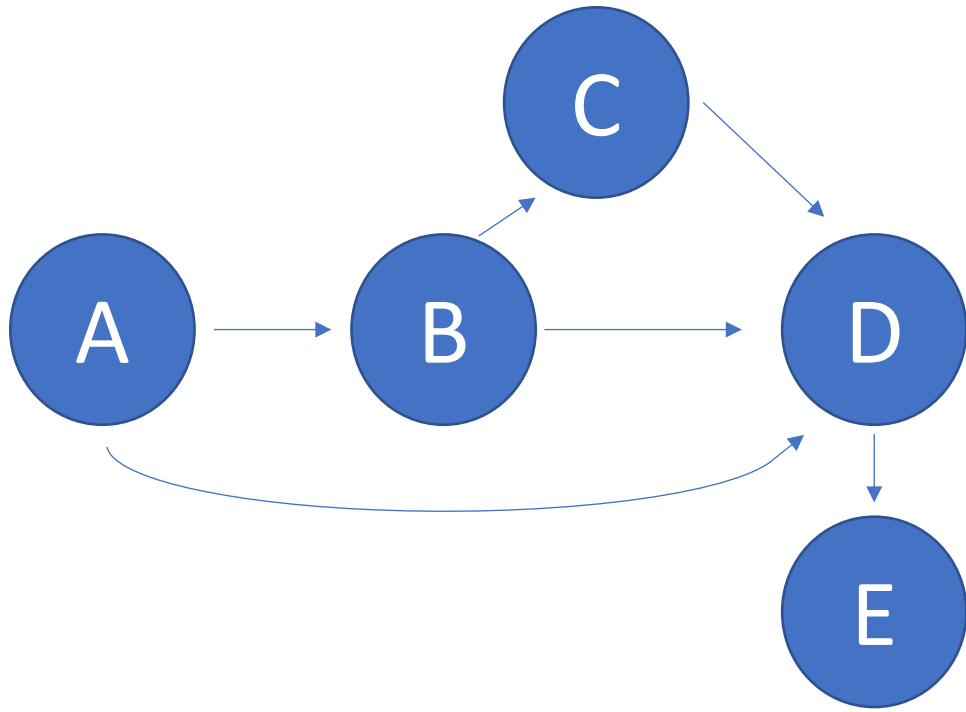


A → B, D
B → C, D
C → D
D → E
E → \

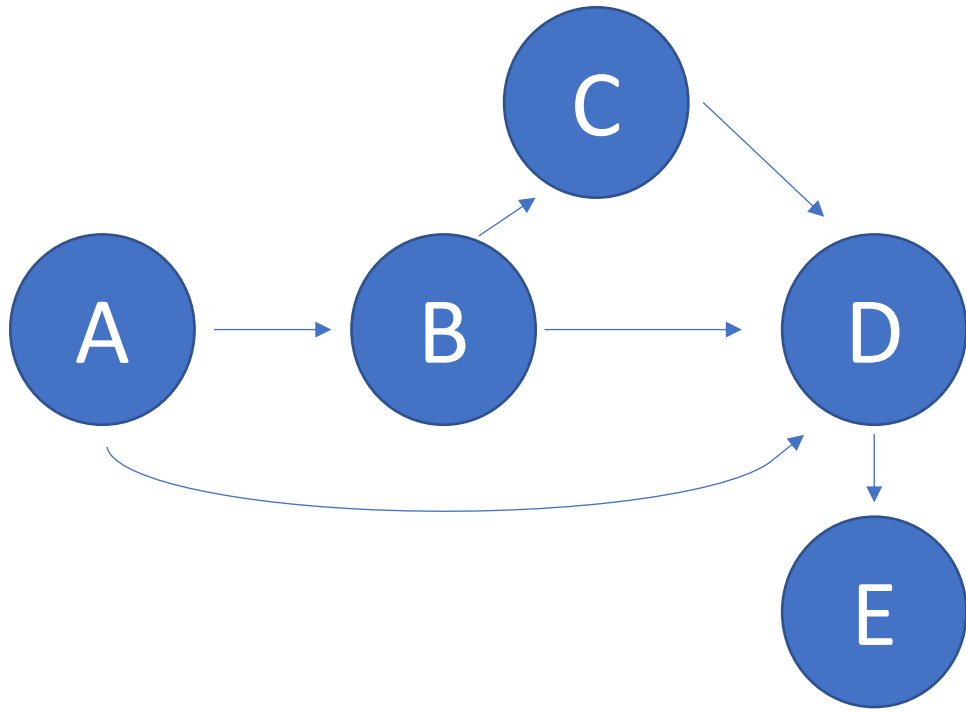


A → B, D
B → C, D
C → D
D → E
E → \

All nodes get
an initial value
of $1/N$

Initial Values

| A | B | C | D | E |
|-----|-----|-----|-----|-----|
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

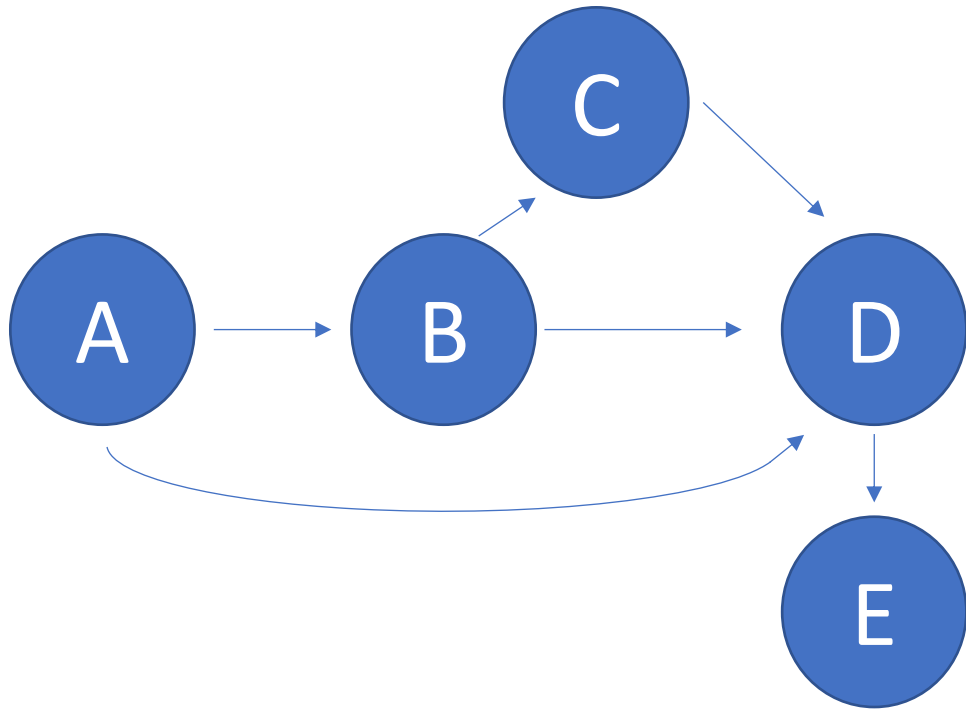


A → B, D
B → C, D
C → D
D → E
E → \

Use initial values as our baseline

“Old” Values

| A | B | C | D | E |
|-----|-----|-----|-----|-----|
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |



A → B, D
 B → C, D
 C → D
 D → E
 E → \

A

“New” Values

$$A =$$

$$B = \frac{(.2 * .85)}{2}$$

$$C =$$

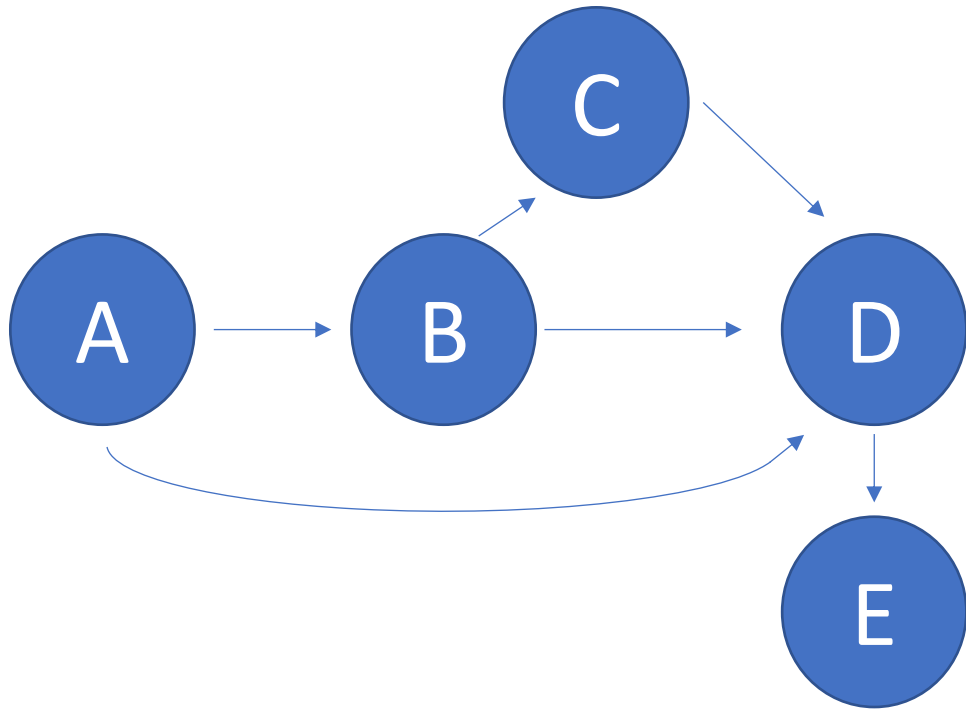
$$D = \frac{(.2 * .85)}{2}$$

$$E =$$

“Old” Values

| A | B | C | D | E |
|-----|-----|-----|-----|-----|
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

Set initial values to 0 in the “New” values. Split the old values of A between everything A points to, multiplied by the “decay” factor (.85)



$A \rightarrow B, D$
 $B \rightarrow C, D$
 $C \rightarrow D$
 $D \rightarrow E$
 $E \rightarrow \backslash$

A

“New” Values

A =

B = **.085**

C =

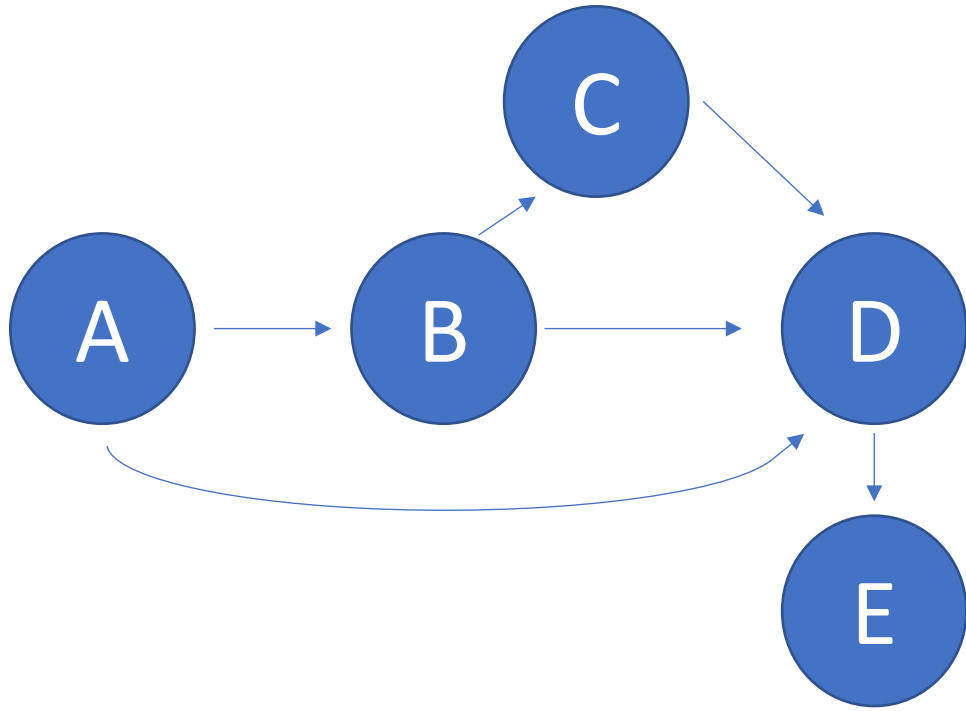
D = **.085**

E =

“Old” Values

| A | B | C | D | E |
|-----|-----|-----|-----|-----|
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

Set initial values to 0 in the “New” values. Split the old values of A between everything A points to, multiplied by the “decay” factor (.85)



$A \rightarrow B, D$
 $B \rightarrow C, D$
 $C \rightarrow D$
 $D \rightarrow E$
 $E \rightarrow \backslash$

B

“New” Values

$$A =$$

$$B = .085$$

$$C = \frac{(.2 * .85)}{2}$$

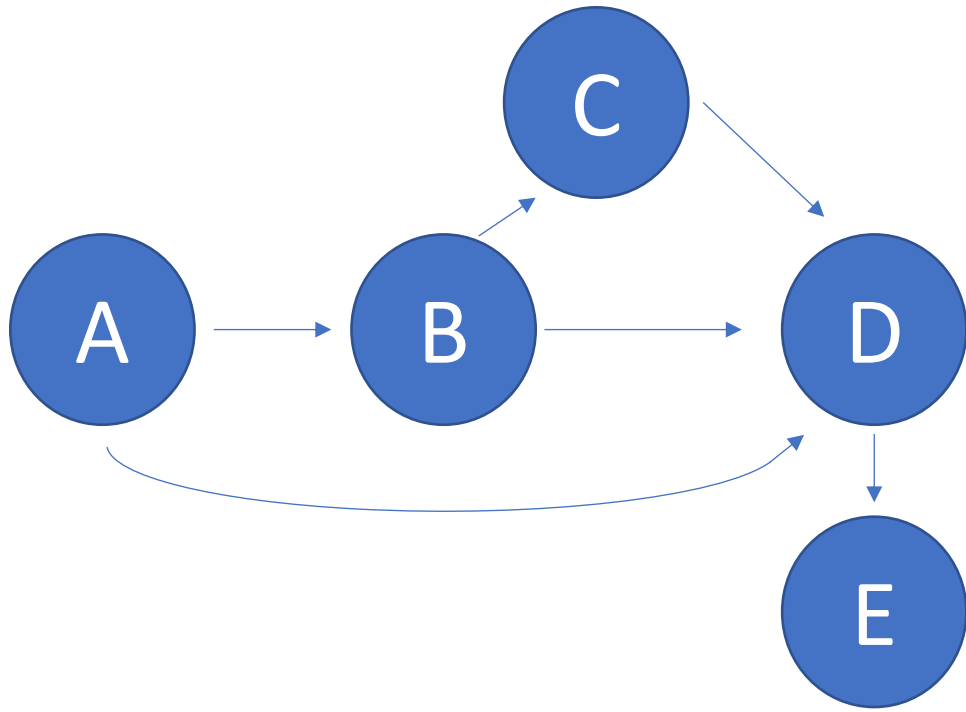
$$D = .085 + \frac{(.2 * .85)}{2}$$

$$E =$$

“Old” Values

| A | B | C | D | E |
|-----|-----|-----|-----|-----|
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

Continue for each of the nodes in our graph



$A \rightarrow B, D$
 $B \rightarrow C, D$
 $C \rightarrow D$
 $D \rightarrow E$
 $E \rightarrow \backslash$

C

“New” Values

A =

B = .085

C = .085

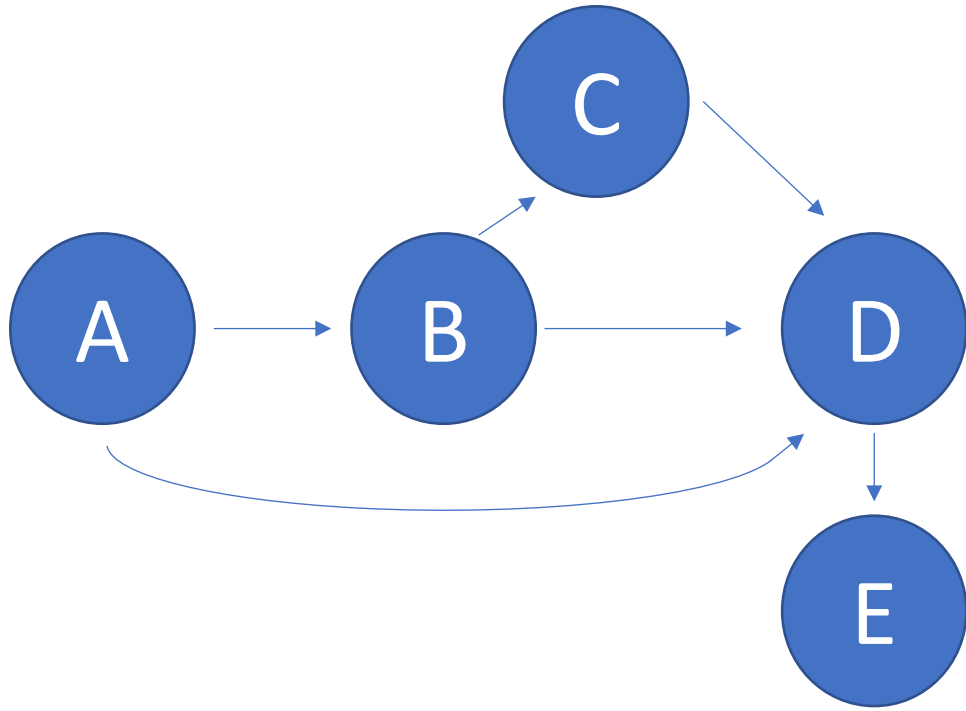
$D = .085 + .085 +$
 $(.2 * .85)$

E =

“Old” Values

| A | B | C | D | E |
|-----|-----|-----|-----|-----|
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

Continue for each of the nodes in our graph



$A \rightarrow B, D$
 $B \rightarrow C, D$
 $C \rightarrow D$
 $D \rightarrow E$
 $E \rightarrow \backslash$

“New” Values

$$A =$$

$$B = .085$$

$$C = .085$$

$$D = .085 + .085 + .17$$

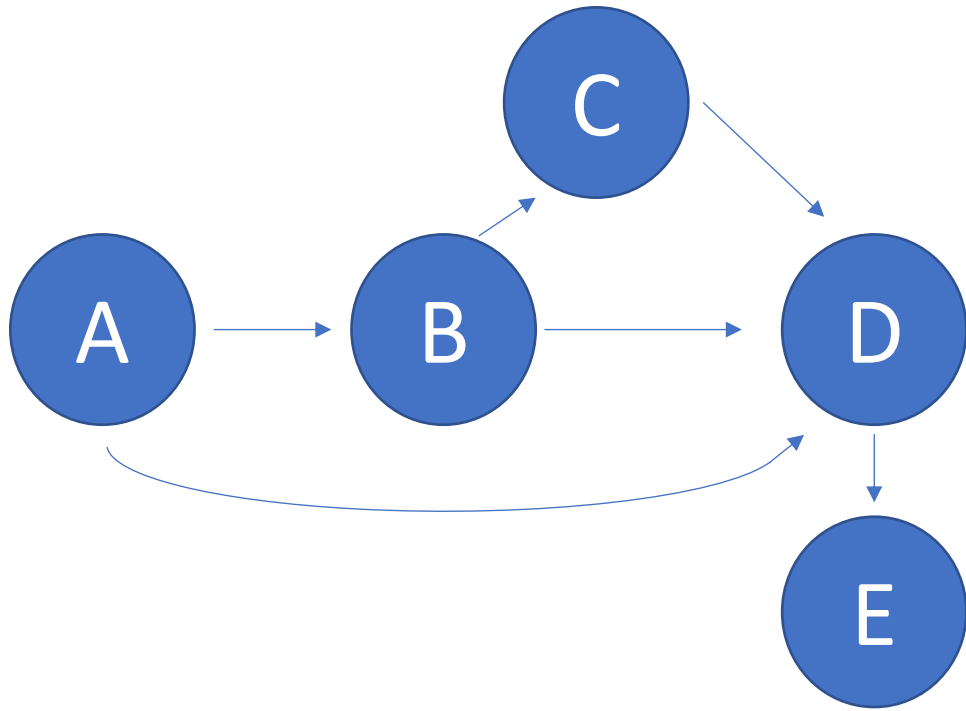
$$E = (.2 * .85)$$

D

“Old” Values

| A | B | C | D | E |
|-----|-----|-----|-----|-----|
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

Continue for each of the nodes in our graph



A → B, D
 B → C, D
 C → D
 D → E
 E → \

E

“Old” Values

| A | B | C | D | E |
|-----|-----|-----|-----|-----|
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

Here the people on E have nowhere to go - so we split the traffic on E between every page

“New” Values

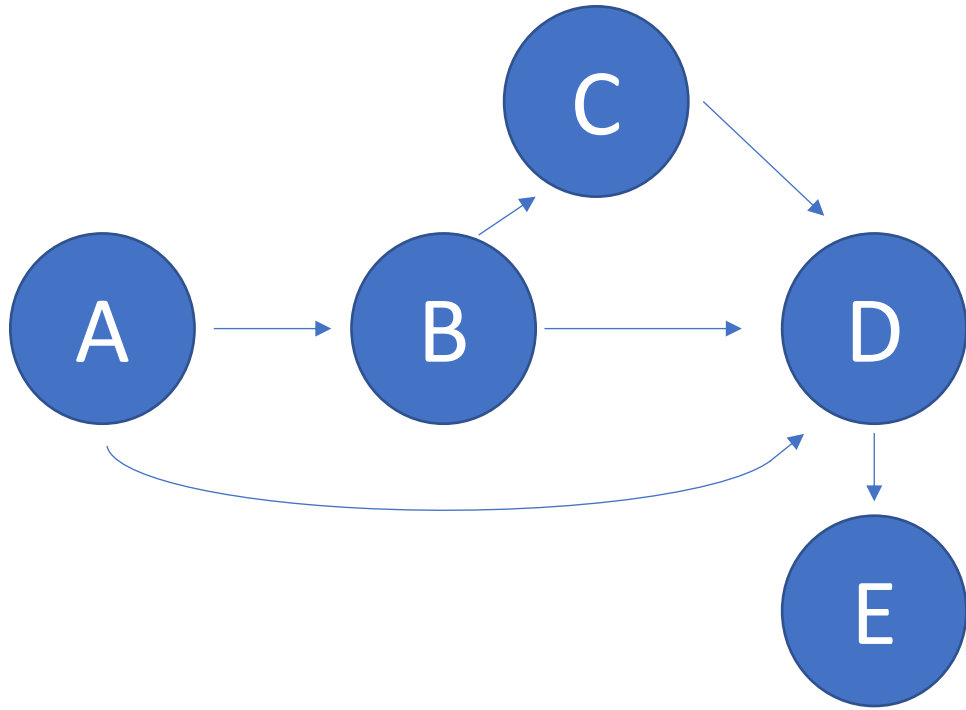
$$A = \frac{(.85 * .2)}{5}$$

$$B = .085 + \frac{(.85 * .2)}{5}$$

$$C = .085 + \frac{(.85 * .2)}{5}$$

$$D = .085 + .085 + .17 + \frac{(.85 * .2)}{5}$$

$$E = .17 + \frac{(.85 * .2)}{5}$$



A → B, D
 B → C, D
 C → D
 D → E
 E → \

“New” Values

$$A = .034$$

$$B = .085 + .034$$

$$C = .085 + .034$$

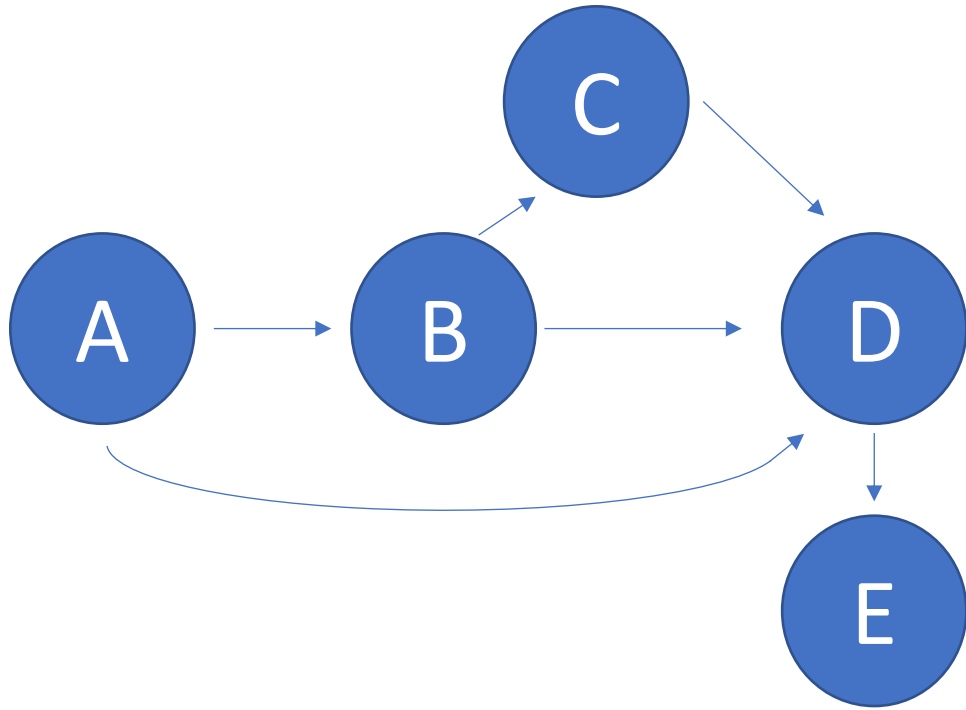
$$D = .085 + .085 + .17 + .034$$

$$E = .17 + .034$$

“Old” Values

| A | B | C | D | E |
|-----|-----|-----|-----|-----|
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

Here the nodes have nowhere to go - so we split the traffic on E between every other page



A → B, D
 B → C, D
 C → D
 D → E
 E → \

“New” Values

A = .034

B = .119

C = .119

D = .374

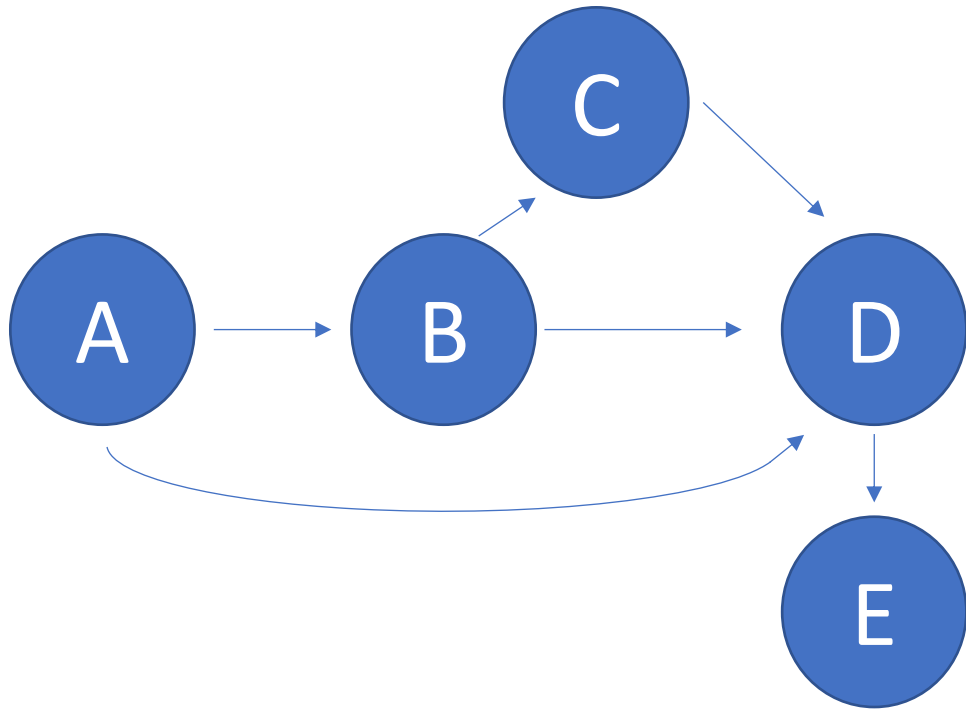
E = .204

“Old” Values

| A | B | C | D | E |
|-----|-----|-----|-----|-----|
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

E

Here the nodes have nowhere to go - so we split the traffic on E between every other page



A → B, D
 B → C, D
 C → D
 D → E
 E → \

“New” Values

$$A = .034 + \frac{.15}{5}$$

$$B = .119 + \frac{.15}{5}$$

$$C = .119 + \frac{.15}{5}$$

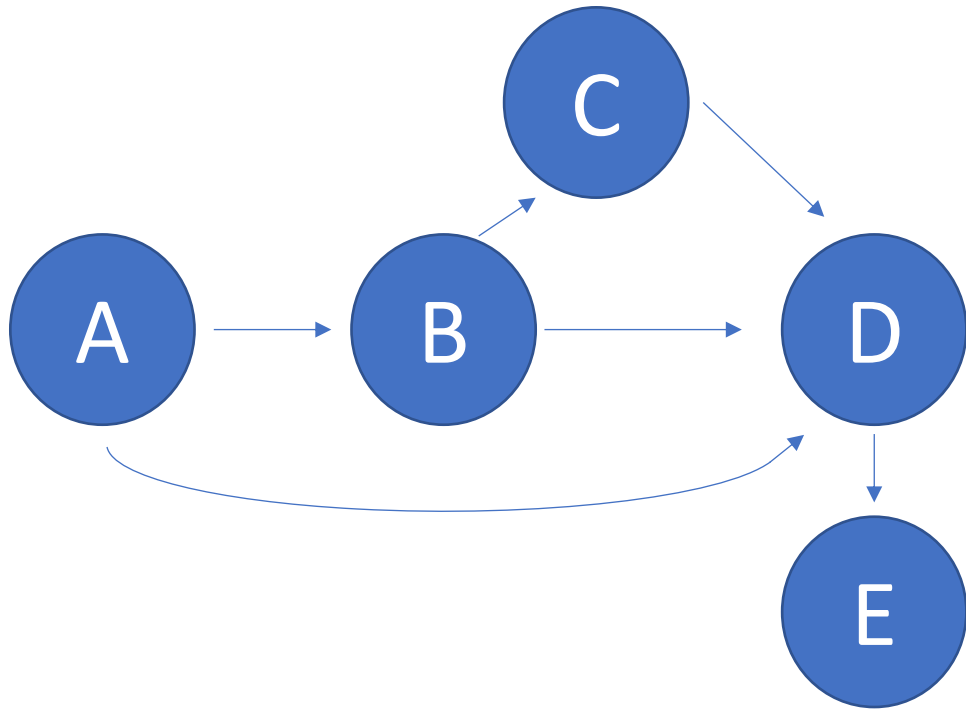
$$D = .374 + \frac{.15}{5}$$

$$E = .204 + \frac{.15}{5}$$

“Old” Values

| A | B | C | D | E |
|-----|-----|-----|-----|-----|
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

Now we need to “undo” the decay by adding $.15/N$ to each page.



$A \rightarrow B, D$
 $B \rightarrow C, D$
 $C \rightarrow D$
 $D \rightarrow E$
 $E \rightarrow \backslash$

“New” Values

$$A = .034 + .03$$

$$B = .119 + .03$$

$$C = .119 + .03$$

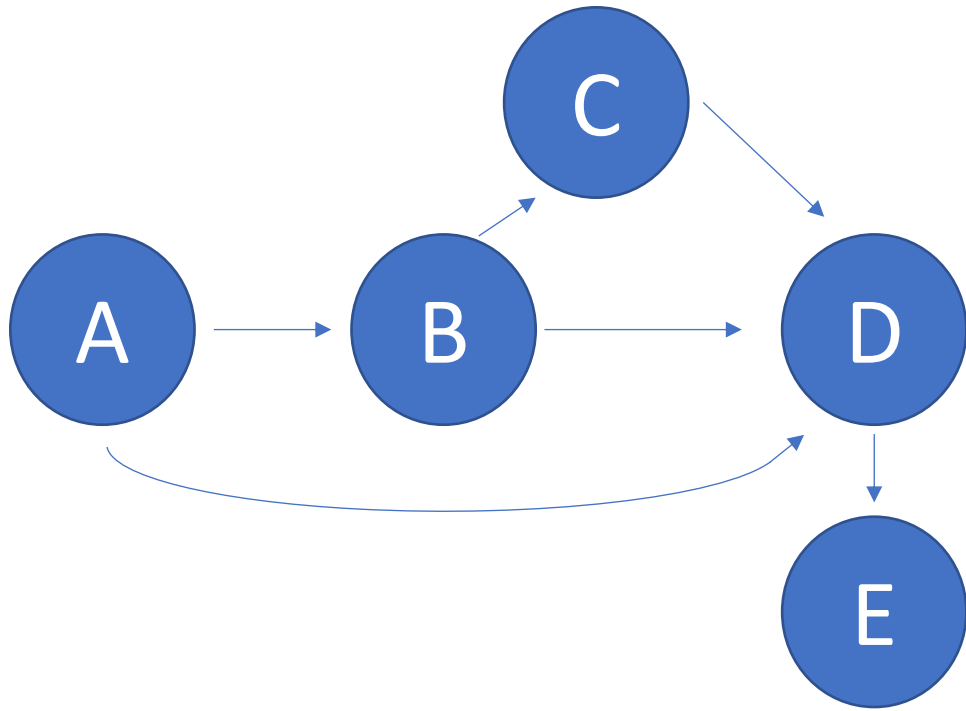
$$D = .374 + .03$$

$$E = .204 + .03$$

“Old” Values

| A | B | C | D | E |
|-----|-----|-----|-----|-----|
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

Now we need to “undo” the decay by adding $.15/N$ to each page.



$A \rightarrow B, D$
 $B \rightarrow C, D$
 $C \rightarrow D$
 $D \rightarrow E$
 $E \rightarrow \backslash$

“New” Values

$$A = .064$$

$$B = .149$$

$$C = .149$$

$$D = .404$$

$$E = .234$$

“Old” Values

| A | B | C | D | E |
|-----|-----|-----|-----|-----|
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

Now we need to “undo” the decay by adding $.15/N$ to each page.

Convergence check!

“Old” Values

| A | B | C | D | E |
|-----|-----|-----|-----|-----|
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

“New” Values

| A | B | C | D | E |
|-------|-------|-------|-------|-------|
| 0.064 | 0.149 | 0.149 | 0.404 | 0.234 |

For every step, check if the old value minus the new value is $<$ epsilon. If EVERY new value is less than an “epsilon” difference, then we’ll accept the old values as our final answers.

Because $|\text{old } A - \text{new } A|$ is greater than epsilon, we need to keep searching.

“Old” Values

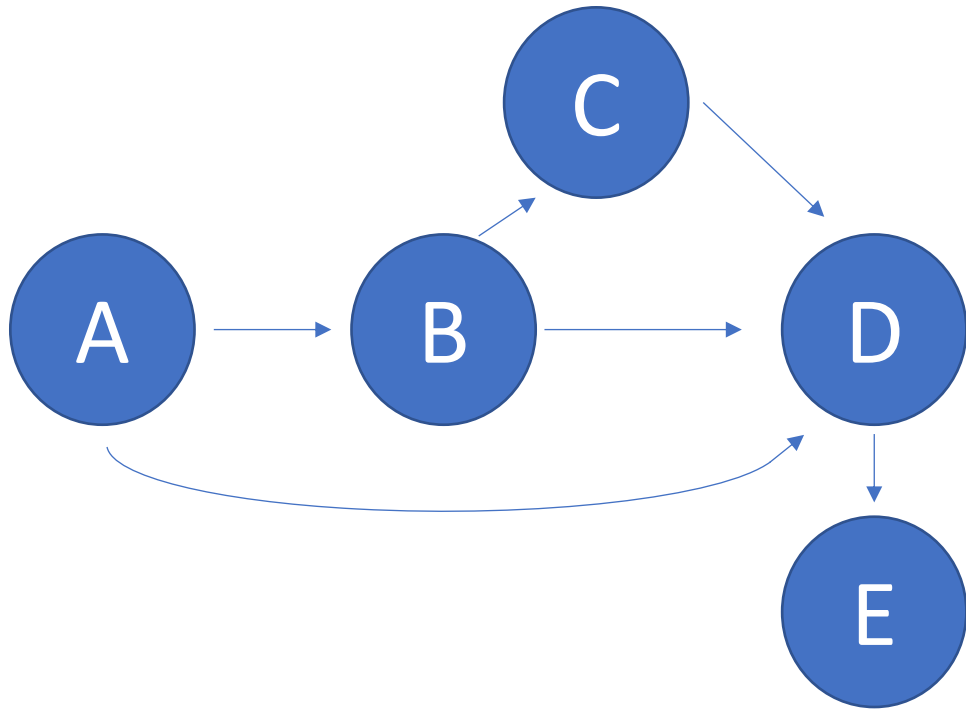
| A | B | C | D | E |
|-----|-----|-----|-----|-----|
| 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |

“New” Values

| A | B | C | D | E |
|-------|-------|-------|-------|-------|
| 0.064 | 0.149 | 0.149 | 0.404 | 0.234 |

For the next iteration, we'll update our old values with our new values

.



$A \rightarrow B, D$
 $B \rightarrow C, D$
 $C \rightarrow D$
 $D \rightarrow E$
 $E \rightarrow \backslash$

A

“New” Values

A =

$$B = \frac{(.064 * .85)}{2}$$

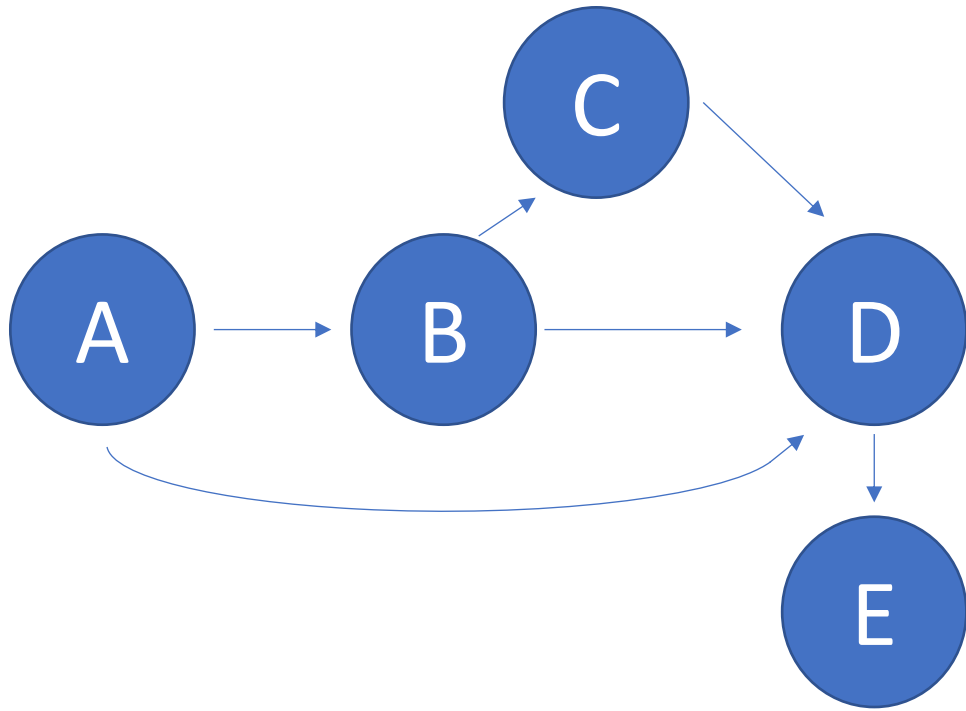
C =

$$D = \frac{(.064 * .85)}{2}$$

E =

“Old” Values

| A | B | C | D | E |
|-------|-------|-------|-------|-------|
| 0.064 | 0.149 | 0.149 | 0.404 | 0.234 |



$A \rightarrow B, D$
 $B \rightarrow C, D$
 $C \rightarrow D$
 $D \rightarrow E$
 $E \rightarrow \backslash$

A

“Old” Values

| A | B | C | D | E |
|--------------|-------|-------|-------|-------|
| <u>0.064</u> | 0.149 | 0.149 | 0.404 | 0.234 |

“New” Values

A =

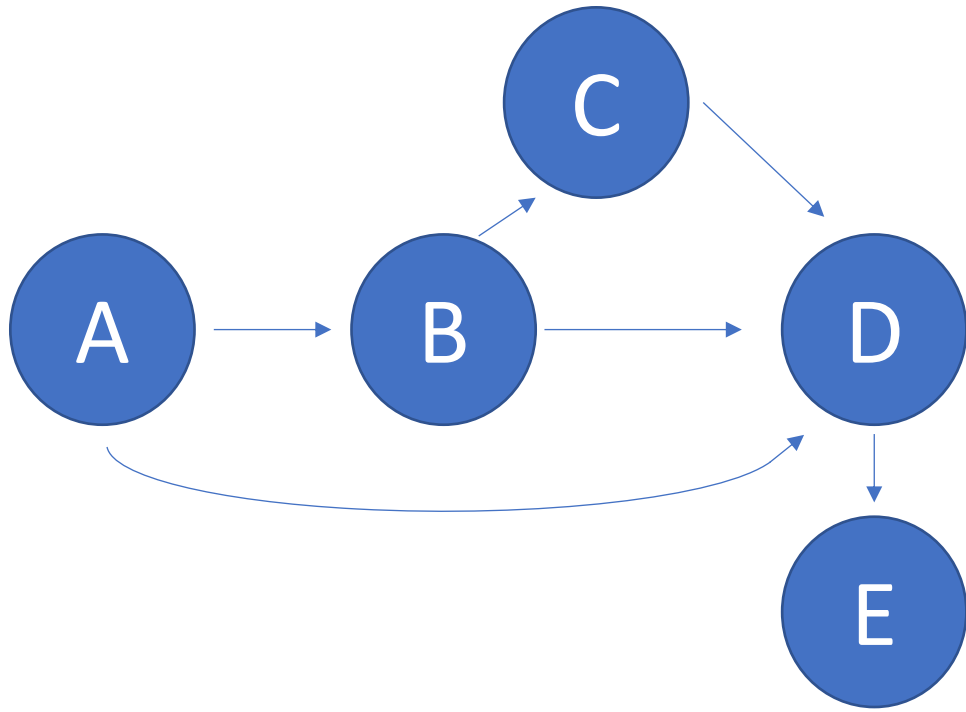
$$B = \frac{(.064 * .85)}{2}$$

C =

$$D = \frac{(.064 * .85)}{2}$$

E =

Notice that we’re using the old value for A now, instead of .2



$A \rightarrow B, D$
 $B \rightarrow C, D$
 $C \rightarrow D$
 $D \rightarrow E$
 $E \rightarrow \backslash$

A

“New” Values

A =

B = 0.0272

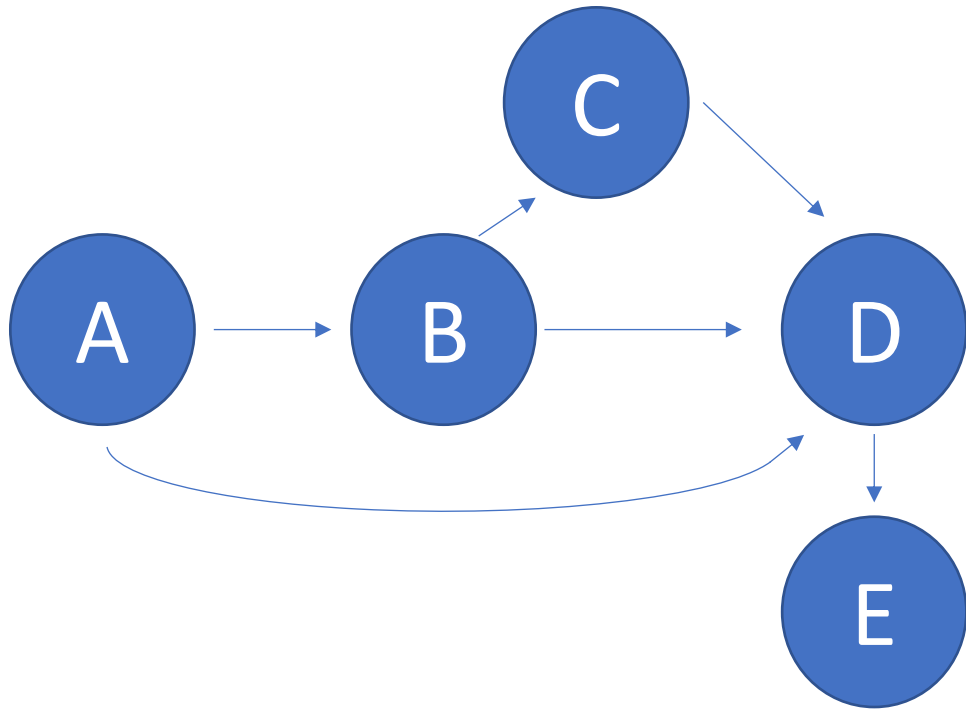
C =

D = 0.0272

E =

“Old” Values

| A | B | C | D | E |
|-------|-------|-------|-------|-------|
| 0.064 | 0.149 | 0.149 | 0.404 | 0.234 |



A → B, D
 B → C, D
 C → D
 D → E
 E → \

B

“Old” Values

| A | B | C | D | E |
|-------|-------|-------|-------|-------|
| 0.064 | 0.149 | 0.149 | 0.404 | 0.234 |

“New” Values

A =

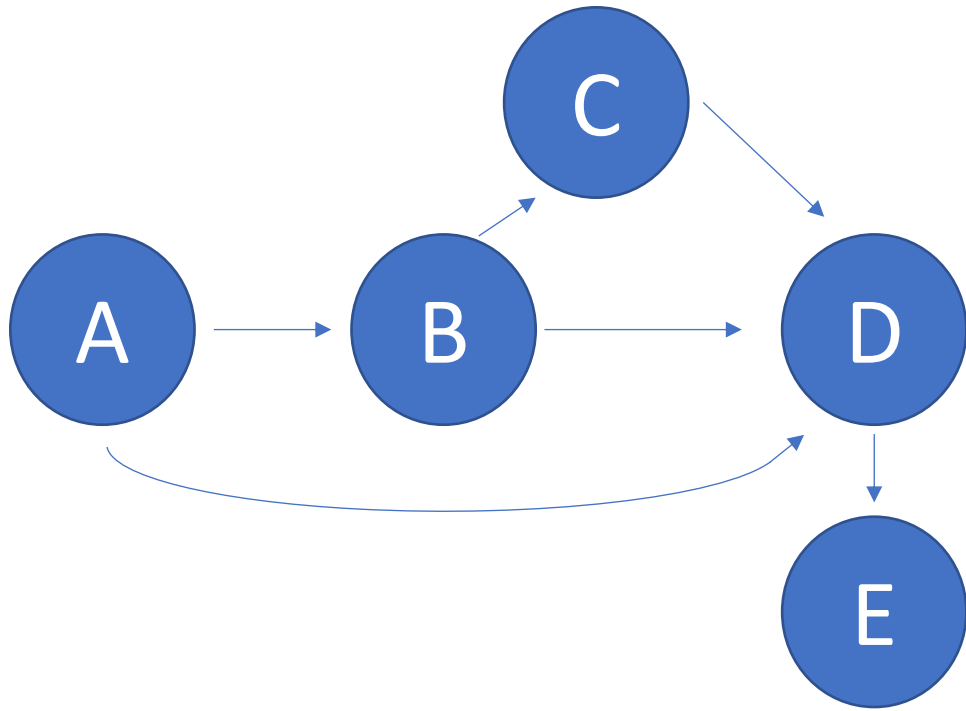
B = 0.0272

C = $\frac{(.149 * .85)}{2}$

D = 0.0272

+ $\frac{(.149 * .85)}{2}$

E =



$A \rightarrow B, D$
 $B \rightarrow C, D$
 $C \rightarrow D$
 $D \rightarrow E$
 $E \rightarrow \backslash$

B

“New” Values

A =

B = 0.0272

C = **0.063325**

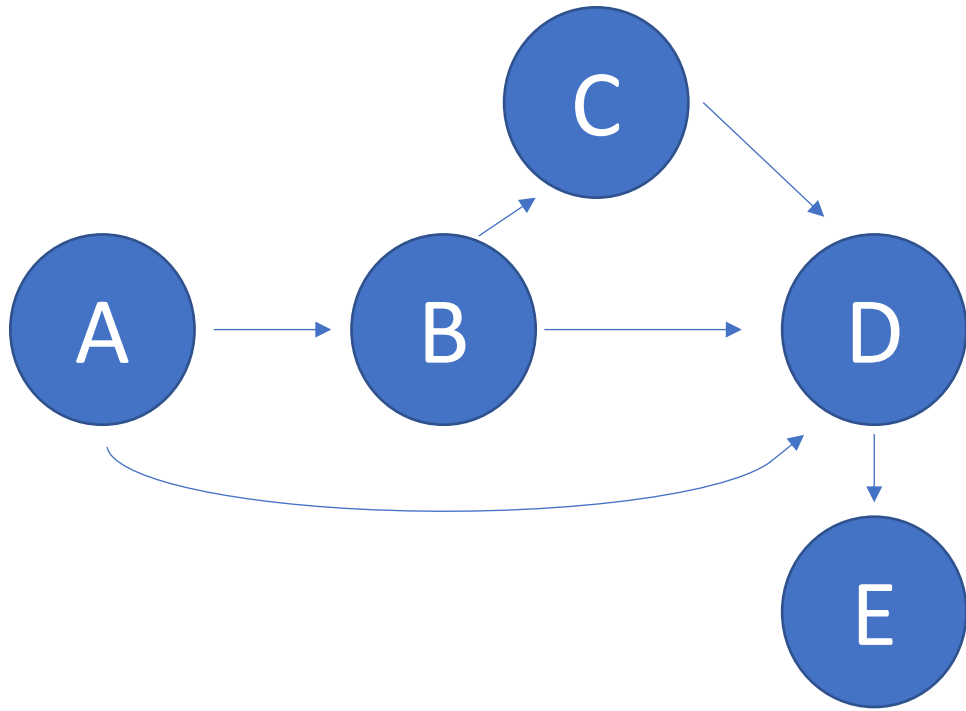
D = 0.0272

+ **0.063325**

E =

“Old” Values

| A | B | C | D | E |
|-------|-------|-------|-------|-------|
| 0.064 | 0.149 | 0.149 | 0.404 | 0.234 |



$A \rightarrow B, D$
 $B \rightarrow C, D$
 $C \rightarrow D$
 $D \rightarrow E$
 $E \rightarrow \backslash$

C

“New” Values

A =

B = 0.0272

C = 0.063325

D = 0.0272

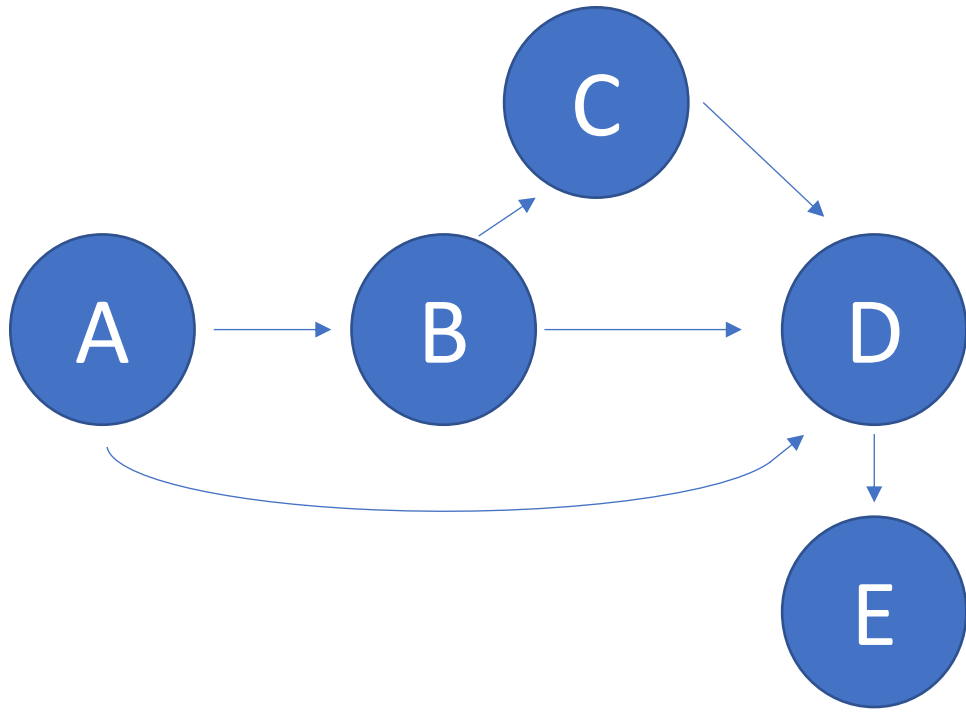
+ 0.063325 +

(.149 * .85)

E =

“Old” Values

| A | B | C | D | E |
|-------|-------|-------|-------|-------|
| 0.064 | 0.149 | 0.149 | 0.404 | 0.234 |



$A \rightarrow B, D$
 $B \rightarrow C, D$
 $C \rightarrow D$
 $D \rightarrow E$
 $E \rightarrow \backslash$

C

“New” Values

A =

B = 0.0272

C = 0.063325

D = 0.0272

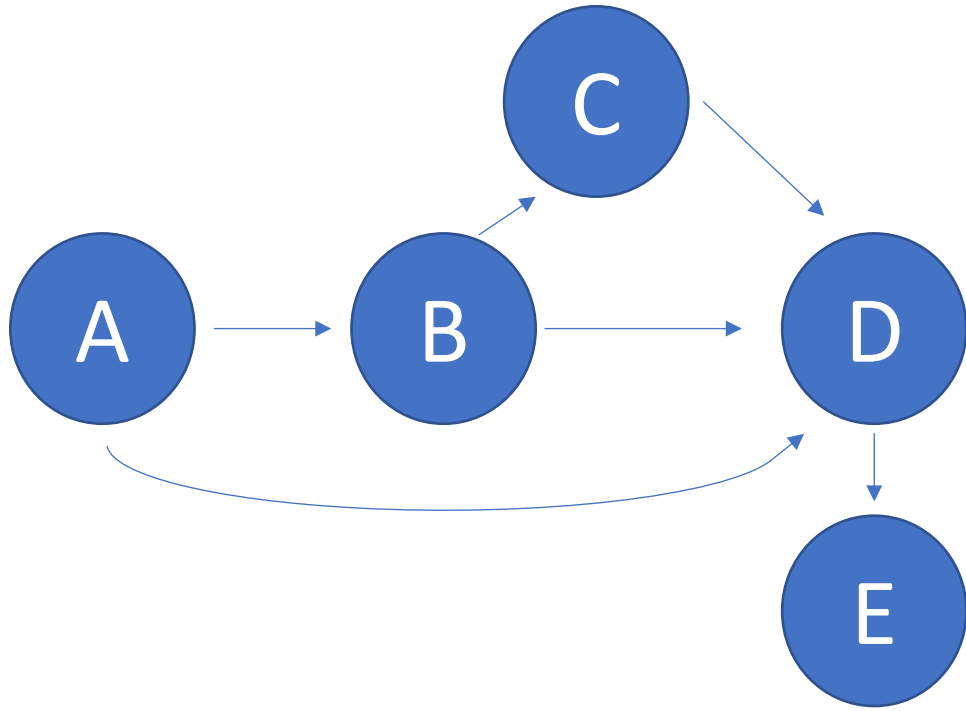
+ 0.063325 +

0.12665

E =

“Old” Values

| A | B | C | D | E |
|-------|-------|-------|-------|-------|
| 0.064 | 0.149 | 0.149 | 0.404 | 0.234 |



$A \rightarrow B, D$
 $B \rightarrow C, D$
 $C \rightarrow D$
 $D \rightarrow E$
 $E \rightarrow \backslash$

D

“Old” Values

| A | B | C | D | E |
|-------|-------|-------|-------|-------|
| 0.064 | 0.149 | 0.149 | 0.404 | 0.234 |

“New” Values

A =

B = 0.0272

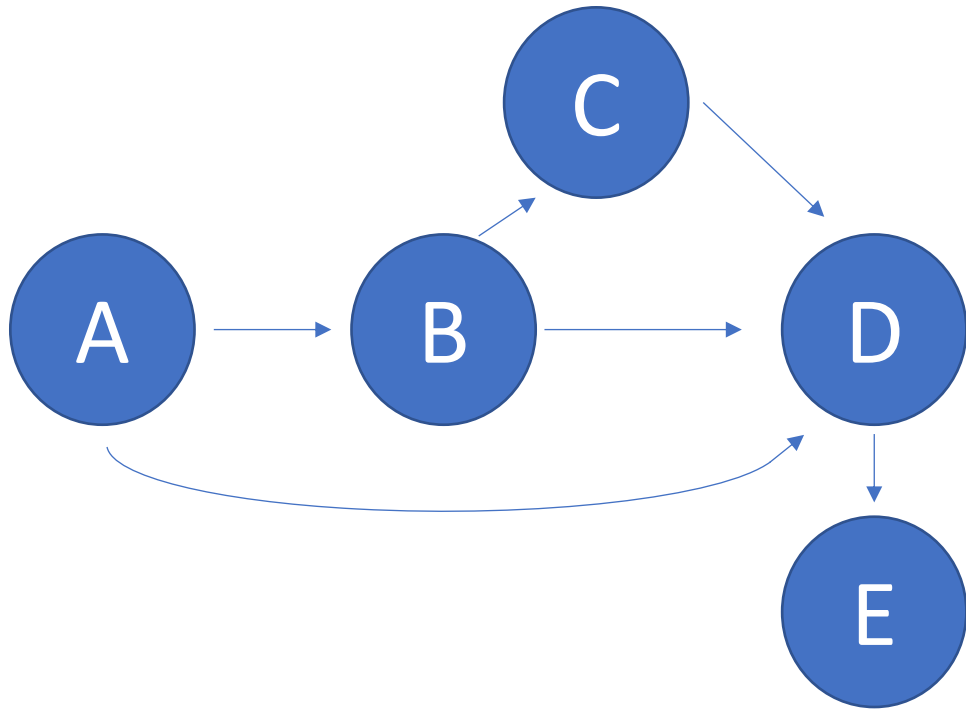
C = 0.063325

D = 0.0272

+ 0.063325 +

0.12665

E = (.404 * .85)



$A \rightarrow B, D$
 $B \rightarrow C, D$
 $C \rightarrow D$
 $D \rightarrow E$
 $E \rightarrow \backslash$

D

“Old” Values

| A | B | C | D | E |
|-------|-------|-------|-------|-------|
| 0.064 | 0.149 | 0.149 | 0.404 | 0.234 |

“New” Values

A =

B = 0.0272

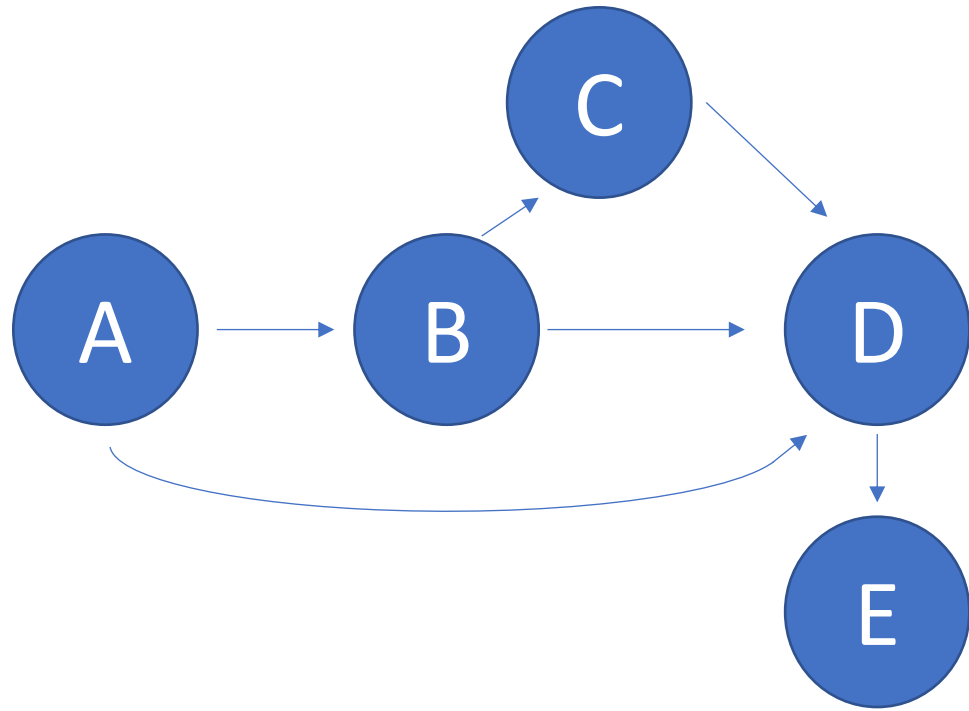
C = 0.063325

D = 0.0272

+ 0.063325 +

0.12665

E = 0.3434



A → B, D
 B → C, D
 C → D
 D → E
 E → \

“New” Values

$$A = \frac{(.85 * .234)}{5}$$

$$B = 0.0272 + \frac{(.85 * .234)}{5}$$

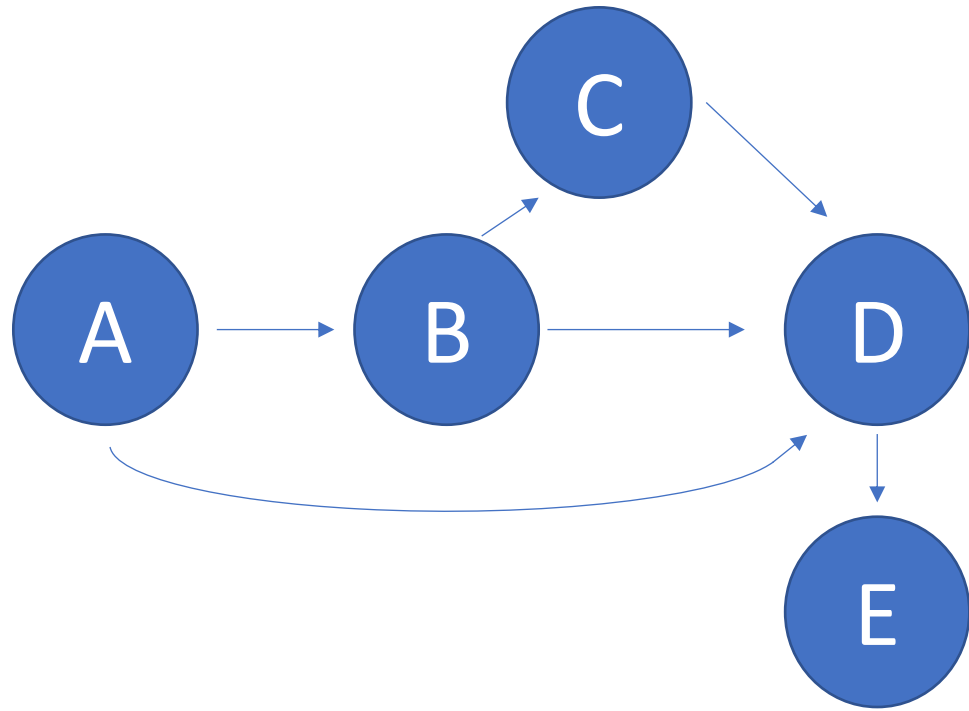
$$C = 0.063325 + \frac{(.85 * .234)}{5}$$

$$D = 0.0272 + 0.063325 + 0.12665 + \frac{(.85 * .234)}{5}$$

$$E = 0.3434 + \frac{(.85 * .234)}{5}$$

“Old” Values

| A | B | C | D | E |
|-------|-------|-------|-------|-------|
| 0.064 | 0.149 | 0.149 | 0.404 | 0.234 |



$A \rightarrow B, D$
 $B \rightarrow C, D$
 $C \rightarrow D$
 $D \rightarrow E$
 $E \rightarrow \setminus$

“New” Values

$$A = .03978$$

$$B = 0.0272 + .03978$$

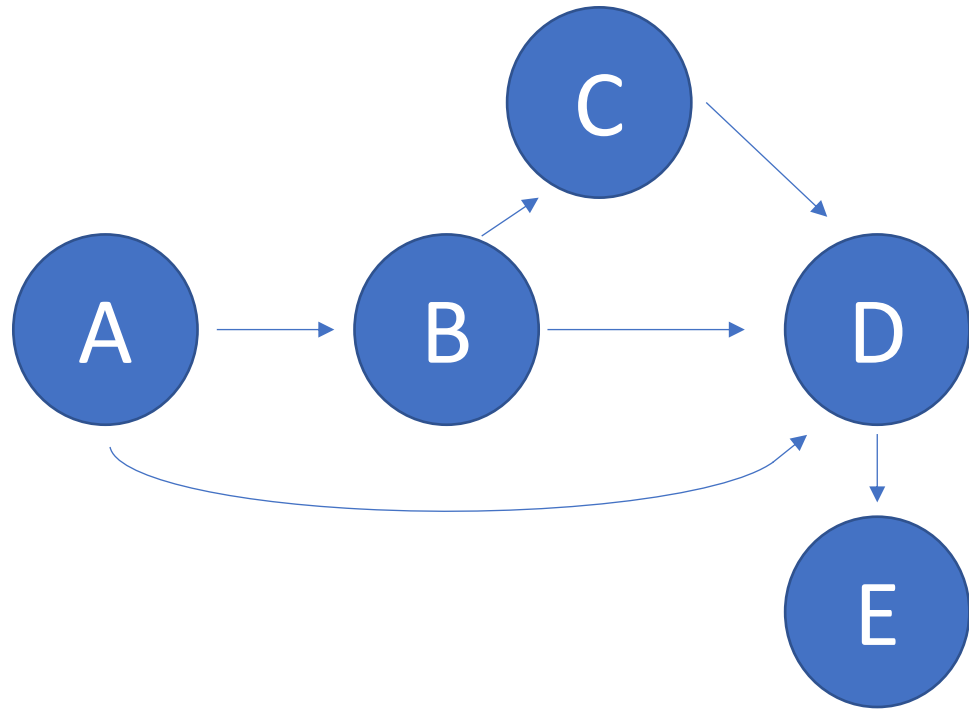
$$C = 0.063325 + .03978$$

$$D = 0.0272 + 0.063325 + 0.12665 + .03978$$

$$E = 0.3434 + .03978$$

“Old” Values

| A | B | C | D | E |
|-------|-------|-------|-------|-------|
| 0.064 | 0.149 | 0.149 | 0.404 | 0.234 |



$A \rightarrow B, D$
 $B \rightarrow C, D$
 $C \rightarrow D$
 $D \rightarrow E$
 $E \rightarrow \backslash$

“New” Values

$$A = .03978$$

$$B = 0.06698$$

$$C = 0.103105$$

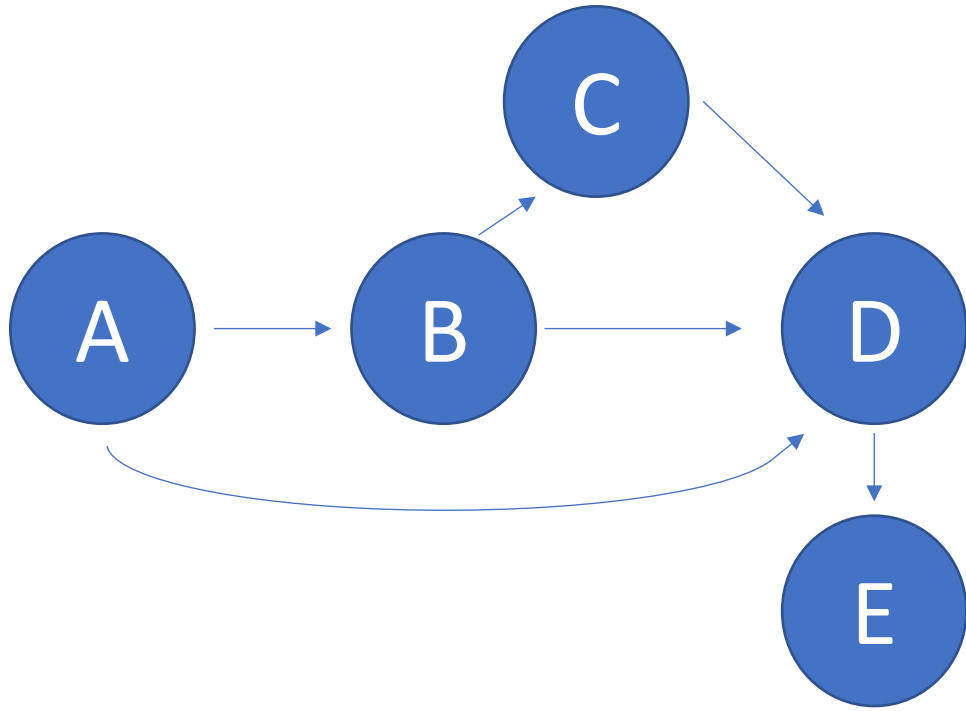
$$D = 0.256955$$

$$E = 0.38318$$

E

“Old” Values

| A | B | C | D | E |
|-------|-------|-------|-------|-------|
| 0.064 | 0.149 | 0.149 | 0.404 | 0.234 |



- A → B, D
- B → C, D
- C → D
- D → E
- E → \

Decay

“New” Values

$$A = .03978 + .03$$

$$B = 0.06698 + .03$$

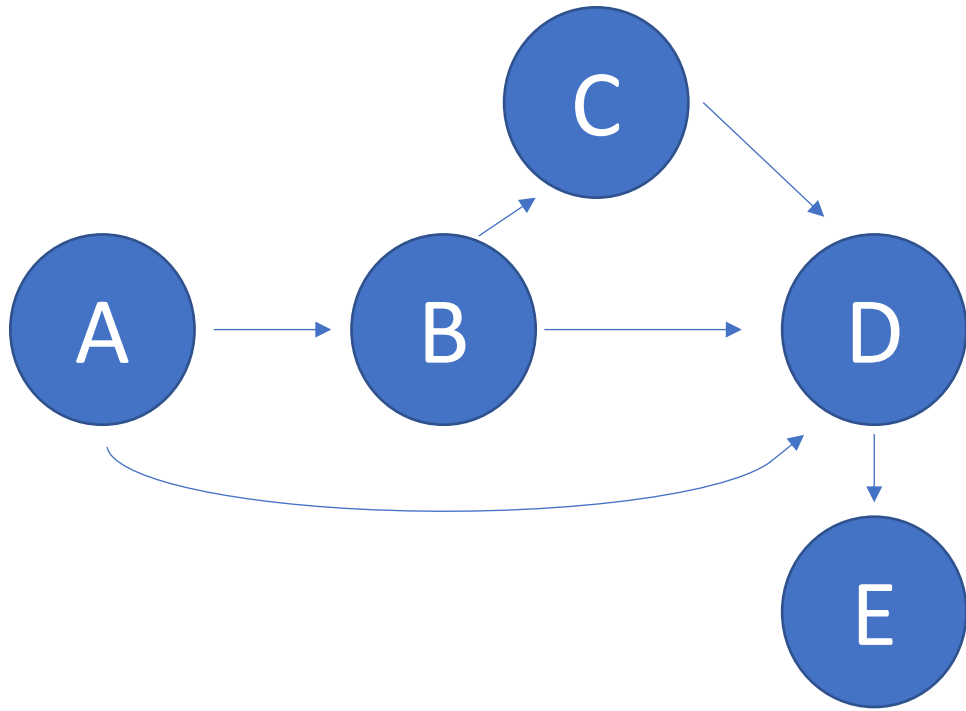
$$C = 0.103105 + .03$$

$$D = 0.256955 + .03$$

$$E = 0.38318 + .03$$

“Old” Values

| A | B | C | D | E |
|-------|-------|-------|-------|-------|
| 0.064 | 0.149 | 0.149 | 0.404 | 0.234 |



$A \rightarrow B, D$
 $B \rightarrow C, D$
 $C \rightarrow D$
 $D \rightarrow E$
 $E \rightarrow \backslash$

“New” Values

$A = .06978$

$B = 0.09698$

$C = 0.133105$

$D = 0.286955$

$E = 0.41318$

“Old” Values

| A | B | C | D | E |
|-------|-------|-------|-------|-------|
| 0.064 | 0.149 | 0.149 | 0.404 | 0.234 |

Convergence check!

“Old” Values

| A | B | C | D | E |
|-------|-------|-------|-------|-------|
| 0.064 | 0.149 | 0.149 | 0.404 | 0.234 |

“New” Values

| A | B | C | D | E |
|--------|---------|----------|----------|---------|
| .06978 | 0.09698 | 0.133105 | 0.286955 | 0.41318 |

For every step, check if the old value minus the new value is $< \epsilon$. If EVERY new value is less than an “epsilon” difference, then we’ll accept the old values as our final answers.

Because we still don’t have convergence on any of our values (and even if we did, we would need to have convergence on ALL of our values), we keep going.