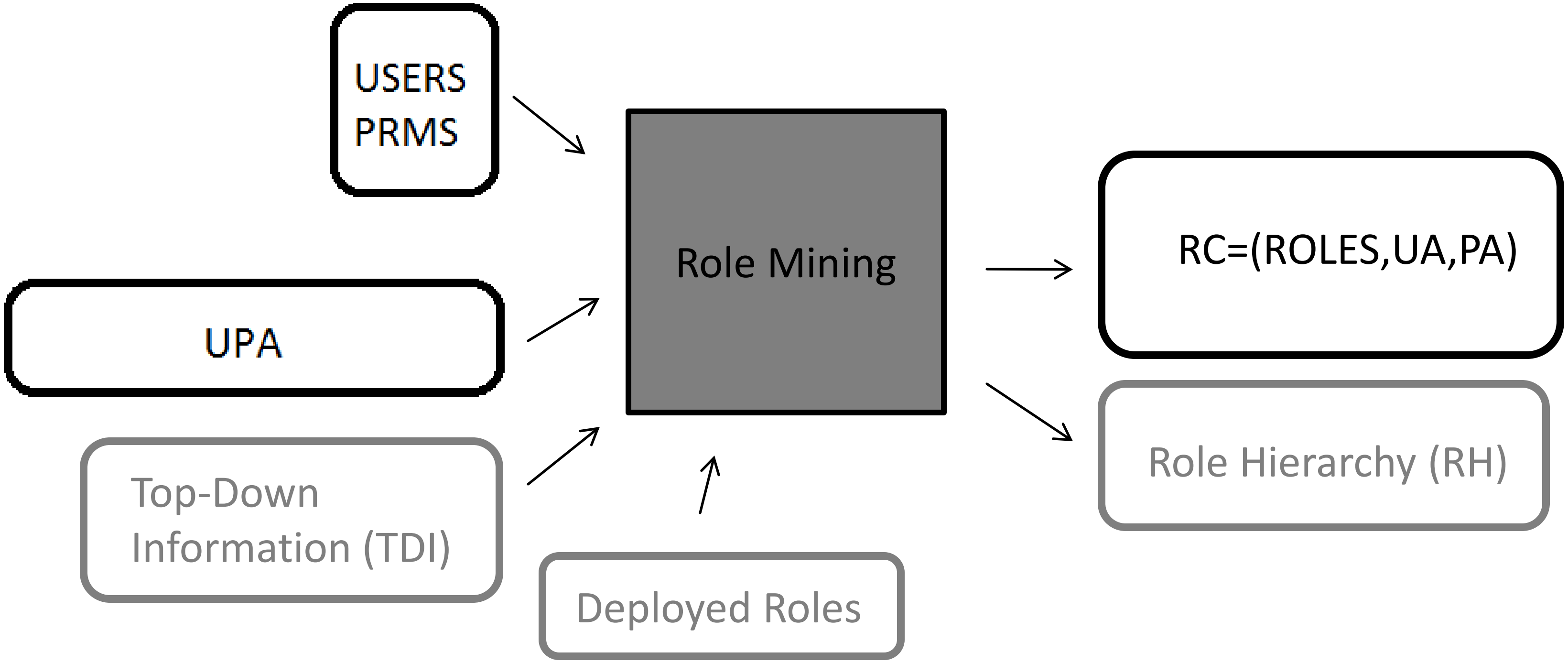
Role Mining

RC=(ROLES,UA,PA)

Input / Output



Input / Output



USERS
PRMS

UPA

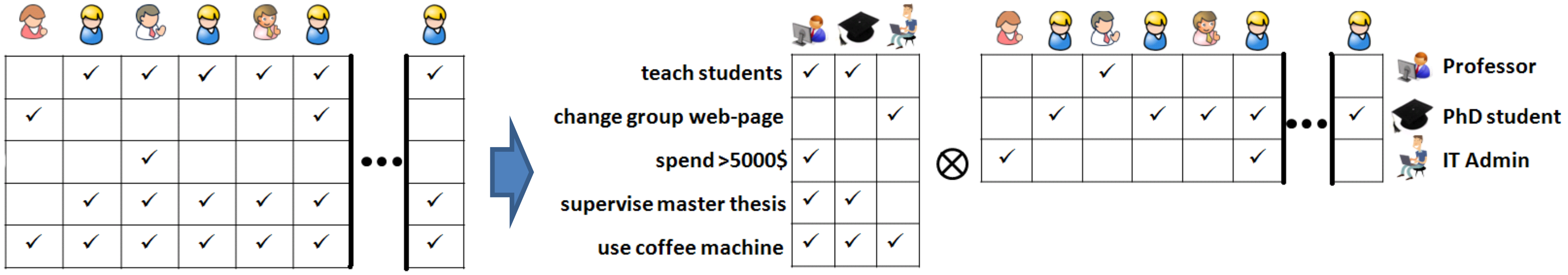
Top-Down Information (TDI)

Deployed Roles

Role Mining

RC=(ROLES,UA,PA)

Role Hierarchy (RH)



						•••	
	✓	✓	✓	✓	✓		✓
✓					✓		
		✓				•••	
	✓	✓	✓	✓	✓		✓
✓	✓	✓	✓	✓	✓		✓

Direct user-permission assignment

teach students	✓	✓	
change group web-page			✓
spend >5000$	✓		
supervise master thesis	✓	✓	
use coffee machine	✓	✓	✓

role-permission assignment

⊗

Professor			✓					
PhD student		✓		✓	✓	✓	•••	✓
IT Admin	✓					✓		

user-role assignment

What is required from an RBAC configuration?

Candidates:

- **Perfect** match with original assignment UPA (``0-consistency“)
- **Best possible** match with UPA.
- The ``smaller“ the configuration the better (**best compression**).
    - Number of roles
    - Number of assignments
    - Number of exceptions
    - Linear combination of size measures
- No transfer of **errors** from UPA to RBAC (violates perfect match)
- …

Hard to decide which ones to take since all very technical.
Our understanding of the requirements are more high-level.

What is required from an RBAC configuration?

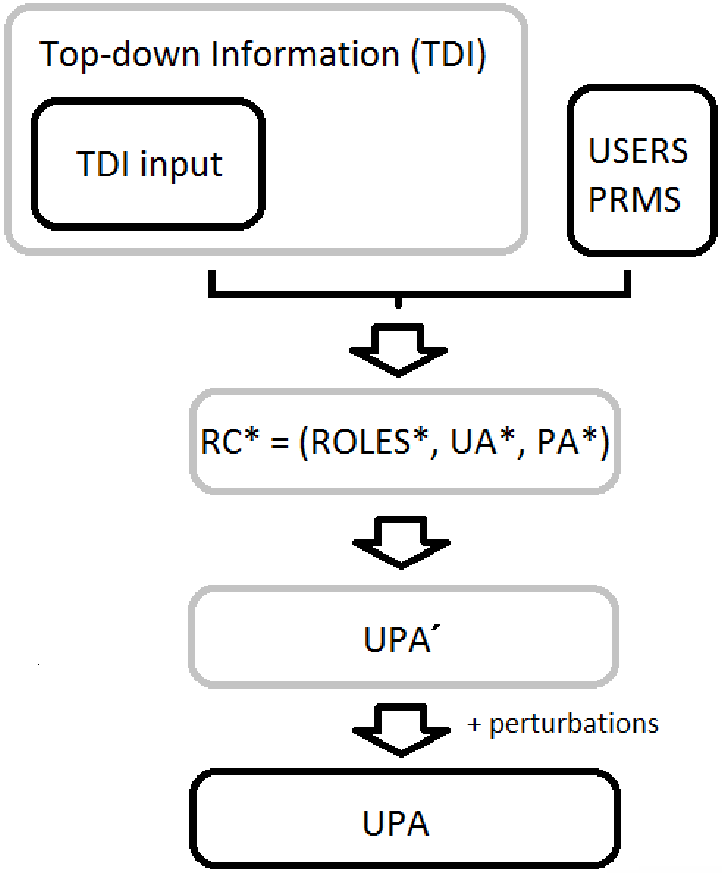
Most important requirements from an enterprises perspective:

- **Provisioning**
  Users are enabled to carry out their tasks.

- **Security**
  Configuration conforms to the enterprise security policies.

- **Maintainability**
  Administration of the system is as easy as possible:
  - understandable roles
  - easy to add users (roles generalize well)

What do we actually get as an input?

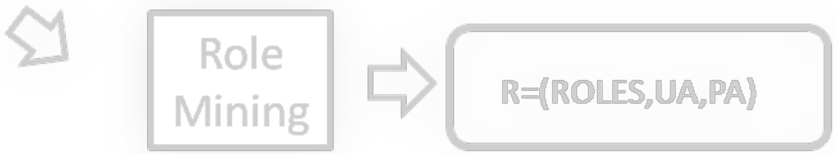


Black boxes: observed entities
Gray boxes: hidden entities

Legend
RC*: hidden role configuration/struture underlying UPA
UPA‘: direct assignment generated from RC*
UPA: UPA‘ perturbed by exceptions/errors (``noise‘‘)
TDI: any information that possibly influenced UPA

Assumptions

1. A hidden structure **RC* underlies UPA**
2. **RC* reflects top-down information** (parts of which are possibly given as additional role mining input).
3. **Exceptions** (errors) might **exist**.



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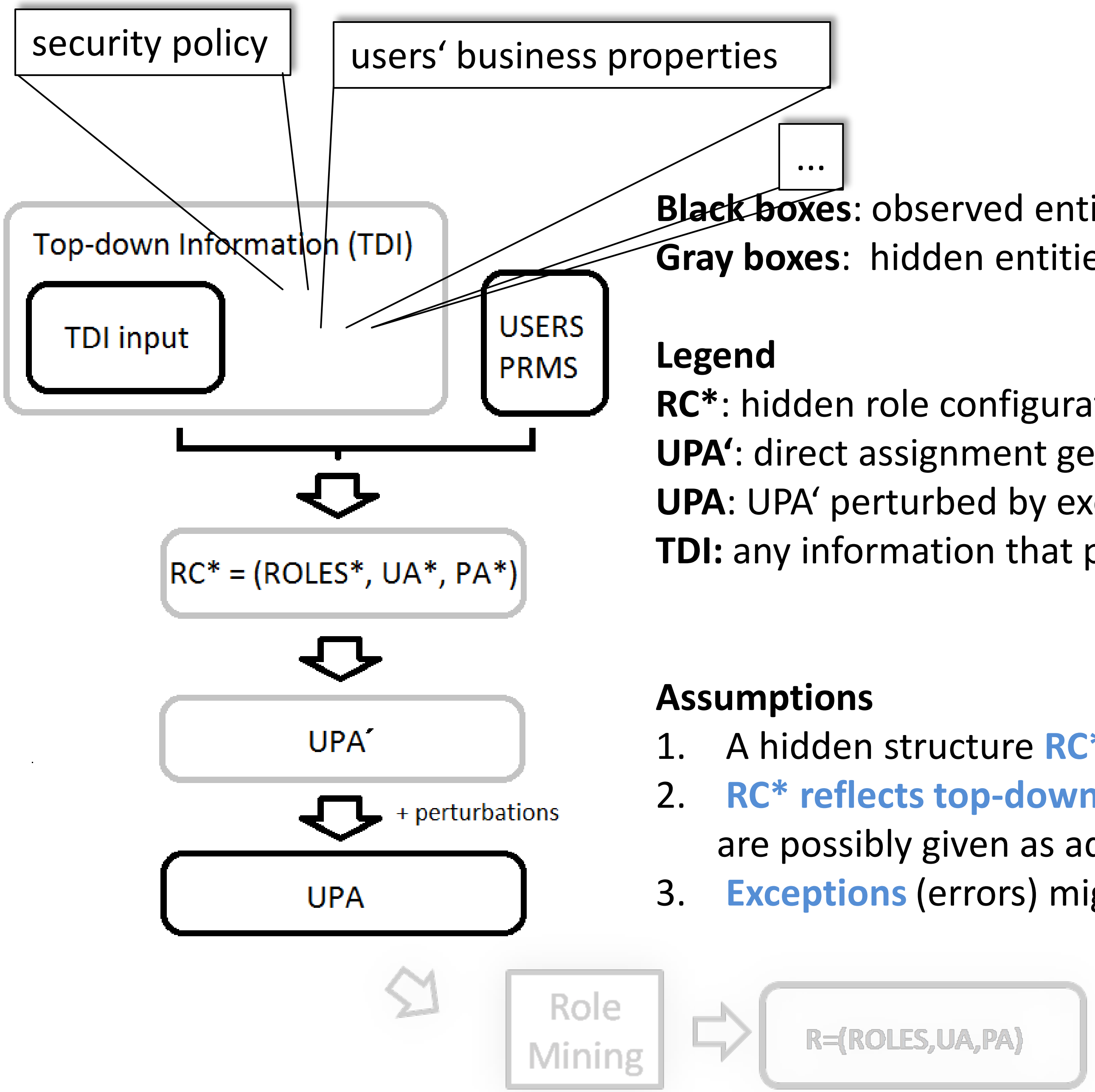

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Legend

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UPA': direct assignment generated from RC*

UPA: UPA' perturbed by exceptions/errors (``noise'')

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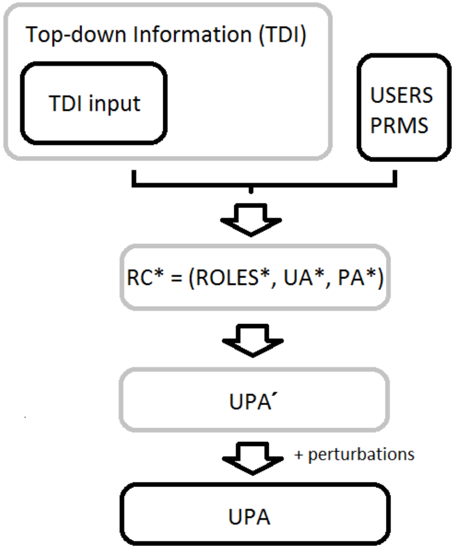
Definition

Definition **INFERENCE RMP**:
Let a set of users USERS, a set of permissions PRMS, a user-permission relation UPA, and, optionally, part of the top-down information TDI be given. Under Assumption 1-3, infer the unknown RBAC configuration RC*=(ROLES*, UA*, PA*).

Assumptions (from last slide):

1. Structure **R* is hidden in UPA**
2. **R* reflects top-down information** (TDI).
3. **Exceptions** (errors) might **exist**.



Why is this a good definition?

Rationale:
The solution fulfills the real-world requirements.

- Input data UPA is generated from underlying RC* (modulo exceptions)
- RC* reflects security policies and business properties of the enterprise

⇨ RC* is configuration that

- fulfills **provisioning** requirement
- **conforms to** the enterprises **security policies**
- is **intuitive**

Solving the problem and assessing solutions

Pointer to some ways of solving and evaluating that problem.

Solving:

- Difficult!

- Use your own method of choice to attack this problem.

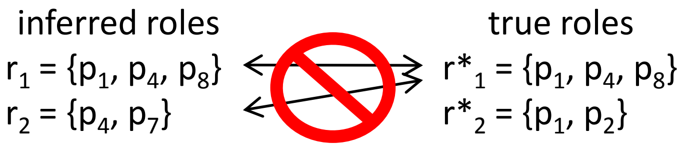
- E.g., we used a probabilistic approach [1,2,3]:
  RC* is the most probable configuration under an
  appropriate model ⇨ RM as a **modeling problem**

[1] A. P. Streich, M. Frank, D. Basin, and J. M. Buhmann. Multi-assignment clustering for Boolean data. ICML '09
[2] M. Frank, A. P. Streich, D. Basin, and J. M. Buhmann. A probabilistic approach to hybrid role mining. CCS '09
[3] M. Frank, D. Basin, and J. M. Buhmann. A class of probabilistic models for role engineering. In CCS '08

Solving the problem and assessing solutions

Assessing:

- easy when RC* is known (artificially created data UPA)
  - avoid repeated comparison! Can give very good scores to trivial solutions.



inferred roles

$r_1 = \{p_1, p_4, p_8\}$

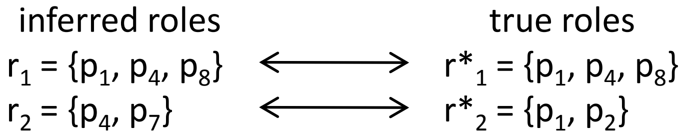
$r_2 = \{p_4, p_7\}$

true roles

$r^*_1 = \{p_1, p_4, p_8\}$

$r^*_2 = \{p_1, p_2\}$

  - find the **global** permutation of roles that minimizes the deviation (can be found via Hungarian method).



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method is demonstrated in [1]

[1] A. P. Streich, M. Frank, D. Basin, and J. M. Buhmann. Multi-assignment clustering for Boolean data. ICML '09

Unknown RC*: Generalization Test

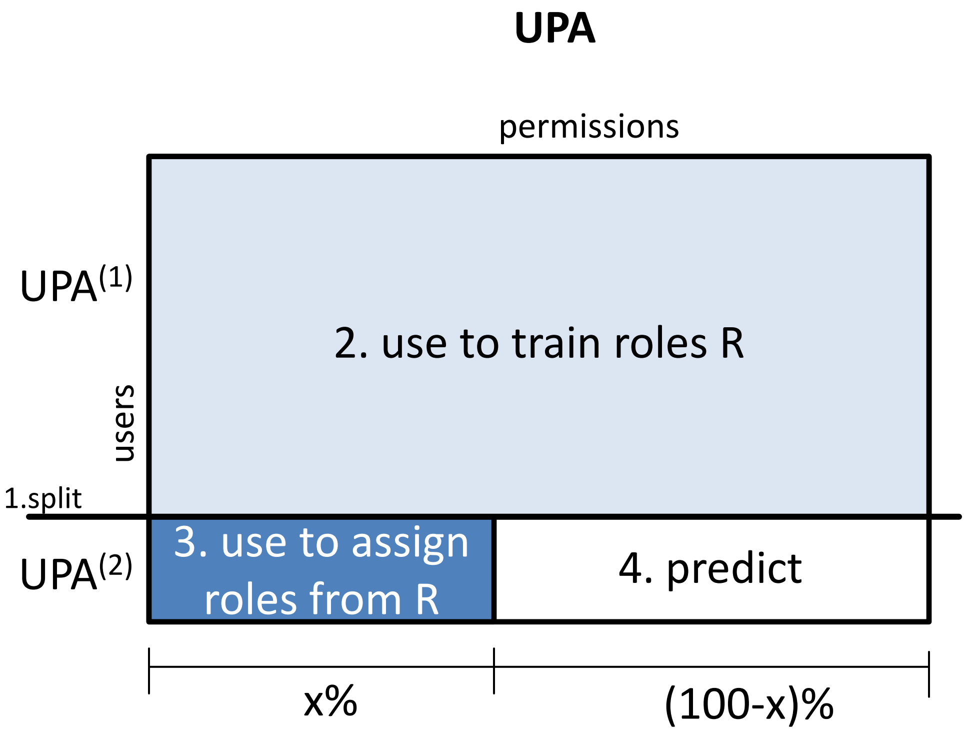
It is still possible to evaluate solutions!
Exploit that undelying structure RC* reproduces over the users, whereas the noise does not.

Generalization test:

1. randomly split UPA in UPA(1) and UPA(2)
2. train roles R on UPA(1)
3. assign users from UPA(2) to roles based on x% of their permissions
4. predict remaining (100-x)% of permissions
5. compute prediction error

The closer solution is to RC* the better is the prediction error.

See [1] for such an evaluation.



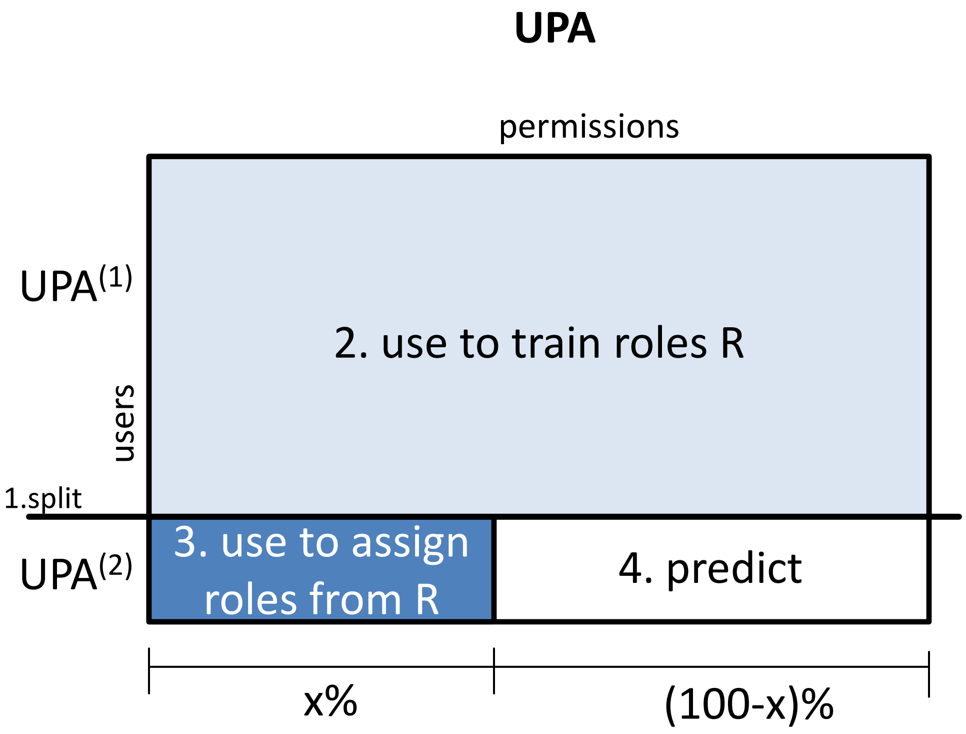
[1] A. P. Streich, M. Frank, D. Basin, and J. M. Buhmann. Multi-assignment clustering for Boolean data. ICML '09

Unknown RC*: Generalization Test with TDI

When top-down information is available it should be included in the assessment of the found RBAC states.

Generalization test (when TDI is given):

1. randomly split UPA in UPA$^{(1)}$ and UPA$^{(2)}$ and split TDI in TDI$^{(1)}$ and TDI$^{(2)}$
2. train roles R on UPA$^{(1)}$ and TDI$^{(1)}$
3. assign users from UPA$^{(2)}$ to roles based on x% of their permissions and their top-down properties
4. predict remaining (100-x)% of permissions
5. compute prediction error



See [2] for such an evaluation.

[1] A. P. Streich, M. Frank, D. Basin, and J. M. Buhmann. Multi-assignment clustering for Boolean data. ICML '09

[2] M. Frank, A. P. Streich, D. Basin, and J. M. Buhmann. A probabilistic approach to hybrid role mining. CCS '09

Summary

We have presented:

- **Novel definition** of the **role mining problem**
    - motivated from **basic requirements** on RBAC and
    - relying on **realistic assumptions** on the input data
- Pointer to high-level solution strategy
- Evaluation techniques exist

Appeal to the community:

- Papers on role mining methods should contain **problem definition** and **evaluation criteria**.
- Definition, algorithm and evaluation should agree.
- Let‘s try to agree on one definition of the problem (**discuss**!).

Thank You