Querying graph databases

Graph mutating and pathfinding

NoSQL: Lecture 4

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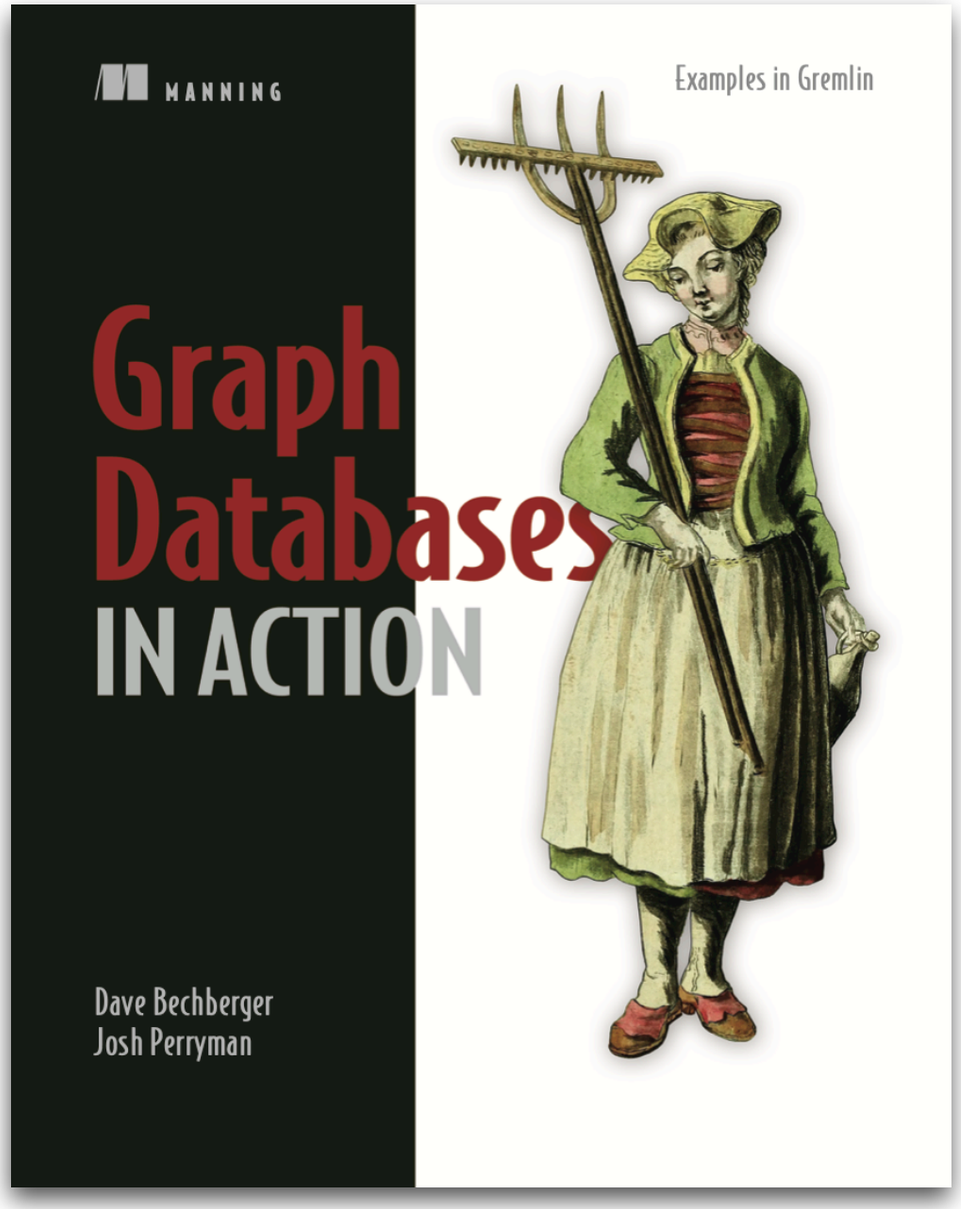
Graph databases In Action

by Dave Bechberger and Josh Perryman

Manning Publications, 2020



Graph mutating

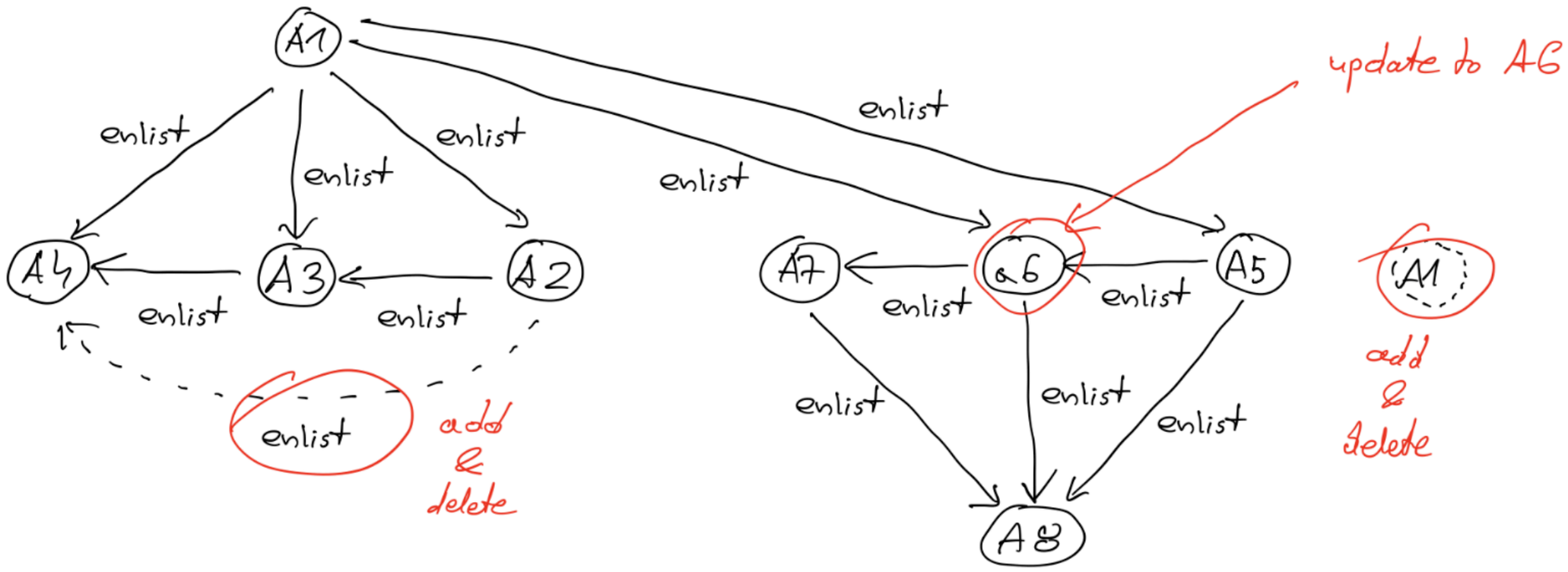
Graph mutating

Mutating simply means changing the graph by adding, modifying, or deleting vertices, edges, and/or properties.

So we will write traversals (yes, we still name it as traversal) to add, modify, and delete vertices, edges, and properties.

Graph mutating

Let's expand the network of secret agents to the following form (use `agent2.groovy` file to (re)create this data)



Graph mutating

Creating vertices and edges

The fundamental concept of creating entities in graph databases isn’t all that different from the relational database world. Creating new vertex entities involves adding the appropriate elements and properties. However, creating new edges is a bit more complicated because we need to specify the vertex that belongs at each end of the edge.

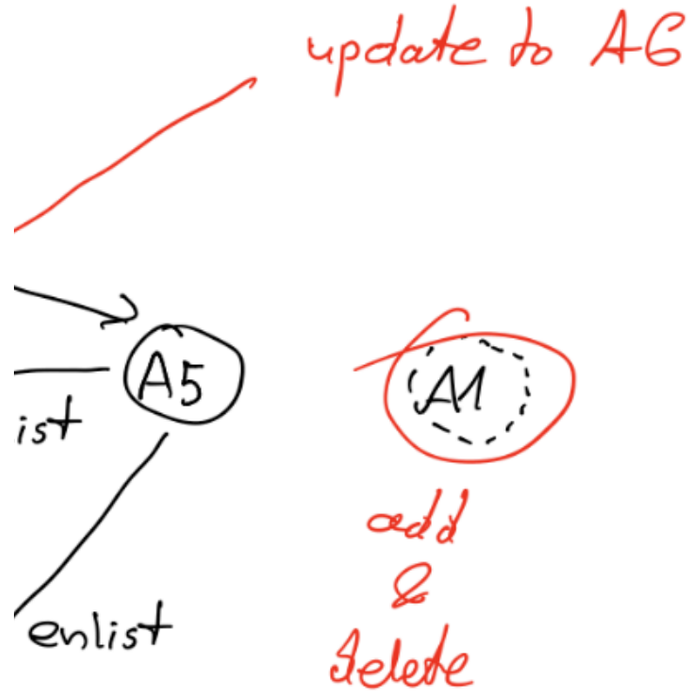
Other words, vertices can exist on its own, while every edge must have its endings "attached" to some vertex - we need to specify the inbound and the outbound vertex for the edge.

Graph mutating

Adding vertices

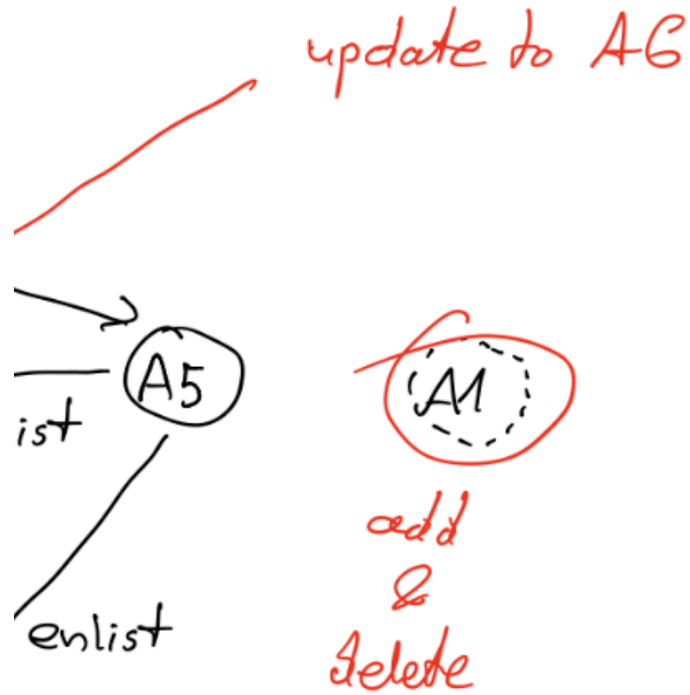
1. Given a traversal source g.
2.
3.

g.



Graph mutating

Adding vertices



1. Given a traversal source g.

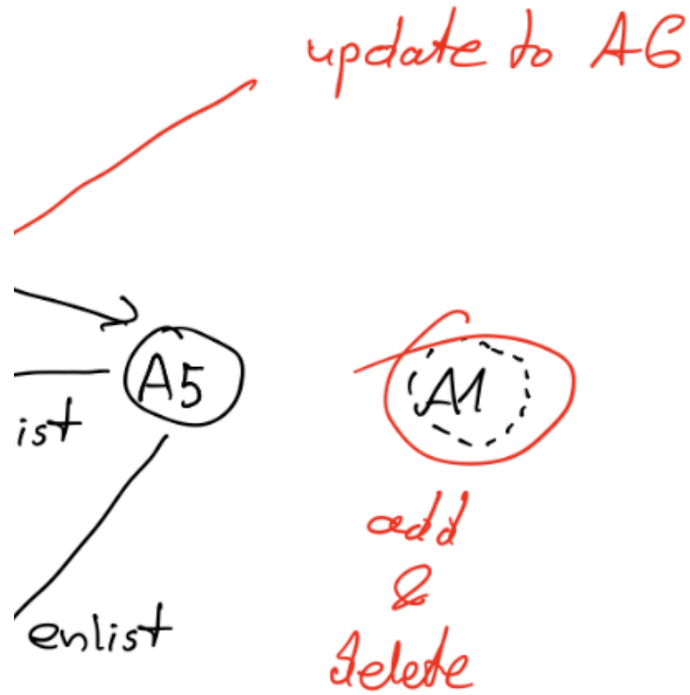
2. Add a new vertex of type *agent*.

3.

```
g.
addV('agent').
```

Graph mutating

Adding vertices



1. Given a traversal source g.

2. Add a new vertex of type *agent*.

3. Add a property to that vertex with the key *pseudonim* and the value *A1*.

```
g.
addV('agent').
property('pseudonim', 'A1')
```

Graph mutating

Adding vertices

```
nosql@nosql:~/Desktop$ ./tinkerpop/gremlin-console/bin/gremlin.sh -i
~/Desktop/nosql_2/agents2.groovy
[ cut some lines here ]
         \,,,/
         (o o)
-----oOOo-(3)-oOOo-----
[ cut some lines here ]
gremlin> graph
==>tinkergraph[vertices:8 edges:12]
gremlin> g.V().elementMap()
==>[id:0,label:agent,pseudonim:A1]
==>[id:2,label:agent,pseudonim:A2]
==>[id:4,label:agent,pseudonim:A3]
==>[id:6,label:agent,pseudonim:A4]
==>[id:8,label:agent,pseudonim:A5]
==>[id:10,label:agent,pseudonim:a6]
==>[id:12,label:agent,pseudonim:A7]
==>[id:14,label:agent,pseudonim:A8]
```

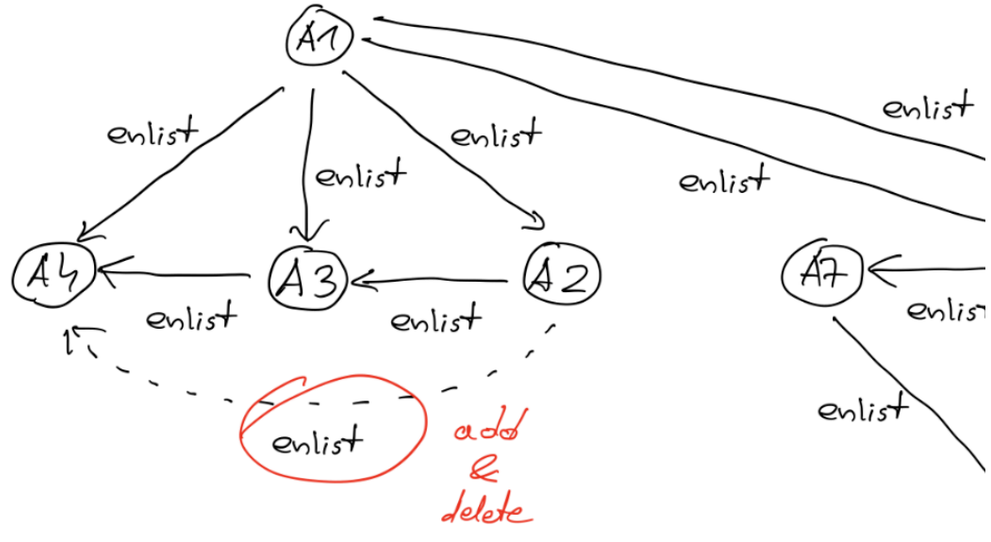
Graph mutating

Adding vertices

```
gremlin> g.V().has('agent', 'pseudonim', 'A1')
==>v[0]
gremlin> g.addV('agent').property('pseudonim', 'A1')
==>v[28]
gremlin> g.V().has('agent', 'pseudonim', 'A1')
==>v[0]
==>v[28]
```

Graph mutating

Adding edges

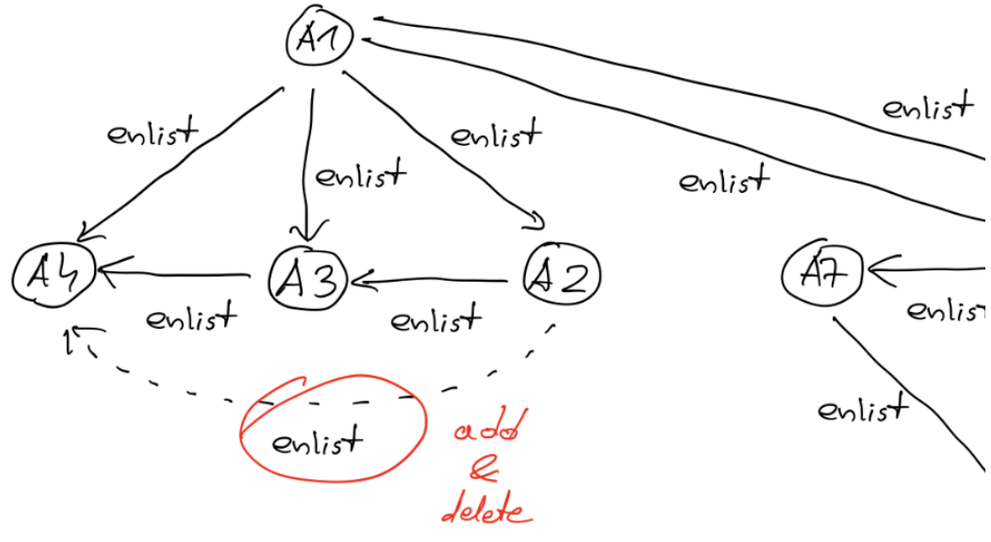


1. Given a traversal source g.
2.
3.
4.

```
g.
```

Graph mutating

Adding edges

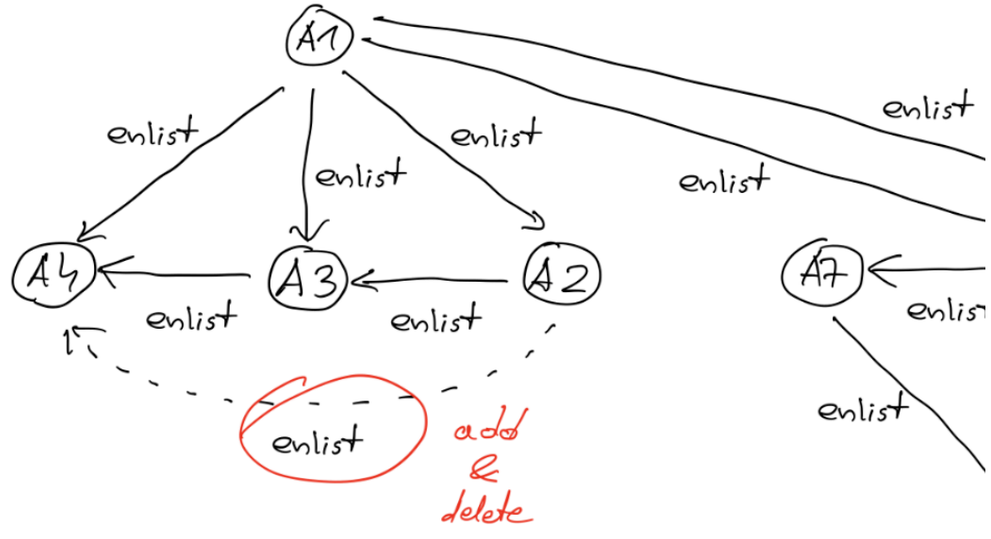


1. Given a traversal source g.
2. Add a new edge with a label *enlist*.
3.
4.

```
g.
addE('enlist').
```

Graph mutating

Adding edges

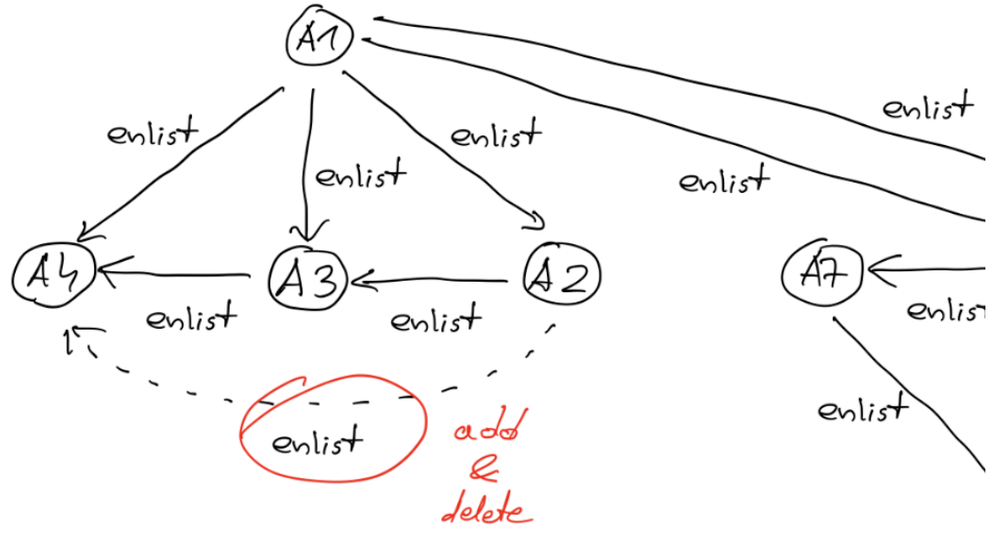


1. Given a traversal source g.
2. Add a new edge with a label *enlist*.
3. Assign the outbound vertex of the edge
4.

```
g.
addE('enlist').
from(

).
```

Graph mutating

Adding edges

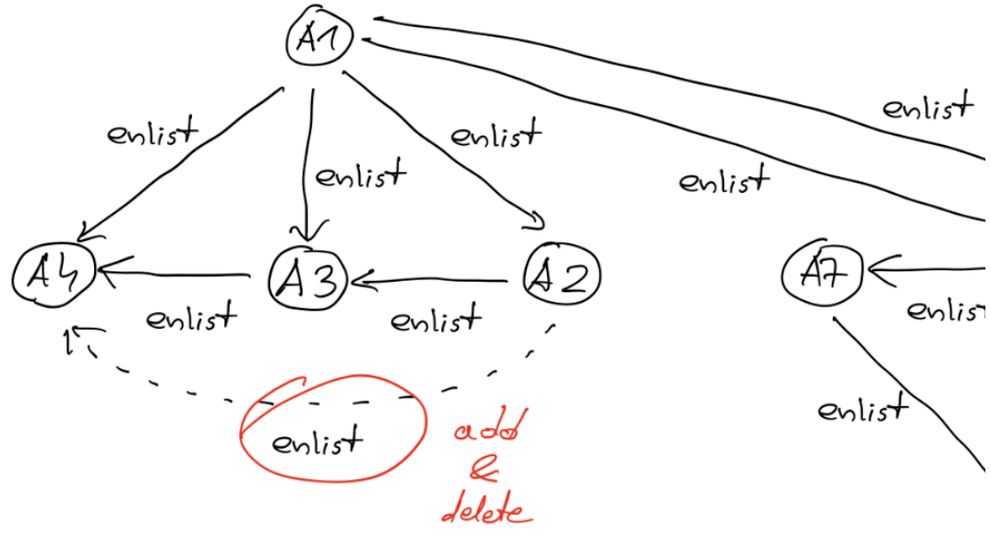


1. Given a traversal source g.
2. Add a new edge with a label *enlist*.
3. Assign the outbound vertex of the edge to the vertex with the key of *pseudonim* and the value of *A2*.
4.

```
g.
addE('enlist').
from(
  V().has('agent', 'pseudonim', 'A2')
).
```

Graph mutating

Adding edges

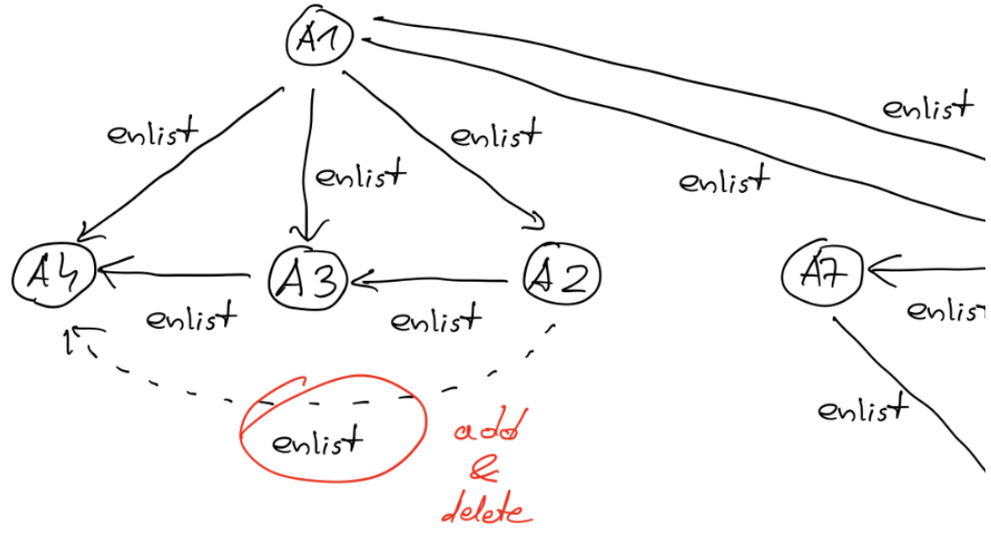


1. Given a traversal source g.
2. Add a new edge with a label *enlist*.
3. Assign the outbound vertex of the edge to the vertex with the key of *pseudonim* and the value of *A2*.
4. Assign the inbound vertex of the edge

```
g.
addE('enlist').
from(
  V().has('agent', 'pseudonim', 'A2')
).
to(

)
```

Graph mutating

Adding edges



1. Given a traversal source g.
2. Add a new edge with a label *enlist*.
3. Assign the outbound vertex of the edge to the vertex with the key of *pseudonim* and the value of *A2*.
4. Assign the inbound vertex of the edge to the vertex with the key of *pseudonim* and the value of *A4*.

```
g.
addE('enlist').
from(
  V().has('agent', 'pseudonim', 'A2')
).
to(
  V().has('agent', 'pseudonim', 'A4')
)
```

Graph mutating

Adding edges

```
gremlin> g.E().elementMap()
==>[id:16,label:enlist,IN:[id:2,label:agent],OUT:[id:0,label:agent]]
==>[id:17,label:enlist,IN:[id:4,label:agent],OUT:[id:0,label:agent]]
==>[id:18,label:enlist,IN:[id:6,label:agent],OUT:[id:0,label:agent]]
==>[id:19,label:enlist,IN:[id:8,label:agent],OUT:[id:0,label:agent]]
==>[id:20,label:enlist,IN:[id:10,label:agent],OUT:[id:0,label:agent]]
==>[id:21,label:enlist,IN:[id:4,label:agent],OUT:[id:2,label:agent]]
==>[id:22,label:enlist,IN:[id:6,label:agent],OUT:[id:4,label:agent]]
==>[id:23,label:enlist,IN:[id:10,label:agent],OUT:[id:8,label:agent]]
==>[id:24,label:enlist,IN:[id:14,label:agent],OUT:[id:8,label:agent]]
==>[id:25,label:enlist,IN:[id:12,label:agent],OUT:
[id:10,label:agent]]
==>[id:26,label:enlist,IN:[id:14,label:agent],OUT:
[id:10,label:agent]]
==>[id:27,label:enlist,IN:[id:14,label:agent],OUT:
[id:12,label:agent]]
```

Graph mutating

Adding edges

```
gremlin> g.addE('enlist').from(V().has('agent','pseudonim','A2')).
to(V().has('agent','pseudonim','A4'))
==>e[30][2-enlist->6]
gremlin> g.E().elementMap()
==>[id:16,label:enlist,IN:[id:2,label:agent],OUT:[id:0,label:agent]]
==>[id:17,label:enlist,IN:[id:4,label:agent],OUT:[id:0,label:agent]]
==>[id:18,label:enlist,IN:[id:6,label:agent],OUT:[id:0,label:agent]]
==>[id:19,label:enlist,IN:[id:8,label:agent],OUT:[id:0,label:agent]]
==>[id:20,label:enlist,IN:[id:10,label:agent],OUT:[id:0,label:agent]]
==>[id:21,label:enlist,IN:[id:4,label:agent],OUT:[id:2,label:agent]]
==>[id:22,label:enlist,IN:[id:6,label:agent],OUT:[id:4,label:agent]]
==>[id:23,label:enlist,IN:[id:10,label:agent],OUT:[id:8,label:agent]]
==>[id:24,label:enlist,IN:[id:14,label:agent],OUT:[id:8,label:agent]]
==>[id:25,label:enlist,IN:[id:12,label:agent],OUT:[id:10,label:agent]]
==>[id:26,label:enlist,IN:[id:14,label:agent],OUT:[id:10,label:agent]]
==>[id:27,label:enlist,IN:[id:14,label:agent],OUT:[id:12,label:agent]]
==>[id:30,label:enlist,IN:[id:6,label:agent],OUT:[id:2,label:agent]]
```

Graph mutating

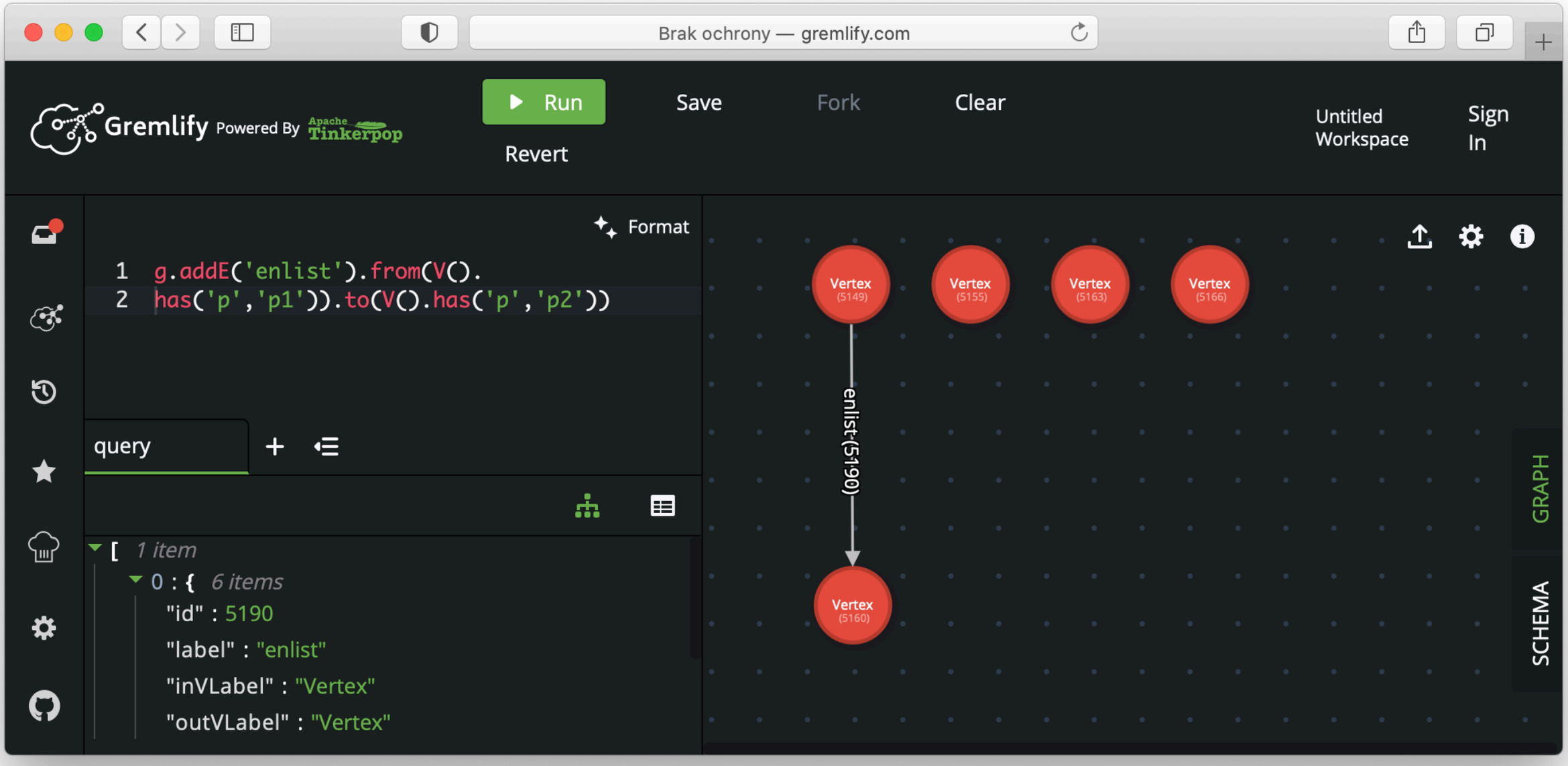
Adding edges - multiple *from* and *to*

We have 2 x 'p1' and 3 x 'p2' vertex

```
g.
addE('enlist').
from(
  V().has('p', 'p1')
).
to(
 V().has('p', 'p2')
)
```

Graph mutating

Adding edges - multiple *from* and *to*



Graph mutating

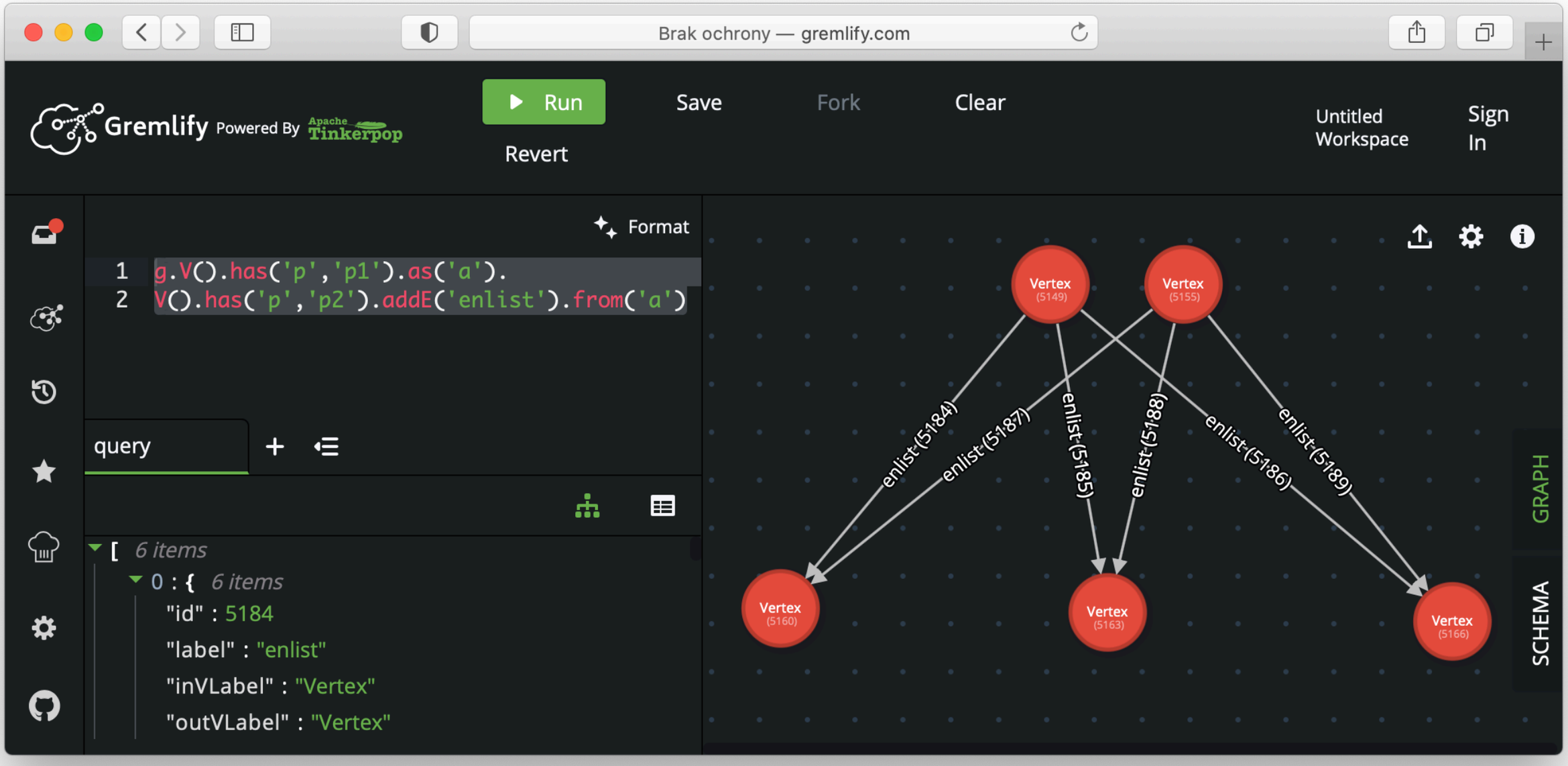
Adding edges - multiple *from* and *to*

We have 2 x 'p1' and 3 x 'p2' vertex

```
g.
V().
has('p', 'p1').
as('a').
V().has('p', 'p2').
addE('enlist').from('a')
```

Graph mutating

Adding edges - multiple *from* and *to*



Graph mutating

Adding property to vertex

gremlin> g.V().elementMap()
==>[id:0,label:agent,pseudonim:A1]
==>[id:2,label:agent,pseudonim:A2]
==>[id:4,label:agent,pseudonim:A3]
==>[id:6,label:agent,pseudonim:A4]
==>[id:8,label:agent,pseudonim:A5]
==>[id:10,label:agent,pseudonim:a6]
==>[id:12,label:agent,pseudonim:A7]
==>[id:28,label:agent,pseudonim:A1] <-- we need this
==>[id:14,label:agent,pseudonim:A8]
gremlin> g.V(28).elementMap()
gremlin> <-- what's wrong?

Graph mutating

Adding property to vertex

gremlin> g.V(28L).elementMap()
==>[id:28,label:agent,pseudonim:A1]
gremlin> v = g.V(28L)
==>v[28]
gremlin> v.property('action','remove')
The traversal strategies are complete and the traversal can no longer be modulated
Type ':help' or ':h' for help.
Display stack trace? [yN]
gremlin> v.class
==>class org.apache.tinkerpop.gremlin.process.traversal.dsl.graph.DefaultGraphTraversal
gremlin> v = g.V(28L).next()
==>v[28]
gremlin> v.class
==>class org.apache.tinkerpop.gremlin.tinkergraph.structure.TinkerVertex
gremlin> v.property('action','remove')
==>vp[action->remove]
gremlin> g.V(28L).elementMap()
==>[id:28,label:agent,action:remove,pseudonim:A1]

Graph mutating

Adding property to edge

gremlin> g.E(30)
gremlin> g.E(30L)
==>e[30][2-enlist->6]
gremlin> g.E(30L).elementMap()
==>[id:30,label:enlist,
IN:[id:6,label:agent],
OUT:[id:2,label:agent]]
gremlin> g.E(30L).property('status','new')
==>e[30][2-enlist->6]
gremlin> g.E(30L).elementMap()
==>[id:30,label:enlist,
IN:[id:6,label:agent],
OUT:[id:2,label:agent],status:new]

Graph mutating

Updating data: vertex

```
gremlin> g.V().has('agent','pseudonim','a6').
elementMap()
==>[id:10,label:agent,pseudonim:a6]
gremlin> g.V(10L).elementMap()
==>[id:10,label:agent,pseudonim:a6]
gremlin> g.V().has('agent','pseudonim','a6').
property('pseudonim','A6')
==>v[10]
gremlin> g.V(10L).elementMap()
==>[id:10,label:agent,pseudonim:A6]
```

Graph mutating

Updating data: edge

```
gremlin> g.E().has('enlist','status','new')
==>e[30][2-enlist->6]
gremlin> g.E().has('status','new')
==>e[30][2-enlist->6]
gremlin> g.E().has('status')
==>e[30][2-enlist->6]
gremlin> g.E().has('status').elementMap()
==>[id:30,label:enlist,
IN:[id:6,label:agent],
OUT:[id:2,label:agent],status:new]
gremlin> g.E().has('status').property('status','to_delete')
==>e[30][2-enlist->6]
gremlin> g.E().has('status').elementMap()
==>[id:30,label:enlist,
IN:[id:6,label:agent],
OUT:[id:2,label:agent],status:to_delete]
```

Graph mutating

Removing data: vertex

```
gremlin> g.V().has('action','remove').elementMap()
==>[id:28,label:agent,action:remove,pseudonim:A1]
gremlin> g.V(28L).elementMap()
==>[id:28,label:agent,action:remove,pseudonim:A1]
gremlin> g.V().has('action','remove').drop()
gremlin> g.V(28L).elementMap()
```

Graph mutating

Removing data: edge

```
gremlin> g.E().has('status','to_delete').
elementMap()
==>[id:30,label:enlist,
IN:[id:6,label:agent],
OUT:[id:2,label:agent],status:to_delete]
gremlin> g.E(30L).elementMap()
==>[id:30,label:enlist,
IN:[id:6,label:agent],
OUT:[id:2,label:agent],status:to_delete]
gremlin> g.E().has('status','to_delete').drop()
gremlin> g.E(30L).elementMap()
```

Pathfinding

Finding the simple path

Finding the paths that connect two vertices

We are looking for the simple path between two vertices, no matter if it's from A to B or from B to A.

```
g.V().
has('pseudonim','A2').
until(
  has('pseudonim','A8')
).
repeat(
  both('enlist')
).
path()
```

Finding the simple path

Finding the paths that connect two vertices

```
gremlin> g.V().has('pseudonim','A2').until(has('pseudonim','A8')).repeat(both('enlist')).path()
==>[v[2],v[0],v[8],v[14]]
==>[v[2],v[0],v[10],v[14]]
==>[v[2],v[4],v[0],v[8],v[14]]
==>[v[2],v[4],v[0],v[10],v[14]]
==>[v[2],v[0],v[8],v[10],v[14]]
==>[v[2],v[0],v[10],v[12],v[14]]
==>[v[2],v[0],v[10],v[8],v[14]]
==>[v[2],v[4],v[6],v[0],v[8],v[14]]
==>[v[2],v[4],v[6],v[0],v[10],v[14]]
==>[v[2],v[4],v[0],v[8],v[10],v[14]]
==>[v[2],v[4],v[0],v[10],v[12],v[14]]
==>[v[2],v[4],v[0],v[10],v[8],v[14]]
==>[v[2],v[4],v[2],v[0],v[8],v[14]]
==>[v[2],v[4],v[2],v[0],v[10],v[14]]
==>[v[2],v[0],v[2],v[0],v[8],v[14]]
==>[v[2],v[0],v[2],v[0],v[10],v[14]]
==>[v[2],v[0],v[4],v[0],v[8],v[14]]
==>[v[2],v[0],v[4],v[0],v[10],v[14]]
==>[v[2],v[0],v[6],v[0],v[8],v[14]]
==>[v[2],v[0],v[6],v[0],v[10],v[14]]
==>[v[2],v[0],v[8],v[10],v[12],v[14]]
==>[v[2],v[0],v[8],v[10],v[8],v[14]]
==>[v[2],v[0],v[8],v[0],v[8],v[14]]
==>[v[2],v[0],v[8],v[0],v[10],v[14]]
==>[v[2],v[0],v[10],v[12],v[10],v[14]]
==>[v[2],v[0],v[10],v[0],v[8],v[14]]
==>[v[2],v[0],v[10],v[0],v[10],v[14]]
==>[v[2],v[0],v[10],v[8],v[10],v[14]]
```

Finding the simple path

Finding the paths that connect two vertices

Be sure to avoid cycles

```
gremlin> g.V().has('pseudonim','A2').until(has('pseudonim','A8')).repeat(both('enlist')).path()
==>[v[2],v[0],v[8],v[14]]
==>[v[2],v[0],v[10],v[14]]
==>[v[2],v[4],v[0],v[8],v[14]]
==>[v[2],v[4],v[0],v[10],v[14]]
==>[v[2],v[0],v[8],v[10],v[14]]
==>[v[2],v[0],v[10],v[12],v[14]]
==>[v[2],v[0],v[10],v[8],v[14]]
==>[v[2],v[4],v[6],v[0],v[8],v[14]]
==>[v[2],v[4],v[6],v[0],v[10],v[14]]
==>[v[2],v[4],v[0],v[8],v[10],v[14]]
==>[v[2],v[4],v[0],v[10],v[12],v[14]]
==>[v[2],v[4],v[0],v[10],v[8],v[14]]
==>[v[2],v[4],v[2],v[0],v[8],v[14]]
==>[v[2],v[4],v[2],v[0],v[10],v[14]]
==>[v[2],v[0],v[2],v[0],v[8],v[14]]
==>[v[2],v[0],v[2],v[0],v[10],v[14]]
==>[v[2],v[0],v[4],v[0],v[8],v[14]]
==>[v[2],v[0],v[4],v[0],v[10],v[14]]
==>[v[2],v[0],v[6],v[0],v[8],v[14]]
==>[v[2],v[0],v[6],v[0],v[10],v[14]]
==>[v[2],v[0],v[8],v[10],v[12],v[14]]
==>[v[2],v[0],v[8],v[10],v[8],v[14]]
==>[v[2],v[0],v[8],v[0],v[8],v[14]]
==>[v[2],v[0],v[8],v[0],v[10],v[14]]
==>[v[2],v[0],v[10],v[12],v[10],v[14]]
==>[v[2],v[0],v[10],v[0],v[8],v[14]]
==>[v[2],v[0],v[10],v[0],v[10],v[14]]
==>[v[2],v[0],v[10],v[8],v[10],v[14]]
```

Finding the simple path

Finding the paths that connect two vertices

```
gremlin> g.V().has('pseudonim','A2').
until(has('pseudonim','A8')).
repeat(both('enlist')).path()
...
==>[v[2],v[0],v[2],v[0],v[8],v[14]]
...
==>[v[2],v[0],v[10],v[8],v[10],v[14]]
...
==>[v[2],v[4],v[6],v[4],v[6],v[0],v[8],v[14]]
...
gremlin>
```

Finding the simple path

Finding the paths that connect two vertices

Be sure to avoid cycles

```
gremlin> g.V().has('pseudonim','A2').
until(has('pseudonim','A8')).
repeat(both('enlist')).path()
...
==>[v[2],v[0],v[2],v[0],v[8],v[14]]
...
==>[v[2],v[0],v[10],v[8],v[10],v[14]]
...
==>[v[2],v[4],v[6],v[4],v[6],v[0],v[8],v[14]]
...
gremlin>
```

Finding the simple path

Finding the paths that connect two vertices

`simplePath()` - Filters out traversers that visit the same vertex more than once.

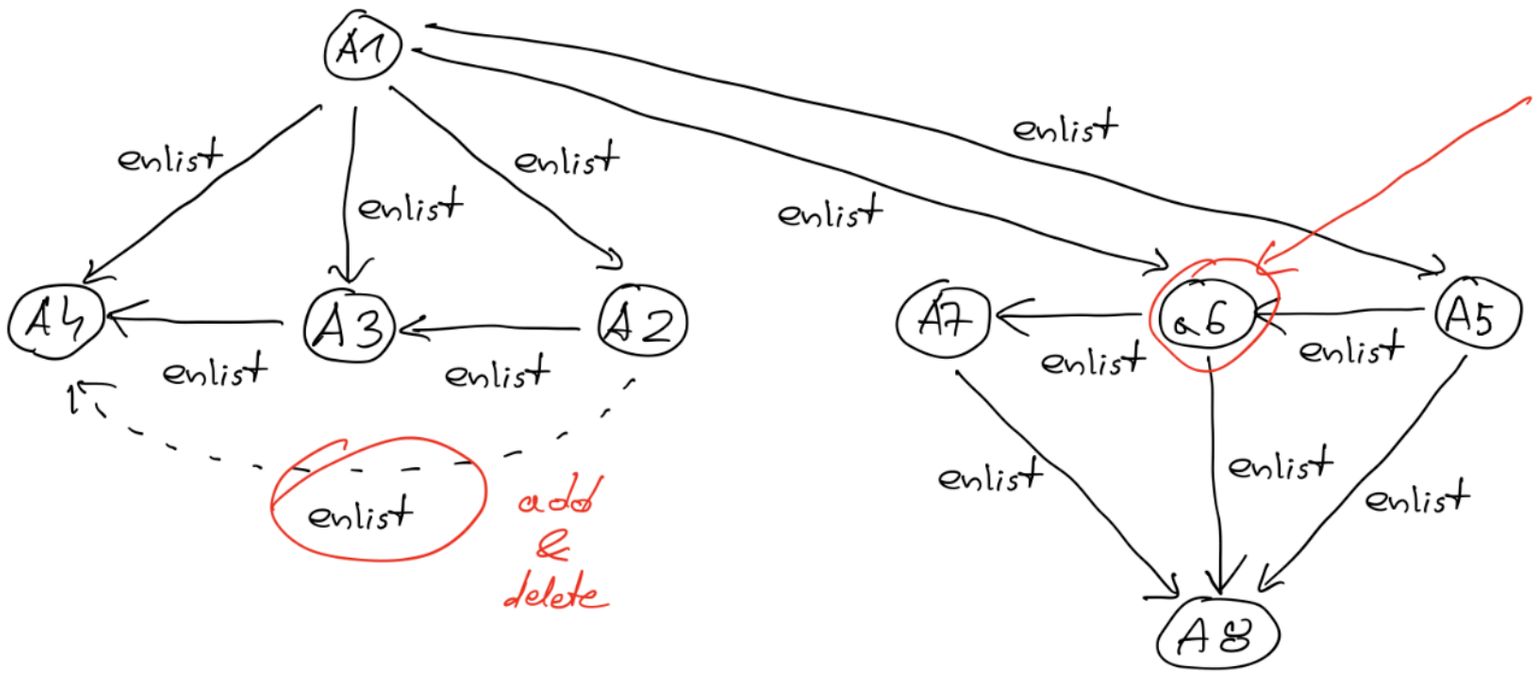
Using this step, we can update our traversal to find the simple path between node A and B.

```
g.V().has('pseudonim','A2').
until(
  has('pseudonim','A8')
).
repeat(
  both('enlist').simplePath()
).
path()
```

Finding the simple path

Finding the paths that connect two vertices

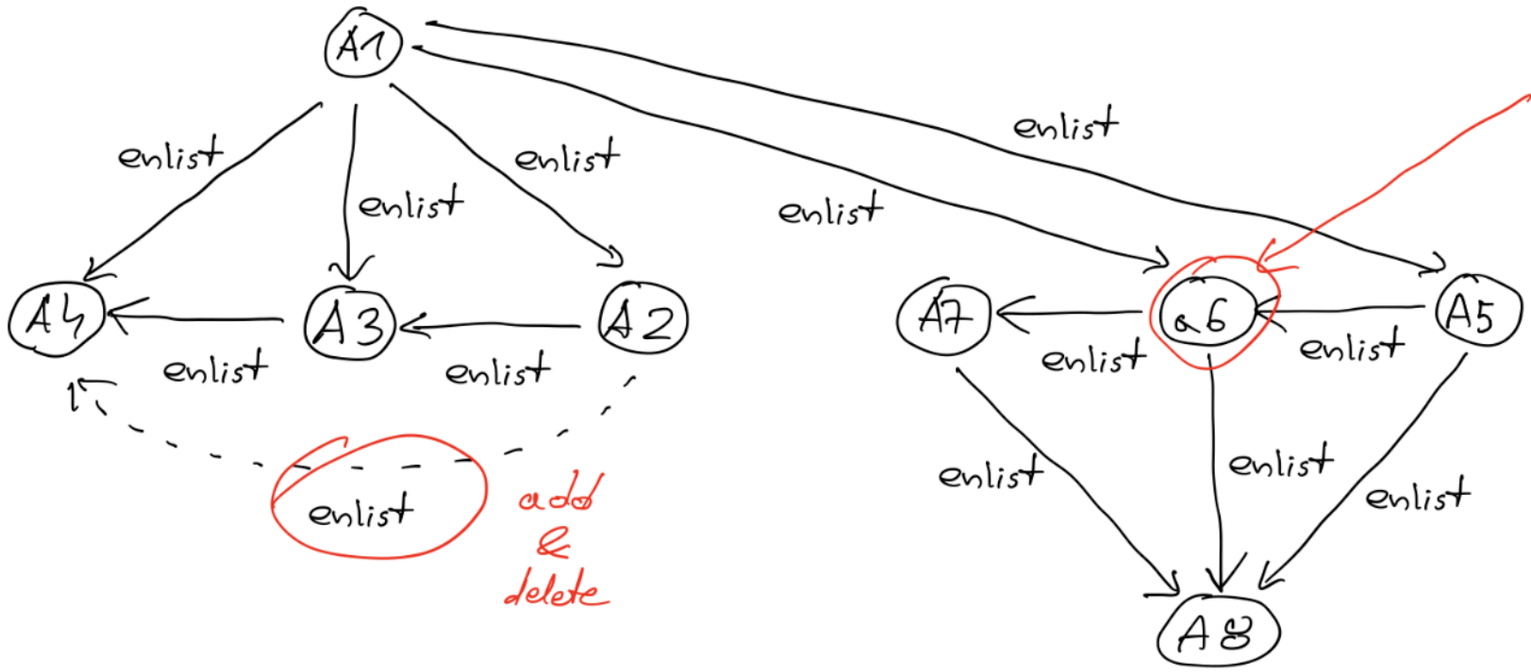
gremlin> g.V().has('pseudonim','A2').until(has('pseudonim','A8')).repeat(both('enlist').simplePath()).path()
==>[v[2],v[0],v[8],v[14]]
==>[v[2],v[0],v[10],v[14]]
==>[v[2],v[4],v[0],v[8],v[14]]
==>[v[2],v[4],v[0],v[10],v[14]]
==>[v[2],v[0],v[8],v[10],v[14]]
==>[v[2],v[0],v[10],v[12],v[14]]
==>[v[2],v[0],v[10],v[8],v[14]]
==>[v[2],v[4],v[6],v[0],v[8],v[14]]
==>[v[2],v[4],v[6],v[0],v[10],v[14]]
==>[v[2],v[4],v[0],v[8],v[10],v[14]]
==>[v[2],v[4],v[0],v[10],v[12],v[14]]
==>[v[2],v[4],v[0],v[10],v[8],v[14]]
==>[v[2],v[0],v[8],v[10],v[12],v[14]]
==>[v[2],v[4],v[6],v[0],v[8],v[10],v[14]]
==>[v[2],v[4],v[6],v[0],v[10],v[12],v[14]]
==>[v[2],v[4],v[6],v[0],v[10],v[8],v[14]]
==>[v[2],v[4],v[0],v[8],v[10],v[12],v[14]]
==>[v[2],v[4],v[6],v[0],v[8],v[10],v[12],v[14]]
gremlin>



Finding the simple path

Finding the paths that connect two vertices

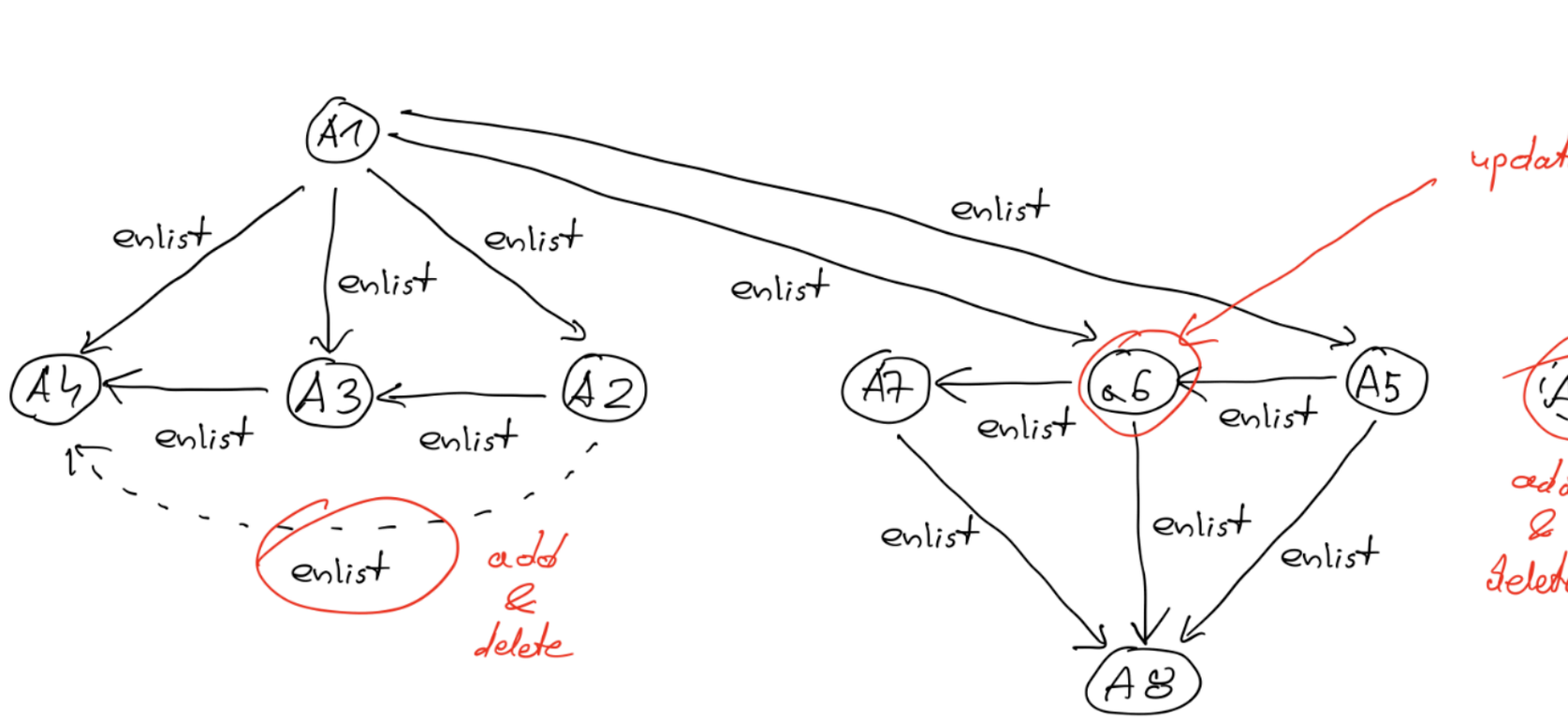
gremlin> g.V().has('pseudonim','A2').until(has('pseudonim','A8')).repeat(both('enlist').
simplePath()).path().unfold().elementMap()
==>[id:2,label:agent,pseudonim:A2]
==>[id:0,label:agent,pseudonim:A1]
==>[id:8,label:agent,pseudonim:A5]
==>[id:14,label:agent,pseudonim:A8]
==>[id:2,label:agent,pseudonim:A2]
==>[id:0,label:agent,pseudonim:A1]
==>[id:10,label:agent,pseudonim:A6]
==>[id:14,label:agent,pseudonim:A8]
==>[id:2,label:agent,pseudonim:A2]
==>[id:4,label:agent,pseudonim:A3]
==>[id:0,label:agent,pseudonim:A1]
==>[id:8,label:agent,pseudonim:A5]
==>[id:14,label:agent,pseudonim:A8]
...
gremlin>



Finding the simple path

Finding the paths that connect two vertices

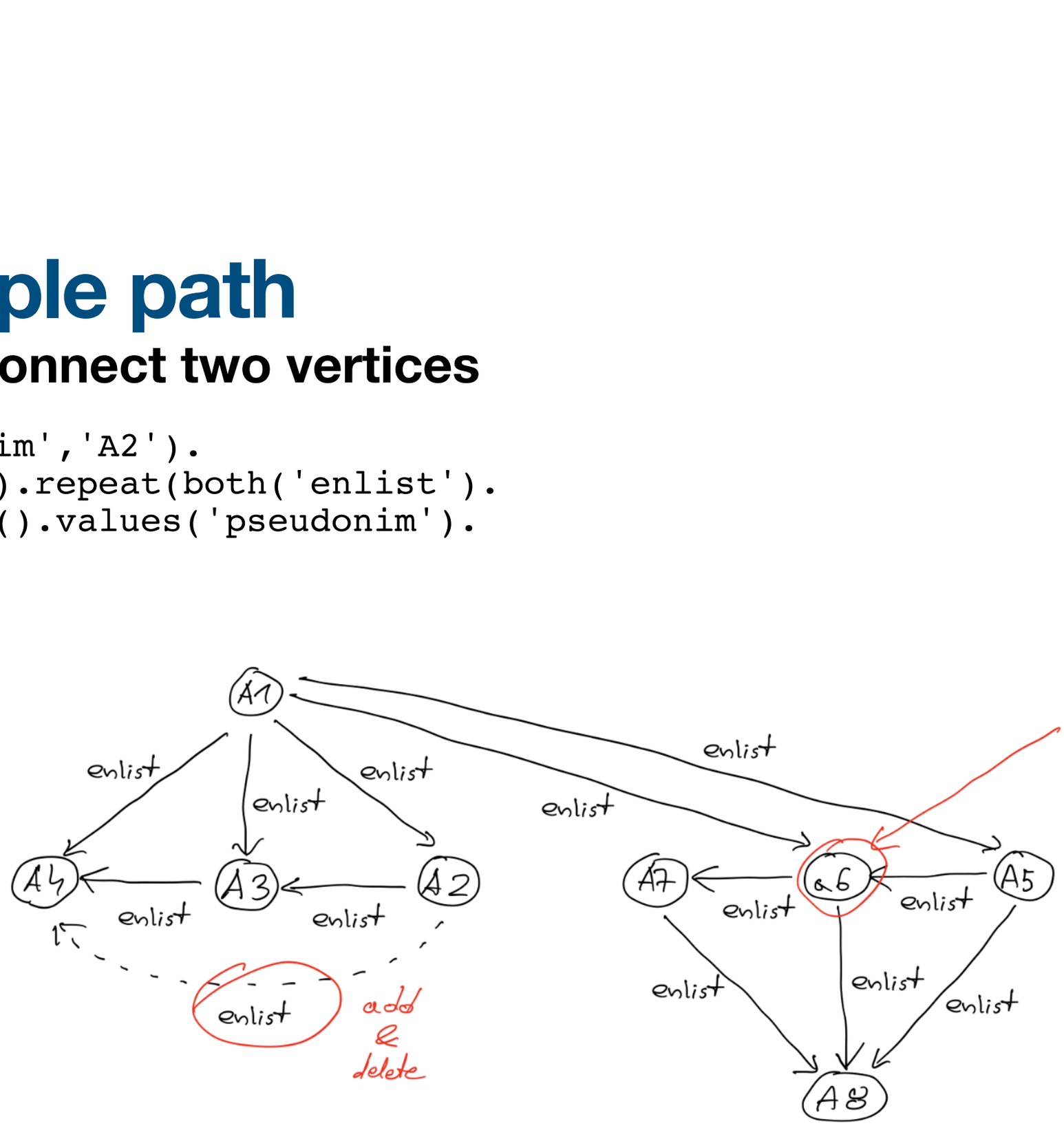
```
gremlin> g.V().has('pseudonim','A2').until(has('pseudonim','A8')).
repeat(both('enlist').simplePath()).path().unfold().
values('pseudonim')
==>A2
==>A1
==>A5
==>A8
==>A2
==>A1
==>A6
==>A8
==>A2
==>A3
==>A1
==>A5
==>A8

...

gremlin>
```



Finding the simple path

Finding the paths that connect two vertices

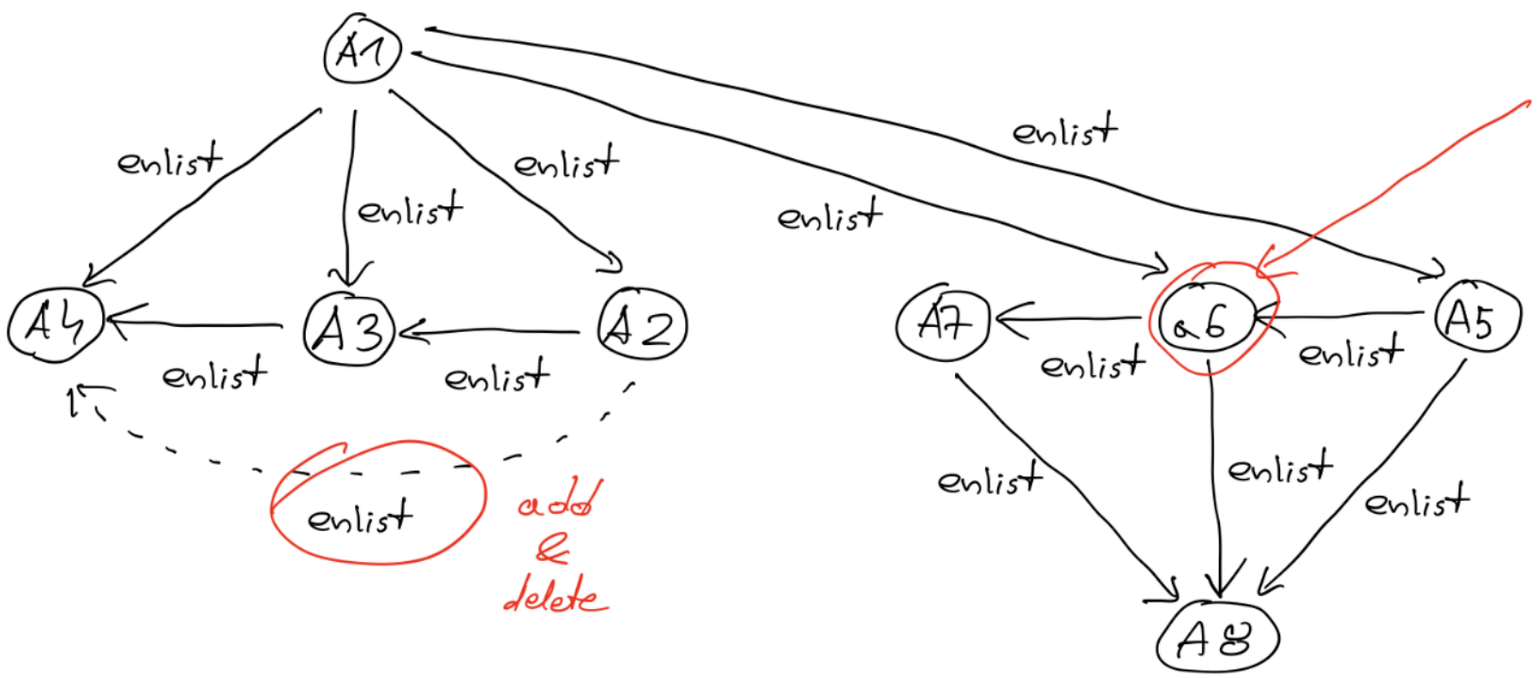
```
gremlin> g.V().has('pseudonim','A2').
until(has('pseudonim','A8')).repeat(both('enlist').
simplePath()).path().unfold().values('pseudonim').
fold()
==>[A2,A1,A5,A8,
A2,A1,A6,A8,
A2,A3,A1,A5,A8,
A2,A3,A1,A6,A8,
A2,A1,A5,A6,A8,
A2,A1,A6,A7,A8,
A2,A3,A4,A1,A6,A8,
A2,A3,A1,A5,A6,A8,
A2,A3,A1,A6,A7,A8,
A2,A3,A1,A6,A5,A8,
A2,A1,A5,A6,A7,A8,
A2,A3,A4,A1,A5,A6,A8,
A2,A3,A4,A1,A6,A7,A8,
A2,A3,A4,A1,A6,A5,A8,
A2,A3,A1,A5,A6,A7,A8,
A2,A3,A4,A1,A5,A6,A7,A8,
A2,A1,A6,A5,A8,
A2,A3,A4,A1,A5,A8]
gremlin>
```



Finding the simple path

Finding the paths that connect two vertices: task

```
gremlin> ???
==>[A2,A1,A5,A8]
==>[A2,A1,A6,A8]
==>[A2,A3,A1,A5,A8]
```



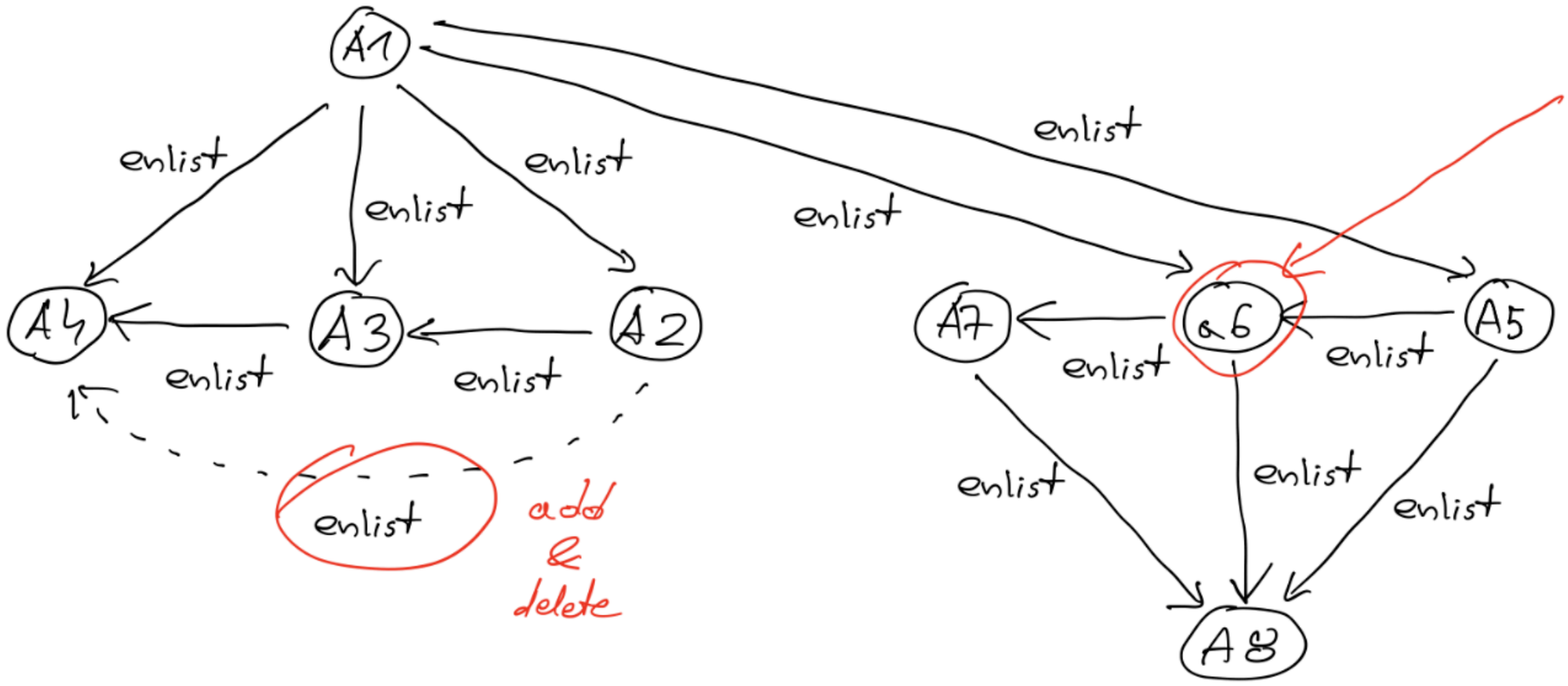
Finding the simple path

Finding the paths that connect two vertices

To be able to print full path info, with vertices and edges, we have to "touch" both edges and vertices during our traversal.

Recall the example of `out()` and `outE()` from the previous part of the lecture.

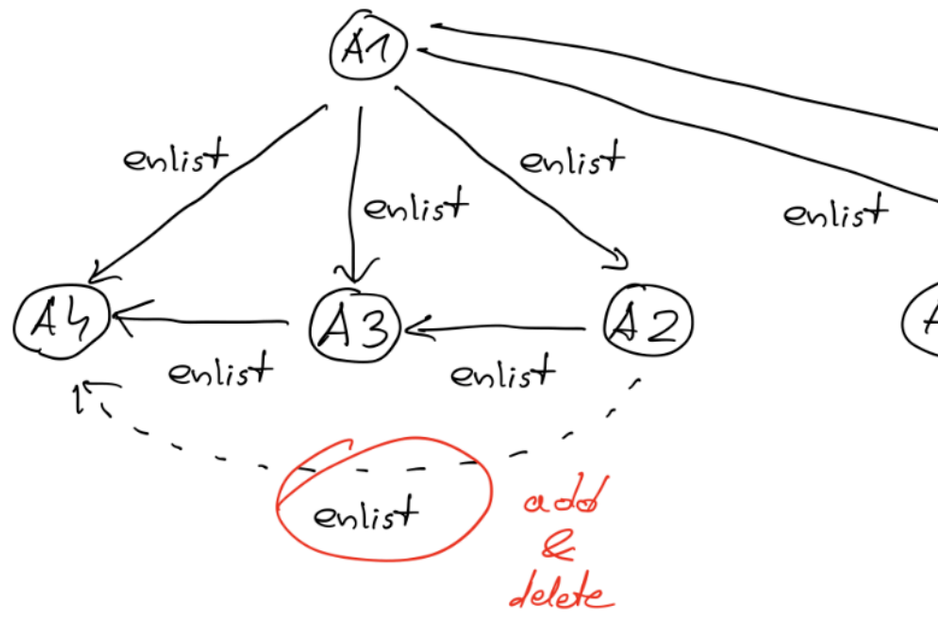
```
gremlin> g.V().has('pseudonim','A2').
until(has('pseudonim','A8')).
repeat(bothE('enlist').otherV().simplePath()).
path()
==>[v[2],e[16][0-enlist->2],v[0],e[19][0-enlist-
>8],v[8],e[24][8-enlist->14],v[14]]
==>[v[2],e[16][0-enlist->2],v[0],e[20][0-enlist-
>10],v[10],e[26][10-enlist->14],v[14]]
==>[v[2],e[21][2-enlist->4],v[4],e[17][0-enlist-
>4],v[0],e[19][0-enlist->8],v[8],e[24][8-enlist-
>14],v[14]]
```



Working with subgraphs

Simple example

```
gremlin> subgraph = g.V().has('pseudonim','A3').bothE().subgraph('sg').
cap('sg').next()
==>tinkergraph[vertices:4 edges:3]
gremlin> sg=subgraph.traversal()
==>graphtraversalsource[tinkergraph[vertices:4 edges:3], standard]
gremlin> sg.V()
==>v[0]
==>v[2]
==>v[4]
==>v[6]
gremlin> sg.E()
==>e[17][0-enlist->4]
==>e[21][2-enlist->4]
==>e[22][4-enlist->6]
gremlin> sg.V().elementMap()
==>[id:0,label:agent,pseudonim:A1]
==>[id:2,label:agent,pseudonim:A2]
==>[id:4,label:agent,pseudonim:A3]
==>[id:6,label:agent,pseudonim:A4]
gremlin> sg.E().elementMap()
==>[id:17,label:enlist,IN:[id:4,label:agent],OUT:[id:0,label:agent]]
==>[id:21,label:enlist,IN:[id:4,label:agent],OUT:[id:2,label:agent]]
==>[id:22,label:enlist,IN:[id:6,label:agent],OUT:[id:4,label:agent]]
```



Bibliography

- [Bec] Dave Bechberger, Josh Perryman, *Graph Databases in Action*, Manning Publications, 2020