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ASGraph

A Mutable Multi-Versioned Graph Container with High Analytical Performance

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Safe Harbor Statement

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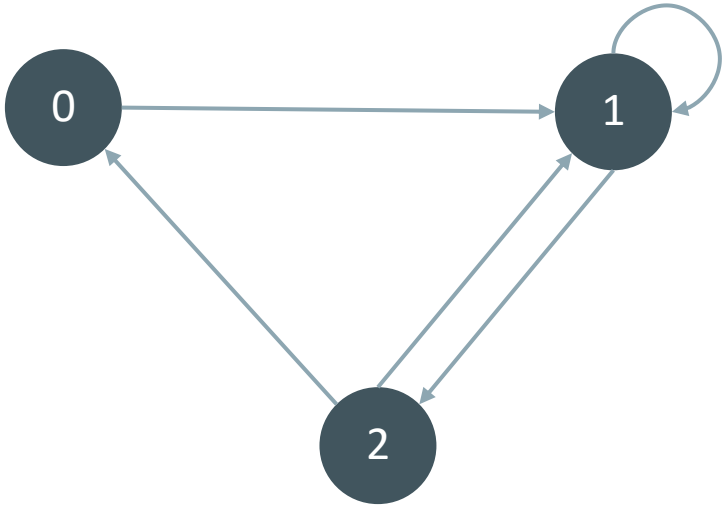
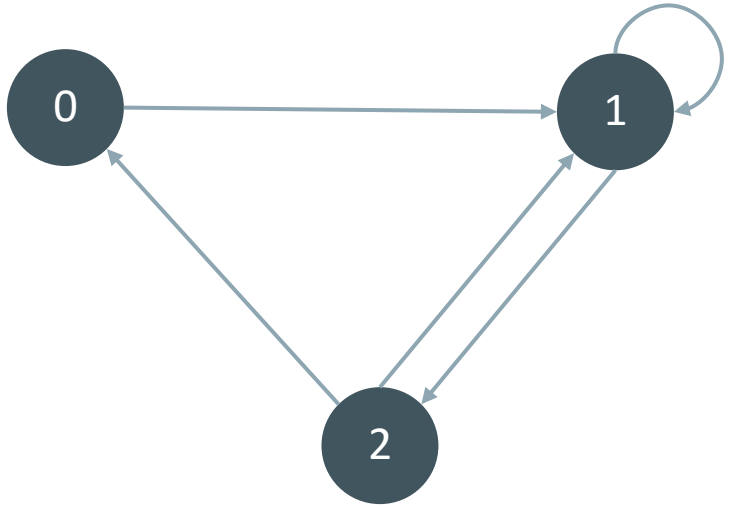
How do we store graphs?



How do we store graphs?

Adjacency matrix

	A	B	C
A		x	
B		x	x
C	x	x	



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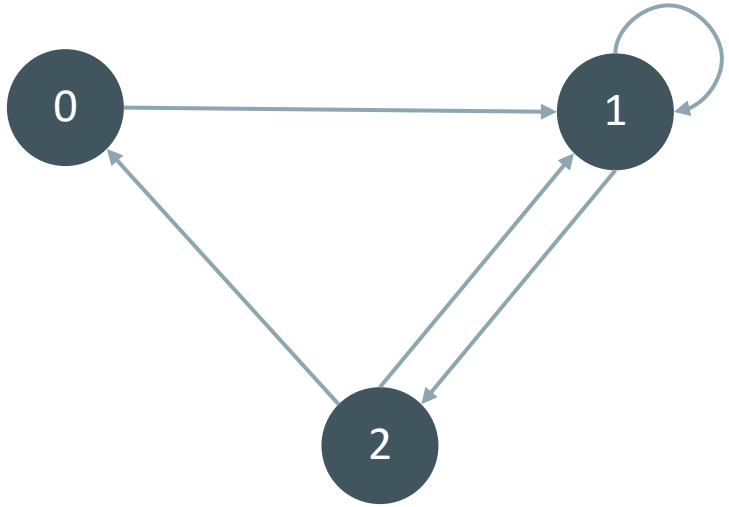
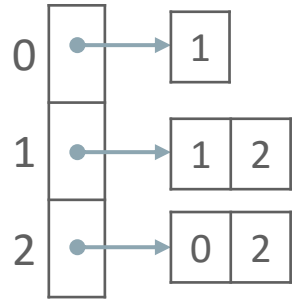


Adjacency Lists



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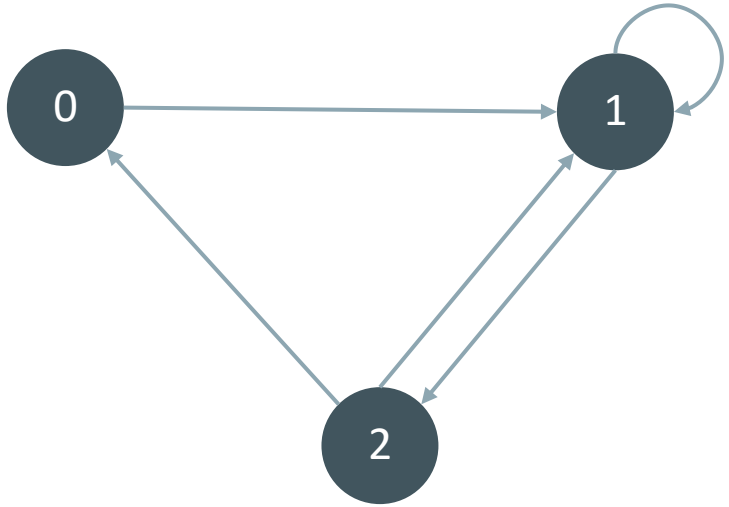

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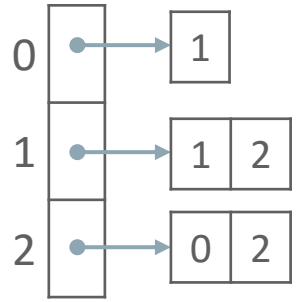
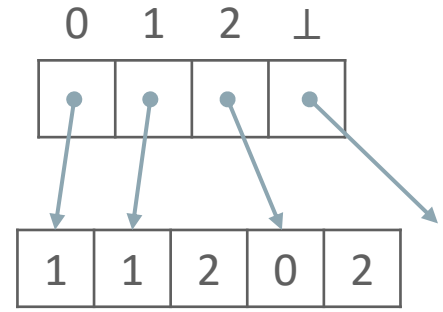


Compressed Sparse Row



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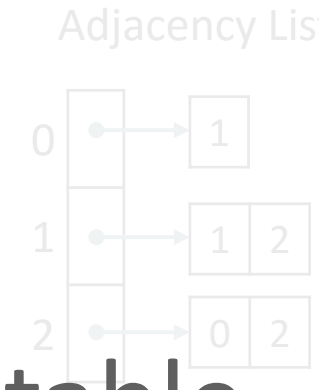
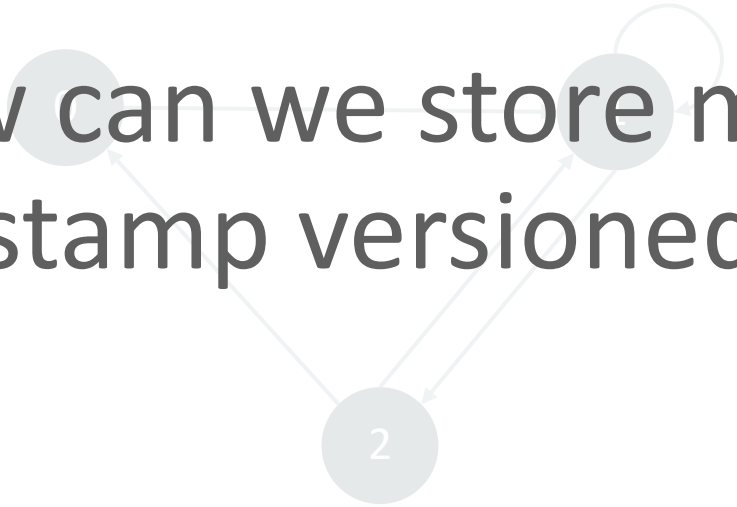
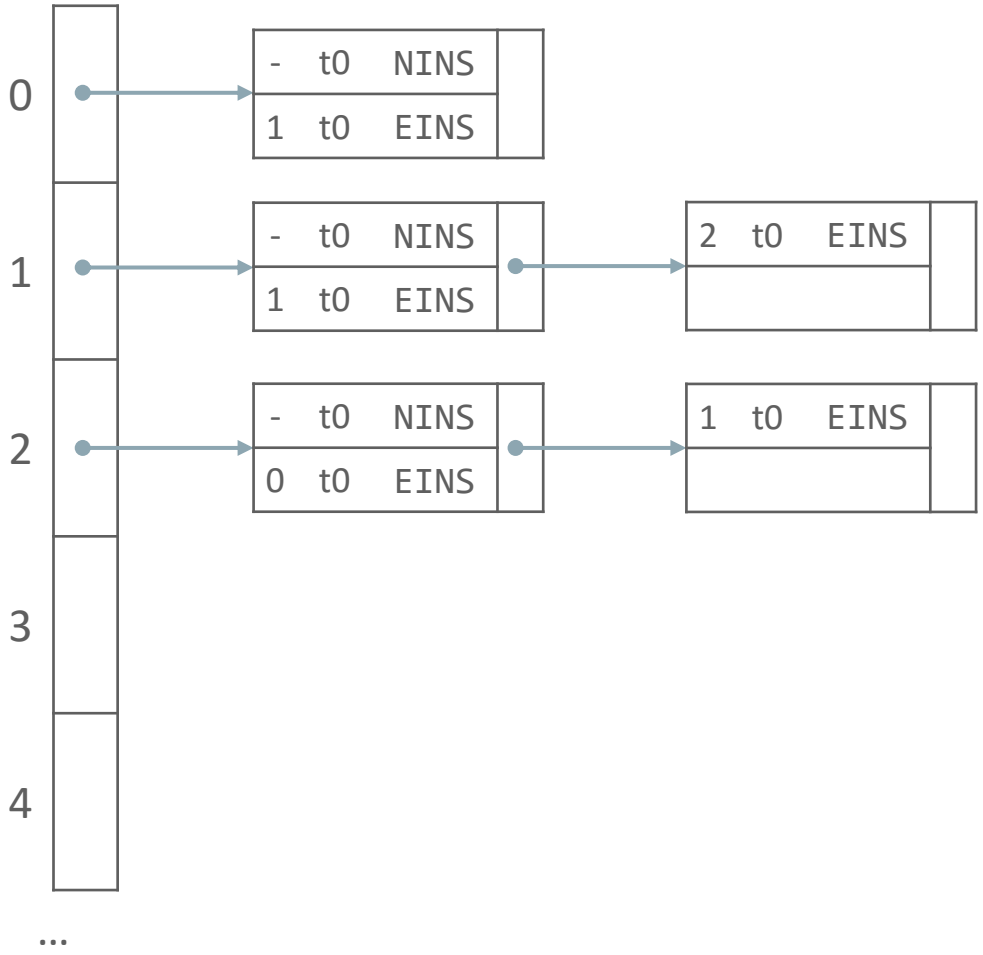
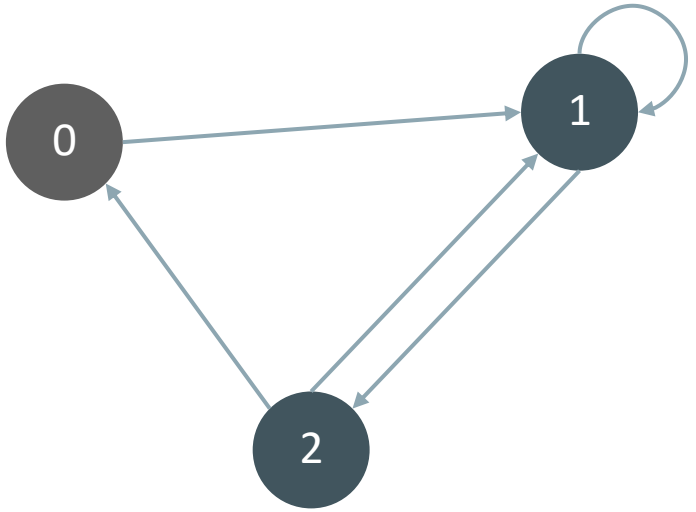


How can we store mutable, timestamp versioned graphs?



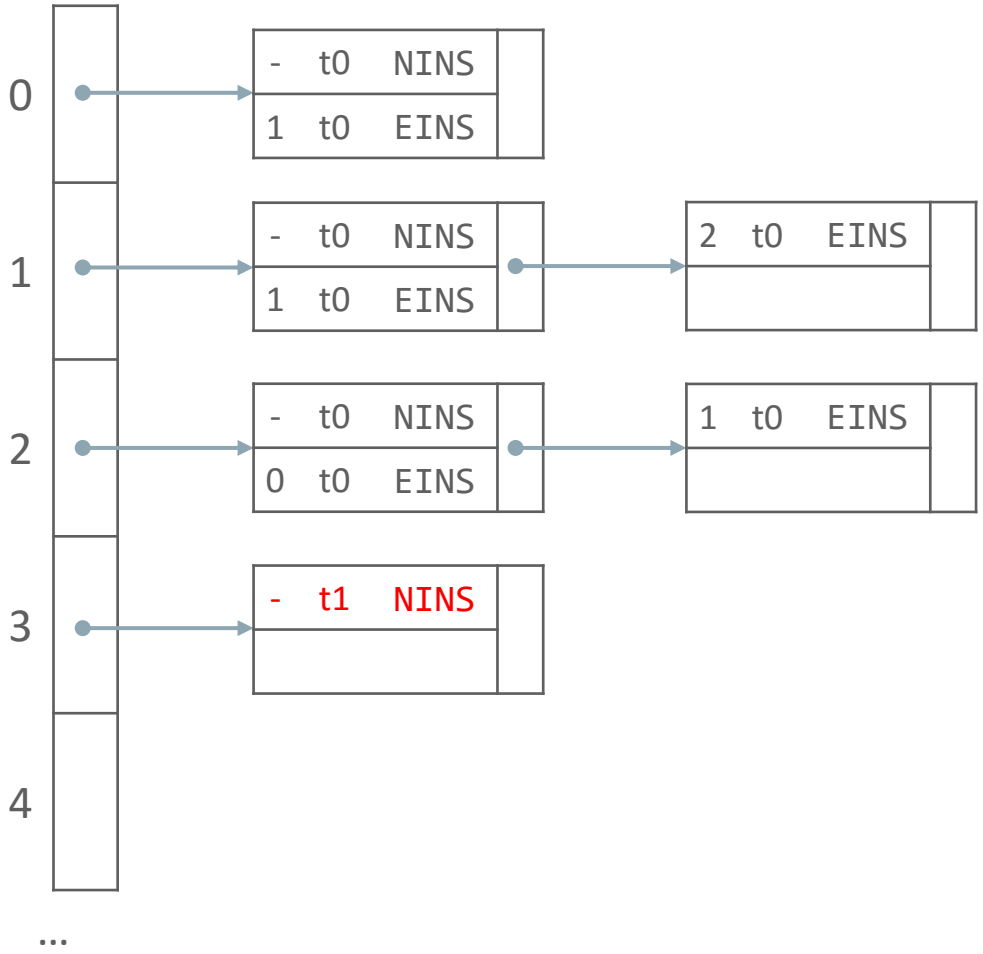
ASGraph (=Analytical Snapshot Graph)

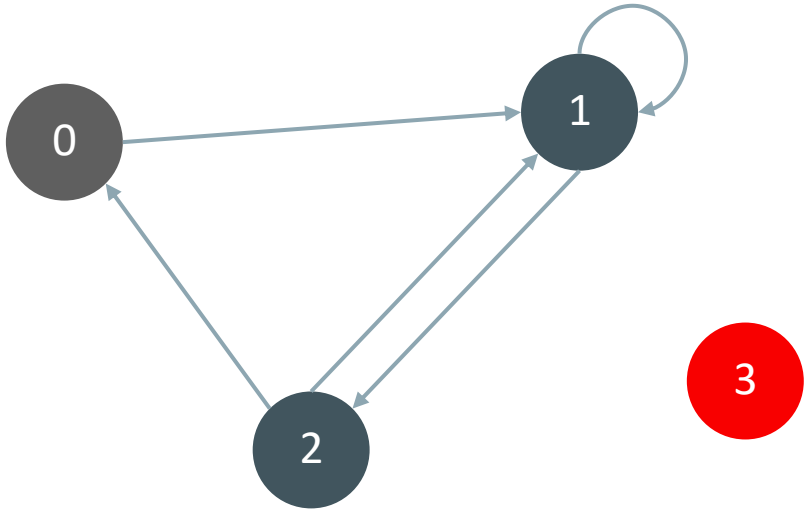




Operation Types	
NINS	Node Insert
NDEL	Node Delete
EINS	Edge Insert
EDEL	Edge Delete

ASGraph





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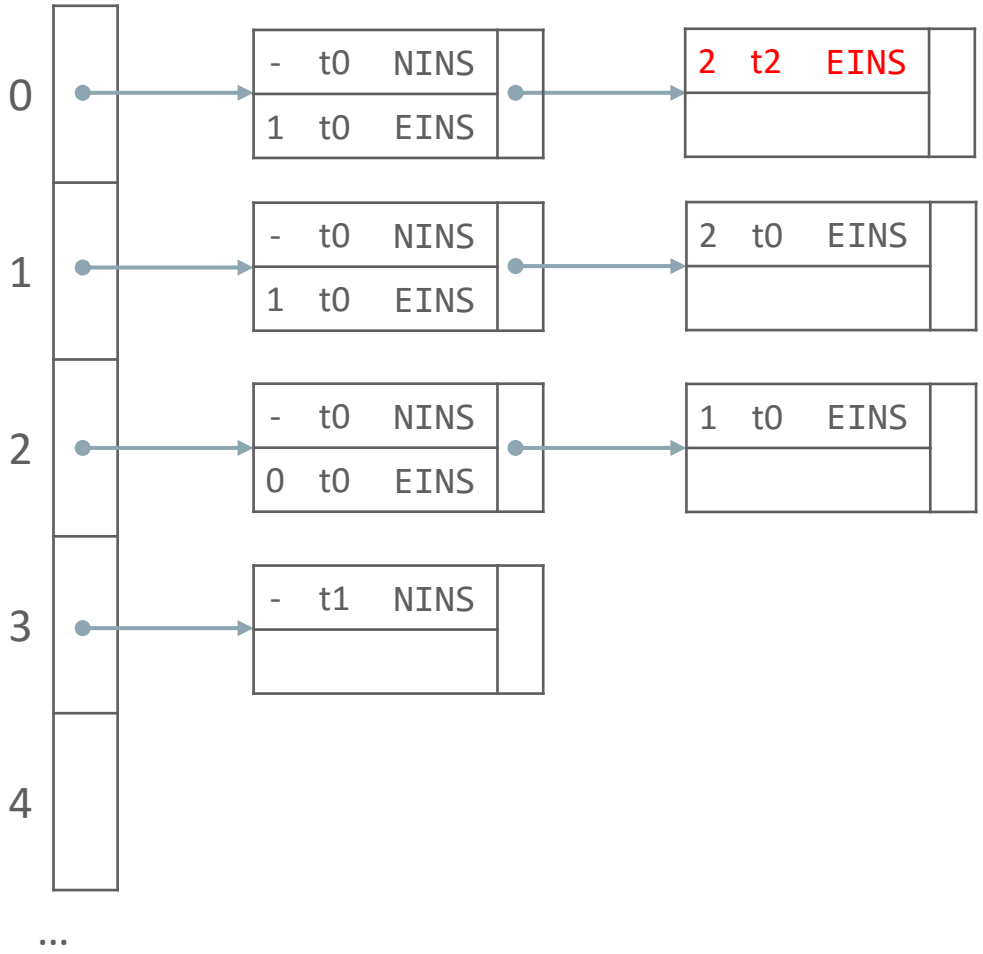

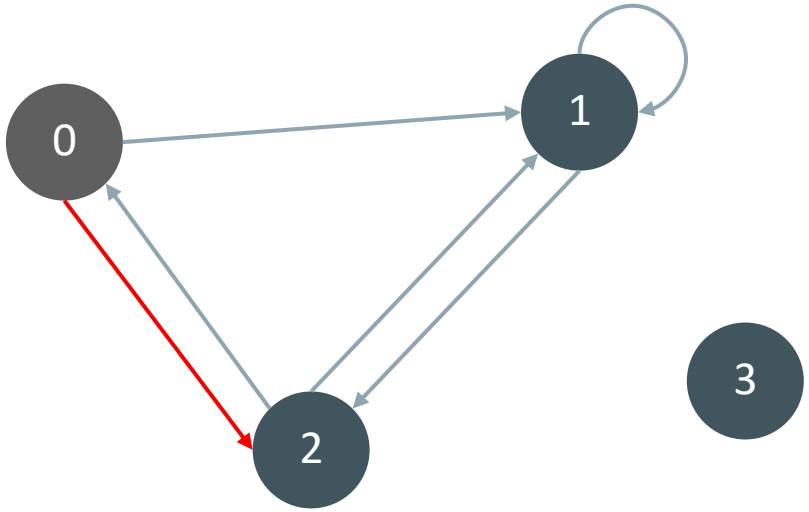

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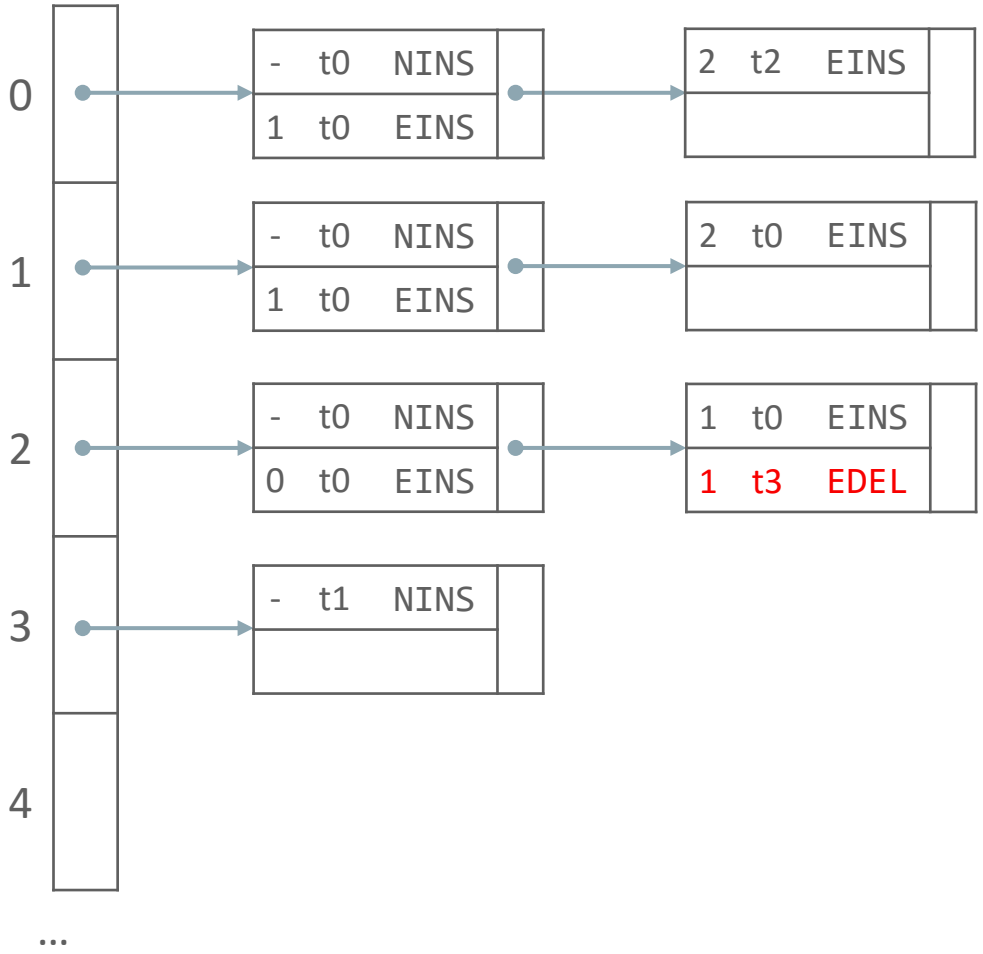

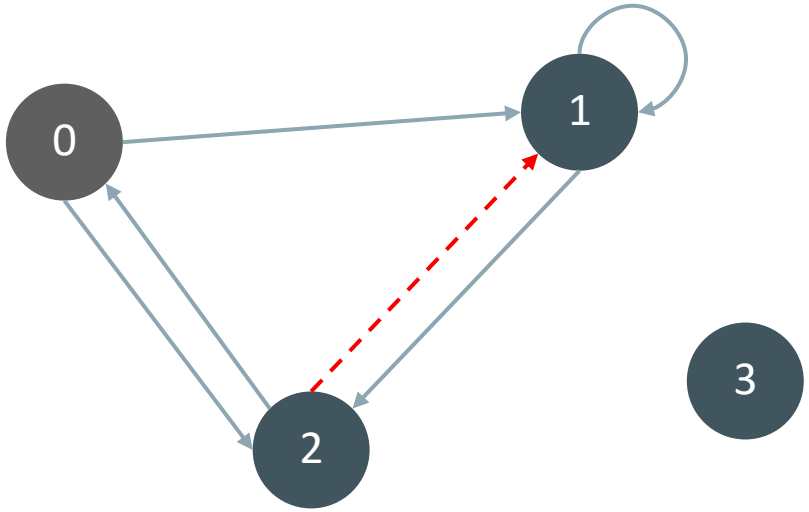

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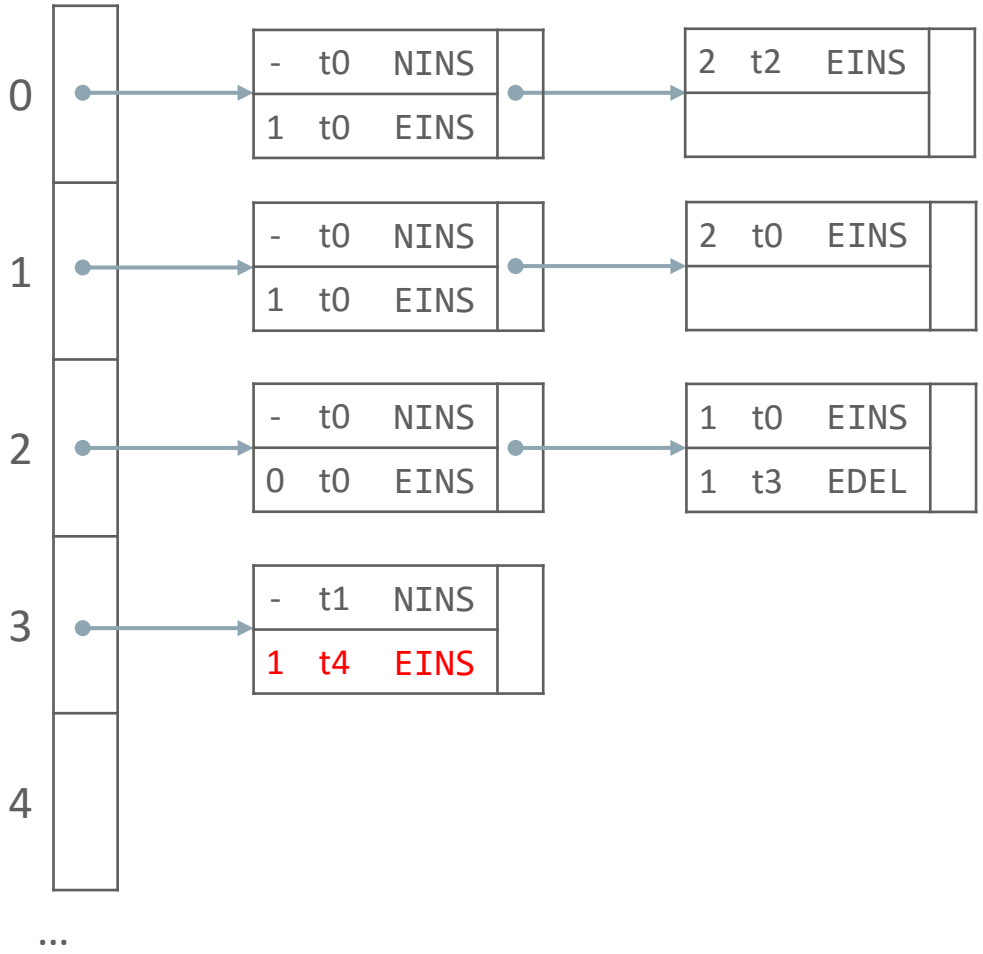

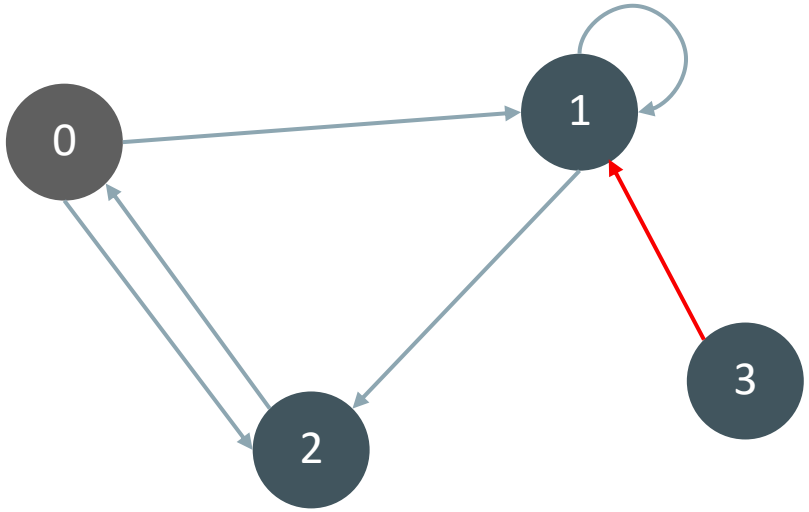

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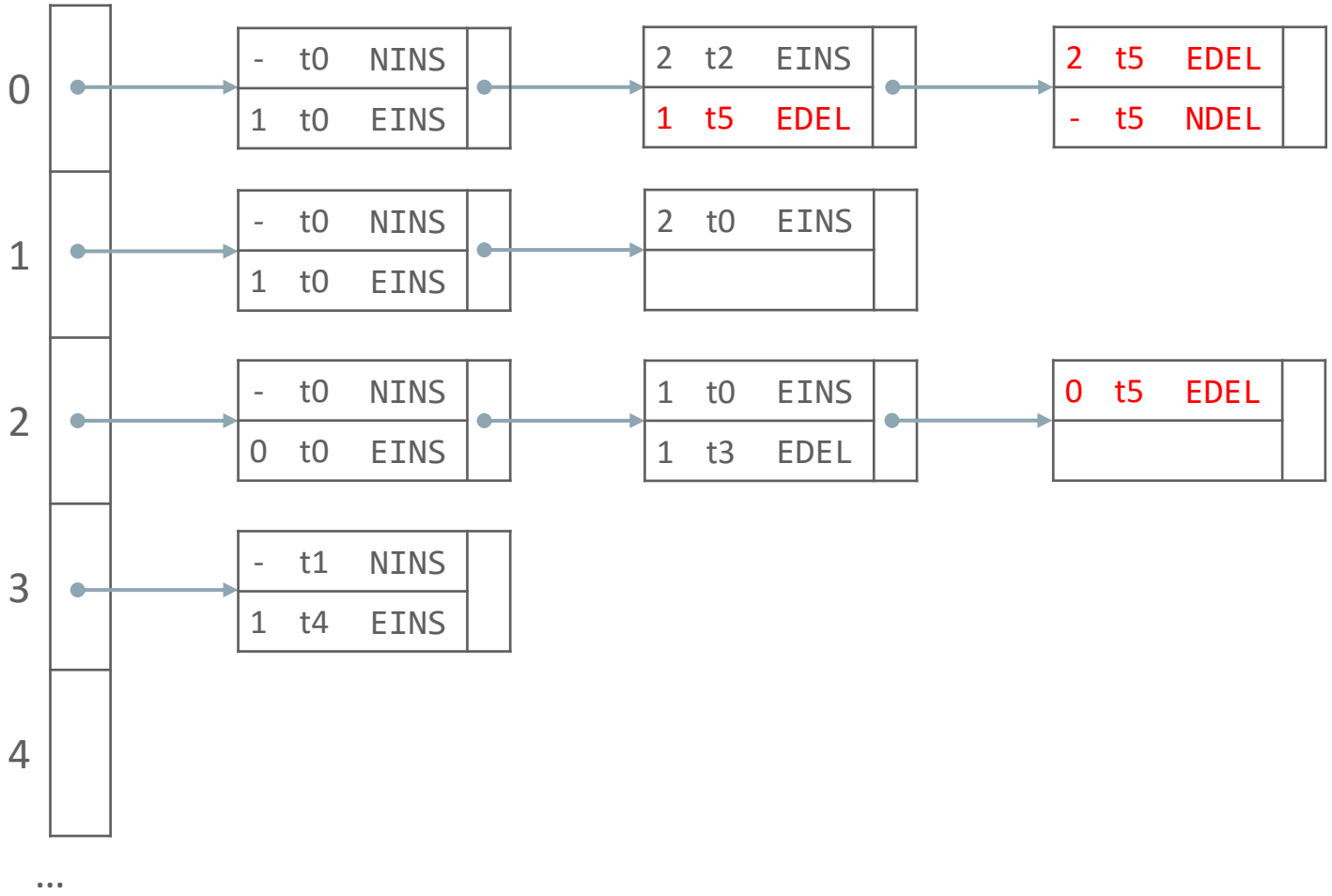

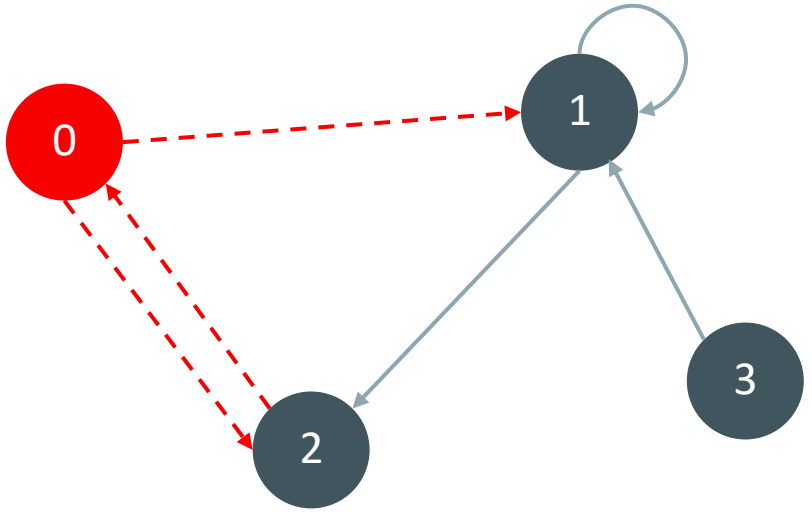

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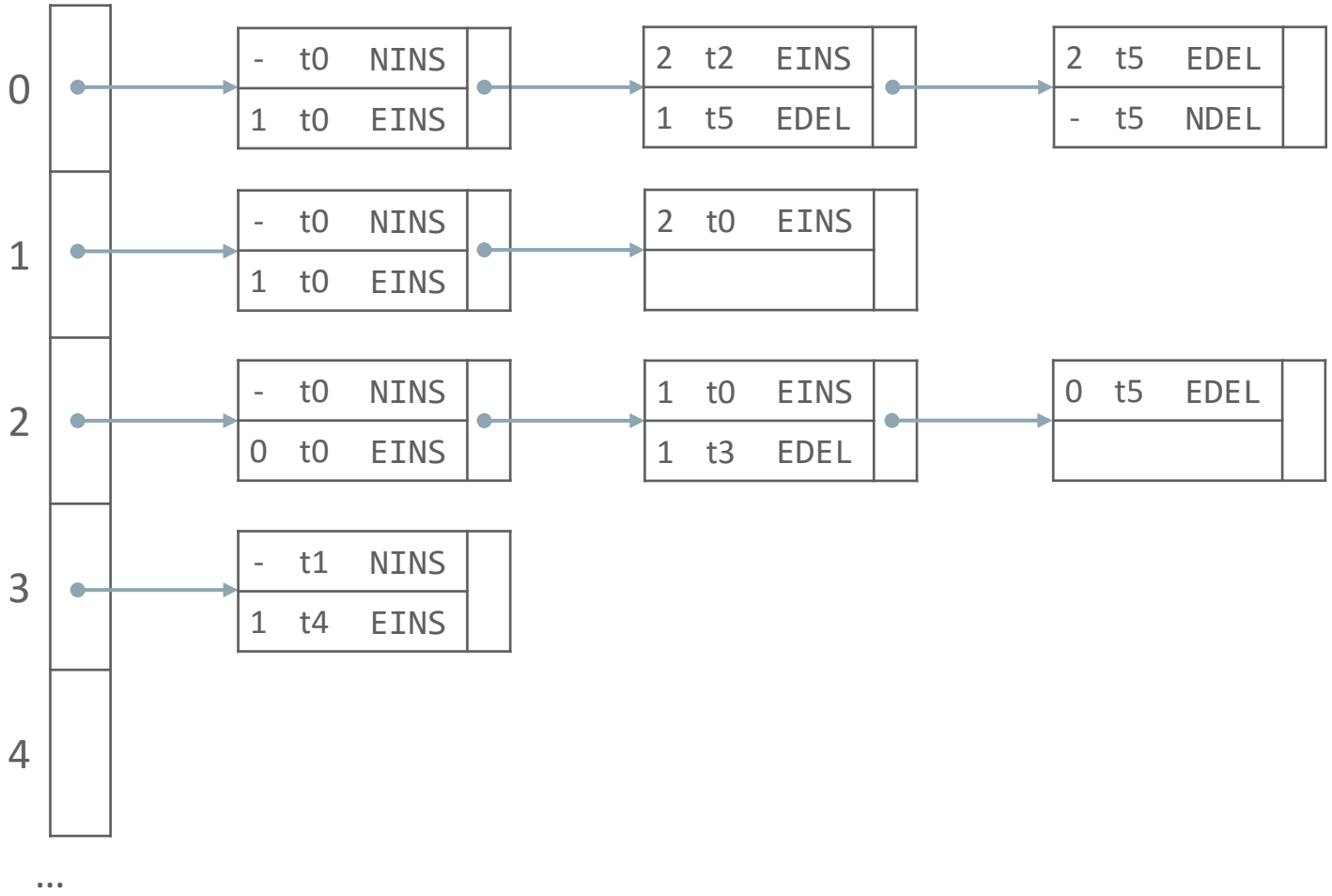

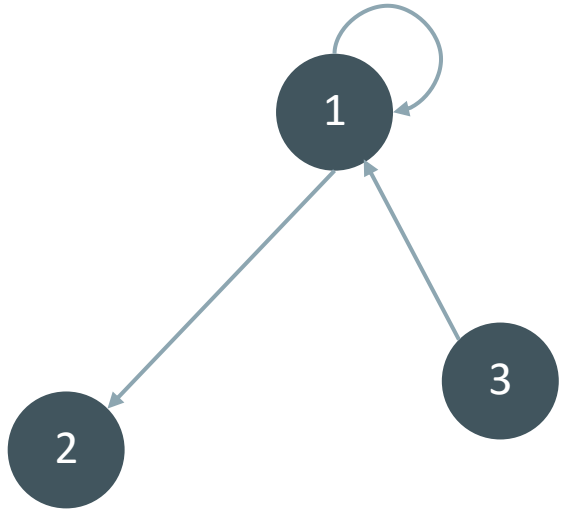

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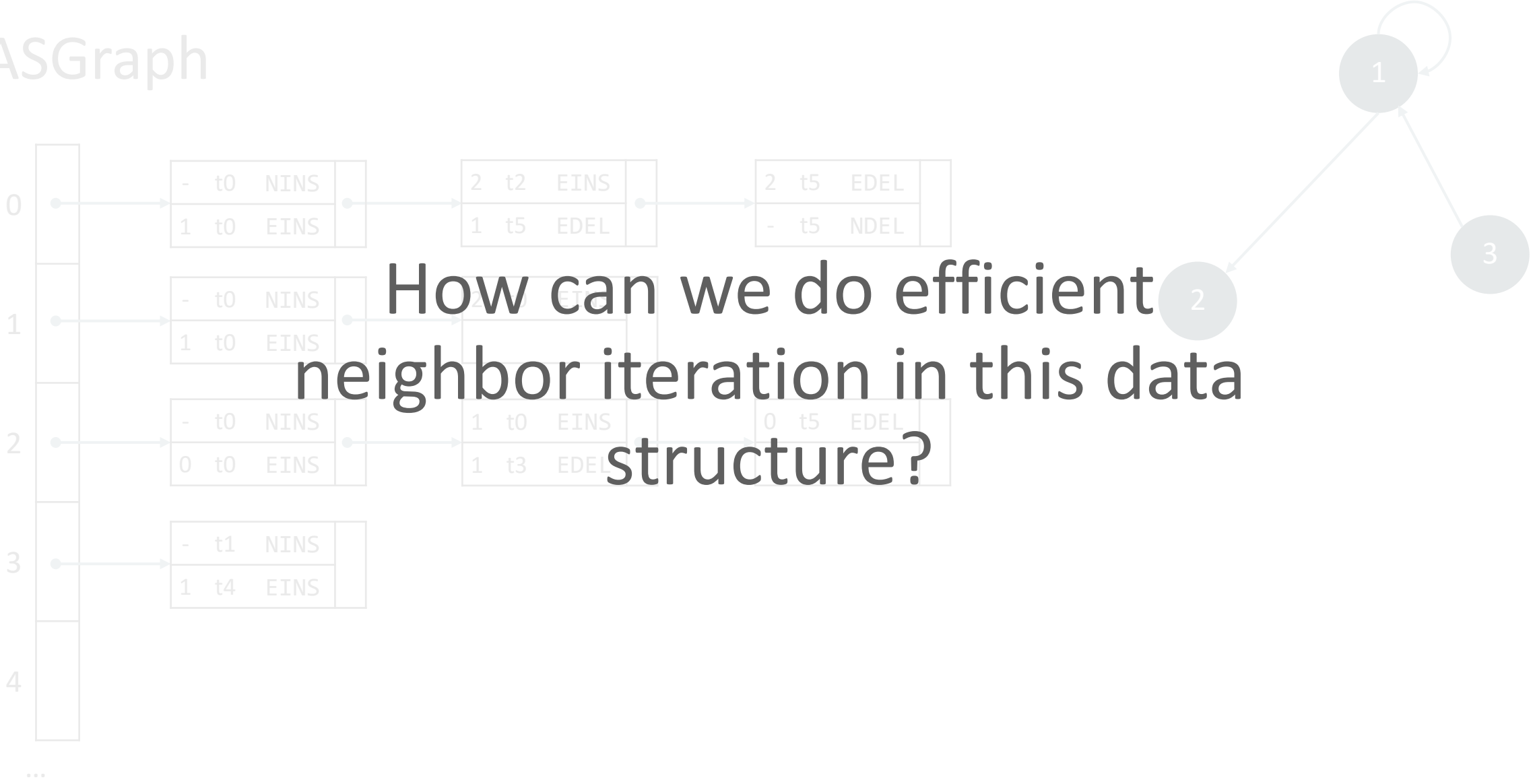
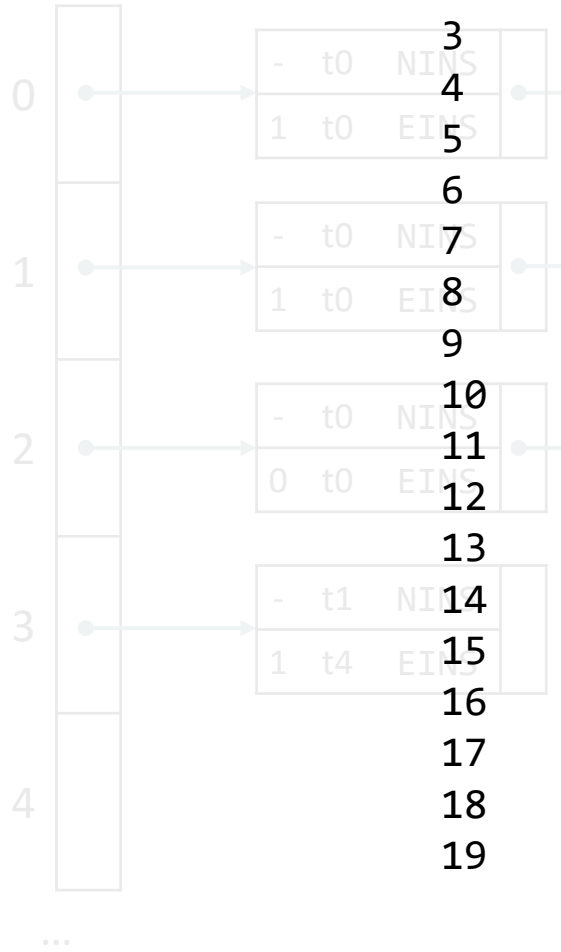
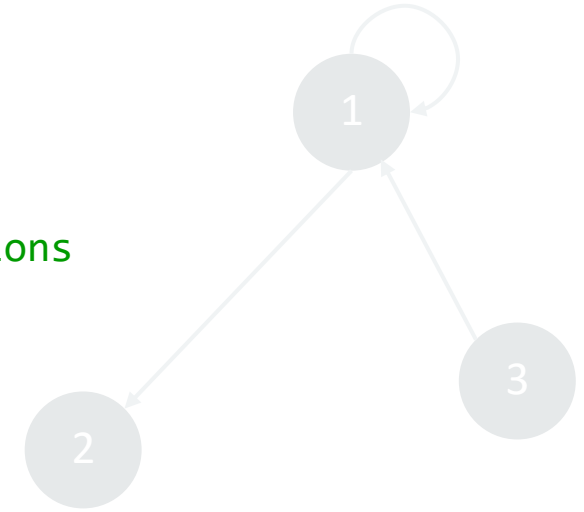


How can we do efficient neighbor iteration in this data structure?

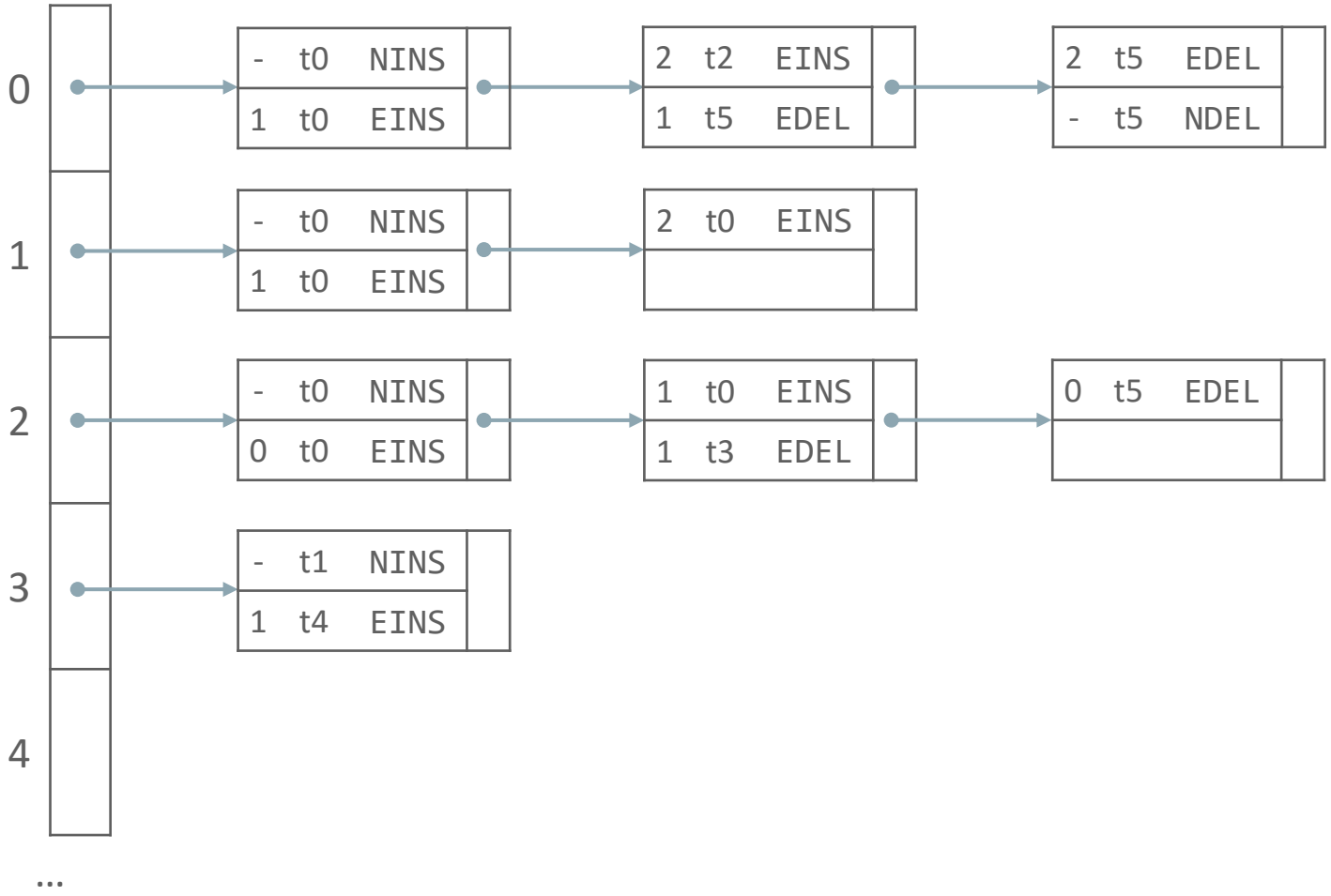
ASGraph



```
0 createSnapshot(TS t)
1   for n : nodes
2      var CAND := List[operation] //edge candidates
3      var REST := List[operation] //remaining operations
4      var DEL := Map[nodeId->timestamp]
5      for op : n.operations
6         if(op.type == EINS && op.timestamp <= t)
7            CAND.append(op)
8         else
9            REST.append(op)
10           if(op.type == EDEL)
11              DEL[op.to] = op.timestamp
12     for c : CAND
13        if(c.timestamp <= DEL[c.to])
14        //move c to REST
15        var tmp = CAND.remove(c)
16        REST.append(tmp)
17        //OPTIONALLY: sort CAND at this point
18        //Replace bucket content with reordered operations
19     n.operations <- concat(CAND,[EOS],REST)
```



createSnapshot(t5)

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1 for n : nodes
2    var CAND := List[operation]
3    var REST := List[operation]
4    var DEL := Map[nodeId->timestamp]
5    for op : n.operations
6       if(op.type == EINS && op.timestamp <= t)
7          CAND.append(op)
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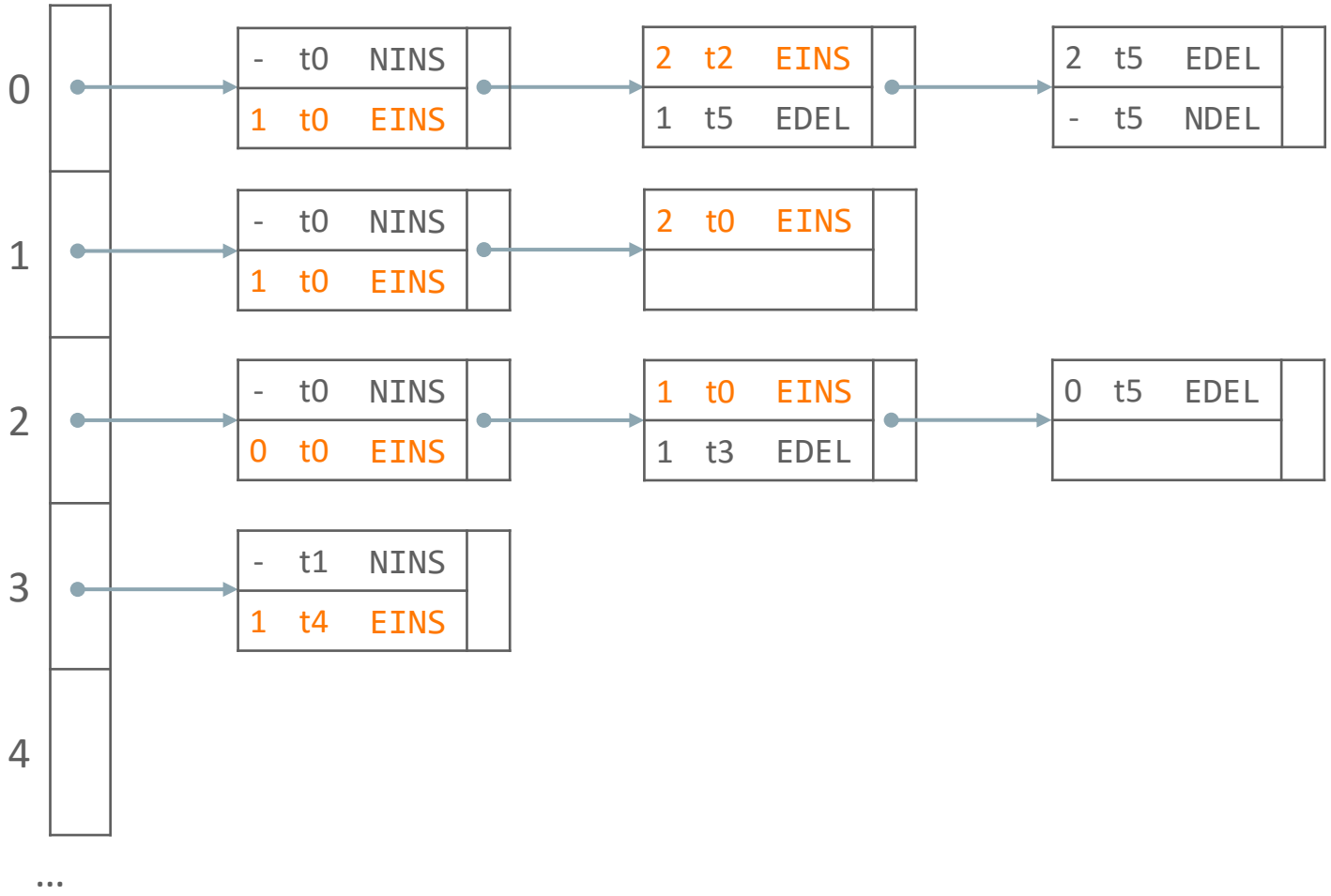


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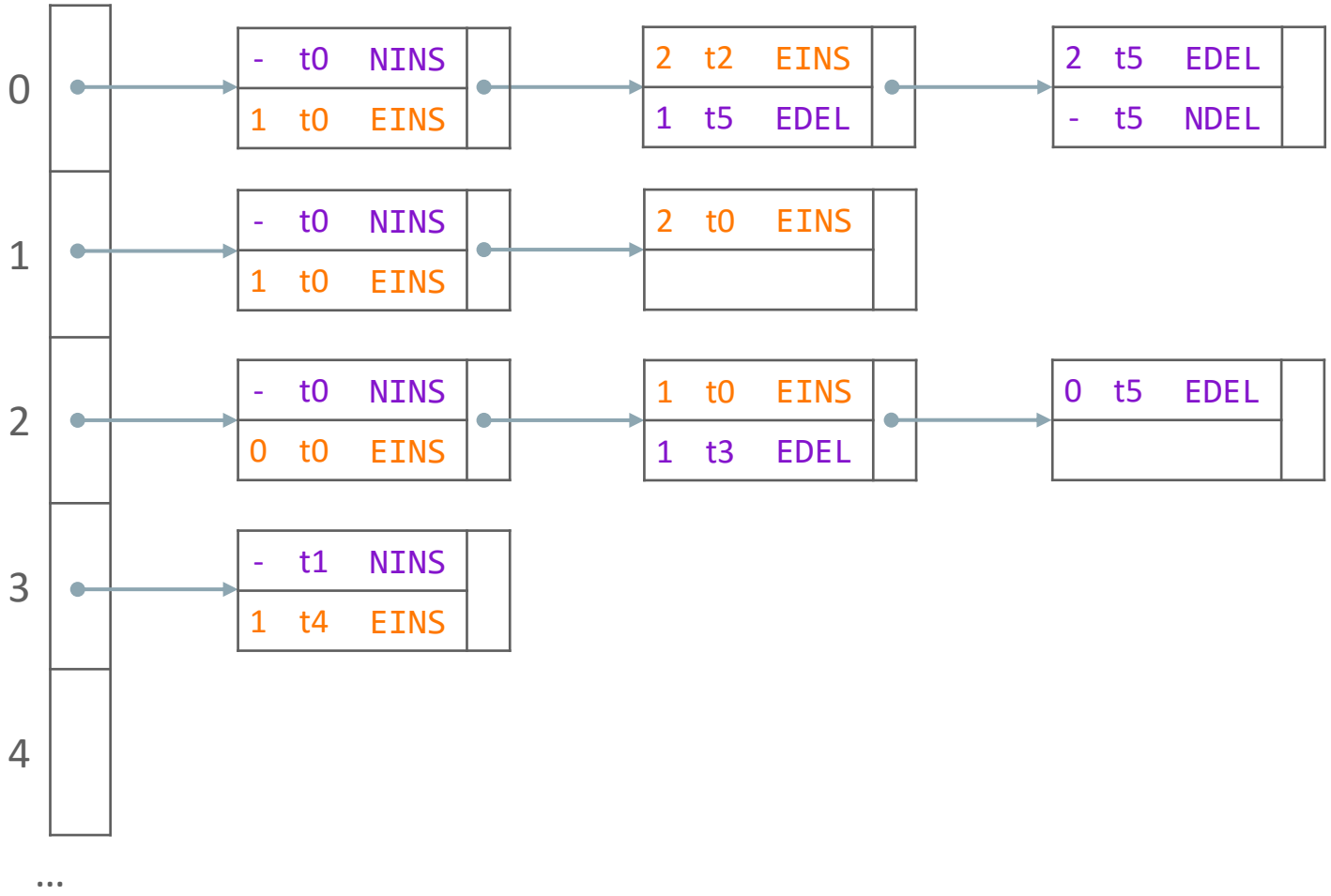


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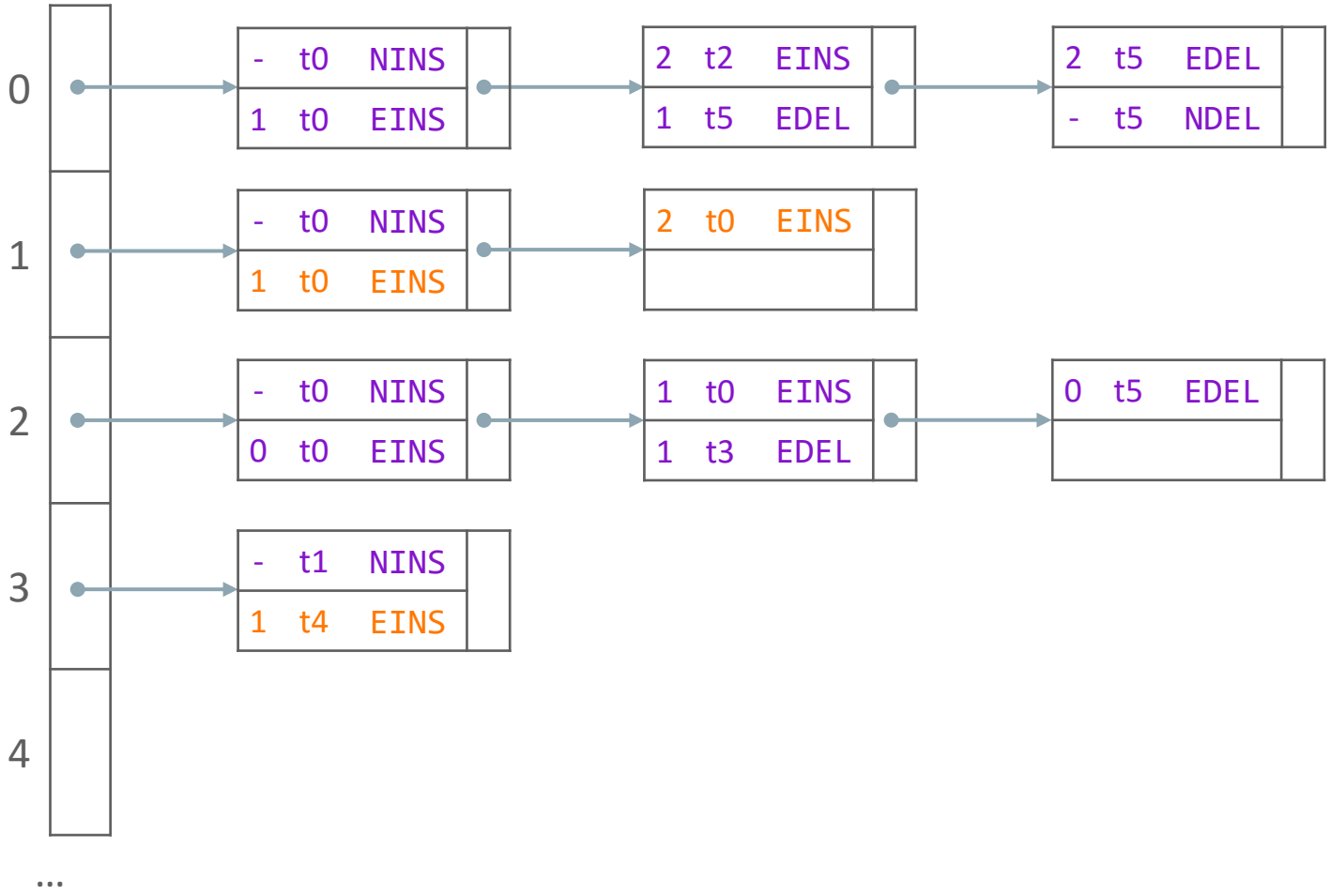


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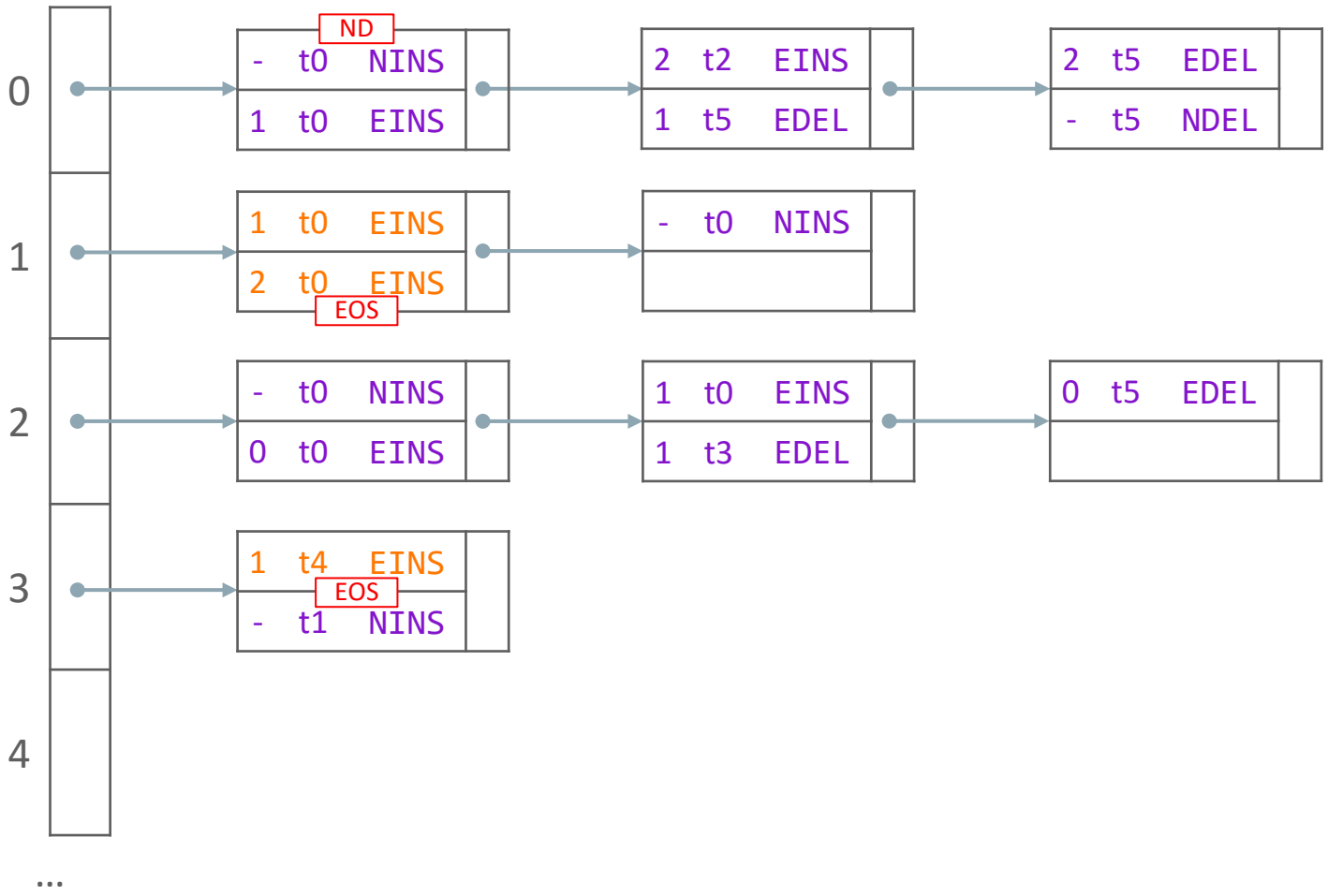

Marker Types	
[EOS]	End of Snapshot
[ND]	Node Deleted

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2    var CAND := List[operation]
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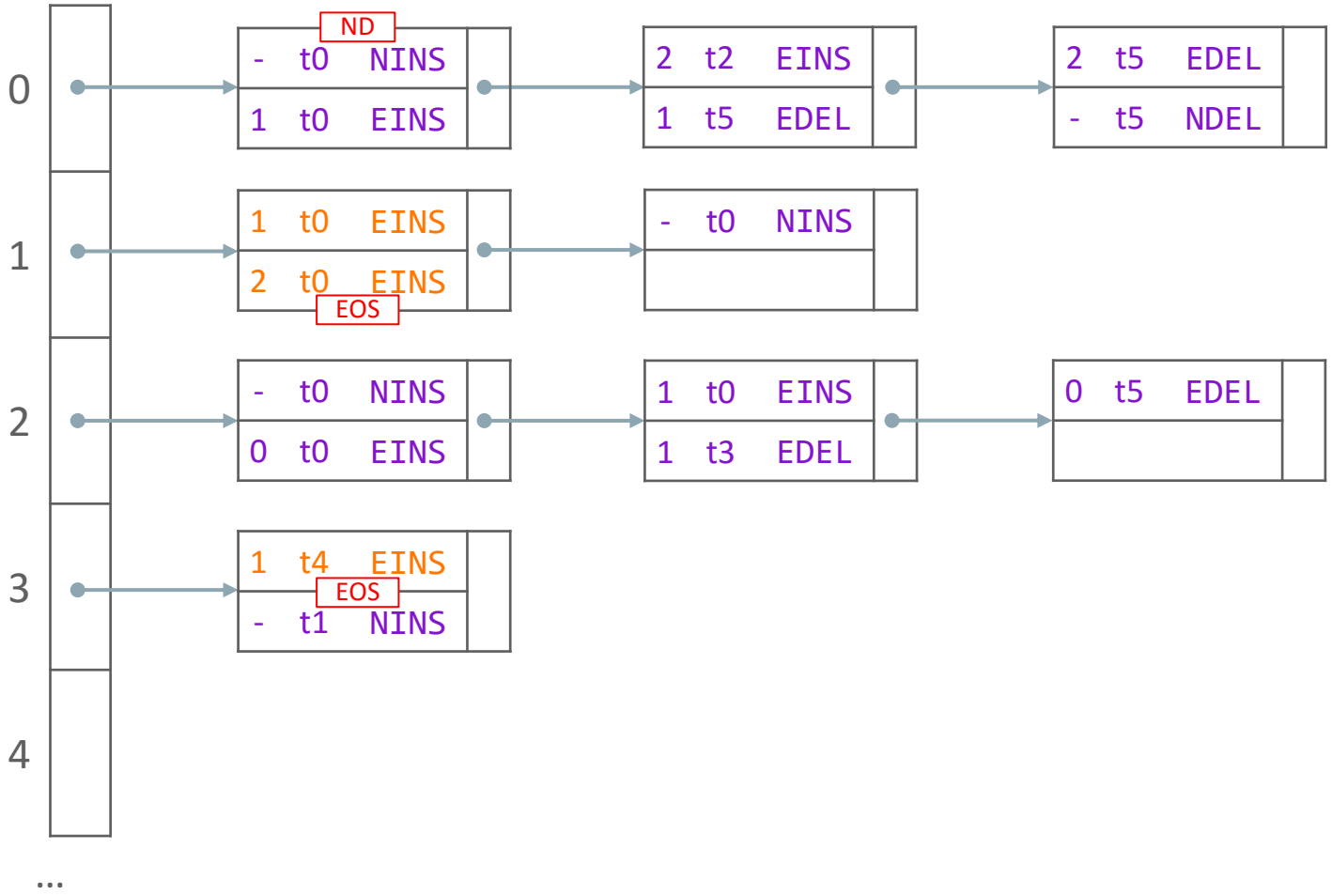

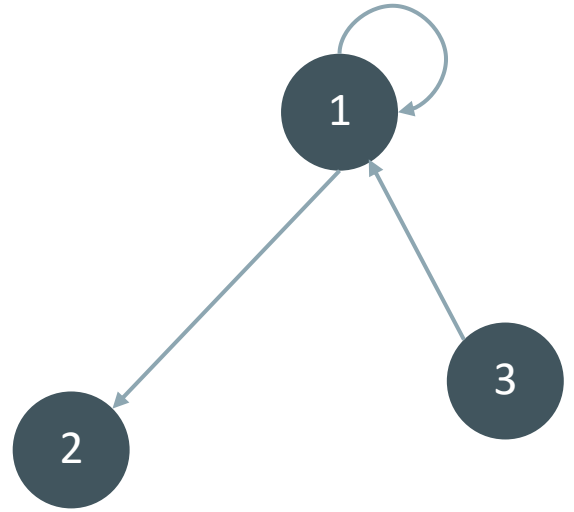


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```

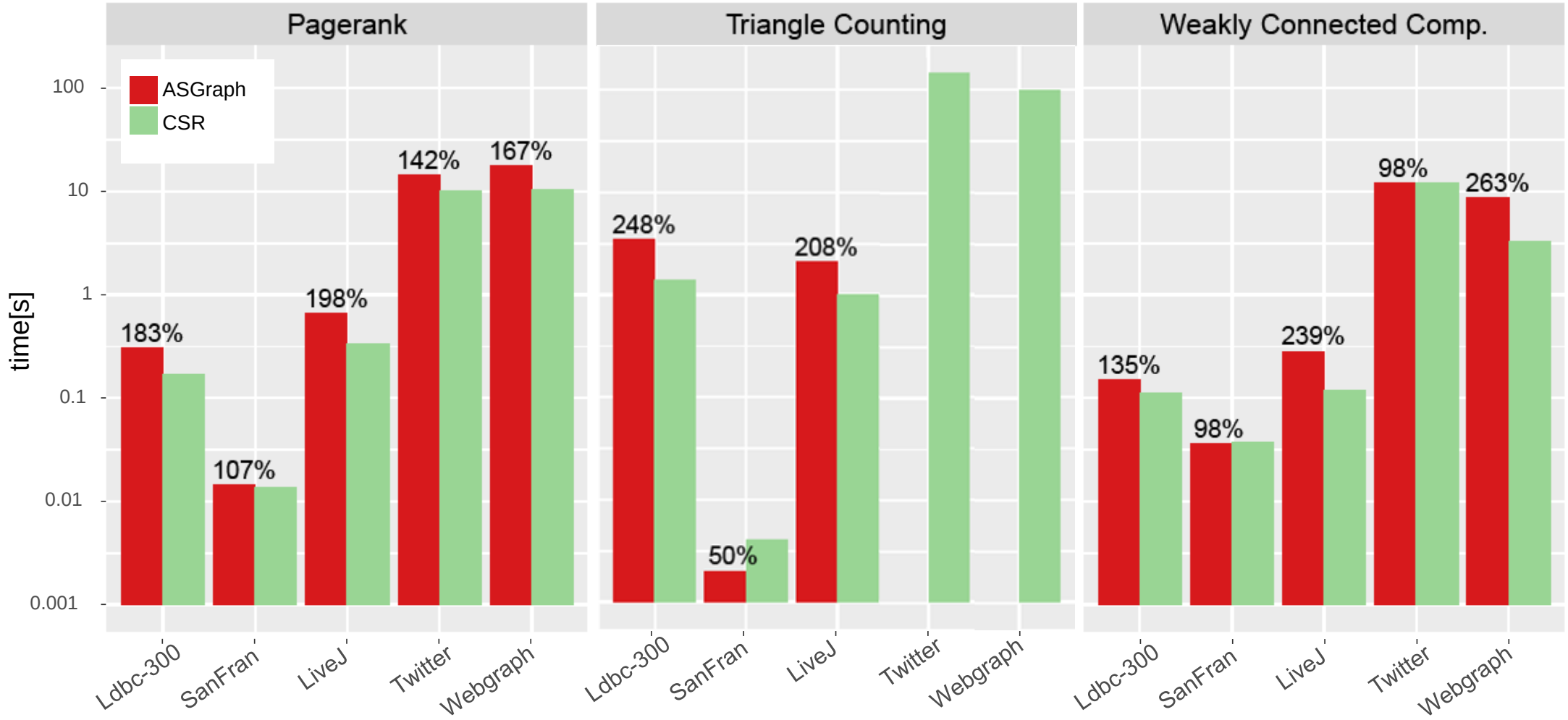
Advantages of this approach

- Keep the iteration logic simple
  - ➔ better code generation & branch prediction
- Prefetch next buckets explicitly
  - ➔mitigate effects of cache misses
- Concurrent updates are possible
  - ➔We do not touch memory beyond the last entry at the time of snapshot creation

Disadvantages

- Neighbors can be accessed only via forward iteration, no random access
  ➔ Common neighbor iteration profits heavily from random access
- High memory consumption
  - Additional header data per bucket
  - Fill factor of the buckets
  - Timestamps and OpTypes

Evaluation – Algorithm Comparison



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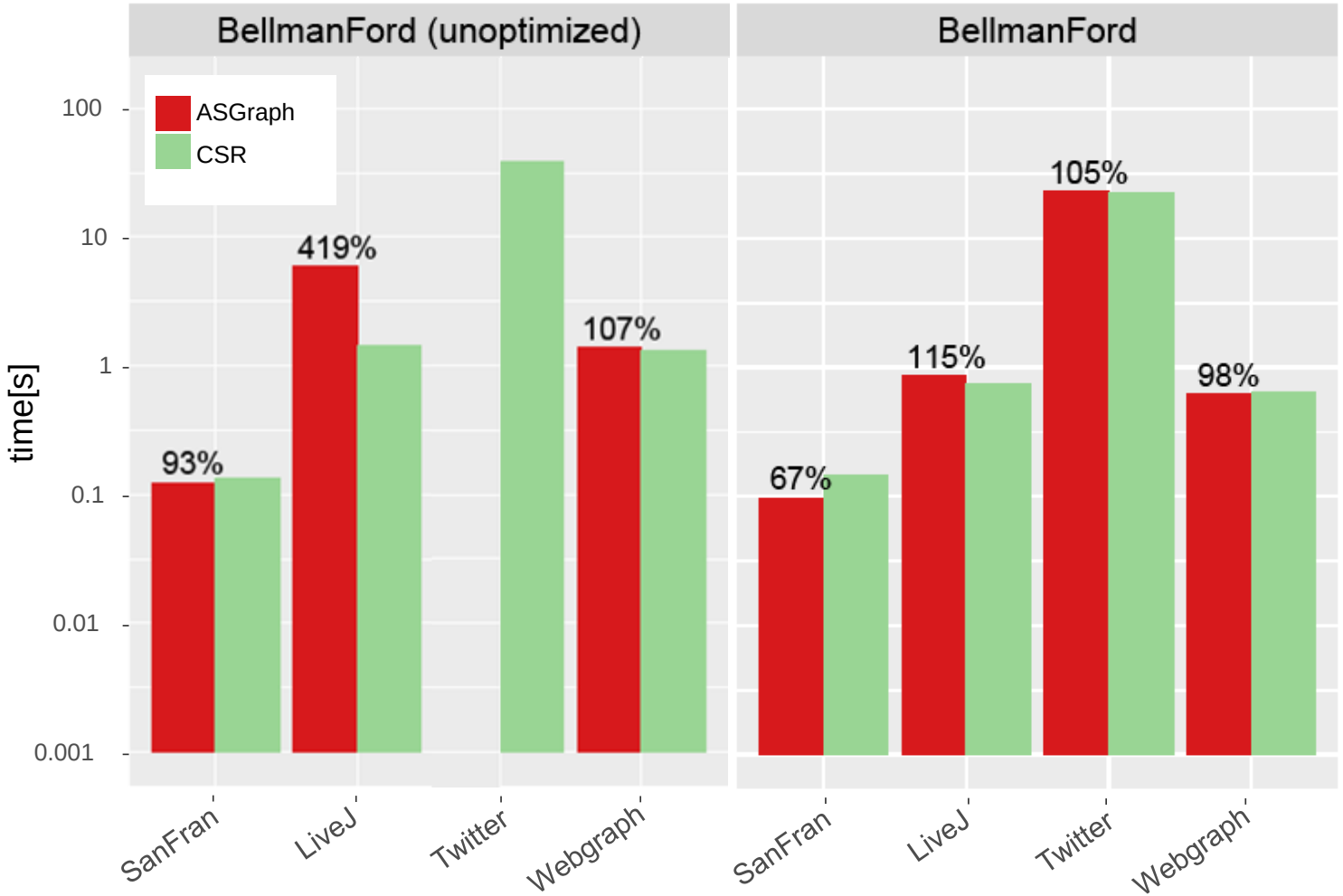
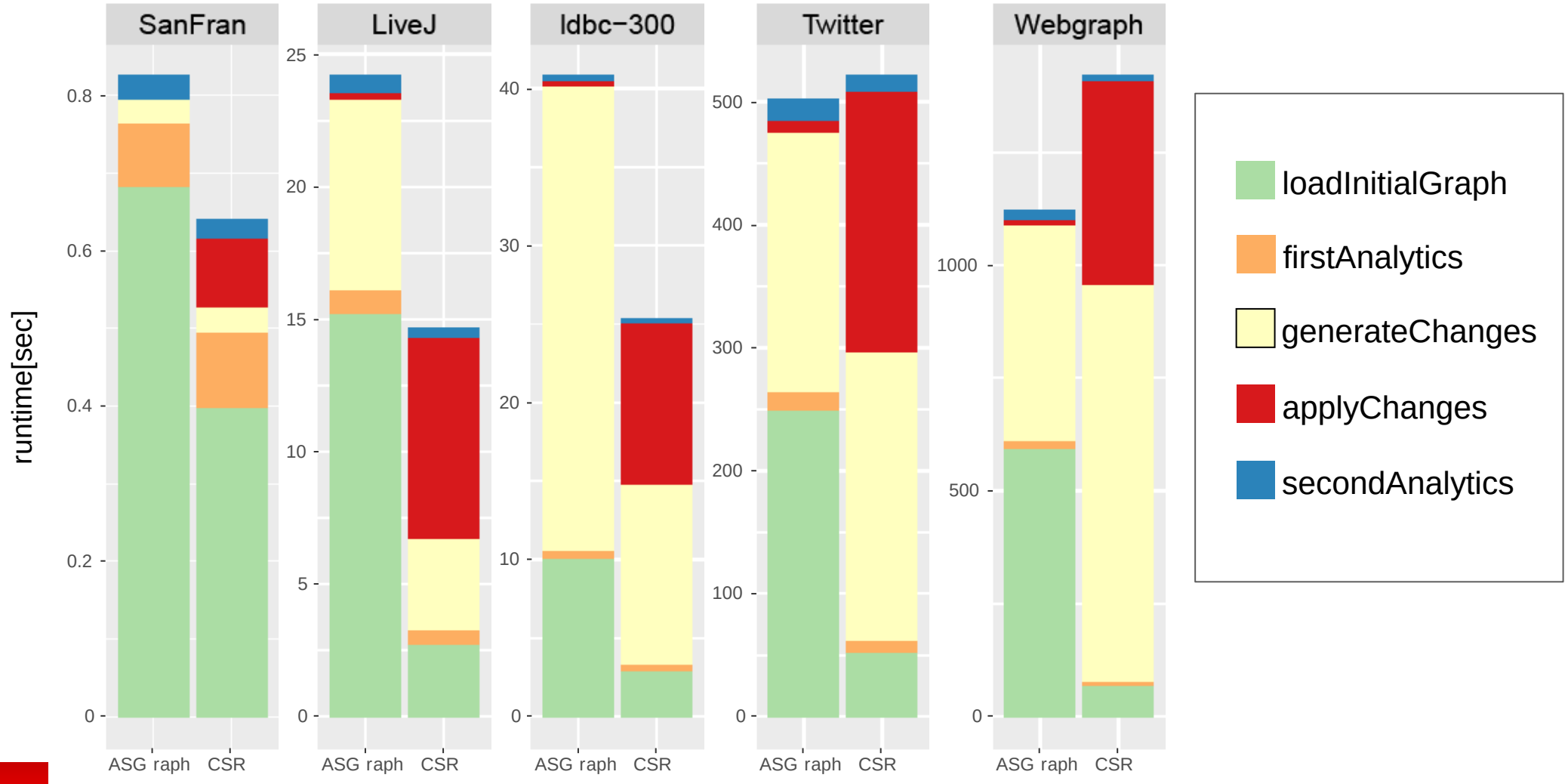


Evaluation – Complex Scenario



Summary

- ASGraph has performance in the same order of magnitude as CSR
- Performance independent on #snapshots
- Concurrent updates during analysis
- Outperforms CSR when graph is updated between multiple analysis

Future Work

- Resizing of the node directory
- Concurrent access to multiple versions
- Re-Mapping of vertex ids to a dense range
- Distributed version of ASGraph
- Reverse bucket lists for stable update performance

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Questions?


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