Chair of Network Architectures and Services
Department of Informatics
Technical University of Munich

Exposing Insecure Configurations of Network Session and Permission Graphs

Final talk for the Master's Thesis by

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Chair of Network Architectures and Services
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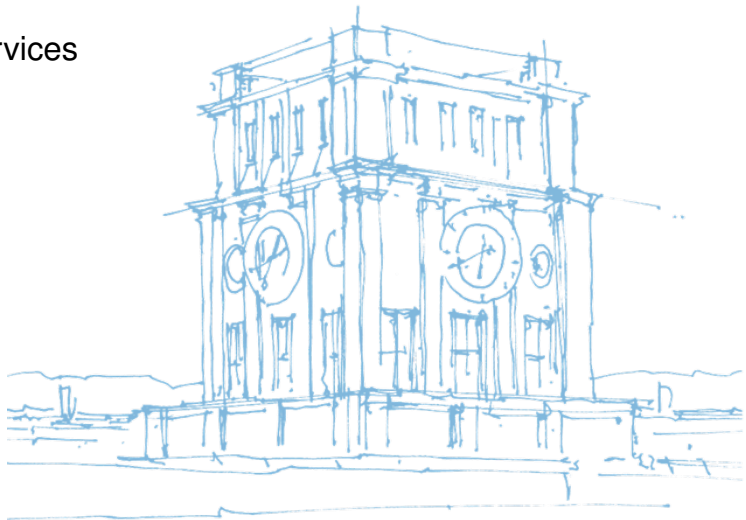

Introduction

Problem:
Lateral Movement in Windows networks

Goal:
Prevention of Identity Snowball Attacks

Contribution:
Solution based on graph-theoretic metrics

Agenda

Problem and Motivation

Problem Analysis

Exposing Insecure Configurations

Design and Implementation

Evaluation

Related Work

Problem and Motivation

Identity Snowball Attack

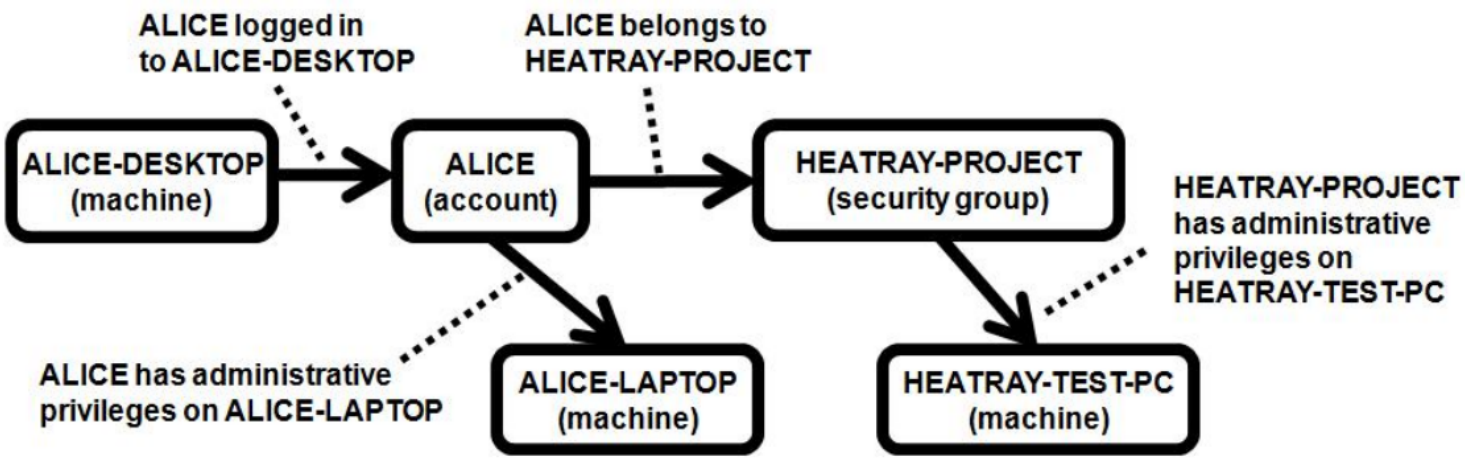

Figure 1: Identity Snowball Attack [1]

How to find Undesired Configurations
in Network Session and Permission Graphs?

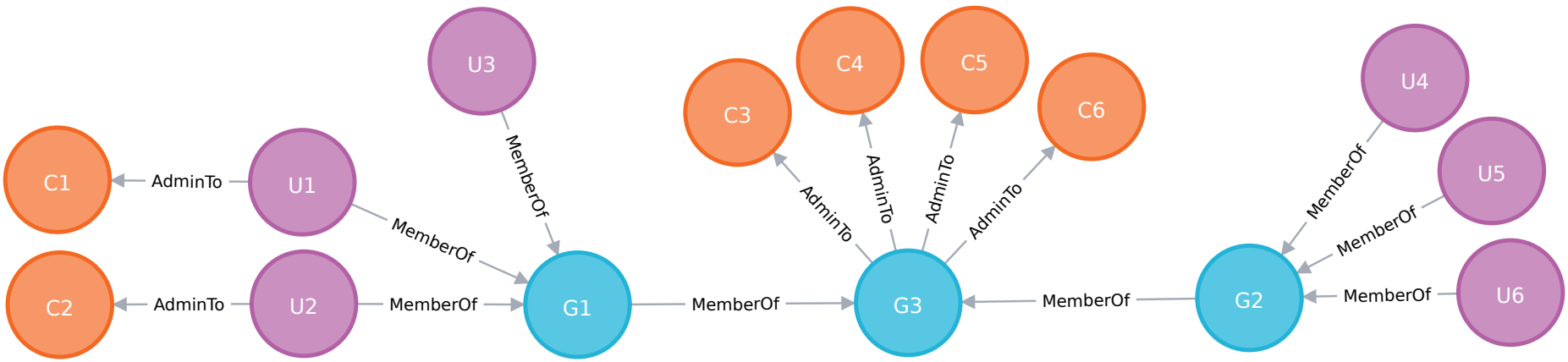

Figure 2: Minimalist sample graph

Problem Analysis

Scope of the Thesis

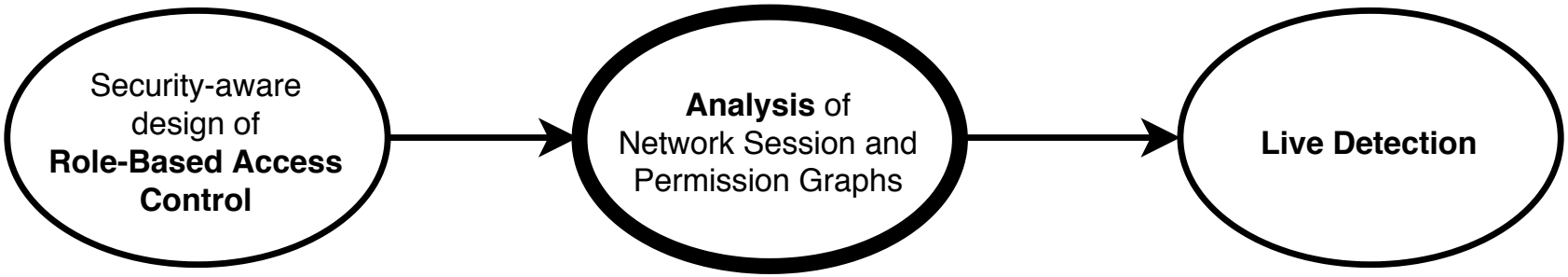

Figure 3: Possible points in time

$\Rightarrow$ Analysis before the actual attack

Problem Analysis

Problem Statement

Analysis of Network Session and Permission Graphs

$\Rightarrow$ We want to ...

- ... **define undesired graph configurations**, deduced from real-world issues.
- ... **detect undesired configurations** within the graph.
- ... be able to **scale** the solution even **for large graphs**.
- ... apply the solutions for network session and permission graphs, not only Active Directory.

Exposing Insecure Configurations

Users, **G**roups, **C**omputers

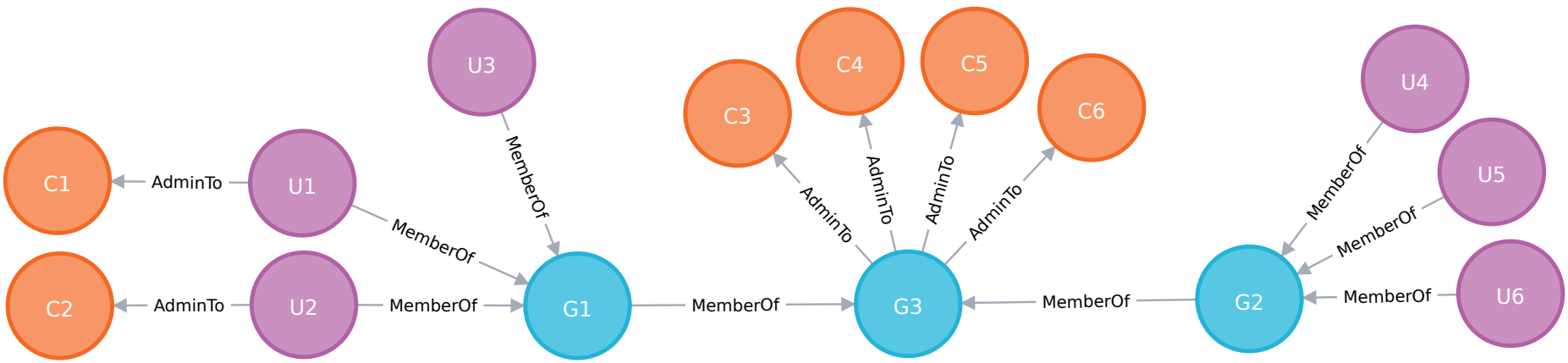

Figure 4: Minimalist sample graph

Exposing Insecure Configurations

Degree Centrality

"Direct neighbors of the attacker"

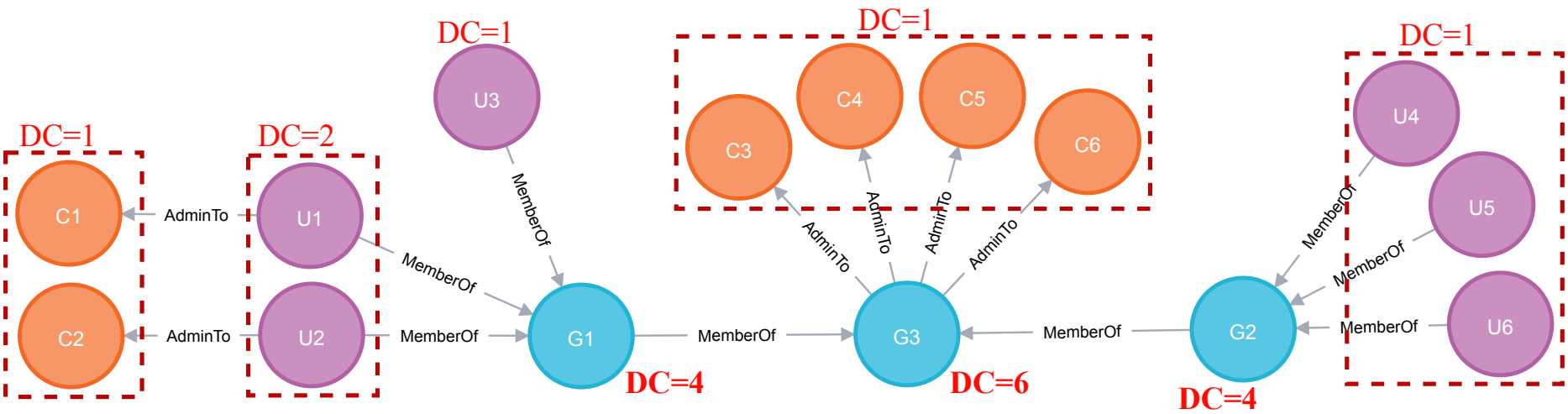

Figure 5: Sample graph with Degree Centrality (DC)

Exposing Insecure Configurations

Betweenness Centrality

"Nodes on the attacker's path"

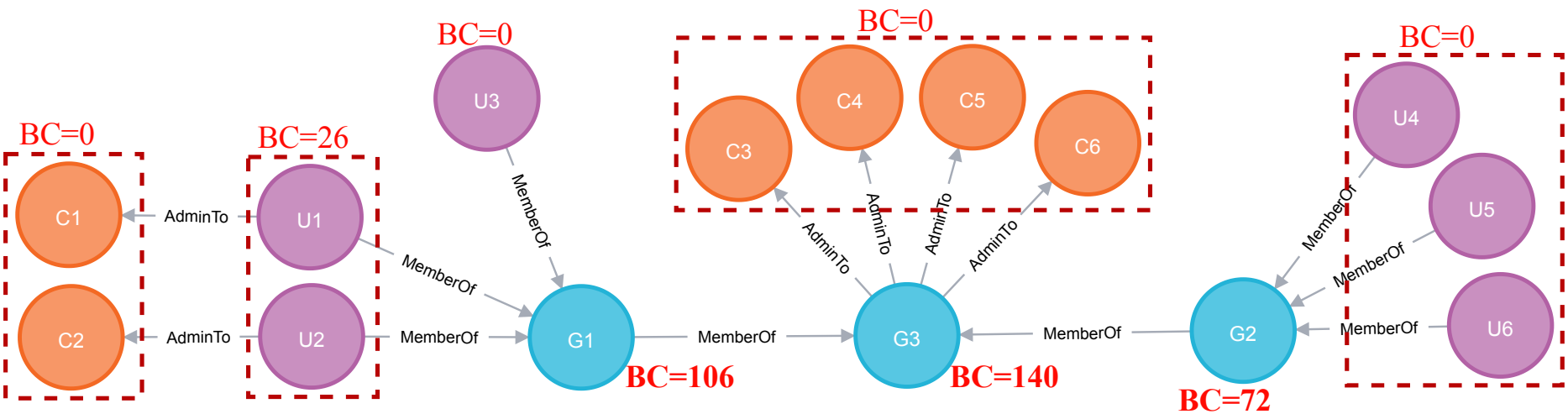

Figure 6: Sample graph with Betweenness Centrality (BC)

Exposing Insecure Configurations

Closeness Centrality

"Closeness to the attacker"

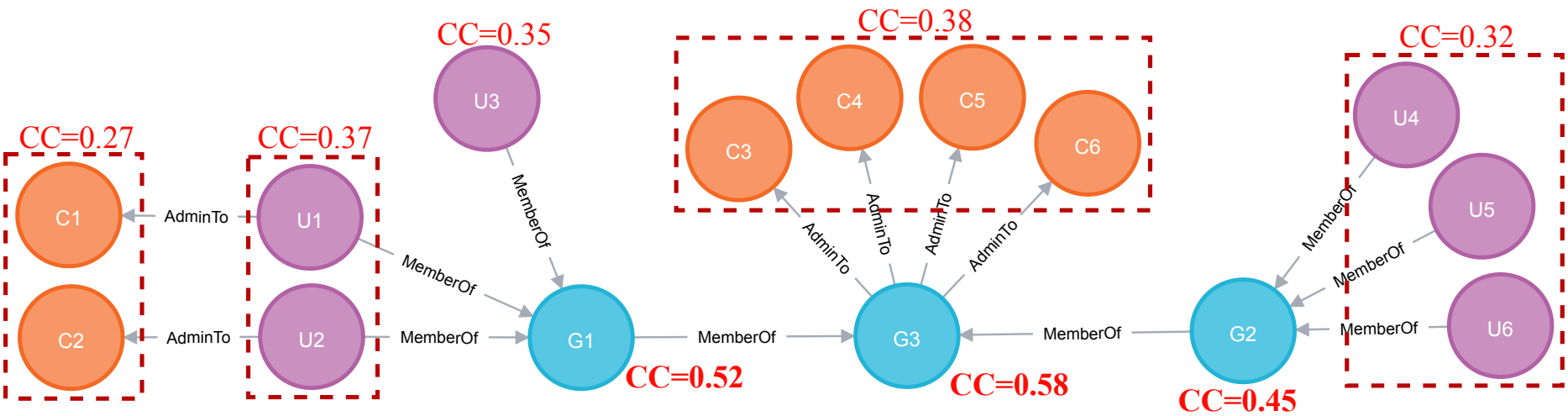

Figure 7: Sample graph with Close Centrality (CC)

Design and Implementation

Investigation Process

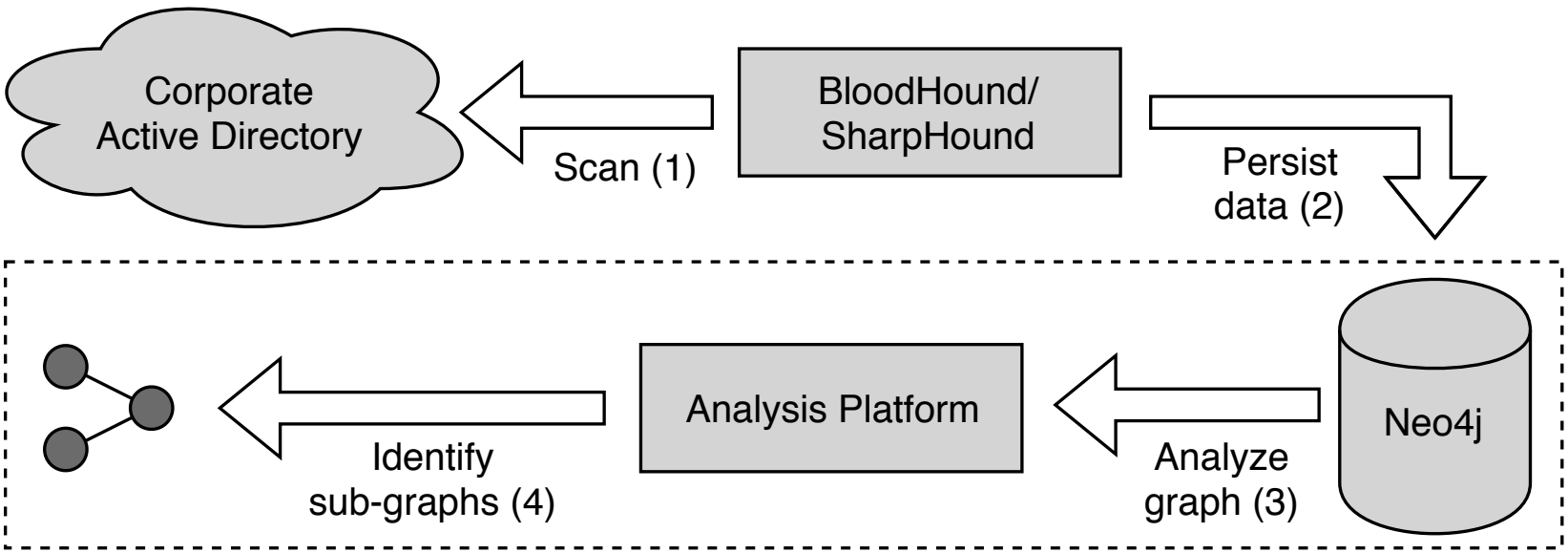

Figure 8: Technical perspective of the investigation process

Design and Implementation

Environments

- Simulated environment
  1. Randomly generate graphs
  2. Inject undesired configurations
  3. Find undesired configurations

- Real-world environment
  1. Collect network session and permission graph
  2. Find undesired configurations
  3. Discussion about meaningfulness of findings

Design and Implementation

Architecture Overview

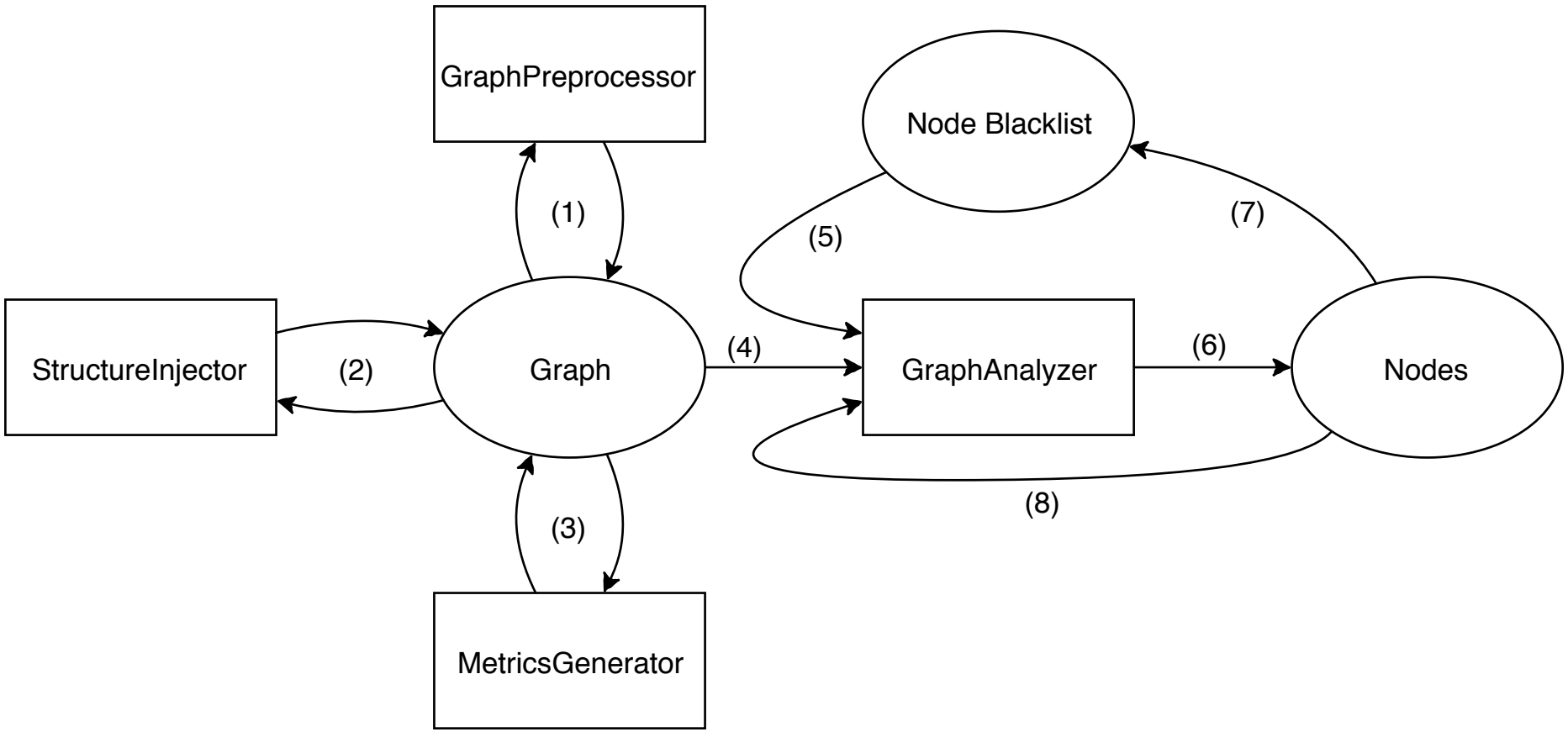

Figure 9: Analysis platform

Evaluation

Injection of Undesired Configuration

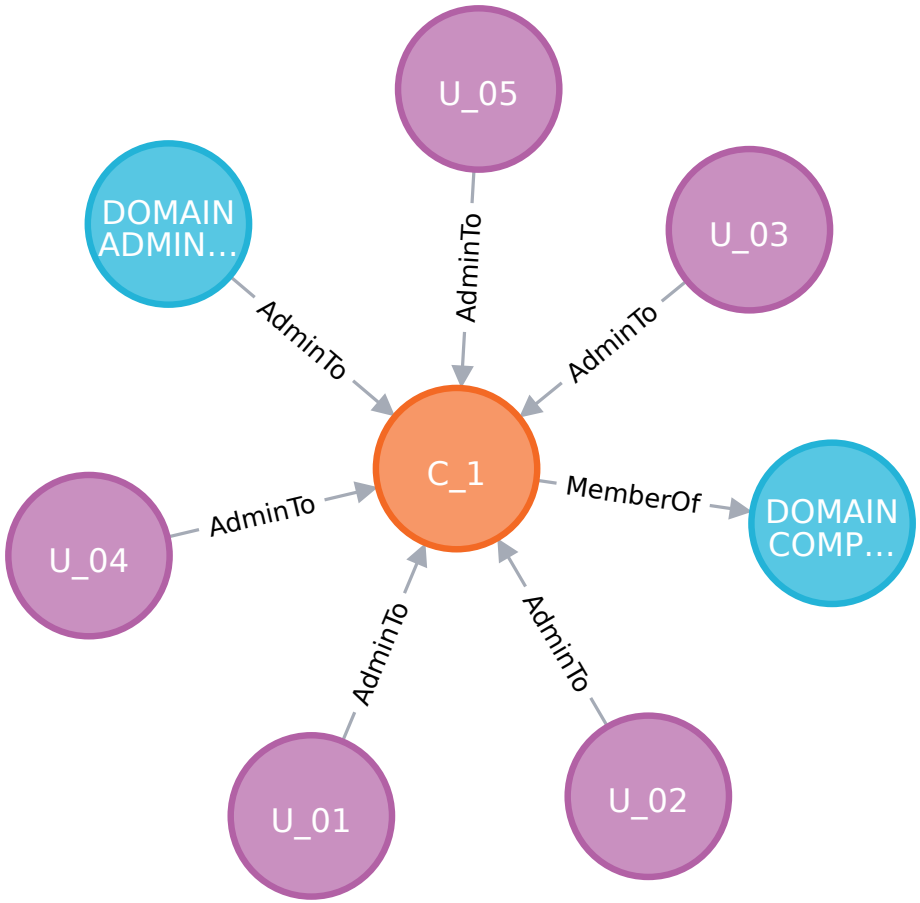

Figure 10: Undesired configuration: One computer with five admin users

Evaluation

Node with Betweenness Centrality *BC* = 7660

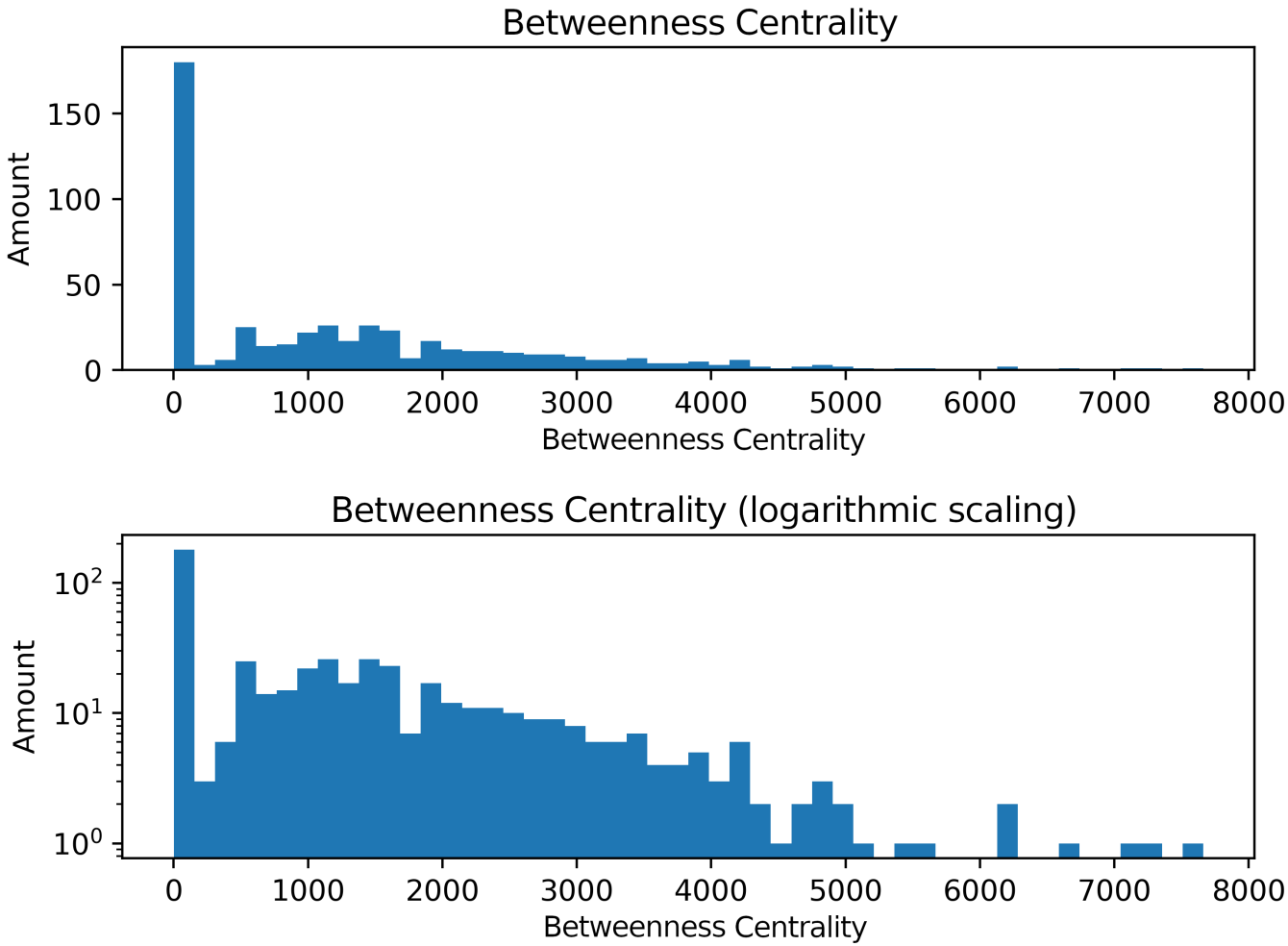

Figure 11: Betweenness Centrality of a graph (injected one computer with ten admin users)

Evaluation

Real Environment

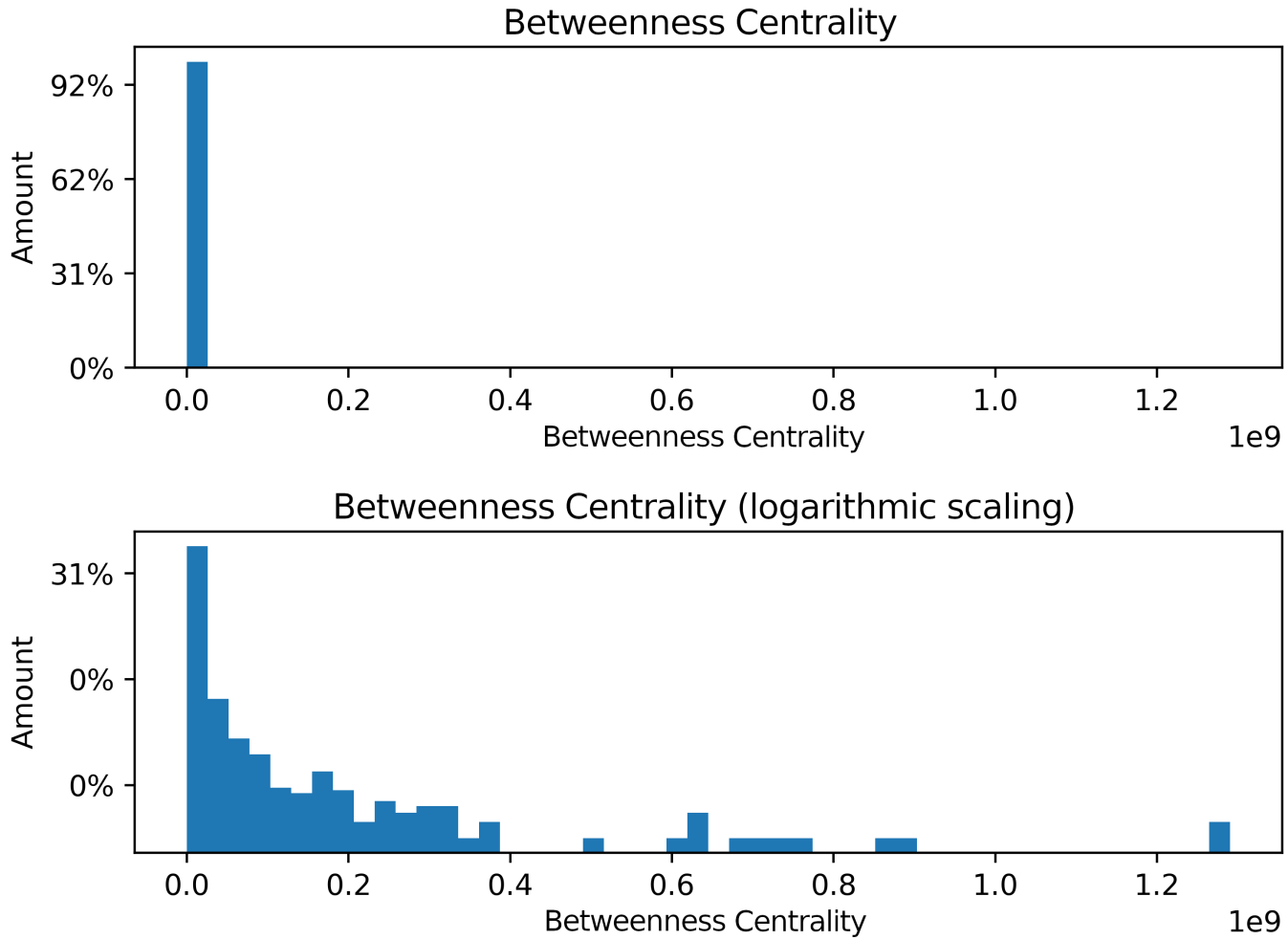

Figure 12: Betweenness Centrality of a real AD network

Evaluation

Results

- Found common AD groups
  e.g. `DOMAIN USERS`, `DOMAIN ADMINS`
  $\Rightarrow$ Intentionally blacklisted
- Found undesired sub-structures (intentionally injected)
  e.g. users with many administrative permissions
- Found odd configurations
  e.g. users in many groups
- PageRank may be a comprehensive metric

Related Work

Comparison to Other Approaches

- **Automated Analysis**: Heat-ray by Microsoft [1]
  $\Rightarrow$ Limited usage of graph metrics (only one variation of Betweenness Centrality)

- **Manual Analysis**: BloodHound AD [3]
  $\Rightarrow$ Manual investigation per path, user, group or machine is necessary

Summary

- **Problems** with existing solutions to prevent Identity Snowball Attacks
- **Analysis** of Network Session and Permission Graphs
- **Novel centralized approach** for detection with centrality metrics
- **Evaluation** in a real-world and a simulated environment

Bibliography

[1] John Dunagan, Alice X. Zheng, and Daniel R. Simon.
Heat-ray: Combating identity snowball attacks using machine learning, combinatorial optimization and attack graphs.
In *Proceedings of the ACM SIGOPS 22Nd Symposium on Operating Systems Principles*, SOSP '09, pages 305–320. ACM.

[2] Didier Stevens.
Windows Credential Guard & Mimikatz.
https://blog.nviso.be/2018/01/09/windows-credential-guard-mimikatz/.

[3] Andrew Robbins, Rohan Vazarkar, and Will Schroeder.
BloodHound: Six Degrees of Domain Admin.
https://github.com/BloodHoundAD/BloodHound.

Additional Ideas (Backup Slide)

Page Rank

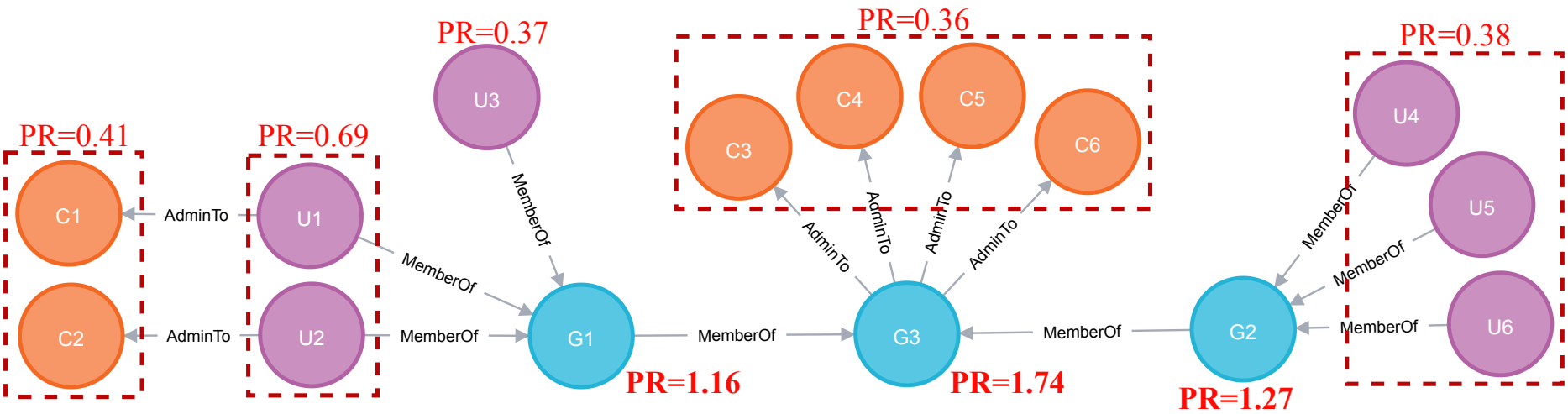

Figure 13: Example graph with Page Rank (PR)