Generic Program Querying of Higher-Order Languages

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Idea

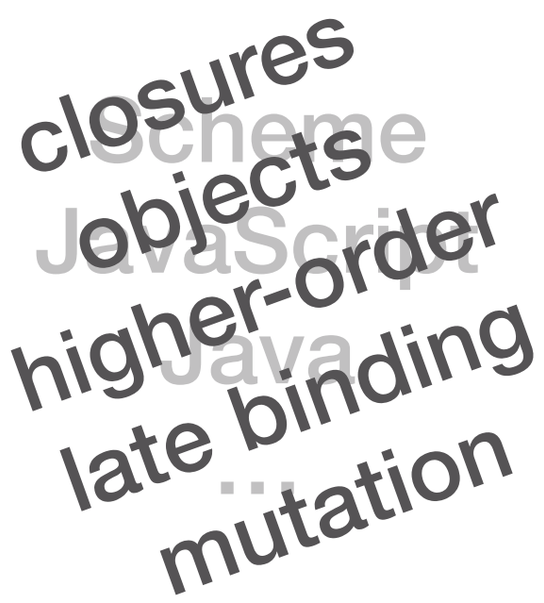
SE tools require static analysis

Scheme
JavaScript
Java
...

liveness
dependence
purity
constant propagation
...

Idea

SE tools require static analysis



common ground

Idea

Don't start from scratch

Plan

```
Pushdown.pathsBwTo =
  function (s, target, etg)
  {
    var todo = [s];
    var visited = ArraySet.empty();
    var paths = ArraySet.empty();
    while (todo.length > 0)
    {
      var q = todo.shift();
      if (q.equals(target) || visited.contains(q))
      {
        continue;
      }
      visited = visited.add(q);
      var incoming = etg.incoming(q)
      paths = paths.addAll(incoming);
      var qs = incoming.map(Edge.source);
      todo = todo.concat(qs);
    }
    return paths.values();
  }
```

Plan

```
(letrec ((factor (lambda (n)
                   (let ((extract-twos
                          (lambda (n)
                            (letrec ((loop (lambda (two-list rest)
                                             (if (even? rest)
                                                 (loop (cons 2 two-list) (quotient rest 2))
                                                 (cons rest two-list)))))
                              (loop '() n)))))
                     (let ((extract-odd-factors
                            (lambda (partial-factorization)
                              (letrec ((loop (lambda (so-far odd-product trial-divisor)
                                               (if (< odd-product (* trial-divisor trial-divisor))
                                                   (reverse (cons odd-product so-far))
                                                   (if (= (remainder odd-product trial-divisor) 0)
                                                       (loop (cons trial-divisor so-far)
                                                             (quotient odd-product trial-divisor)
                                                             trial-divisor)
                                                       (loop so-far
                                                             odd-product
                                                             (+ trial-divisor 2)))))))
                                (loop (cdr partial-factorization) (car partial-factorization) 3)))))
                       (let ((partial-factorization (extract-twos n)))
                         (if (= (car partial-factorization) 1)
                             (cdr partial-factorization)
                             (extract-odd-factors partial-factorization))))))))
  (factor 35742549198872617291))
```

```
Pushdown.pathsBwTo =
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  {
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    var paths = ArraySet.empty();
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    {
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      paths = paths.addAll(incoming);
      var qs = incoming.map(Edge.source);
      todo = todo.concat(qs);
    }
    return paths.values();
  }
```

```
public void prune(DirectedGraph<Vertex, Edge> g)
{
  Deque<Vertex> todo = new ArrayDeque<Vertex>(g.vertexSet());
  Set<Object> seen = new HashSet<Object>();
  while (!todo.isEmpty())
  {
    Vertex v = todo.pop();
    if (seen.contains(v))
    {
      continue;
    }
    seen.add(v);
    List<Vertex> targets = Graphs.successorListOf(g, v);
    for (int i = 0; i < targets.size(); i++)
    {
      for (int j = i; j < targets.size(); j++)
      {
        Vertex vi = targets.get(i);
        Vertex vj = targets.get(j);
        List<Edge> path = DijkstraShortestPath.findPathBetween(g, vi, vj);
        if (path != null && !path.isEmpty())
        {
          Edge edge = g.getEdge(v, vj);
          g.removeEdge(edge);
          LOGGER.info("removed " + edge + " because of " + path + " for " + v);
        }
      }
    }
  }
}
```

Plan

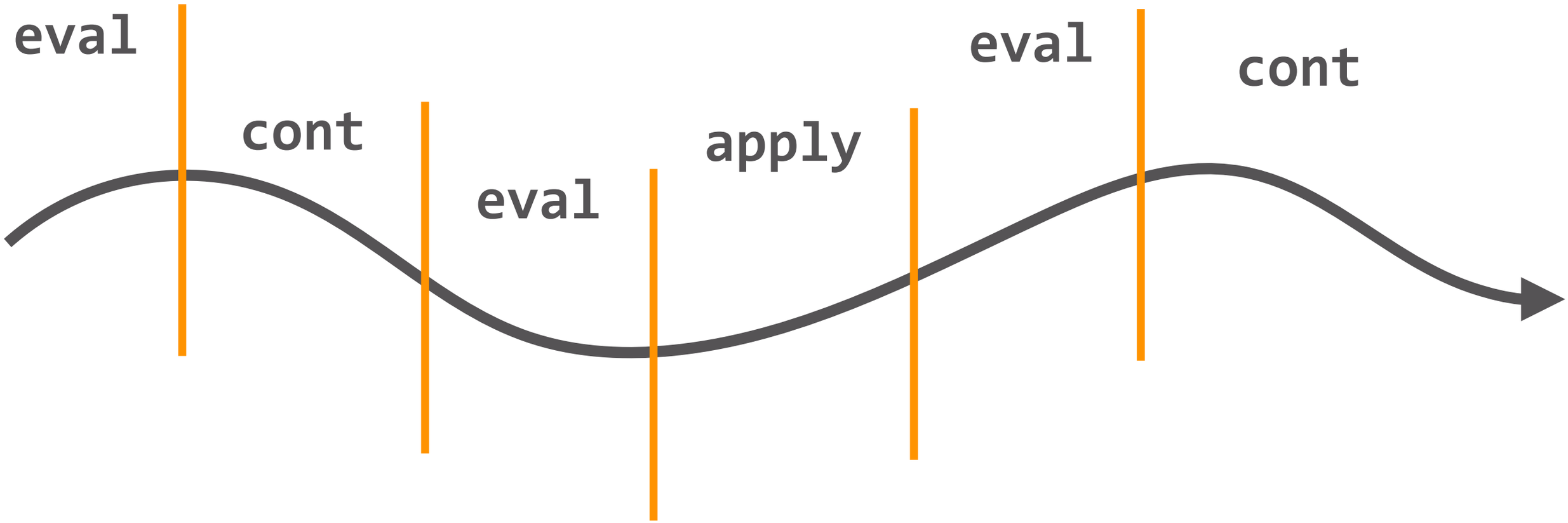
liveness analysis

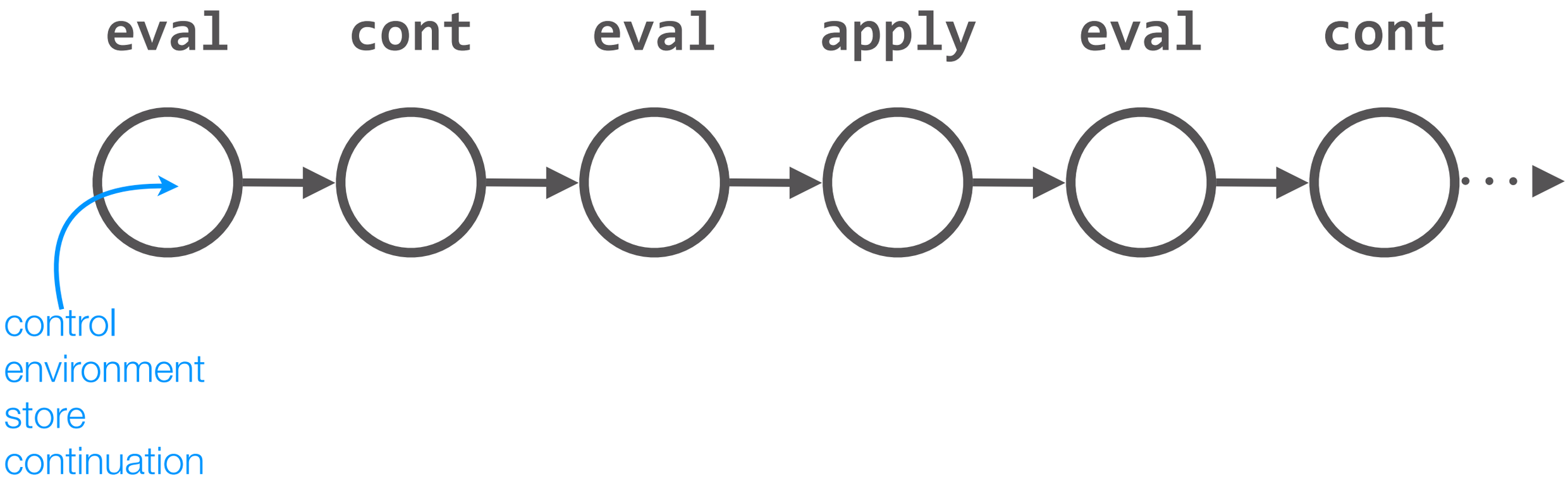
purity analysis

dependence analysis

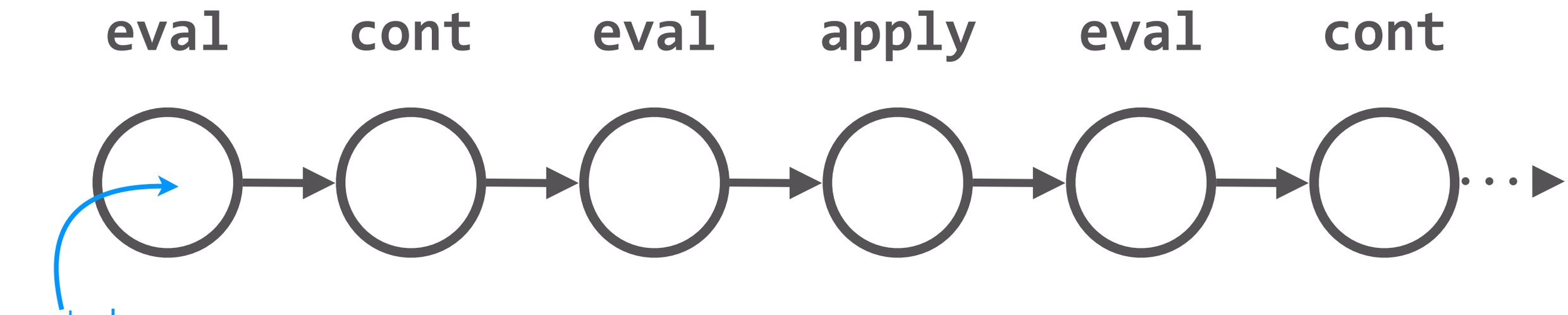
constant propagation

...


eval
cont
eval
apply
eval
cont

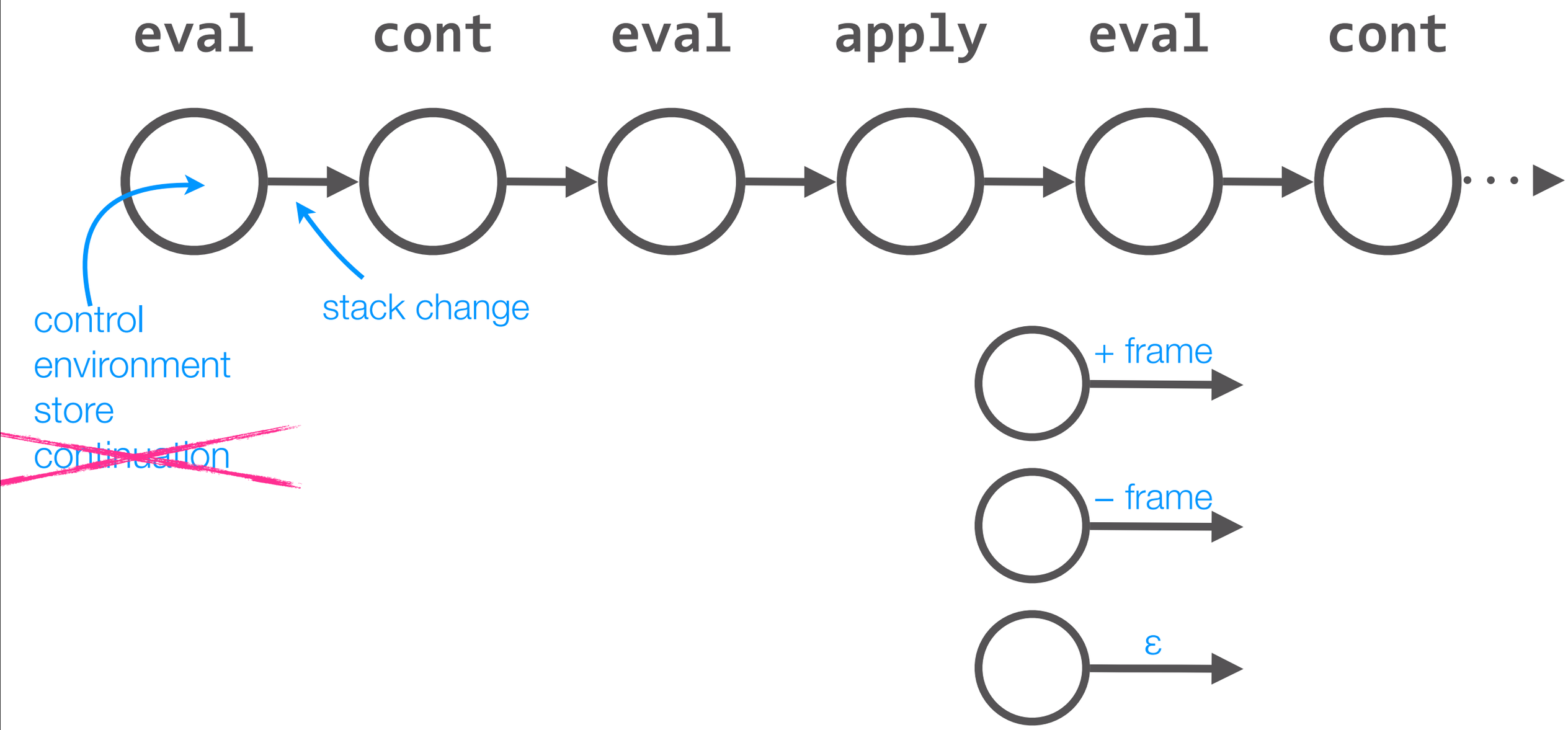

eval
cont
eval
apply
eval
cont
control
environment
store
continuation

Abstract Interpretation



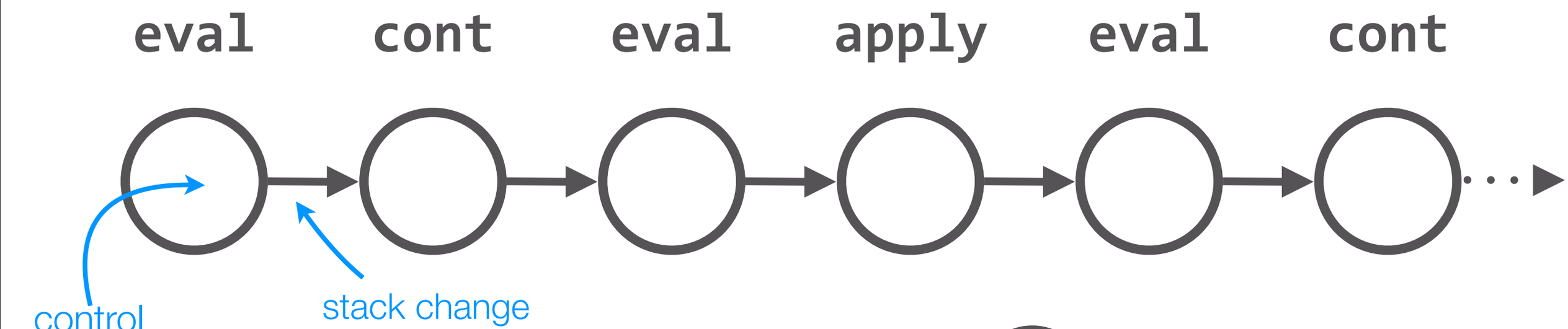
- finite number of abstract values
- finite number of addresses

(Abstracting Abstract Machines, Van Horn and Might, ICFP2010)

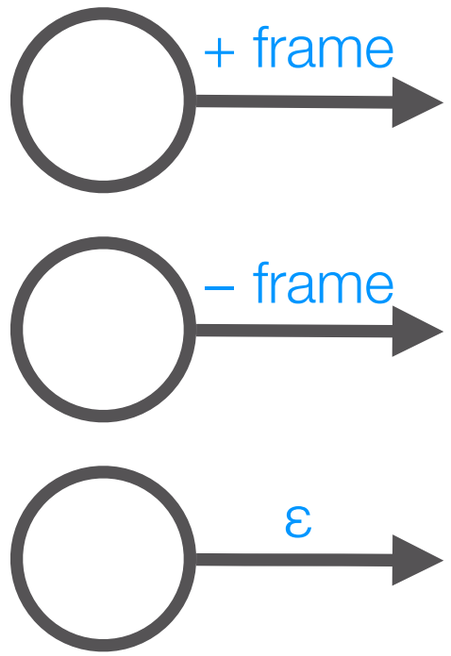


(Pushdown control-flow analysis of higher-order programs, Earl et al., Scheme2010)

Pushdown Analysis

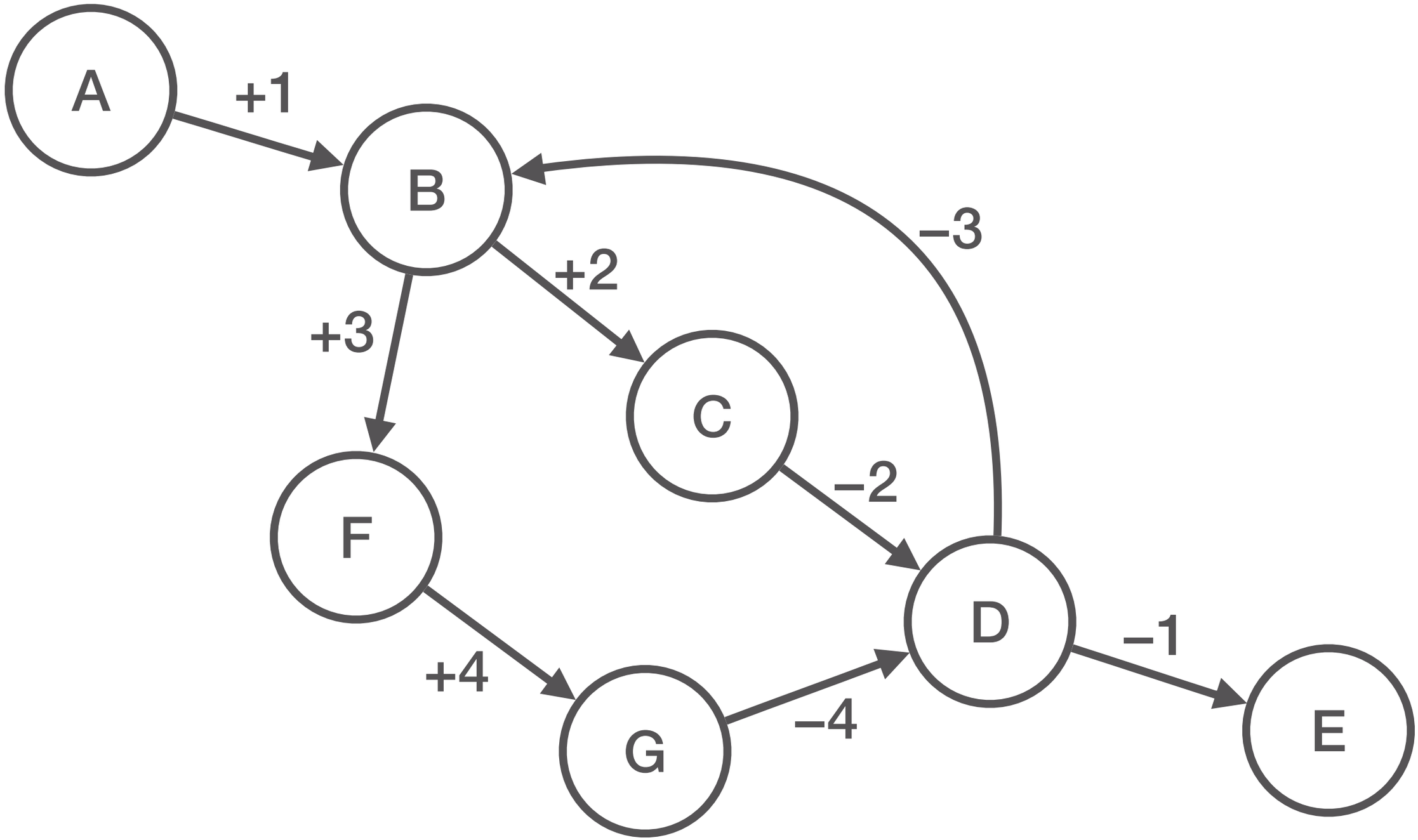


+ pushdown driver

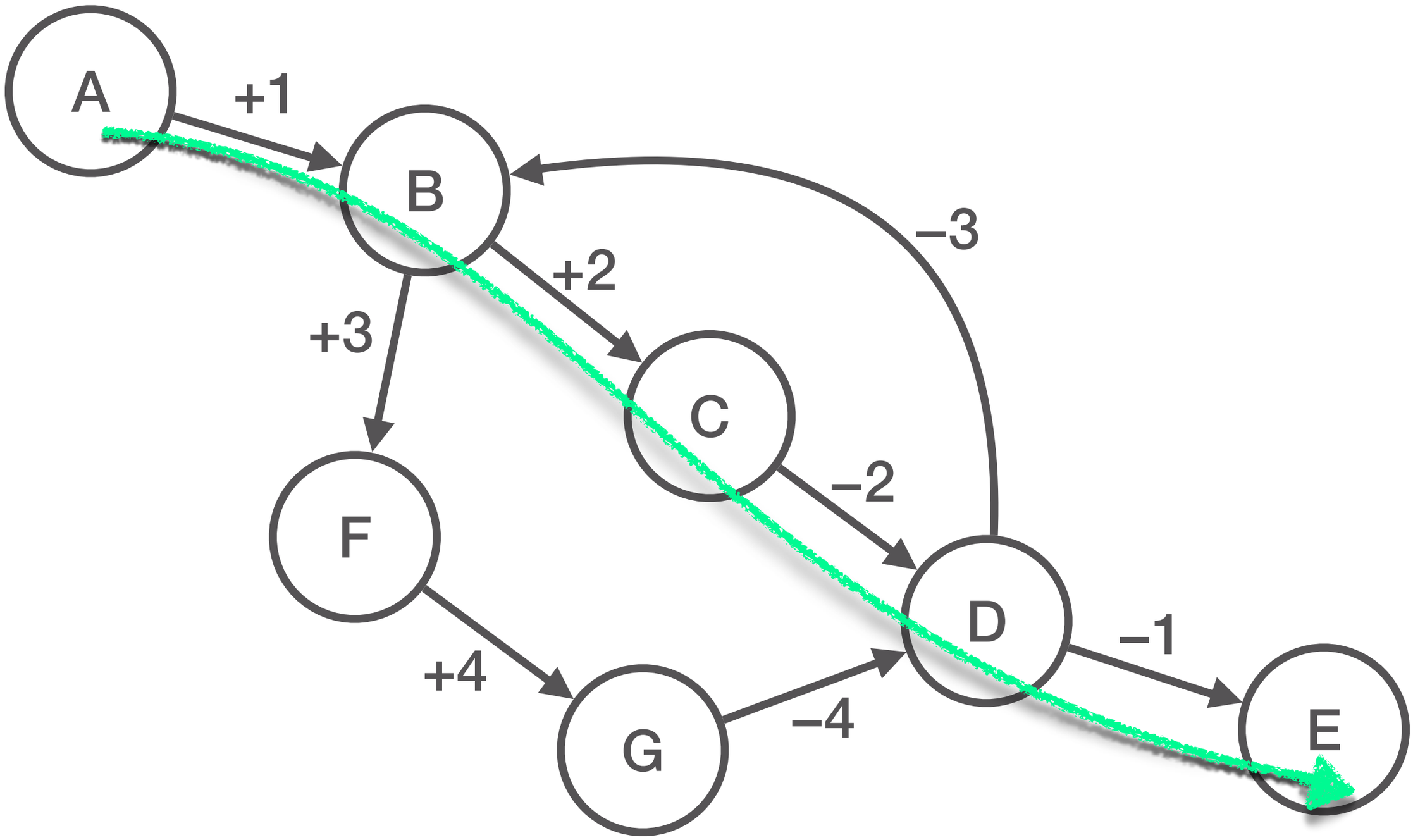


(Pushdown control-flow analysis of higher-order programs, Earl et al., Scheme2010)

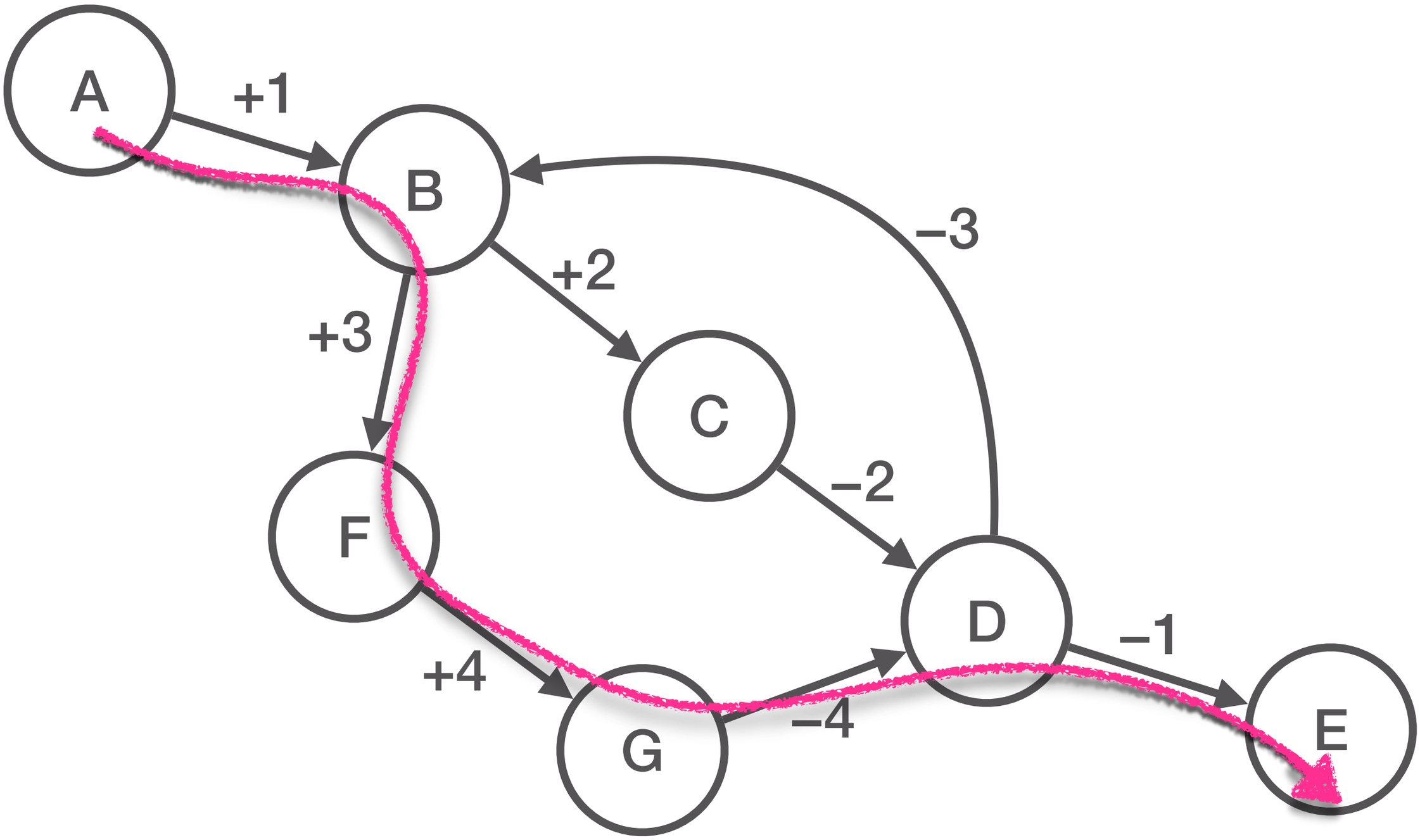
Dyck State Graph



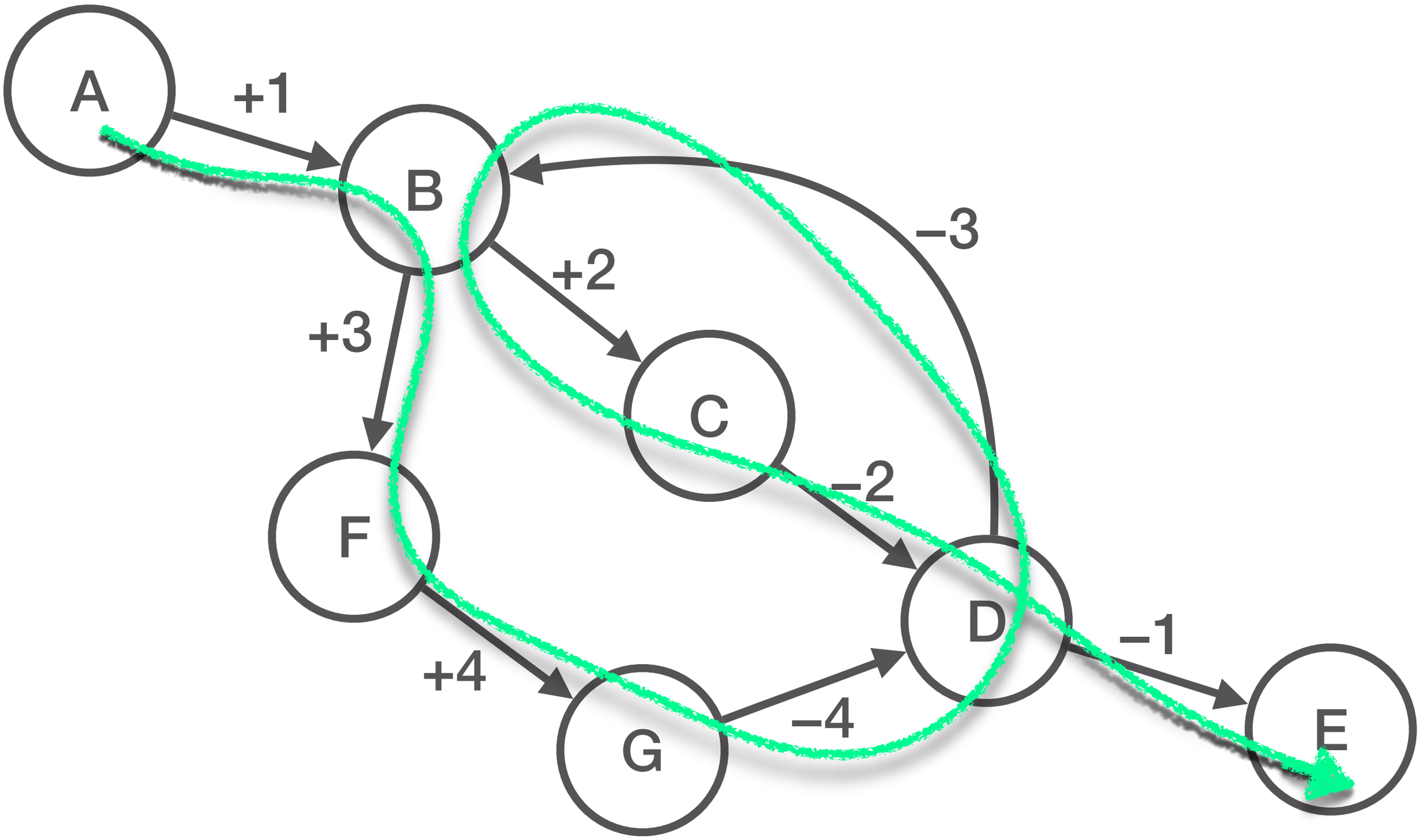
Legal Path



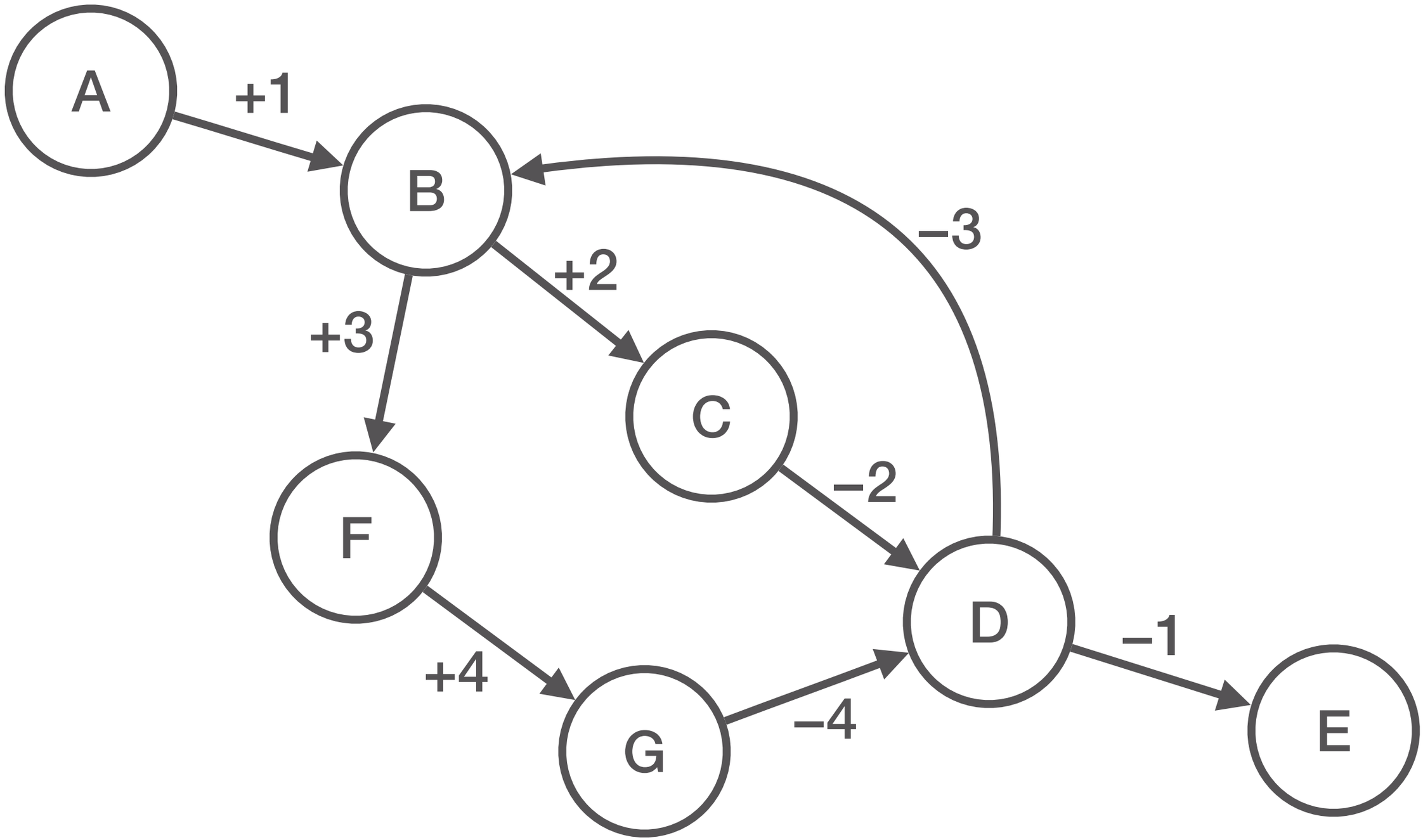
~~Legal~~ Path



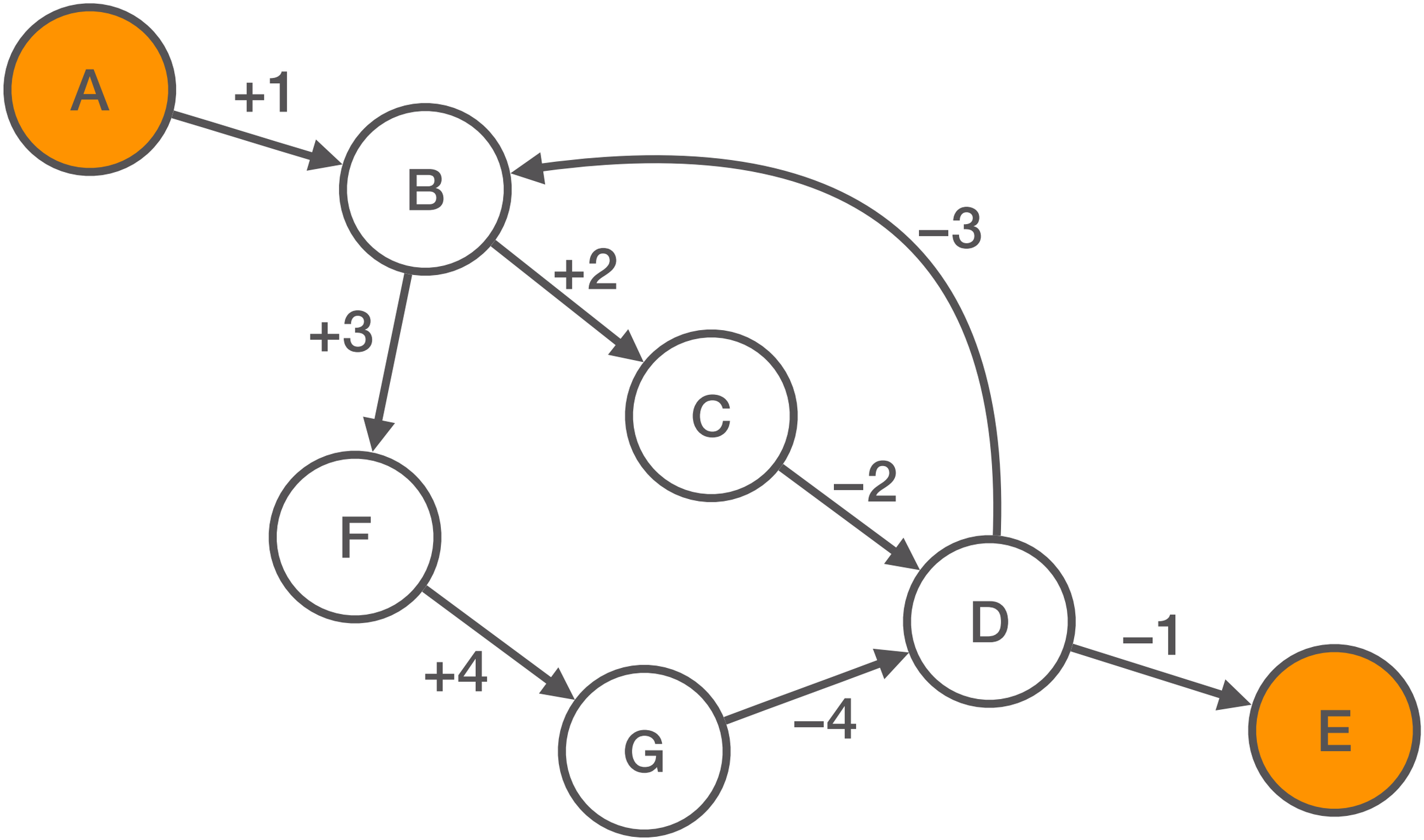
Legal Path



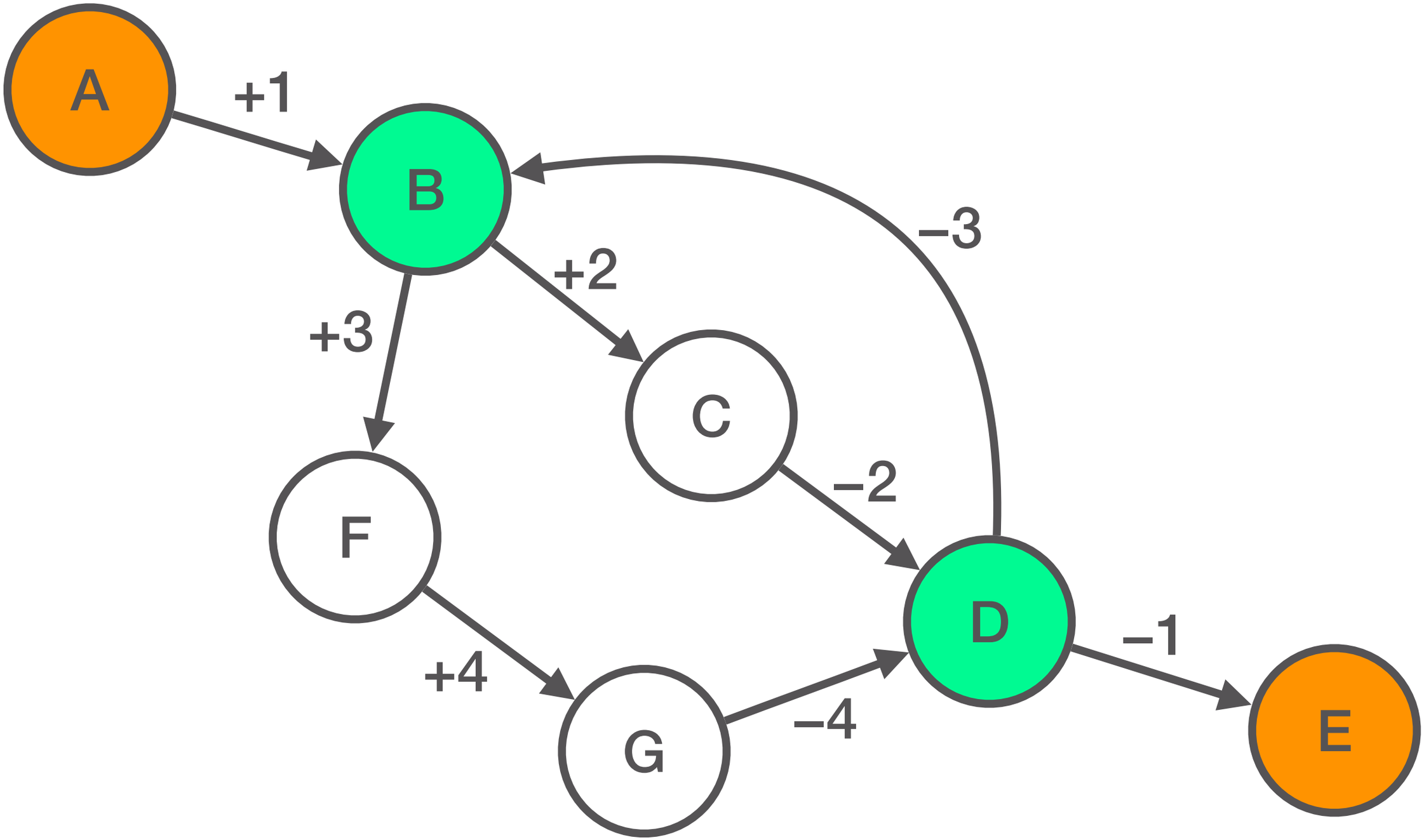
finite representation of unbounded stack



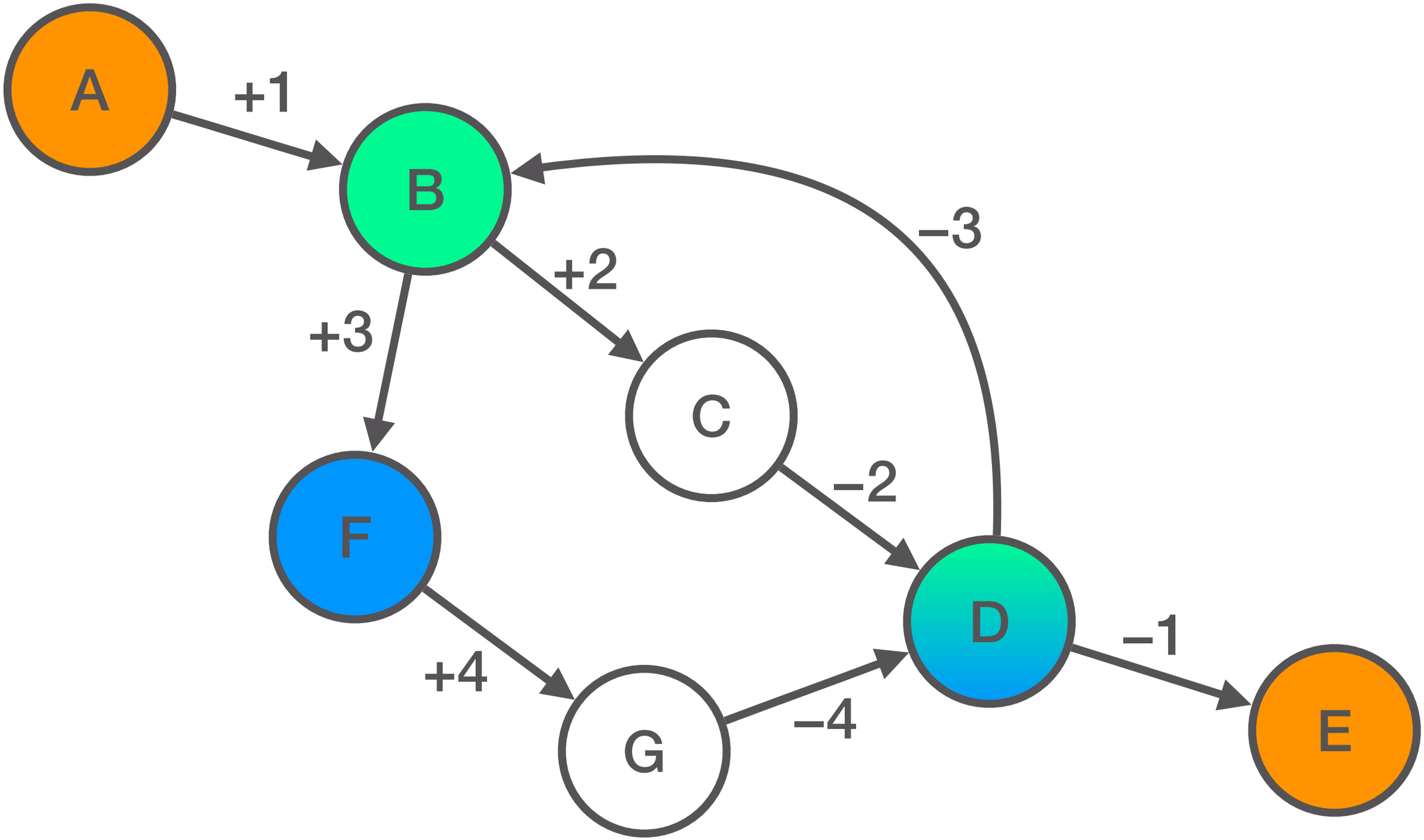
Stack Change



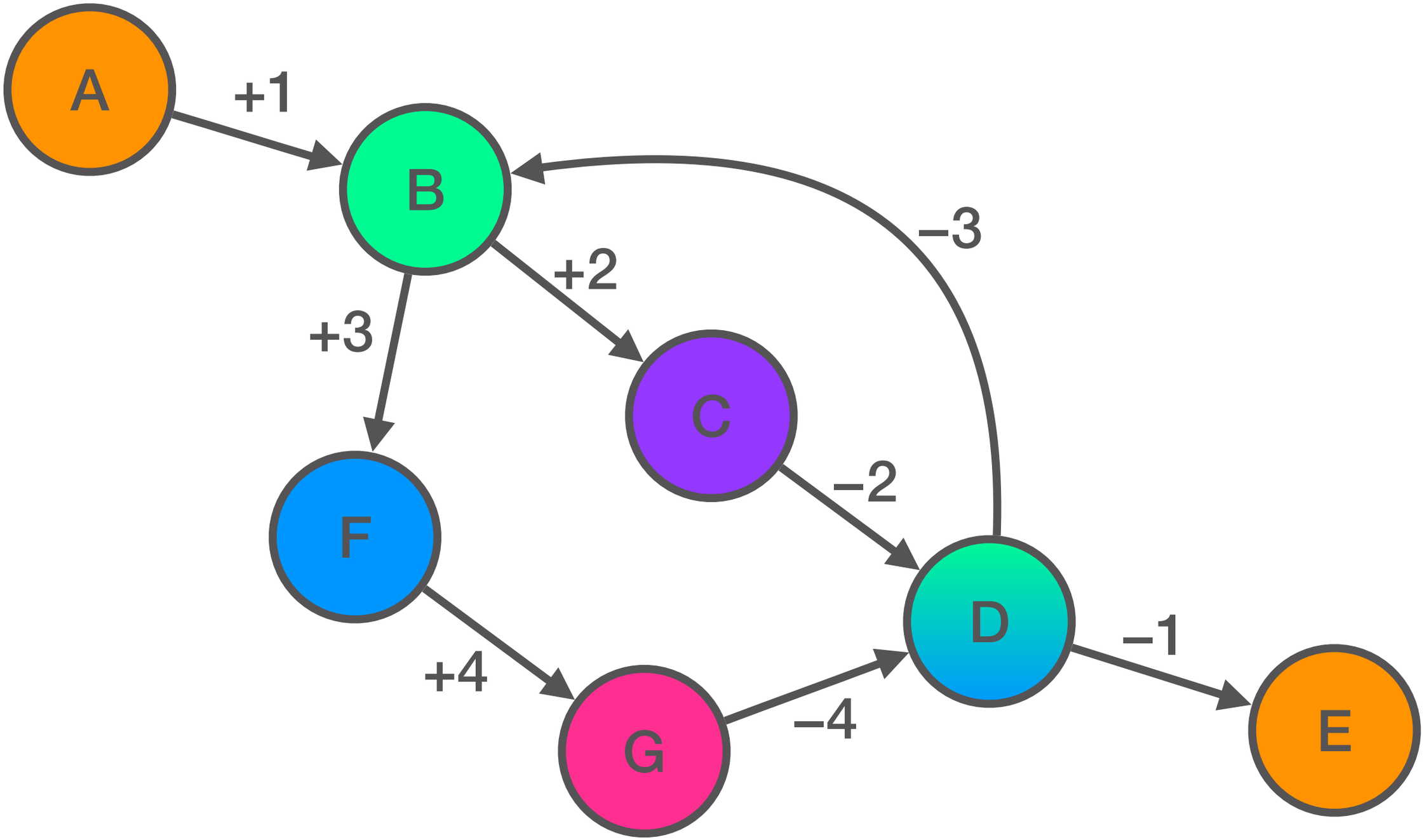
Stack Change



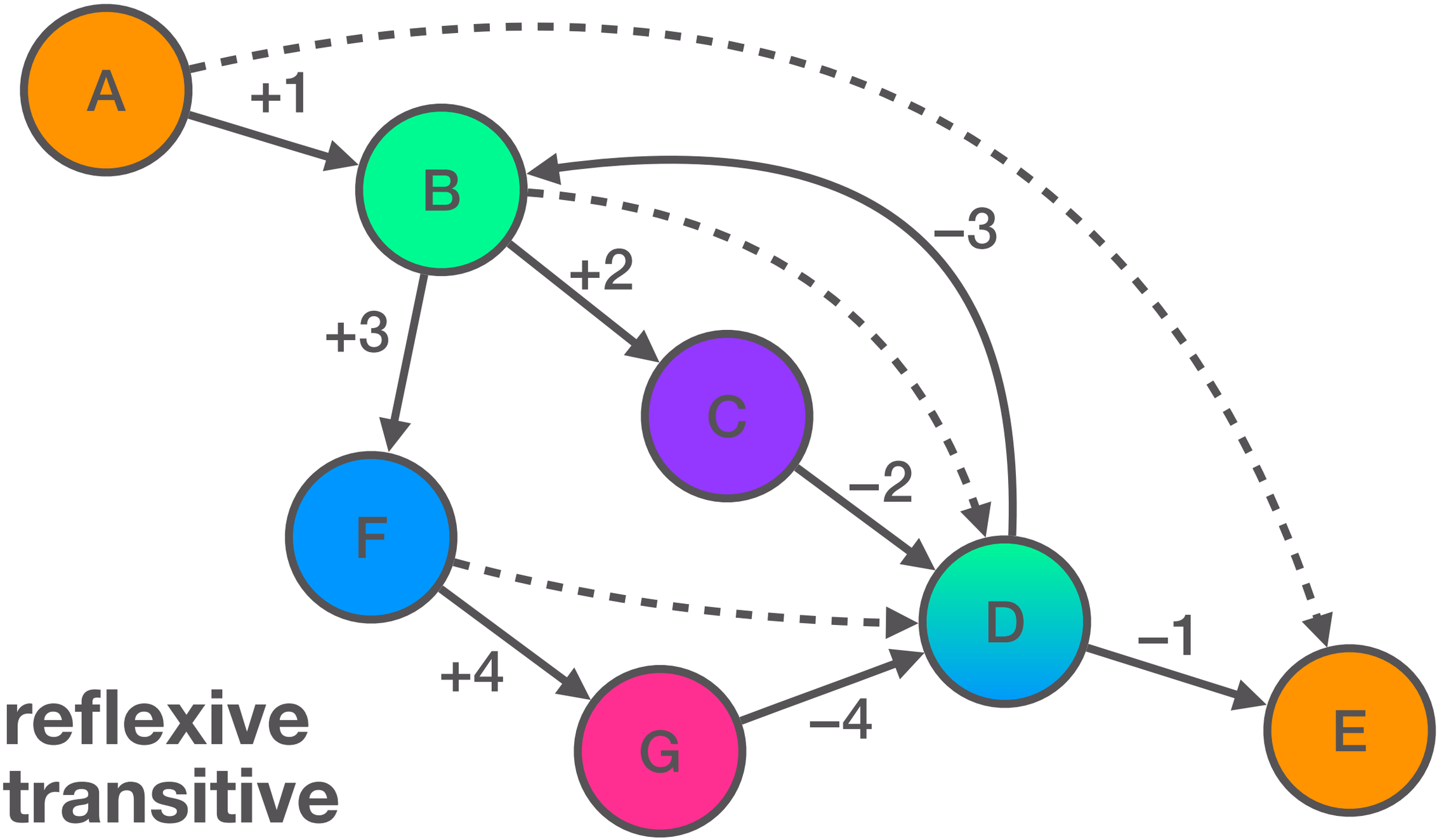
Stack Change



Stack Change

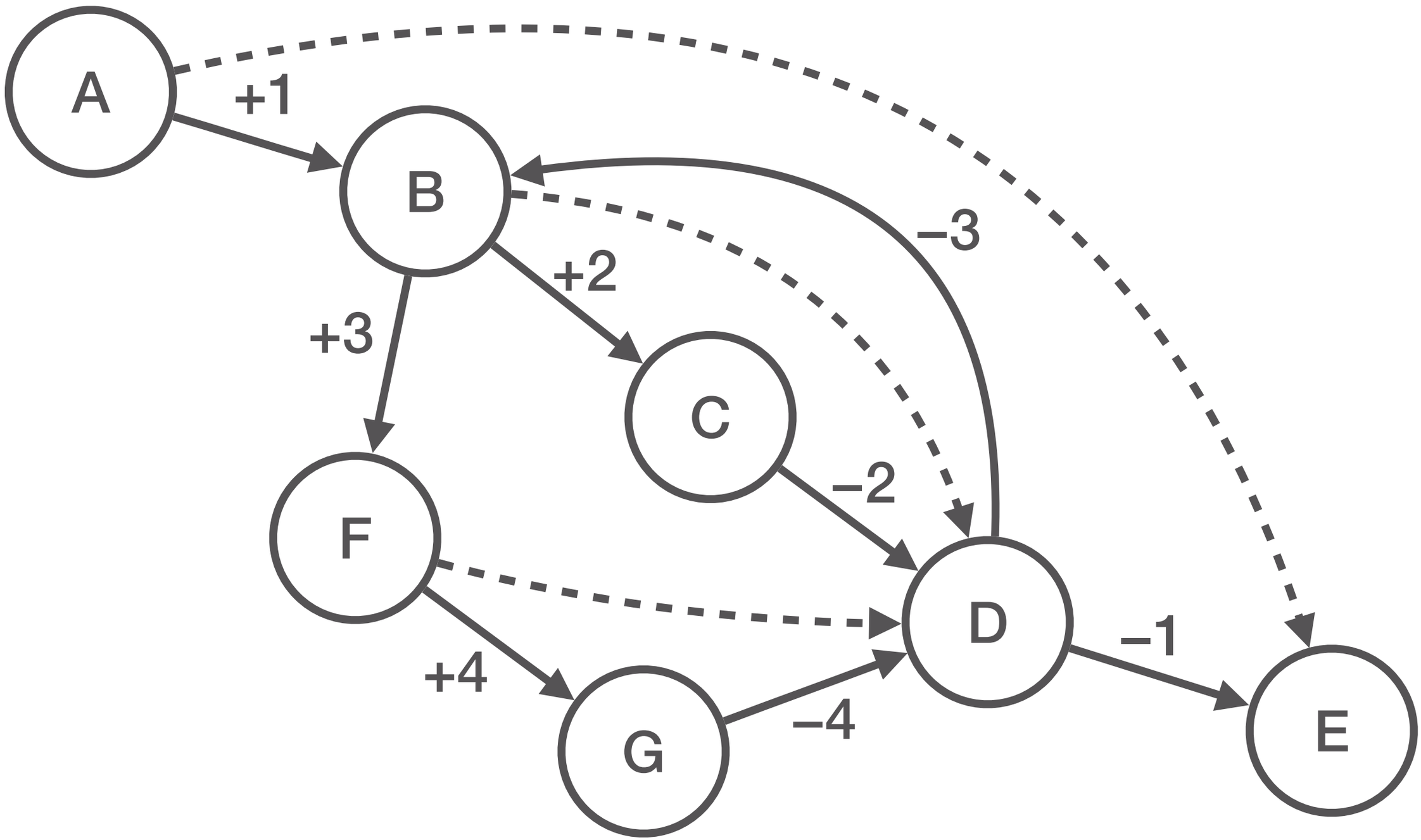


Summary Edges

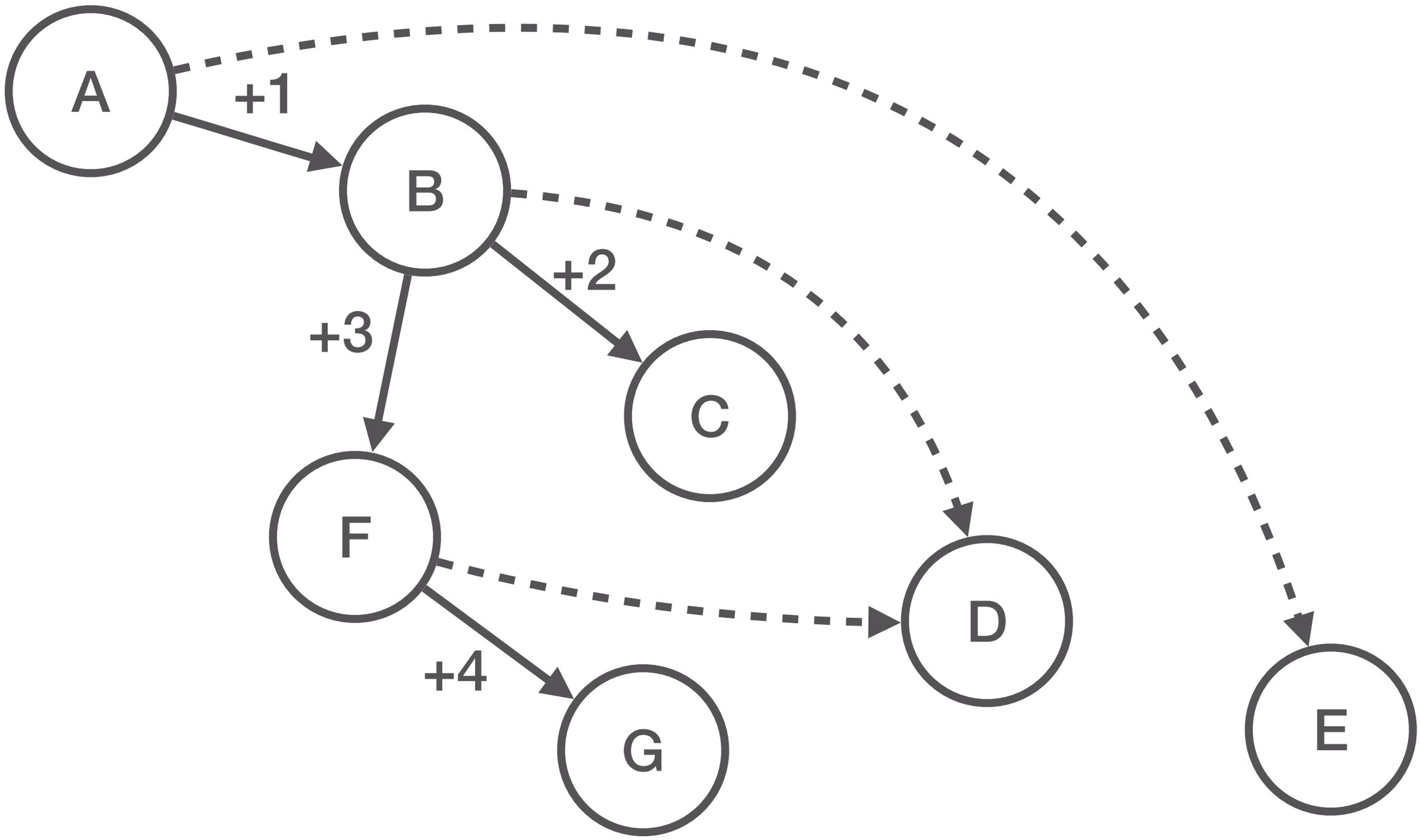


+ reflexive
+ transitive

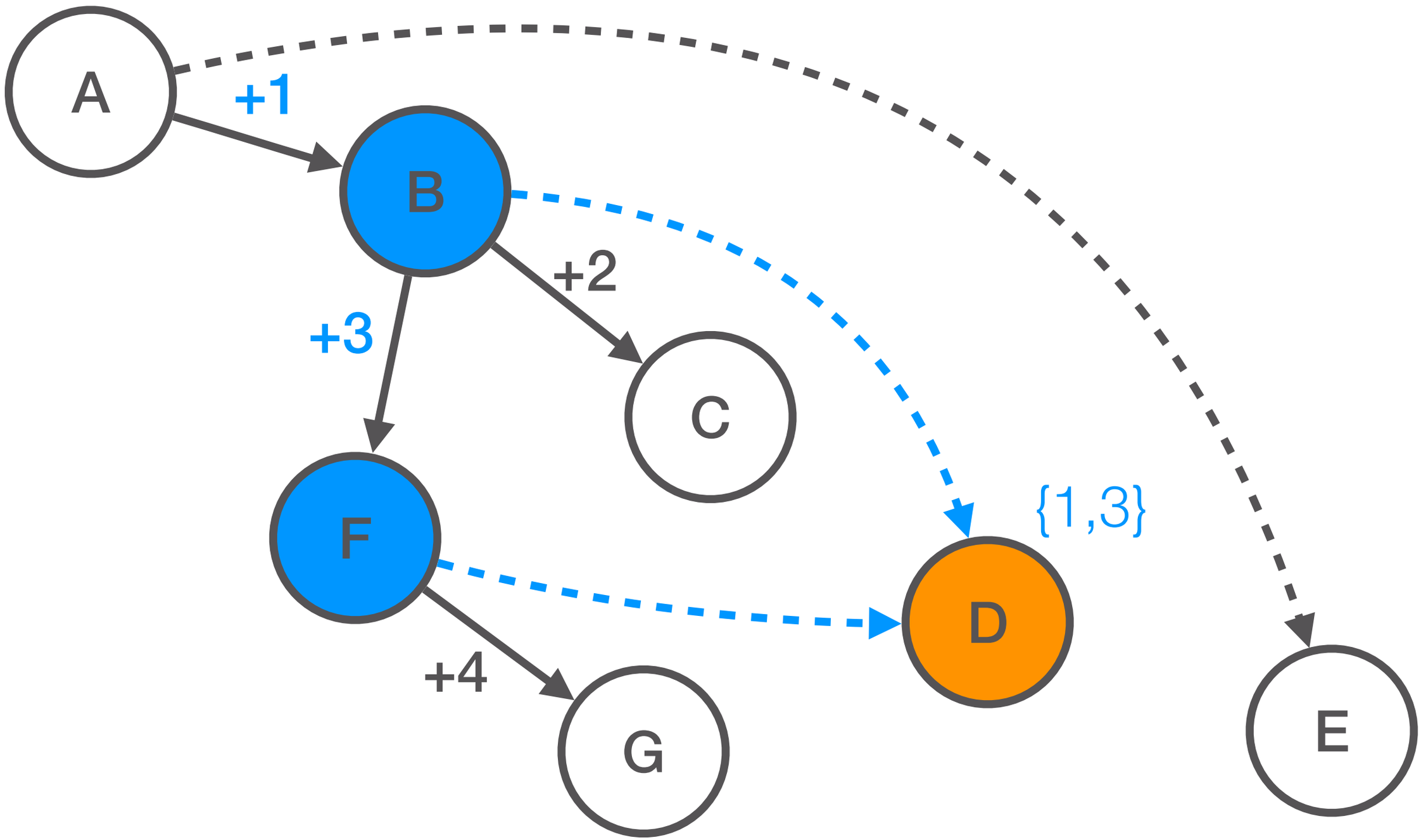
DSG Querying



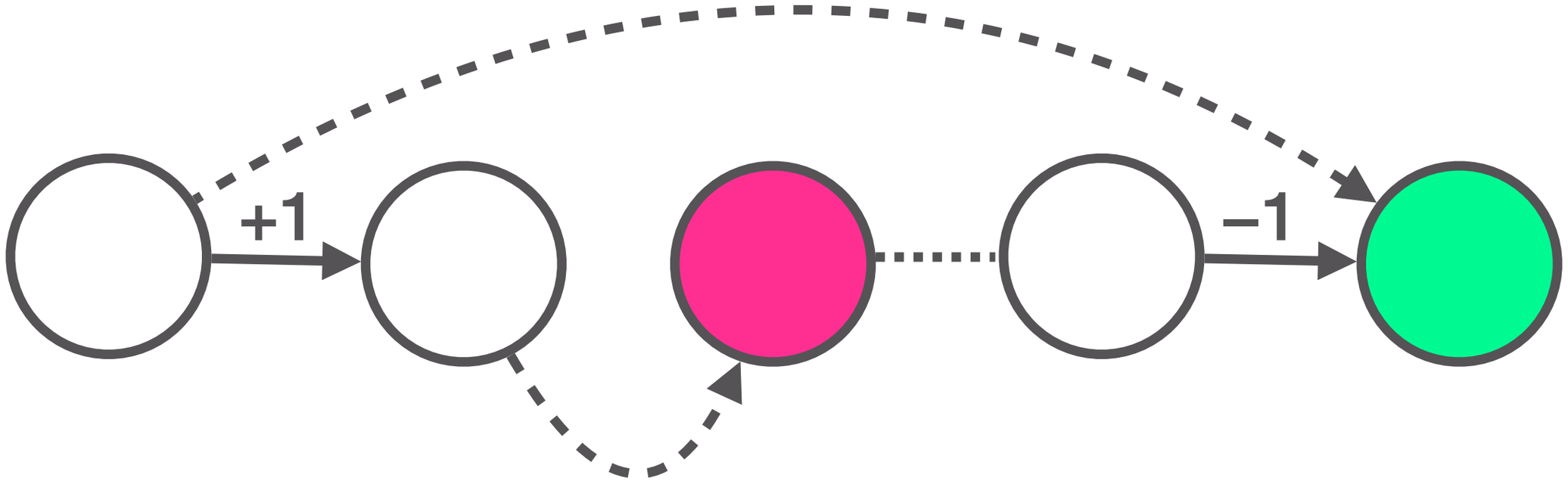
topOfStack



topOfStack



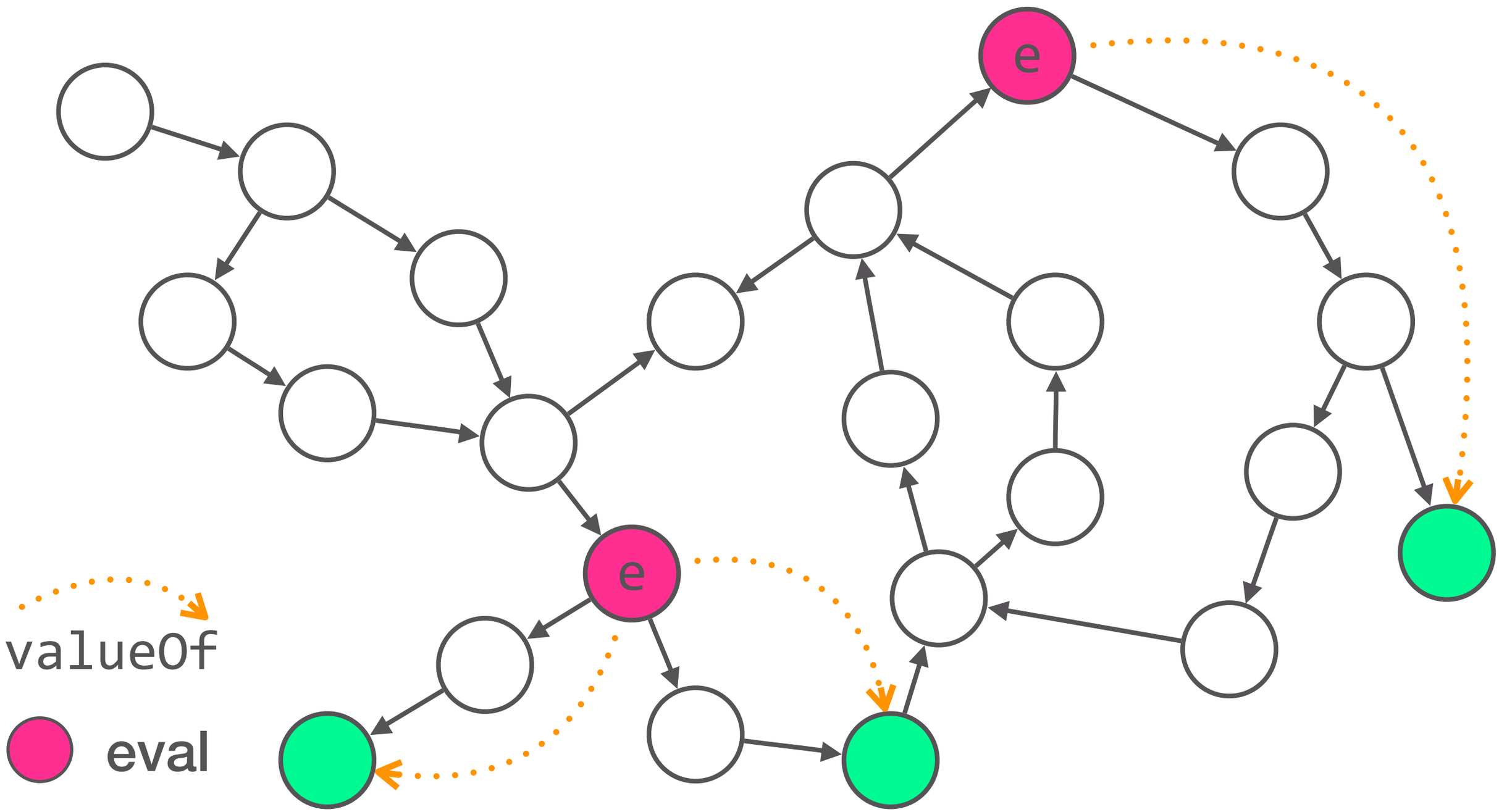
valueOf



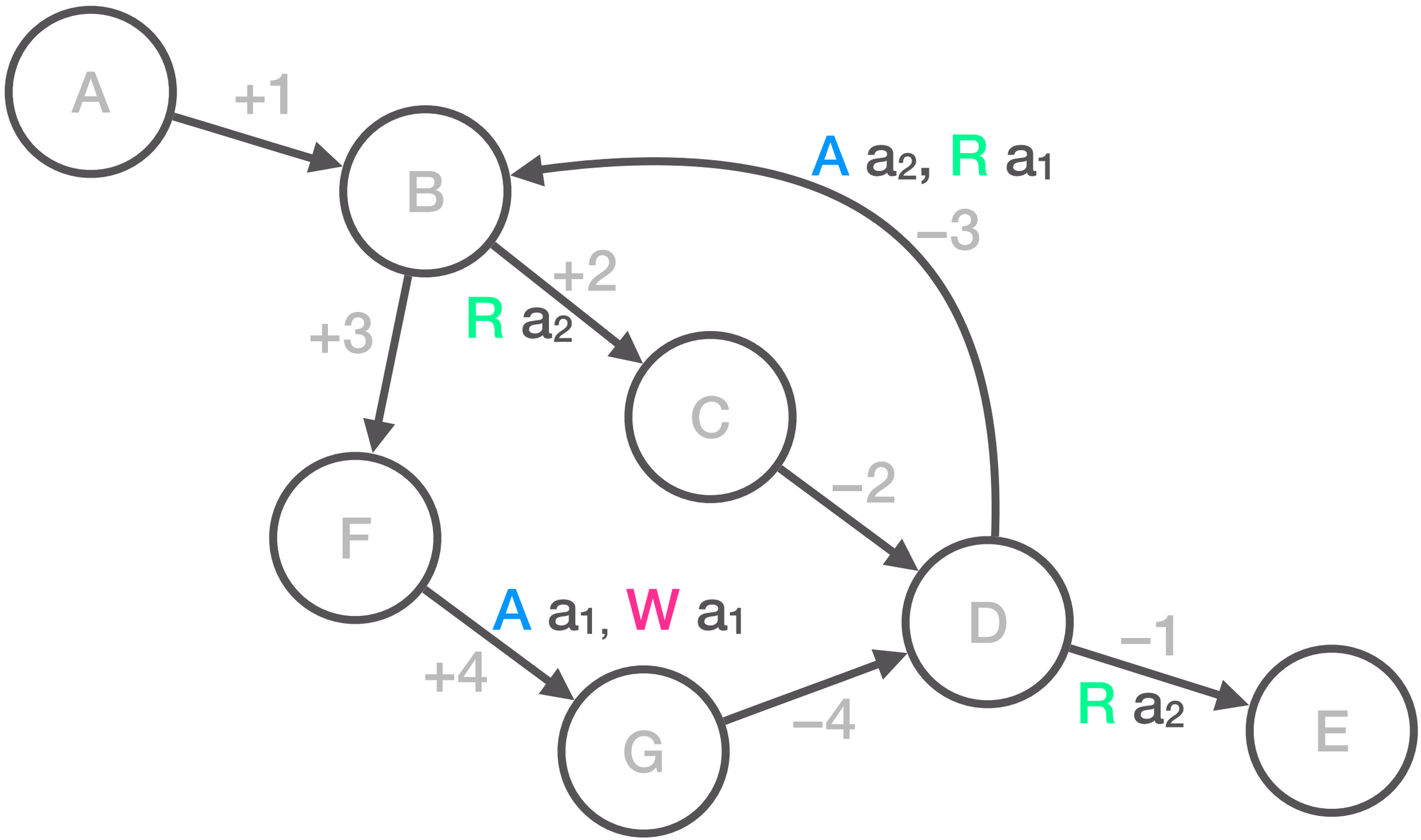
eval

cont

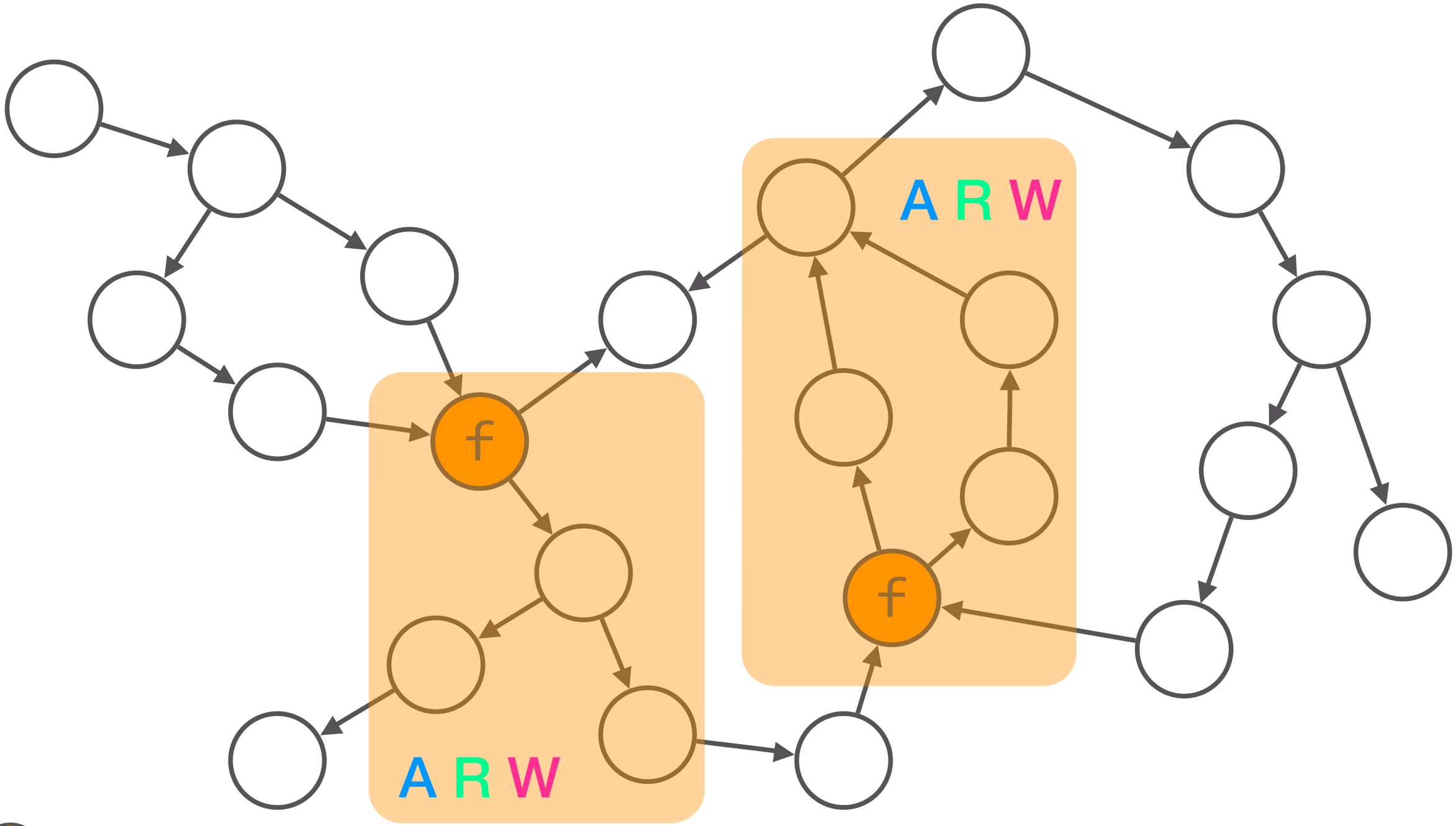
valueOf(e)



Effects



Purity Analysis

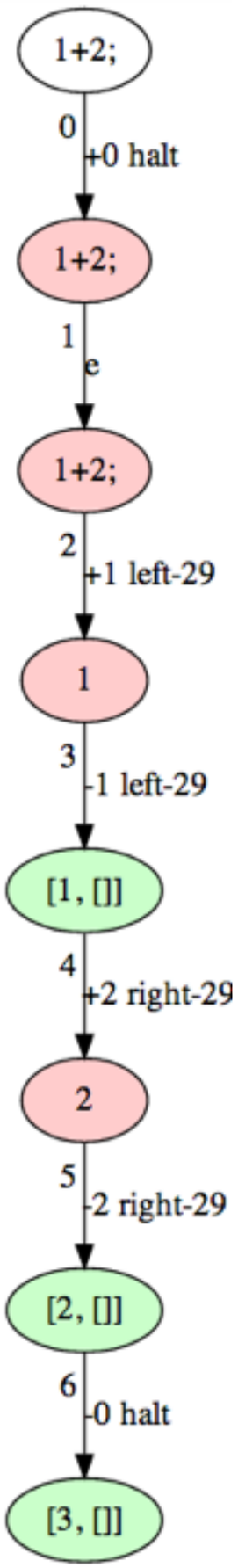


Wrap Up

- build generic pushdown analyses machinery
  - input languages
  - Dyck state graph queries
- find and exploit commonalities
- implementations: `https://github.com/jensnicolay`

Thanks!

1+2


1+2;
0
+0 halt
1+2;
1
e
1+2;
2
+1 left-29
1
3
-1 left-29
[1, []]
4
+2 right-29
2
5
-2 right-29
[2, []]
6
-0 halt
[3, []]