On Data Provenance in Group-centric Secure Collaboration

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CollaborateCom

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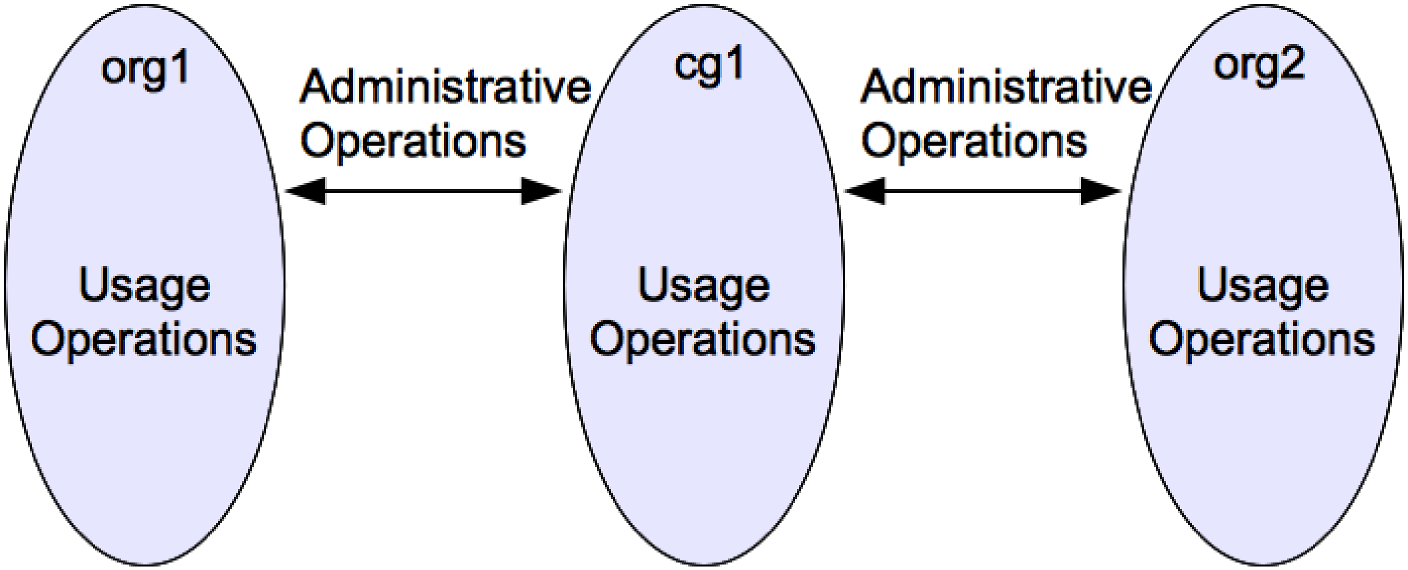
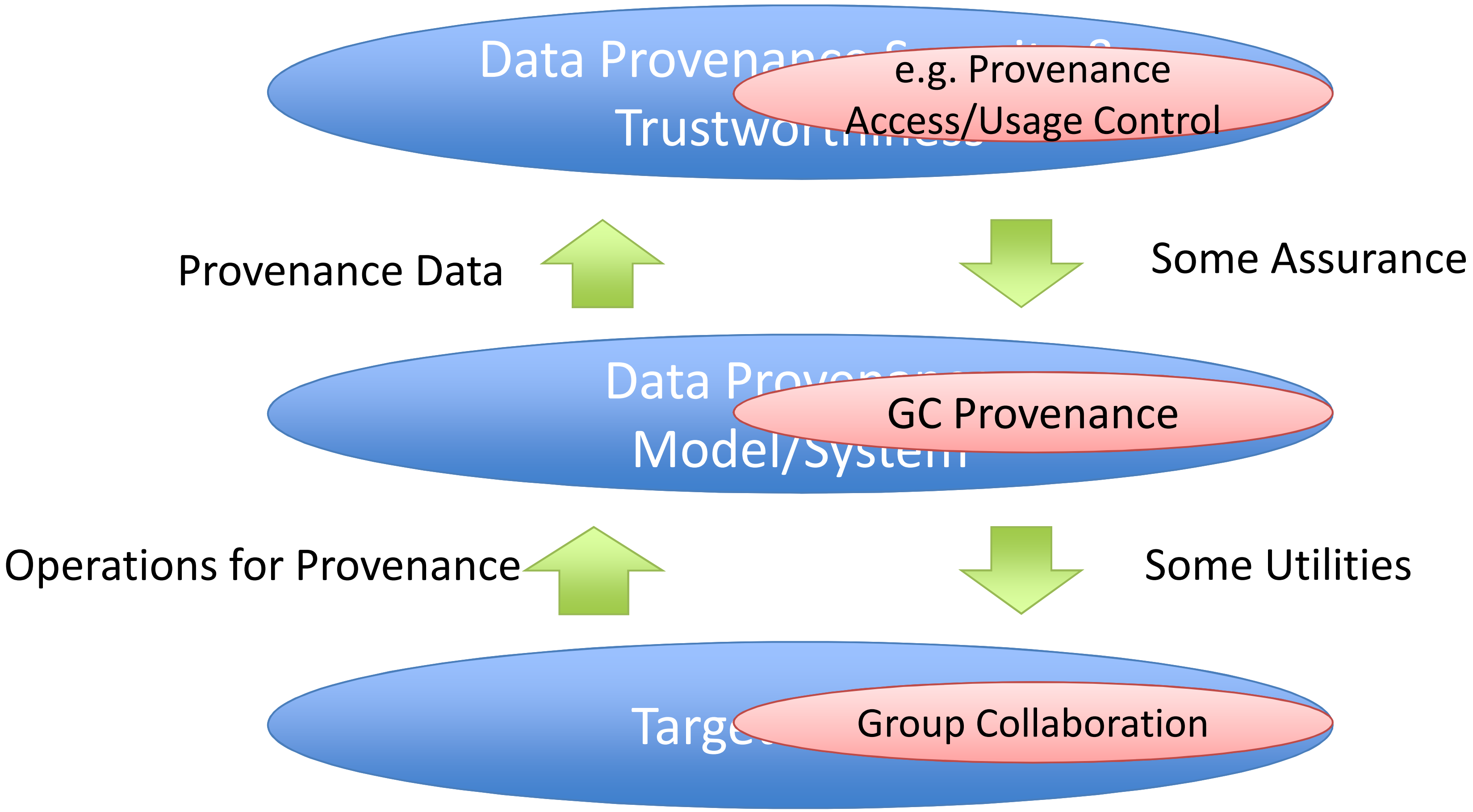
Group-centric Collaboration



Group Collaboration Operations

- Administrative operations
  - Establish/disband groups, join/leave/substitute users, add/remove object versions to/from a group, import/merge object versions from a group to an org
- Usage operations
  - Read/update/create object versions

Towards Assured Data Provenance



Data Provenance Security & Trustworthiness

e.g. Provenance Access/Usage Control

Provenance Data

Some Assurance

Data Provenance Model/System

GC Provenance

Operations for Provenance

Some Utilities

Targ

Group Collaboration

Data Provenance

- Utilities of data provenance
  - – Pedigree, Usage tracking, Versioning capability
  - – Trustworthiness, Accountability, Compliance
  - – Depend on the kinds of provenance data that are captured

Capturing Provenance Data

- Capturing a complete provenance data for all operations is neither feasible nor necessary
  - Some can be captured only by user’s manual declaration (i.e., user intention) while user’s memory is limited and cannot identify all the source information (i.e., citations in scientific research article).
  - Not all operation information provide additional provenance utilities
- For proper discussion, we need a specific application domain where a set of operations can be specified and expressed

Data Provenance Requirements

- Identifying operations for provenance data
- Capturing operations as provenance data in a provenance model ← OPM
- Provenance data expression ← RDF
- Provenance data querying ← SPARQL w/ GLEEN
- Provenance data analysis

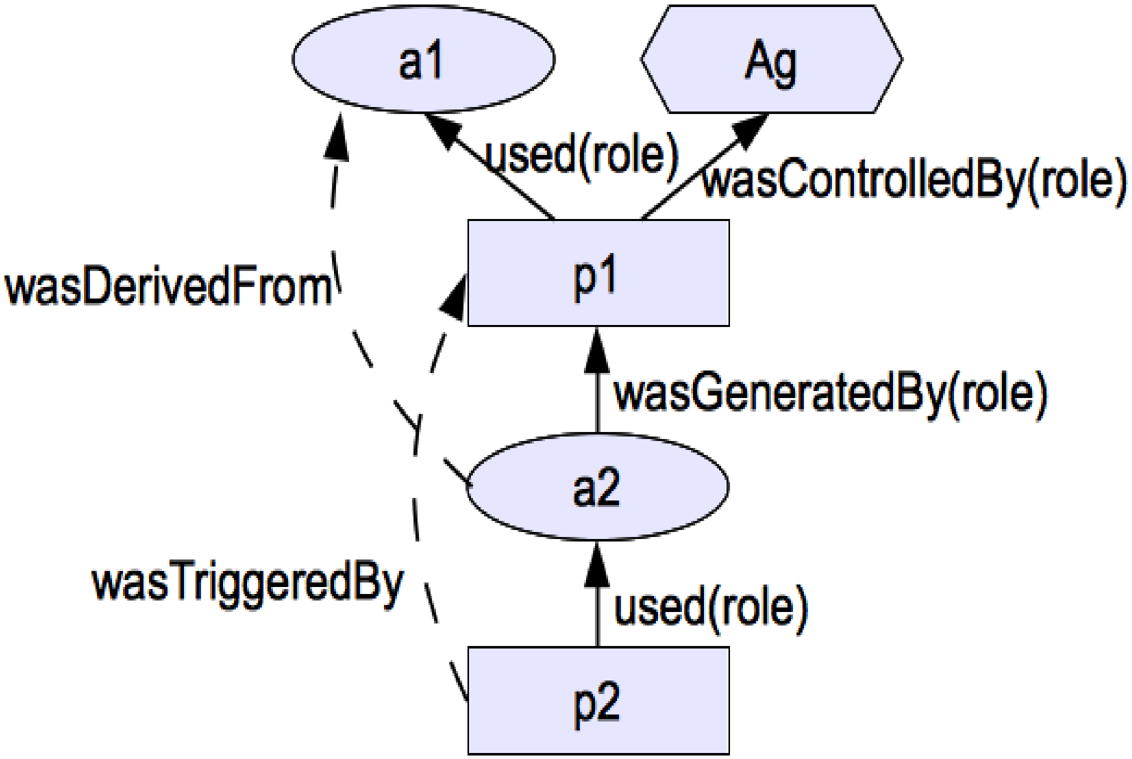
- Data Provenance Assurance
  - Access/usage Control, trustworthiness, integrity, accountability, etc.

Data Object Versioning

- One object can have multiple versions
- Each version can have a multiple identical copies
- The versions of an object form a rooted tree structure, relating a parent version to its immediate children versions
- Each copy is considered as a separate object.

Open Provenance Model (OPM) Notations

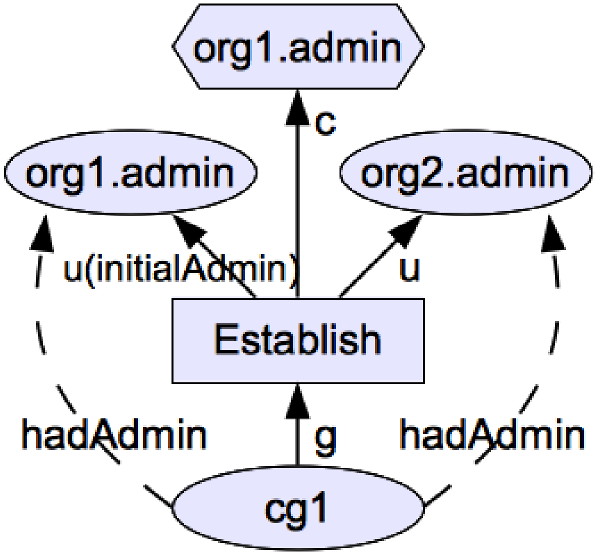
- 3 Nodes
  - Artifact (ellipse)
  - Process (Rectangle)
  - Agent (Octagon)
- 5 Causality dependency edges (not dataflow)



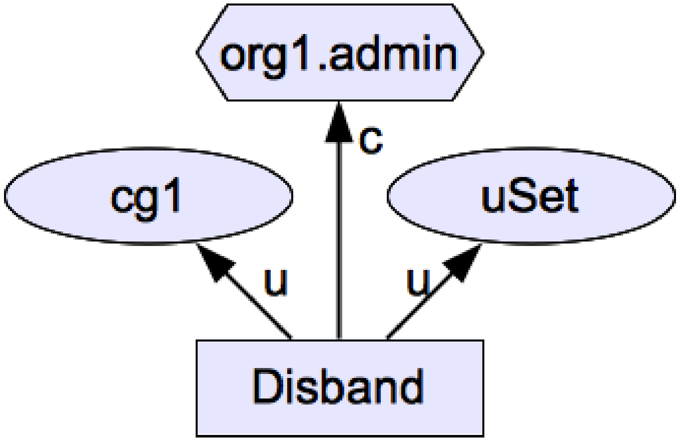
OPM includes…

- A unique identifier for each node
  - To distinguish nodes of the same type
- Accounts
  - Multiple abstracted views of provenance graph by utilizing indirect (dashed) edges
- OPM Profile
  - Includes domain specific subtypes of edges that are defined for additional semantics
  - Includes role-specific (solid) edges

Establish/Disband operations

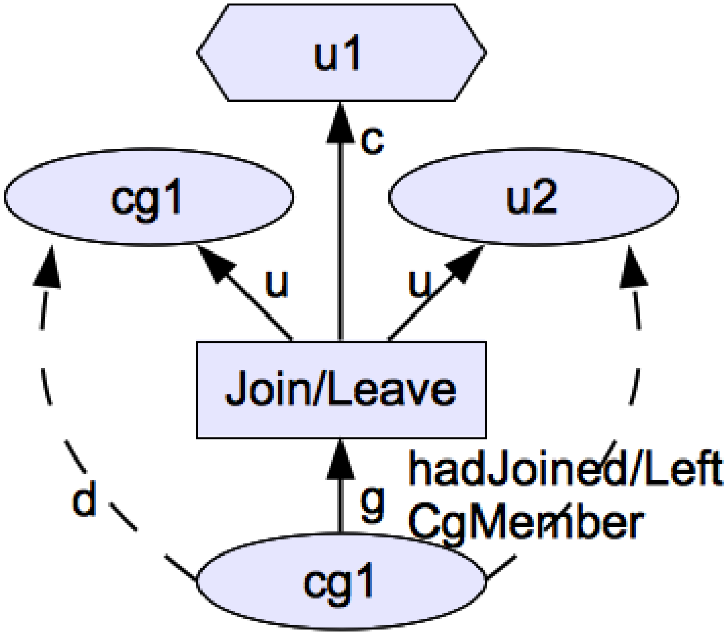


a) Establish operation using orgs' admin

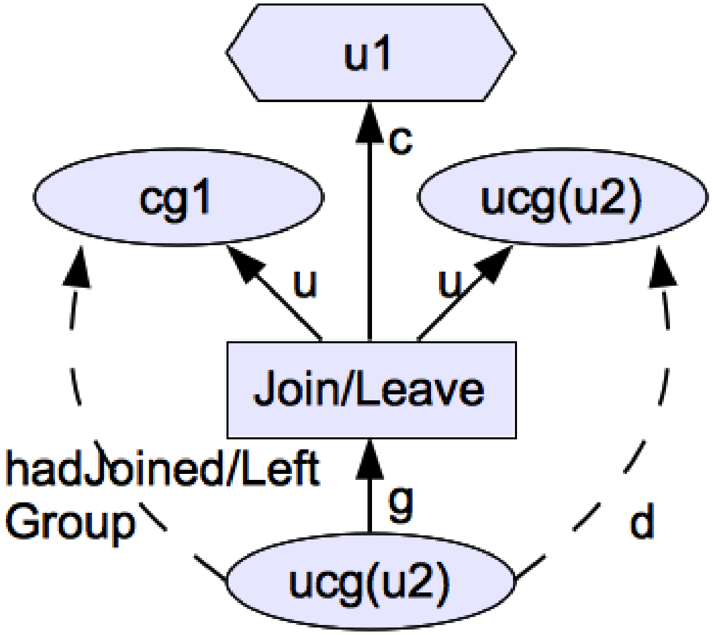


b) Disband operation

Join/Leave Operations

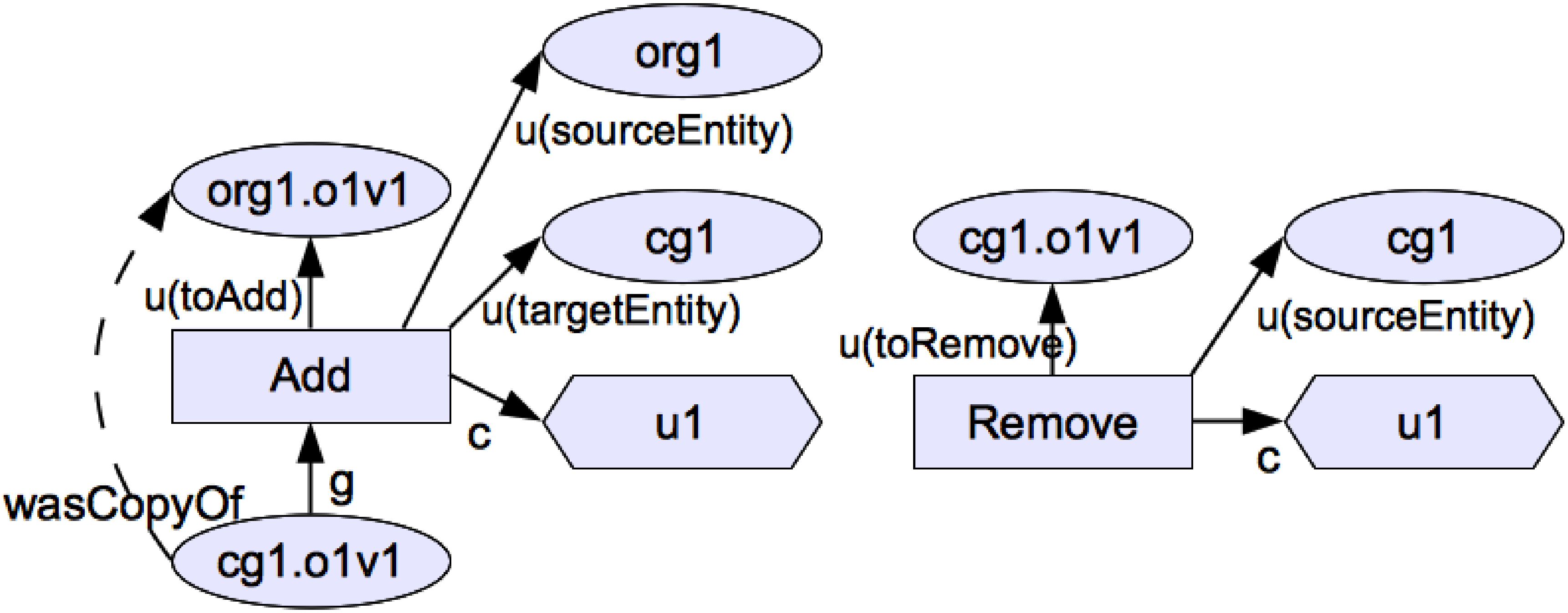


a) Join/Leave operation
on group



b) Join/Leave operation
w/ attribute update

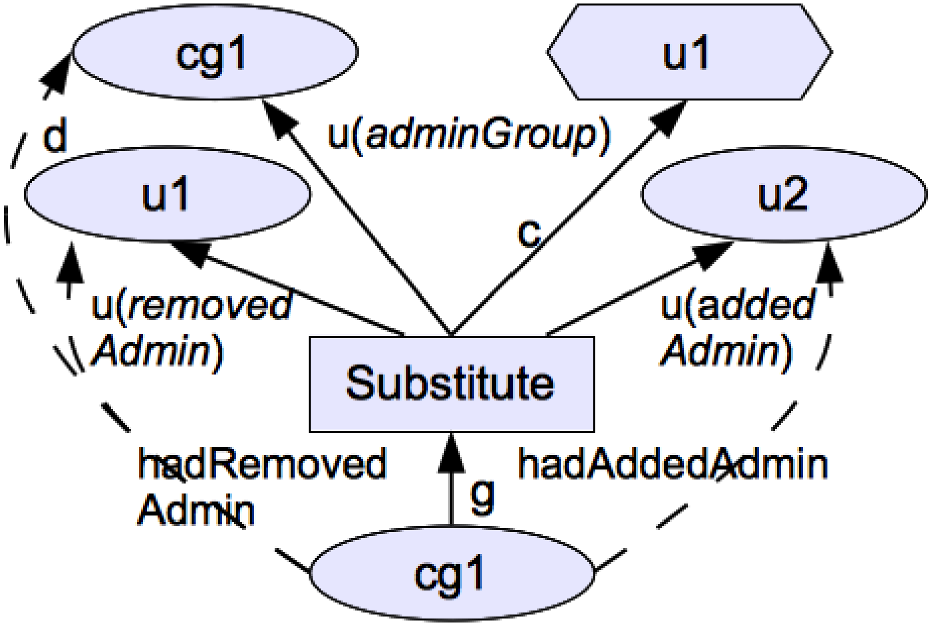
Add/Remove Operations



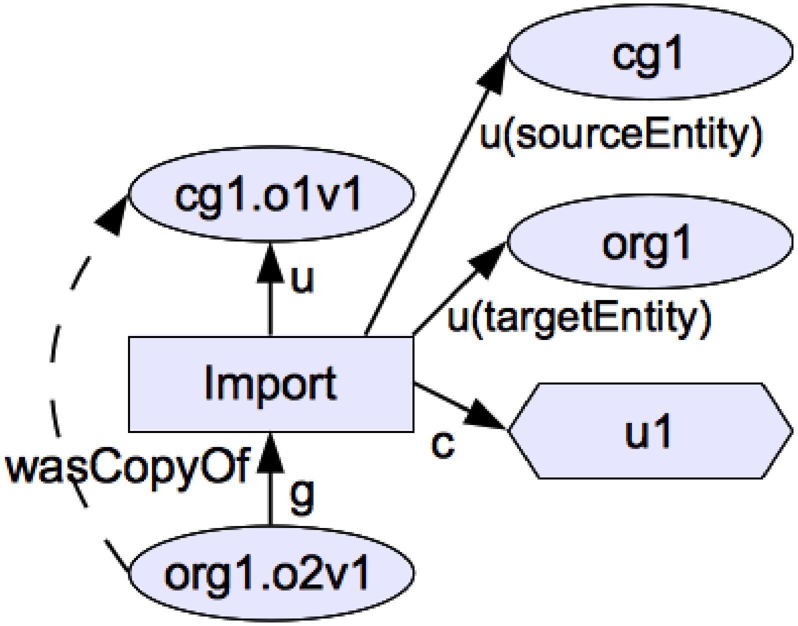
a) Add operation

b) Remove operation

Substitute/Import Operations



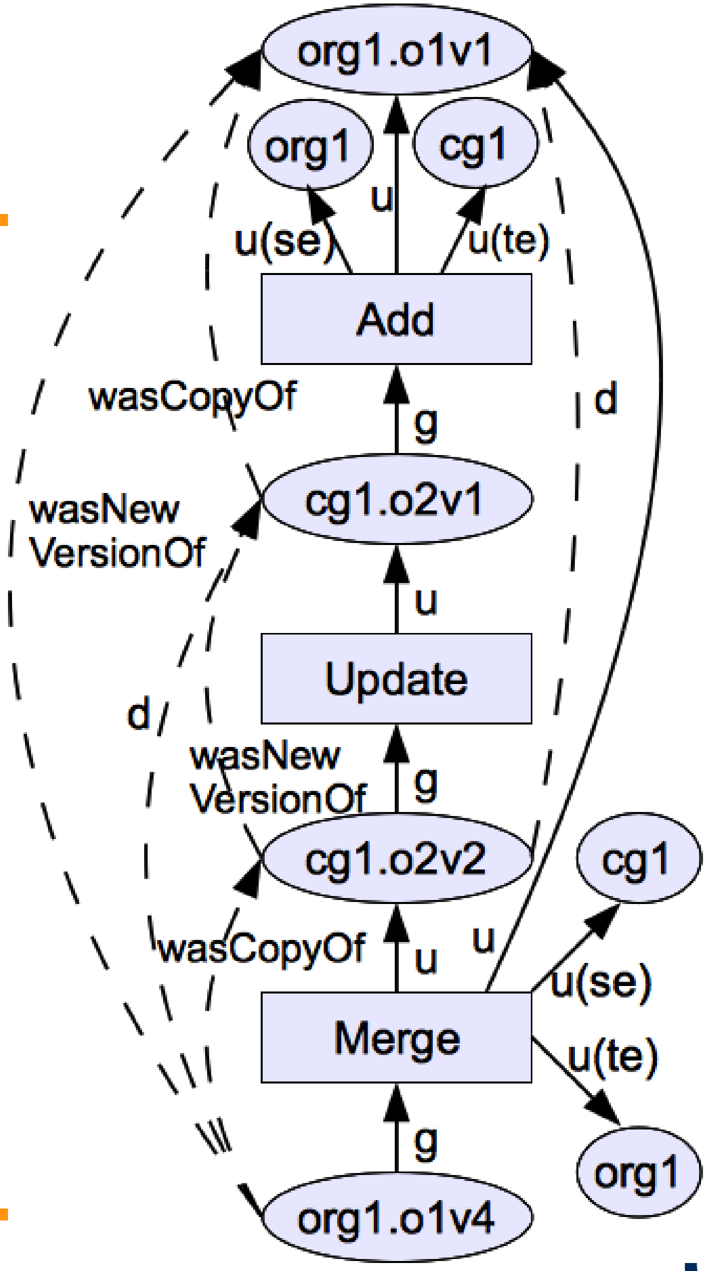
a) Substitute operation



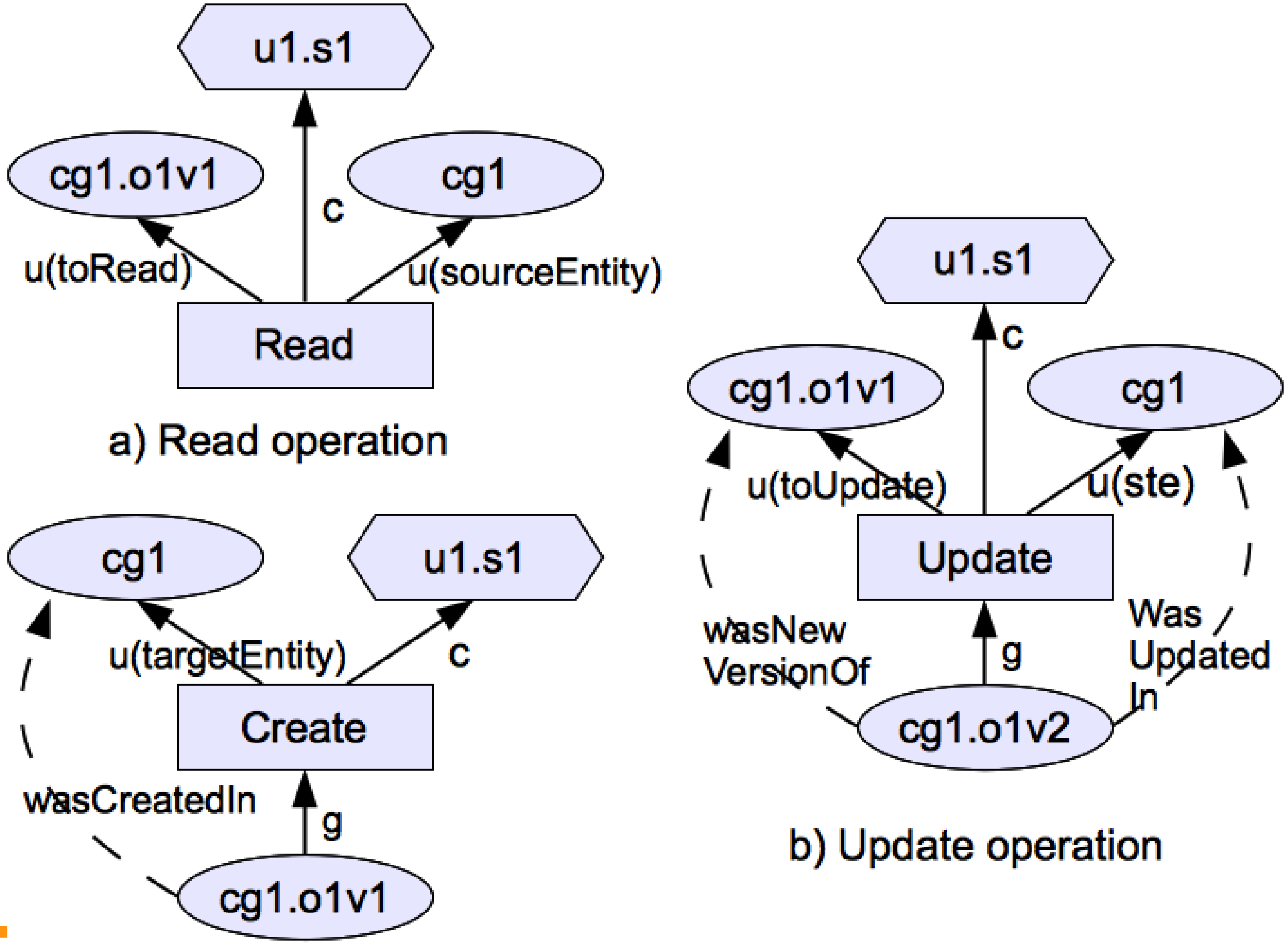
b) Import operation

Merge Operation

- Similar to "import"
  - A version is copied from cg to org
- Different from "import"
  - The initial version of the merged version in cg was added from the org while the initial version of imported version is newly created in cg
  - The merged version becomes a new version of the original version in org



Read/Update/Create Operations



a) Read operation

b) Update operation

c) Create operation

OPM in RDF Expression

- Using RDF (Resource Description Framework) data representation to express provenance data
- RDF supports a directed graph

```
<opm:process><opm:used><opm:artifact>
<opm:artifact><opm:wasGeneratedBy><opm:process>
<opm:process><opm:wasControlledBy><opm:agent>
<opm:process><opm:wasTriggeredBy><opm:process>
<opm:artifact><opm:wasDerivedFrom><opm:artifact>
```

OPM Profile for Group Collaboration Operations (subtypes of "wasDerivedFrom")

<gcp:artifact><gcp:wasCopyOf><gcp:artifact>

<gcp:artifact><gcp:wasNewVersionOf><gcp:artifact>

<gcp:artifact><gcp:HadAdmin><gcp:artifact>

<gcp:artifact><gcp:HadJoinedCgMember><gcp:artifact>

<gcp:artifact><gcp:HadLeftCgMember><gcp:artifact>

<gcp:artifact><gcp:HadRemovedAdmin><gcp:artifact>

<gcp:artifact><gcp:HadAddedAdmin><gcp:artifact>

<gcp:artifact><gcp:wasCreatedIn><gcp:artifact>

<gcp:artifact><gcp:wasUpdatedIn><gcp:artifact>

Roles for “*Used*” Edges

<gcp:process><gcp:u(sourceEntity)><gcp:artifact>

<gcp:process><gcp:u(targetEntity)><gcp:artifact>

<gcp:process><gcp:u(adminGroup)><gcp:artifact>

<gcp:process><gcp:u(removedAdmin)><gcp:artifact>

<gcp:process><gcp:u(addedAdmin)><gcp:artifact>

<gcp:process><gcp:u(initialAdmin)><gcp:artifact>

<gcp:process><gcp:u(toJoin)><gcp:artifact>

<gcp:process><gcp:u(toLeave)><gcp:artifact>

<gcp:process><gcp:u(toAdd)><gcp:artifact>

<gcp:process><gcp:u(toRemove)><gcp:artifact>

<gcp:process><gcp:u(toImport)><gcp:artifact>

<gcp:process><gcp:u(toMergeTo)><gcp:artifact>

<gcp:process><gcp:u(toMergeFrom)><gcp:artifact>

<gcp:process><gcp:u(toRead)><gcp:artifact>

<gcp:process><gcp:u(toUpdate)><gcp:artifact>

Roles for “*WasGeneratedBy*” Edges

<gcp:artifact><gcp:g(toEstablish)><gcp:process>

<gcp:artifact><gcp:g(toJoin)><gcp:process>

<gcp:artifact><gcp:g(toLeave)><gcp:process>

<gcp:artifact><gcp:g(toAdd)><gcp:process>

<gcp:artifact><gcp:g(toSubstitute)><gcp:process>

<gcp:artifact><gcp:g(toImport)><gcp:process>

<gcp:artifact><gcp:g(toMerge)><gcp:process>

<gcp:artifact><gcp:g(toCreate)><gcp:process>

<gcp:artifact><gcp:g(toUpdate)><gcp:process>

SPARQL Query Expression

- Standard query language for RDF
- Can query by stating a consecutive path of specific triple types of subject, predicate, and object

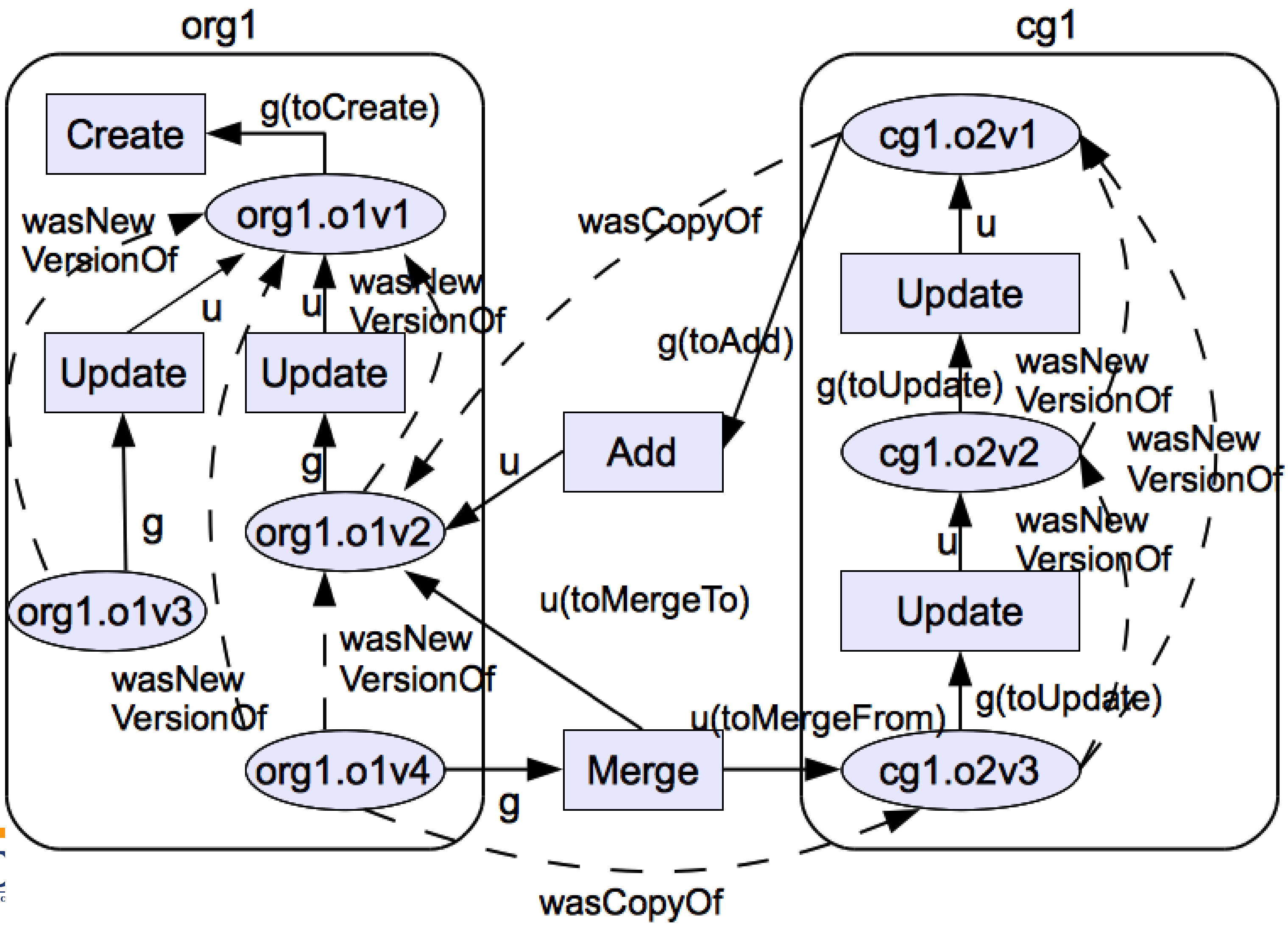
```
SELECT ?ver
WHERE{
   gcp:cg1.o2v2  gcp:wasCopyOf  ?obj.
   ?obj  gcp:wasNewVersionOf  ?ver.}
```

GLEEN-enabled SPARQL

- Gleen is a plugin for the ARQ query engine.
- ARQ is a query engine for Jena, a semantic web framework for Java which supports the SPARQL RDF query language
- Gleen onPath function supports regular expression-based recursive path patterns

subject gleen:OnPath (pathExpression object)

Provenance Data Example



Sample Query 1

- Identify the very initial version of cg1.o2v3 and whether it is created in the current group or added from an organization.
- The query will return “*cg1.o2v1*” and “*add*”

```
SELECT ?obj ?proc
WHERE{
    gcp:cg1.o2v3 gleen:OnPath(
         ”[gcp:wasNewVersionOf]∗” ?obj ).
    ?obj gleen:OnPath(
         [gcp:g(toCreate)]|[gcp:g(toAdd)] ?proc).}
```

Sample Query (cont.)

- To verify users who may have influenced (update/create) an object content regardless of the fact that whether the influence is done on a version of the same object or a version of a copied object of the object.

```
SELECT ?agent
WHERE{
    gcp:org1.o1v4  gleen:OnPath(
            ”([ gcp:wasNewVersionOf ]|[gcp:wasCopyOf])∗” ?obj).
    ?obj gleen:OnPath([gcp:g(toUpdate )]|[gcp:g(toCreate)]
    ?proc).
    ?proc gcp:wasControlledBy ?agent.}
```

Summary

- Identified/captured available or necessary operations as provenance data for group collaboration environment
- Expressed in RDF triples so it can be queried by utilizing a regular expression based path patterns in SPARQL query language
- Showed some utilities of data provenance in a group collaboration environment
- Provides an initial foundation for data provenance access control in group collaboration environment

- Questions and Comments?