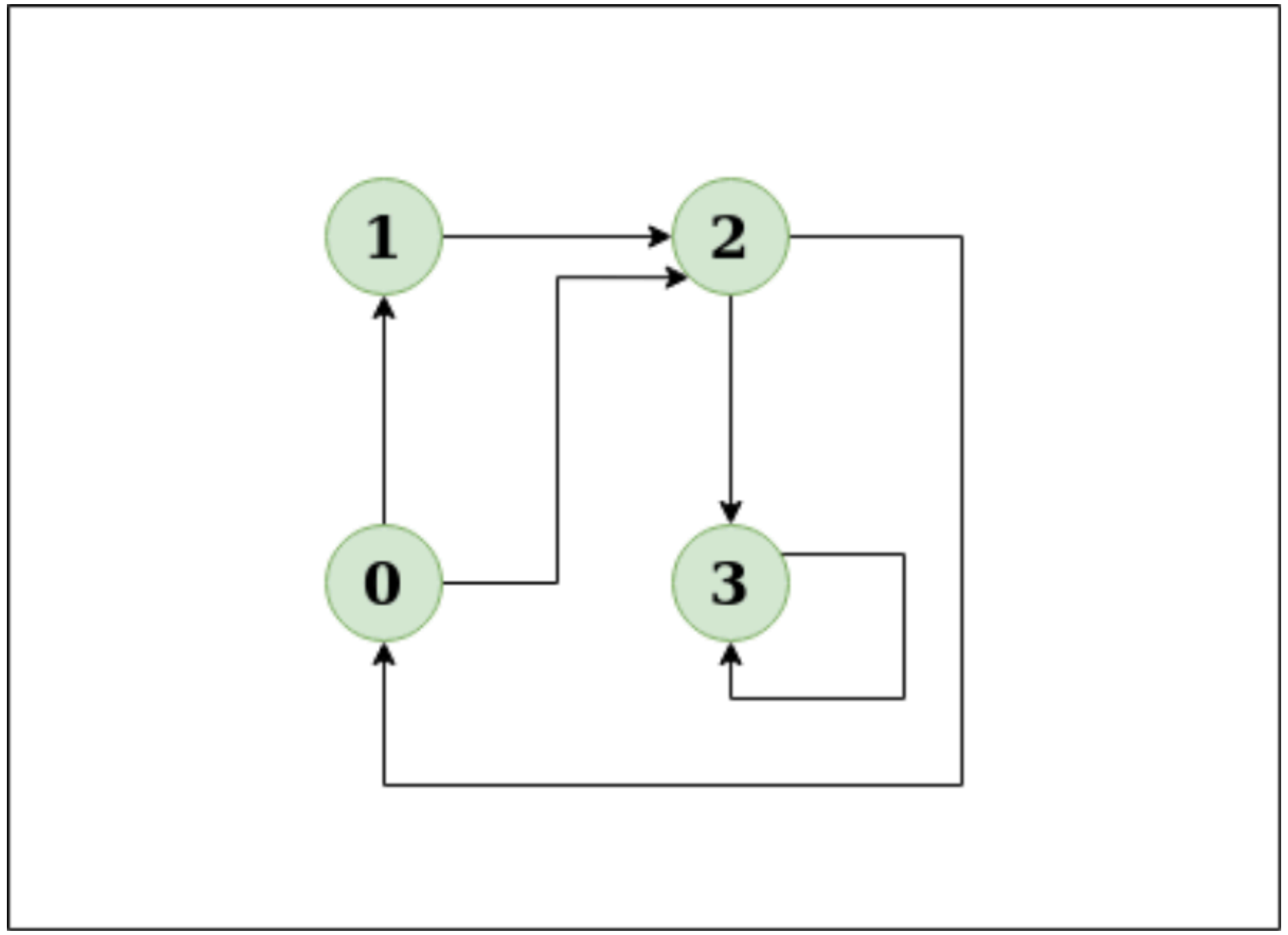
Does a graph have a cycle?

Mar 25


1
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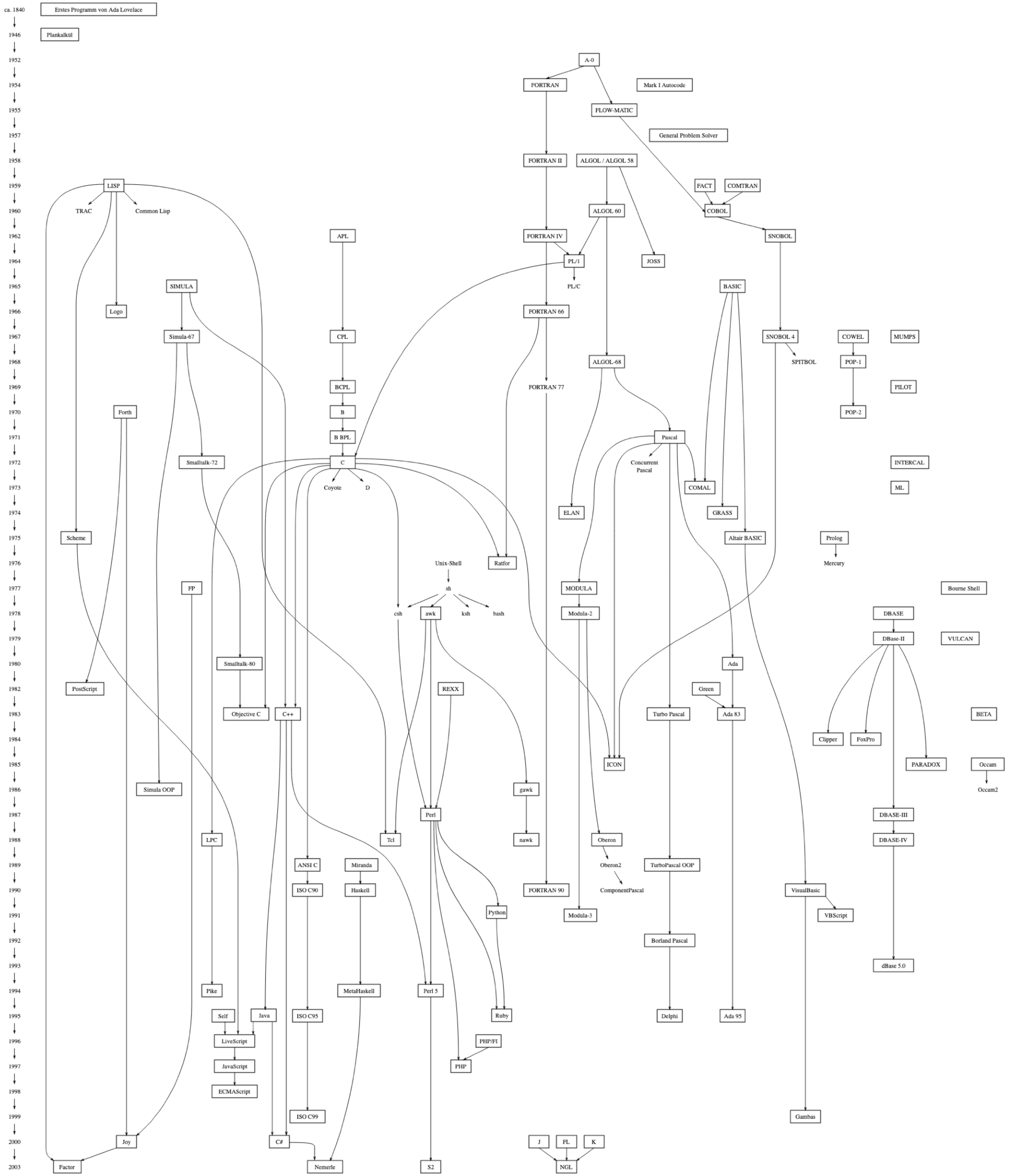
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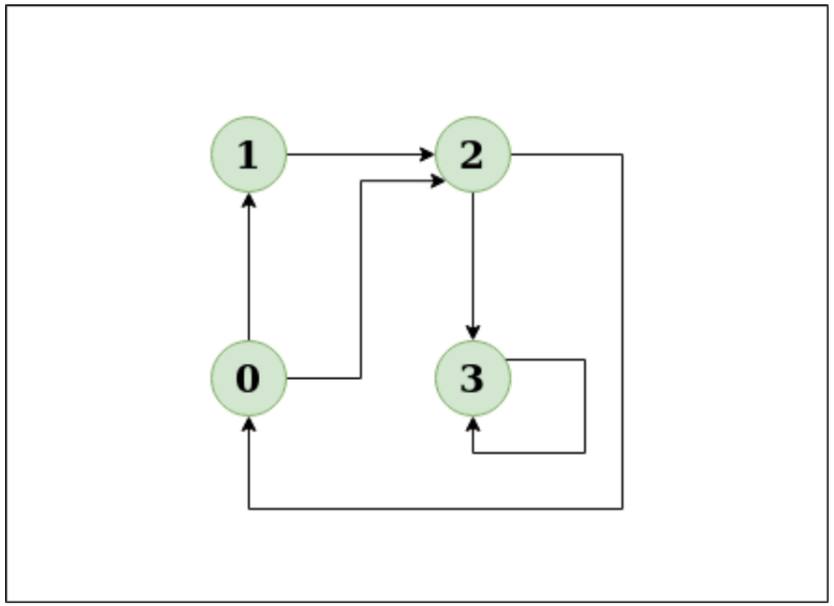
Erstes Programm von Ada Lovelace
Plankalkül
A-0
FORTRAN
Mark I Autocode
FLOW-MATIC
General Problem Solver
FORTRAN II
ALGOL / ALGOL 58
LISP
FACT
COMTRAN
TRAC
Common Lisp
ALGOL 60
COBOL
APL
FORTRAN IV
SNOBOL
PL/1
JOSS
SIMULA
PL/C
BASIC
Logo
FORTRAN 66
Simula-67
CPL
SNOBOL 4
COWEL
MUMPS
ALGOL-68
SPITBOL
POP-1
BCPL
FORTRAN 77
PILOT
Forth
B
POP-2
B BPL
Pascal
Smalltalk-72
C
Concurrent Pascal
INTERCAL
Coyote
D
COMAL
ML
ELAN
GRASS
Scheme
Altair BASIC
Prolog
Unix-Shell
Ratfor
Mercury
FP
sh
MODULA
Bourne Shell
csh
awk
ksh
bash
Modula-2
DBASE
DBase-II
VULCAN
Smalltalk-80
Ada
PostScript
REXX
Green
Objective C
C++
Turbo Pascal
Ada 83
BETA
Clipper
FoxPro
ICON
PARADOX
Occam
Simula OOP
gawk
Occam2
Perl
DBASE-III
LPC
Tcl
nawk
Oberon
DBASE-IV
ANSI C
Miranda
Oberon2
TurboPascal OOP
ISO C90
Haskell
FORTRAN 90
ComponentPascal
VisualBasic
Python
Modula-3
VBScript
Borland Pascal
dBase 5.0
Pike
MetaHaskell
Perl 5
Self
Java
ISO C95
Ruby
Delphi
Ada 95
LiveScript
PHP/FI
JavaScript
PHP
ECMAScript
ISO C99
Gambas
Joy
C#
J
FL
K
Factor
Nemerle
S2
NGL

Representing a graph

- Use an adjacency list




```
Node:
    id: an integer
    links: an array of integers

Graph:
    g: an array of nodes
```

Position	Node
0	{id: 0, links: [1,2]}
1	{id: 1, links:[2]}
2	{id: 2, links:[0,3]}
3	{id: 3: links[3]}

Depth First Search

On an acyclic graph

- Recursion
- No base case!
- Time / space complexity

- Will this explore whole graph?
- How do we handle possibility of cycles?

```
Given: g – a graph
       n – an integer
           (of some node in graph)

DFS(g, n):
    for link in g[n].links:
        DFS(g, link)
```

Coloring

Extending Node

- white: unvisited
- grey: being processed
- black: visited

- Start by setting color of every node to white

```
Node:
    id: an integer
    links: an array of integers
    color: white, black, or grey

Graph:
    g: an array of nodes
```

DFS: with coloring

- Is this enough?
  - Detect a cycle if it exists?
  - Stops if there is a cycle?

```
Given: g – a graph
       n – an integer
           (of some node in graph)
Return -- true if there is a cycle

DFS(g, n):
    g[n].color=grey
    for link in g[n].links:
        if g[link].color==grey
           return true
        if DFS(g, link)==true
           return true
    g[n].color=black
    return false
```

Final Algorithm

```
for i in 0..nodes.count
    g[i].color=white
for i in 0..nodes.count
    if g[i].color==white
       if DFSc(g,i)
           return true
return false
```

```
Given: g - a graph
       n - an integer
           (of some node in graph)
Return -- true if there is a cycle

DFSc(g, n):
    g[n].color=grey
    for link in g[n].links:
         if g[link].color==grey
            return true
         if DFSc(g, link)==true
            return true
    g[n].color=black
    return false
```

Aliases

assignment_num	count	graded
2	12	18
3	11	13
4	9	17
5	9	16
6	6	15
20	1	
21	1	

Graph Representations

Name			
Implementation (Java)			
O(space)			

Topological sort

- Realistically do not need, just need to find nodes with in-degree of zero
  - Complexity of finding this?

- Can we use my cycle colorer to determine path from Washington to DC

Finding Cycles
and Topological Sort

Topo Sort Algorithm

```
Count in-degree of all nodes
Add all indegree=0 to Q
While Q
  remove n from Q
  for each e (edge from n)
    reduce indegree of node e.too
    if indegree of e.too == 0
      add e.too to Q
```

- for a graph G is topo sort unique

- For cycle finding do I need to do a full Topological Sort?
- if not, what do I need?

Graph Representations

Name			
Implementation (Java)			
O(space)			
Cost to find indegree: of each node of a given node			
Cost to find outdegree: of each node of a given node			

Final Algorithm With Topo Step 1

```
for i in 0..nodes.count
    g[i].color=white
for n in nodes with indegree==0
    if g[i].color==white
       if DFSc(g,i)
           return true
return false
```

```
Given: g - a graph
       n - an integer
           (of some node in graph
Return -- true if there is a cycl

DFSc(g, n):
    g[n].color=grey
    for link in g[n].links:
         if g[link].color==grey
            return true
         if DFSc(g, link)==true
            return true
    g[n].color=black
    return false
```

Is Topo (step 1) worth doing?

- Time complexity??

- Likely real-world time??

Use Coloring for maze walking?

"Death of a salesman" problem is, at core, a maze

- Can I?
- Algorithm
  - change from -->
- Benefits?
- Costs?

```
Given: g – a graph
       n – an integer
           (of some node in graph)
Return -- true if there is a cycle

DFSc(g, n):
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    for link in g[n].links:
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    return false
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