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Towards Collaboration-Aware Resource Sharing in Research Computing Infrastructures

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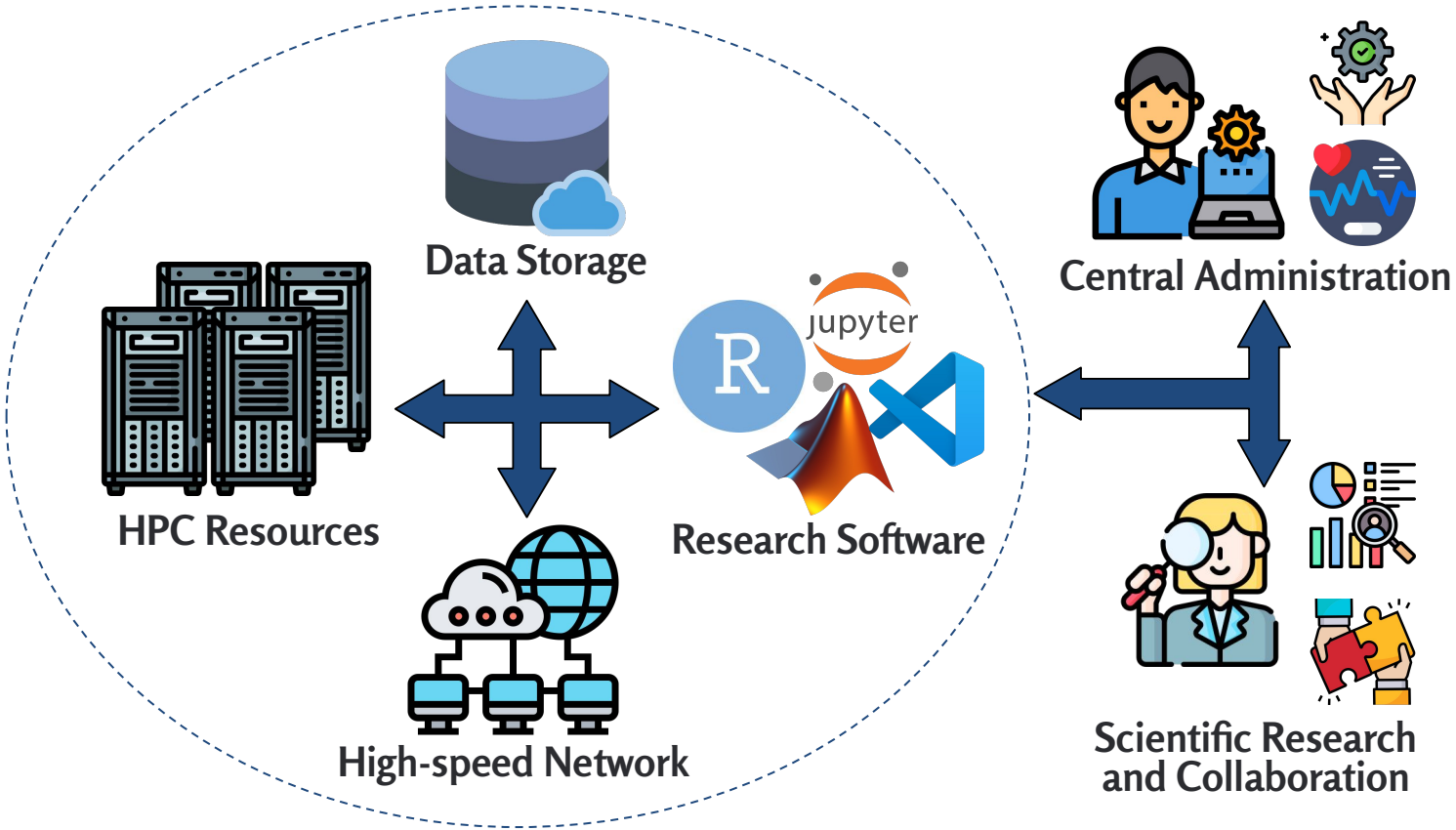
Research Computing Infrastructure (RCI)



Research Questions

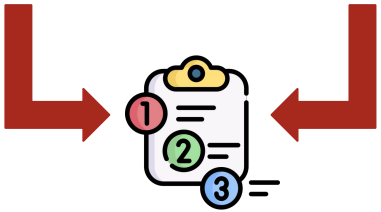
- **RQ1:** What are the **existing challenges** around access control and resource sharing practices within RCIs?
- **RQ2:** From an access control perspective, what **unique requirements** must be addressed to support effective and secure resource sharing in RCIs?
- **RQ3:** How can **collaboration contexts be conceptualized, designed, and utilized** to enable secure and flexible resource sharing authorization within RCIs?

Overview of Approach

Requirement Elicitation

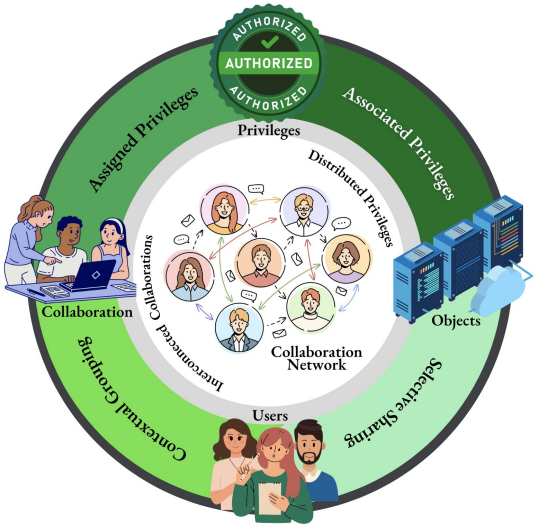
System Exploration

Illustrative Workflow



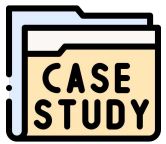
Requirements

Design & Implementation



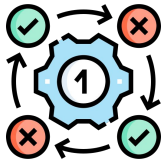
CoLlaboration-awarE Authorization for Resource Sharing (CLEARS)

Evaluation



Case Study

Experiments



Correctness

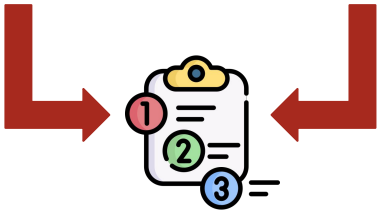
Performance

Overview of Approach

Requirement Elicitation

System Exploration

Illustrative Workflow



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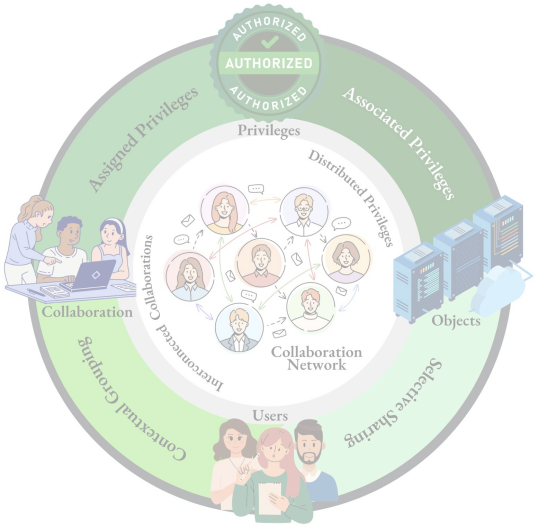
Design & Implementation



CoLlaboration-awarE Authorization for Resource Sharing (CLEARS)

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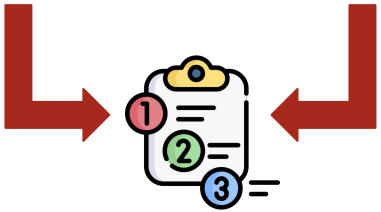
Requirements for Collaboration-Aware Resource Sharing

Requirement Elicitation

System Exploration

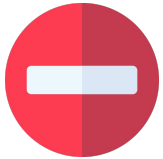
Illustrative Workflow



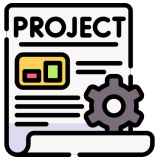
Requirements

Selective Sharing

Selective Revocation



Automatic Revocation



Project-specific Sharing & Revocation

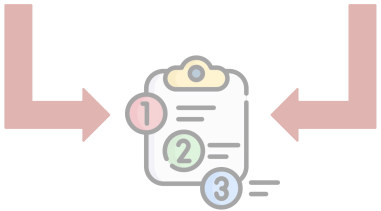
Uniform Interface for Resource Sharing

Overview of Approach

Requirement Elicitation

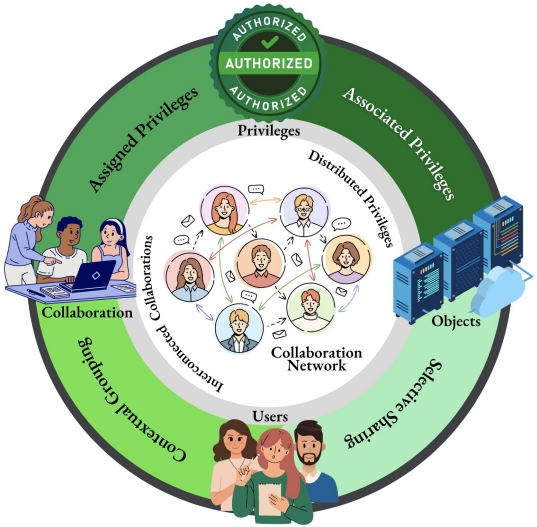
System Exploration

Illustrative Workflow



Requirements

Design & Implementation



CoLlaboration-awarE Authorization for Resource Sharing (CLEARS)

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Overview of CLEARS

Users

Objects

Privileges

Project

Collaboration

Collaboration Network

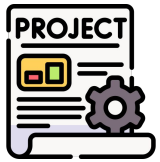
Privilege Expansion & Contraction

Projects and Collaboration

Users

Objects

Privileges



Project

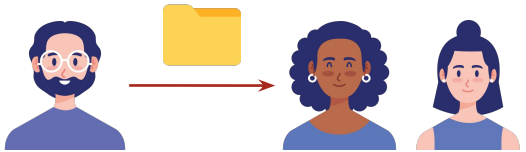
Collaboration

Collaboration Network

Privilege Expansion & Contraction

$C_i = \{U_j \mid U_j \subseteq U_i, 2 \leq |U_j| \leq |U_i|\}$, *a set of collaborations under a project* pr_i,

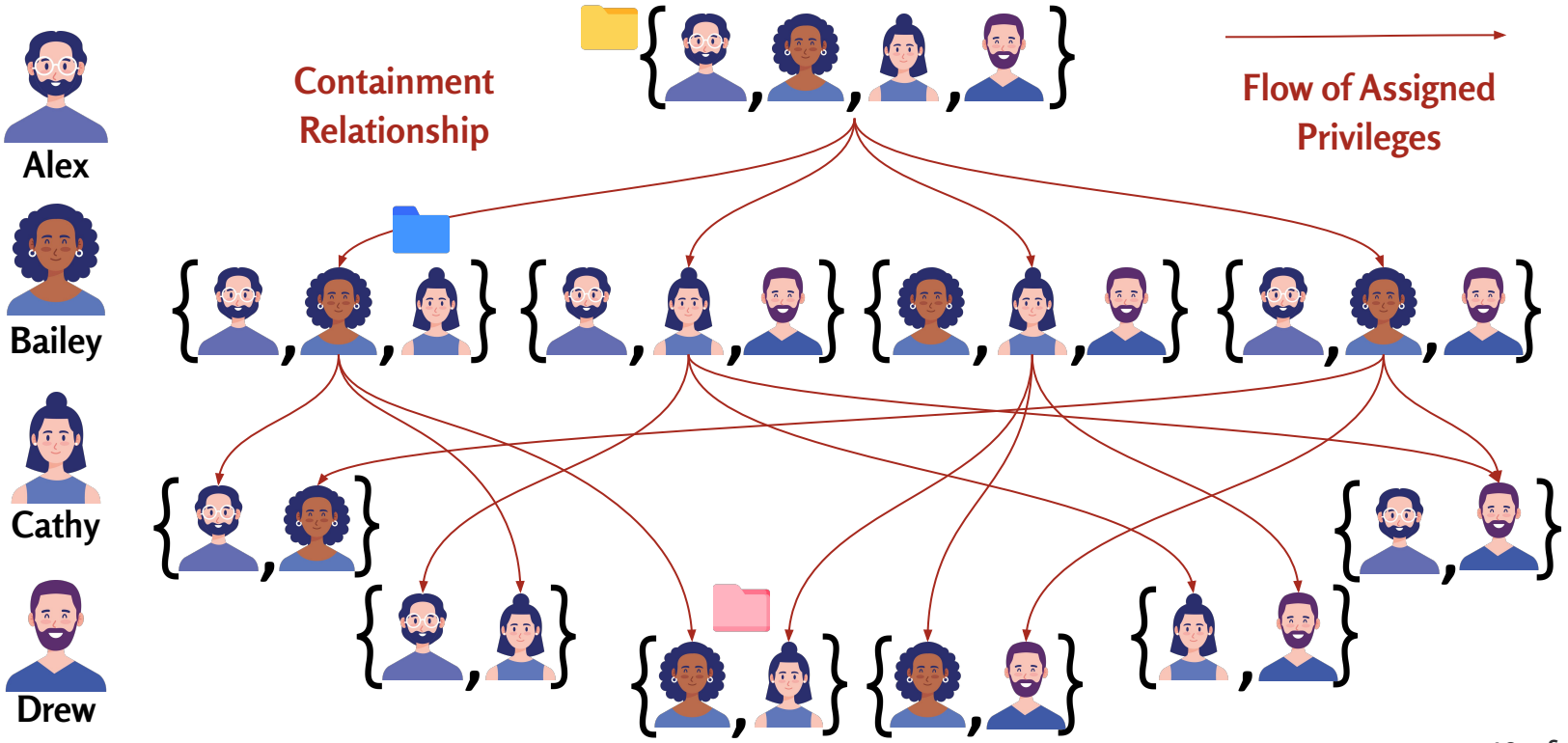
Flexibility in Privilege Assignment and Revocation



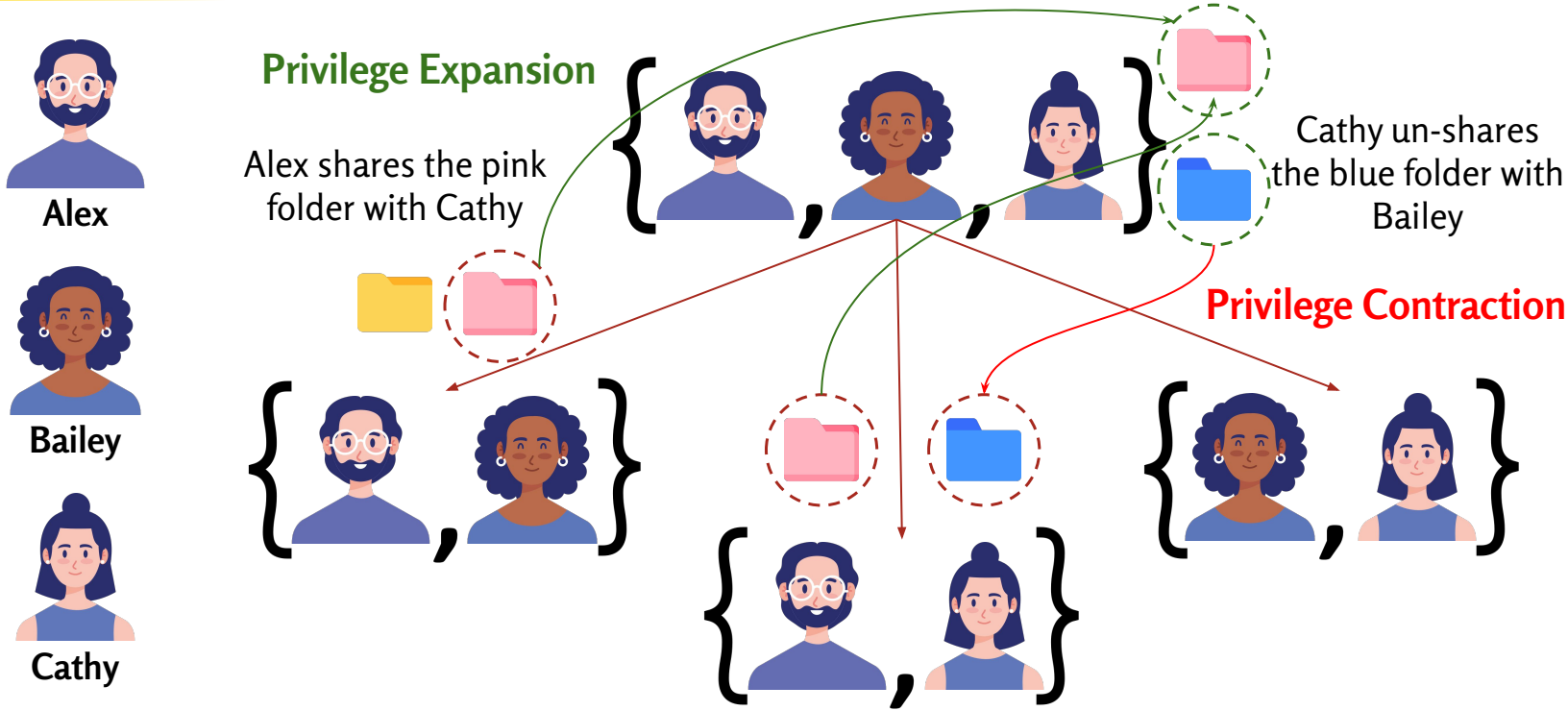
$AP_i = \{(c_{ij}, p_k) \mid j \in \mathbb{N}, c_{ij} \in C_i \text{ and } p_k \in P\}$, *a set of assigned privileges shared within project* pr_i

Context-aware Privileges

Collaboration Network



Privilege Expansion and Contraction



Overview of CLEARS: There's more!

Model Functions

Authorization of Resource Sharing

Integration with Existing Models

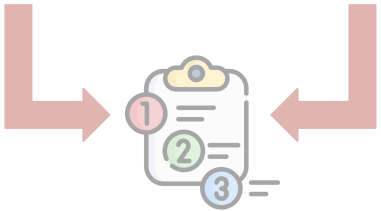
Read the Paper!

Overview of Approach

Requirement Elicitation

System Exploration

Illustrative Workflow



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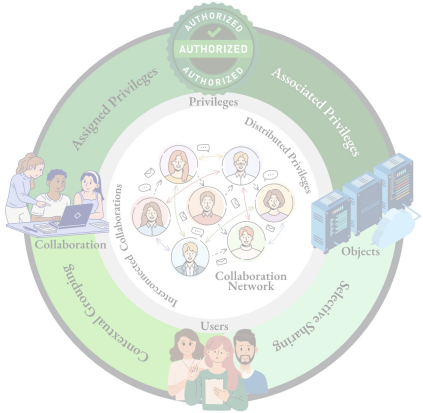

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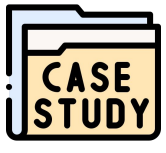
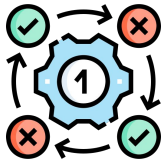


Case Study

Experiments



Correctness

Performance

Correctness Evaluation

Collaborative Workflow-based Case Study

6 Users

10 Resources

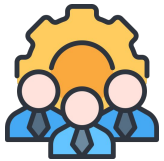
2 Projects

$t = 0$: ProjectX, ProjectY start, and Users are added to projects
$t = 1$: Alice shares $/scratch/alice$ with ALL in both projects
$t = 2$: Alice shares $/data/alice$ with Bob, Connor in ProjectX
$t = 3$: Dave shares $/scratch/dave$ with Alice, Connor in ProjectX
$t = 4$: Alice shares $alice\_partition1$ with Alex in ProjectY
$t = 5$: Bob shares $/data/bob$ with only Alex in ProjectY
$t = 6$: Alice unshares $/scratch/alice$ with ALL in ProjectX
$t = 7$: Alice unshares $/scratch/alice$ with Alex, Drew in ProjectY
$t = 8$: Alice unshares $alice\_partition1$ with Alex in ProjectY
$t = 9$: Dave leaves ProjectX
$t = 10$: ProjectX and ProjectY end and Users are removed

Three Approaches of Resource Sharing

Group-only

User-centric



Role-based

Comparison Metric

 # Permit Decisions

Correctness Evaluation

t	No. of 'Permit' Decisions (out of 60 requests)				
	G	U	R	CLEARS	GT
$t=0$	10	10	10	10	10
$t=1$	$15_{(+5)}{}^{\checkmark}$	$15_{(+5)}{}^{\checkmark}$	$15_{(+5)}{}^{\checkmark}$	$15_{(+5)}{}^{\checkmark}$	$15_{(+5)}$
$t=2$	$18_{(+3)}{}^{\dagger}$	$17_{(+2)}{}^{\checkmark}$	$17_{(+2)}{}^{\checkmark}$	$17_{(+2)}{}^{\checkmark}$	$17_{(+2)}$
$t=3$	$21_{(+3)}{}^{\dagger}$	$19_{(+2)}{}^{\checkmark}$	$19_{(+2)}{}^{\checkmark}$	$19_{(+2)}{}^{\checkmark}$	$19_{(+2)}$
$t=4$	$24_{(+3)}{}^{\dagger}$	$20_{(+1)}{}^{\checkmark}$	$20_{(+1)}{}^{\checkmark}$	$20_{(+1)}{}^{\checkmark}$	$20_{(+1)}$
$t=5$	$27_{(+3)}{}^{\dagger}$	$21_{(+1)}{}^{\checkmark}$	$21_{(+1)}{}^{\checkmark}$	$21_{(+1)}{}^{\checkmark}$	$21_{(+1)}$
$t=6$	$25_{(-2)}{}^{\checkmark}$	$19_{(-2)}{}^{\checkmark}$	$19_{(-2)}{}^{\checkmark}$	$19_{(-2)}{}^{\checkmark}$	$19_{(-2)}$
$t=7$	$22_{(-3)}{}^{\dagger}$	$19_{(-0)}{}^{\dagger}$	$17_{(-2)}{}^{\checkmark}$	$17_{(-2)}{}^{\checkmark}$	$17_{(-2)}$
$t=8$	$19_{(-3)}{}^{\dagger}$	$18_{(-1)}{}^{\dagger}$	$16_{(-1)}{}^{\checkmark}$	$16_{(-1)}{}^{\checkmark}$	$16_{(-1)}$
$t=9$	$18_{(-1)}{}^{\dagger\#}$	$18_{(-0)}{}^{\dagger\#}$	$16_{(-0)}{}^{\dagger\#}$	$14_{(-2)}{}^{\checkmark\#}$	$14_{(-2)}$
$t=10$	$10_{(-8)}{}^{\checkmark\#}$	$15_{(-3)}{}^{\dagger\#}$	$16_{(-0)}{}^{\dagger\#}$	$10_{(-4)}{}^{\checkmark\#}$	$10_{(-4)}$

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$^{\checkmark}$ Matches with the ground truths at each consequent step (green).
† Mismatches with the ground truths at each consequent step (red).
$^{\#}$ Manual revocation of privileges is not assumed.

Group-only Approach (G):

- ✔ Maintains context, each group represents a project
- ✖ Too coarse-grained
- ✖ Either too permissive or too restrictive

User-centric Approach (U):

- ✔ Allows for flexible resource sharing (User-to-User)
- ✖ Allows for ad hoc sharing, no context
- ✖ Lack of context makes revocation an issue

Role-based Approach (U):

- ✔ Allows for flexible resource sharing and revocation
- ✖ Lack of context-awareness, context adds overhead
- ✖ Revocation is still manual

Performance Evaluation

Random Workload-based Experiments

20→100
Users

100
Resources

100
Timestamps

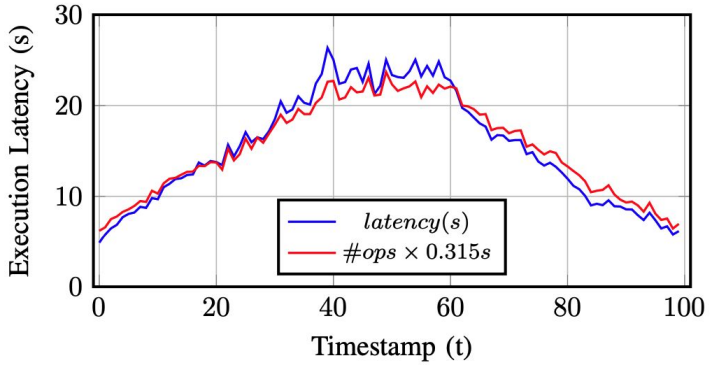
0-39
Ramp-up

40-59
Steady-state

60-99
Wind-down

Execution Latency per Action

Metric	Action	Mean
Minimum Latency	Share	**166**
	Unshare	**159**
Maximum Latency	Share	**711**
	Unshare	**792**
Mean Latency	Share	**331**
	Unshare	**299**



Future Work

Address Operational Concerns

- Investigate Race conditions, Atomicity of Share/Unshare operations, etc.
- Security of system-level mechanisms (e.g., JSON storage, setuid root helper, etc.)

Incorporate Multi-institutional Perspectives

- Explore scenarios involving multi-institutional infrastructures
- Address diverse regulatory and collaborative requirements

User Validation Study

- Incorporate feedback from potential stakeholders (e.g., researchers, admins)
- Explore integration with other access control models

Thank you

Read the Paper

GitHub Repo

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