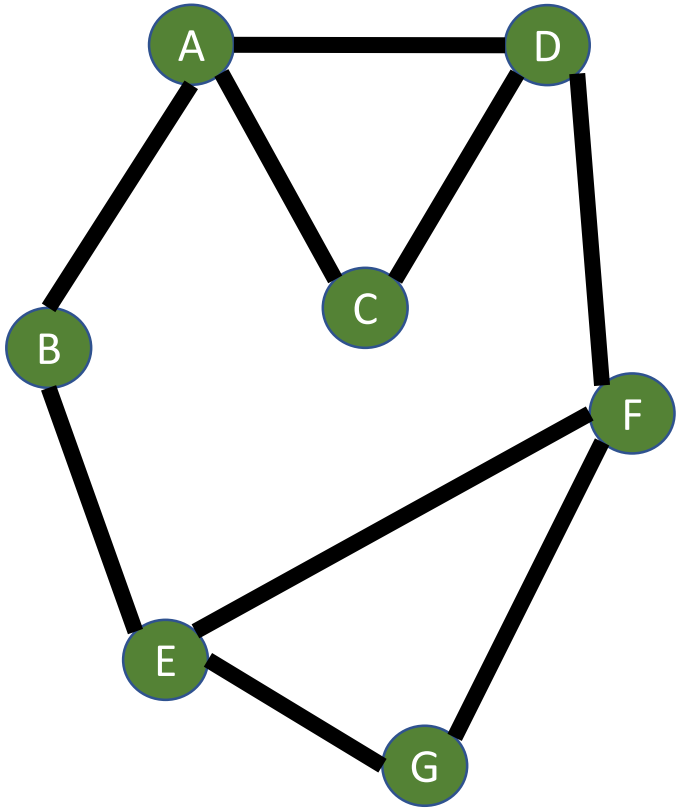
S = A



Q

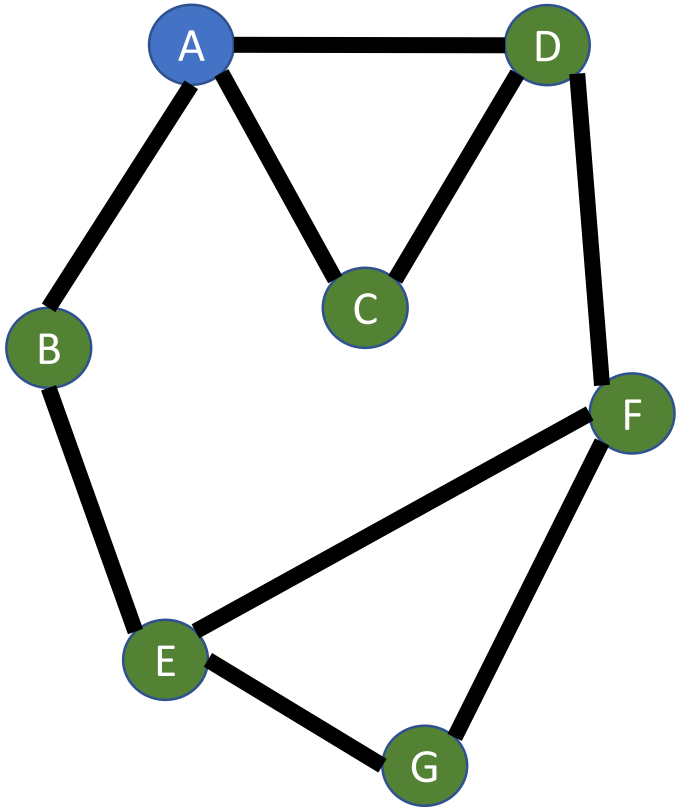
```
Breadth-First-Search( Graph G=(V,E),  s in V )
        //Step 0: Mark s, put s into a queue
        mark s
        Q.enqueue(s)

        //Step 1: Enter BFS loop
        while( Q not empty )
                //Step 1.1: get item from Q
                x = Q.dequeue()

                //Step 1.2: visit all of x's
                //unvisited neighbors
                for each unmarked y in x.neighbors()
                        mark y
                        Q.enqueue(y)

                        //Augment:
                        y.bread = x
```

S = A



Q

A

```
Breadth-First-Search( Graph G=(V,E),  s in V )
        //Step 0: Mark s, put s into a queue
        mark s
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        //Step 1: Enter BFS loop
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                for each unmarked y in x.neighbors()
                        mark y
                        Q.enqueue(y)

                        //Augment:
                        y.bread = x
```
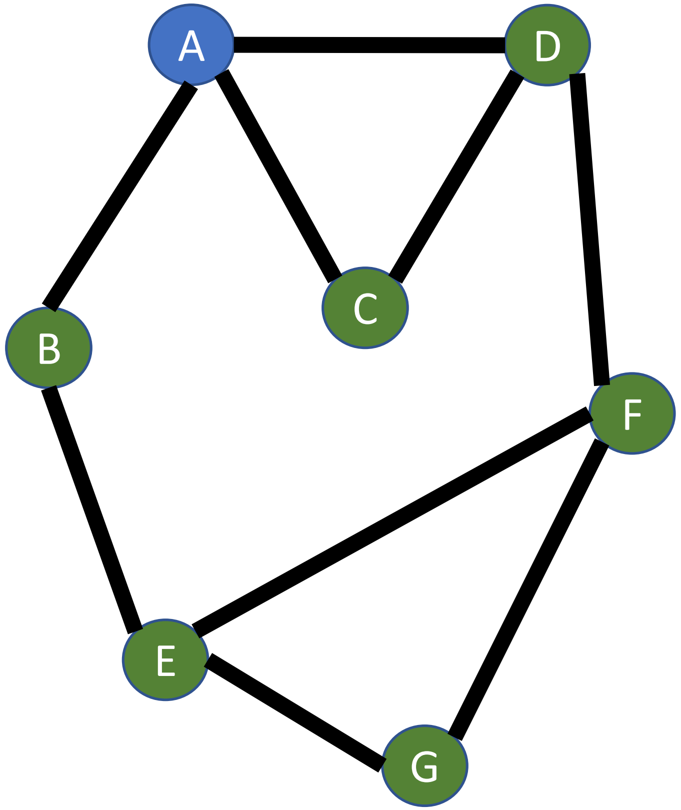

S = A

x = A

Q



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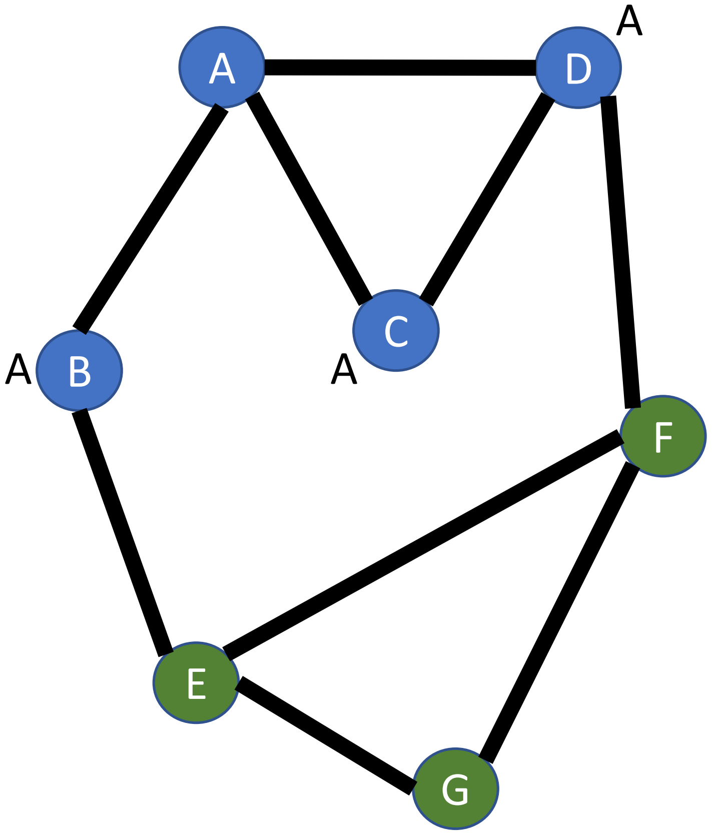
        for each unmarked y in x.neighbors()
            mark y
            Q.enqueue(y)

            //Augment:
            y.bread = x
```

S = A

x = A



Q

B

C

D

```
Breadth-First-Search( Graph G=(V,E),  s in V )
        //Step 0: Mark s, put s into a queue
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        //Step 1: Enter BFS loop
        while( Q not empty )
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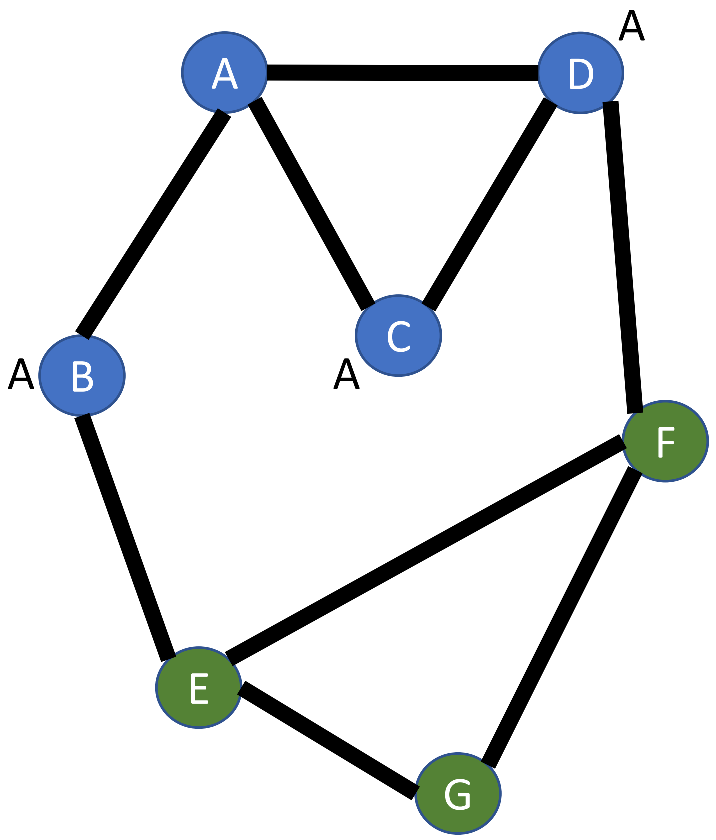
                //unvisited neighbors
                for each unmarked y in x.neighbors()
                        mark y
                        Q.enqueue(y)

                        //Augment:
                        y.bread = x
```

S = A

x = ?



Q

B

C

D

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Breadth-First-Search( Graph G=(V,E),  s in V )
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                        mark y
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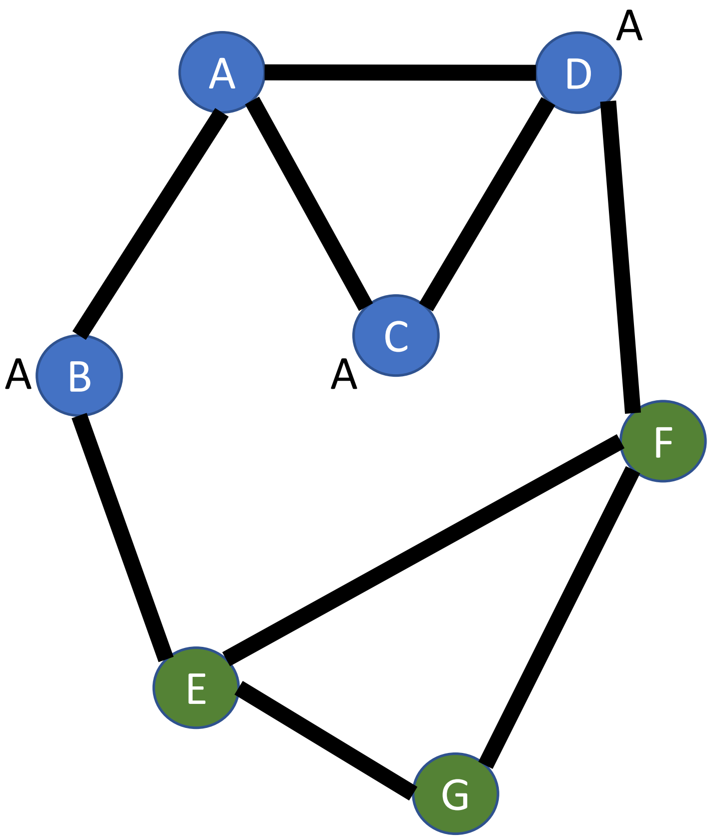
S = A

x = B

Q

C

D



```
Breadth-First-Search( Graph G=(V,E),  s in V )
          //Step 0: Mark s, put s into a queue
          mark s
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          //Step 1: Enter BFS loop
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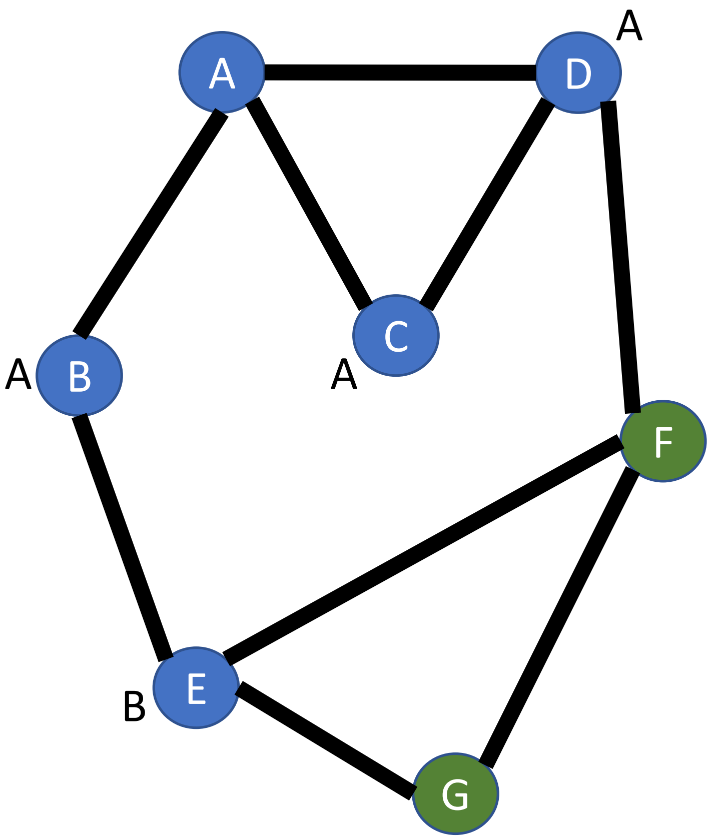
                    for each unmarked y in x.neighbors()
                              mark y
                              Q.enqueue(y)

                              //Augment:
                              y.bread = x
```

S = A

x = B



Q

C

D

E

```
Breadth-First-Search( Graph G=(V,E),  s in V )
        //Step 0: Mark s, put s into a queue
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                        mark y
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                        //Augment:
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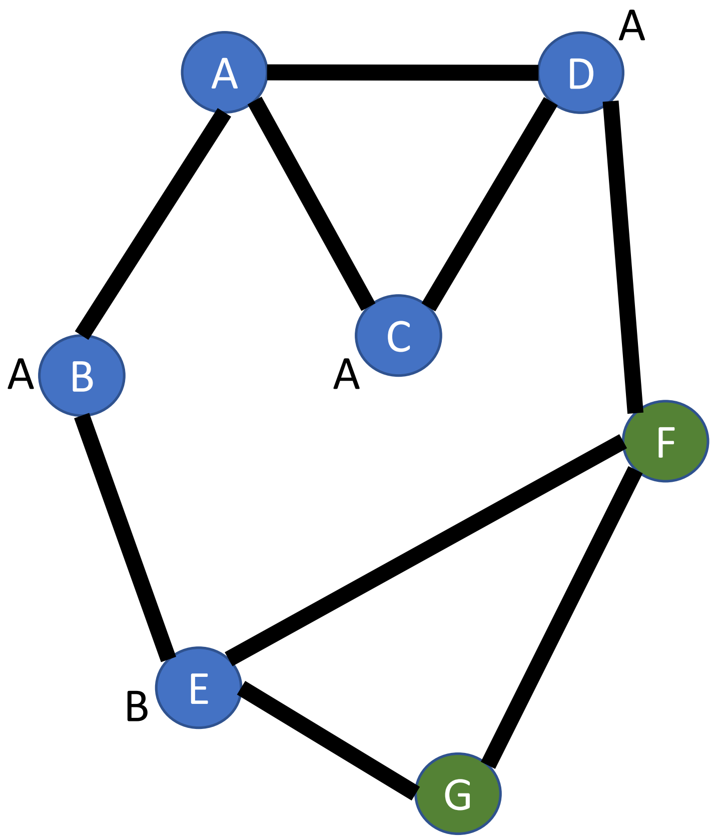
S = A

x = ?



Q

C

D

E

```
Breadth-First-Search( Graph G=(V,E),  s in V )
        //Step 0: Mark s, put s into a queue
        mark s
        Q.enqueue(s)

        //Step 1: Enter BFS loop
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                //unvisited neighbors
                for each unmarked y in x.neighbors()
                        mark y
                        Q.enqueue(y)

                        //Augment:
                        y.bread = x
```

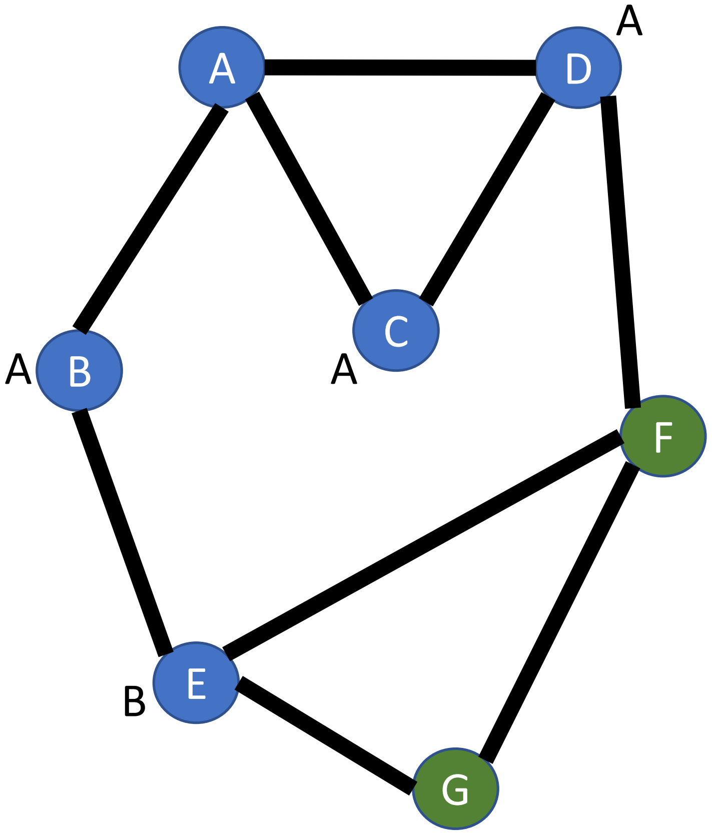
S = A

x = C

Q

D

E



```
Breadth-First-Search( Graph G=(V,E),  s in V )
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                        mark y
                        Q.enqueue(y)

                        //Augment:
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```
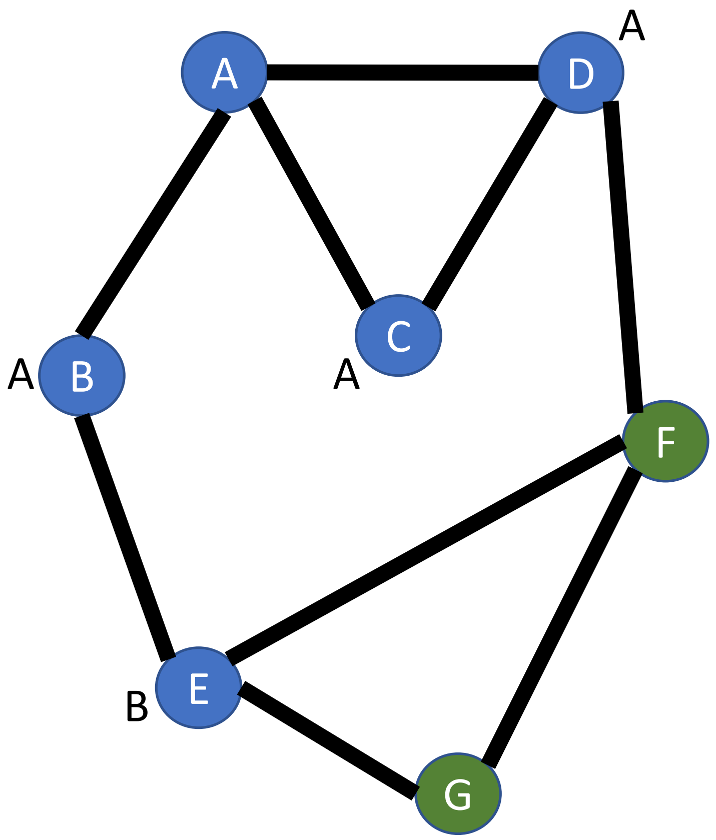

S = A

x = ?



Q

D

E

```
Breadth-First-Search( Graph G=(V,E),  s in V )
        //Step 0: Mark s, put s into a queue
        mark s
        Q.enqueue(s)

        //Step 1: Enter BFS loop
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                        mark y
                        Q.enqueue(y)

                        //Augment:
                        y.bread = x
```
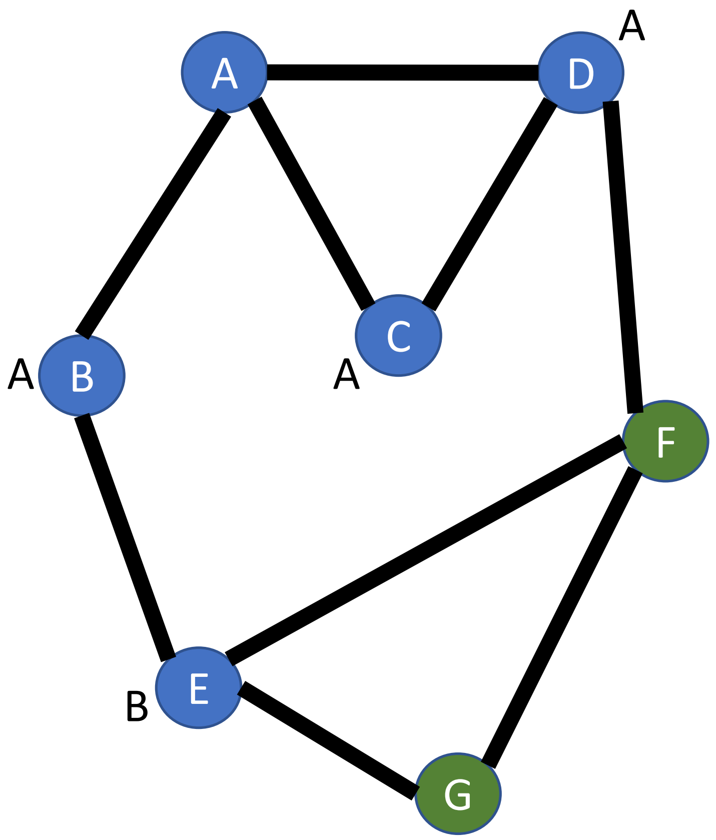

S = A

x = D

Q

E



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        //Step 0: Mark s, put s into a queue
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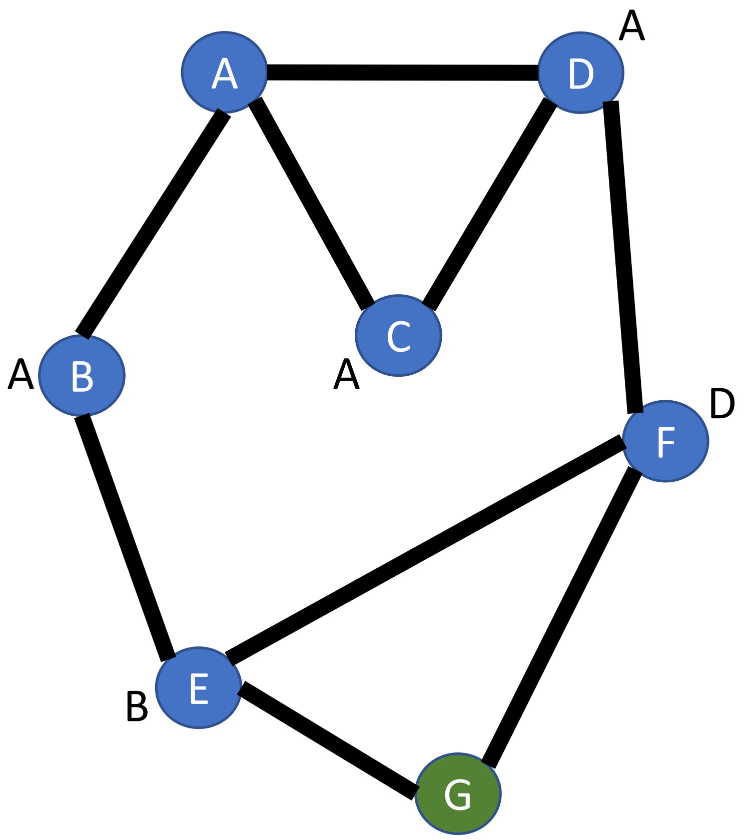
                //unvisited neighbors
                for each unmarked y in x.neighbors()
                        mark y
                        Q.enqueue(y)

                        //Augment:
                        y.bread = x
```

S = A

x = D



Q

E

F

```
Breadth-First-Search( Graph G=(V,E),  s in V )
        //Step 0: Mark s, put s into a queue
        mark s
        Q.enqueue(s)

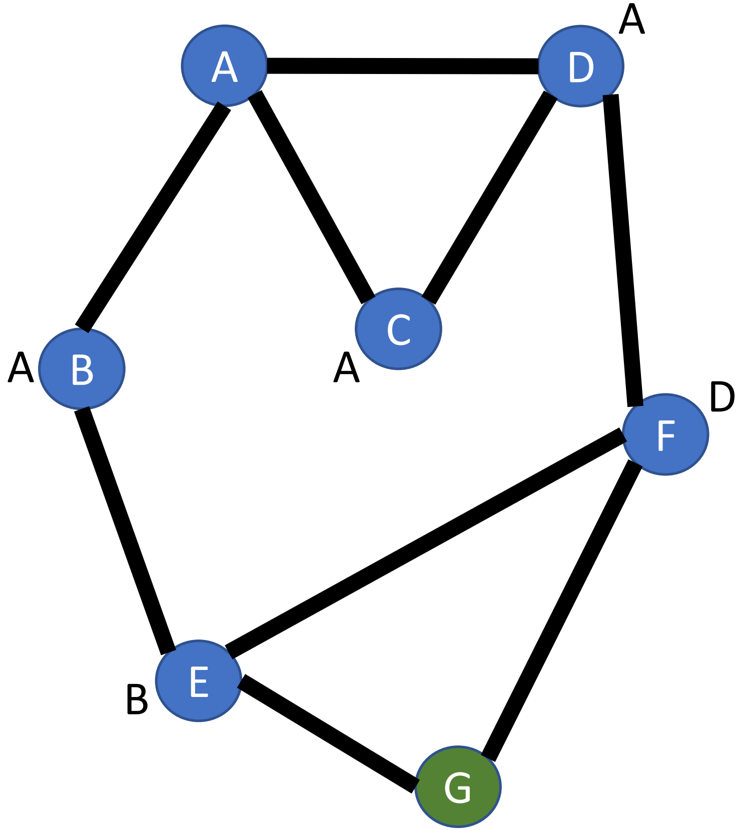
        //Step 1: Enter BFS loop
        while( Q not empty )
                //Step 1.1: get item from Q
                x = Q.dequeue()

                //Step 1.2: visit all of x's
                //unvisited neighbors
                for each unmarked y in x.neighbors()
                        mark y
                        Q.enqueue(y)

                        //Augment:
                        y.bread = x
```

S = A

x = ?



Q

E

F

```
Breadth-First-Search( Graph G=(V,E),  s in V )
        //Step 0: Mark s, put s into a queue
        mark s
        Q.enqueue(s)

        //Step 1: Enter BFS loop
        while( Q not empty )
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                x = Q.dequeue()

                //Step 1.2: visit all of x's
                //unvisited neighbors
                for each unmarked y in x.neighbors()
                        mark y
                        Q.enqueue(y)

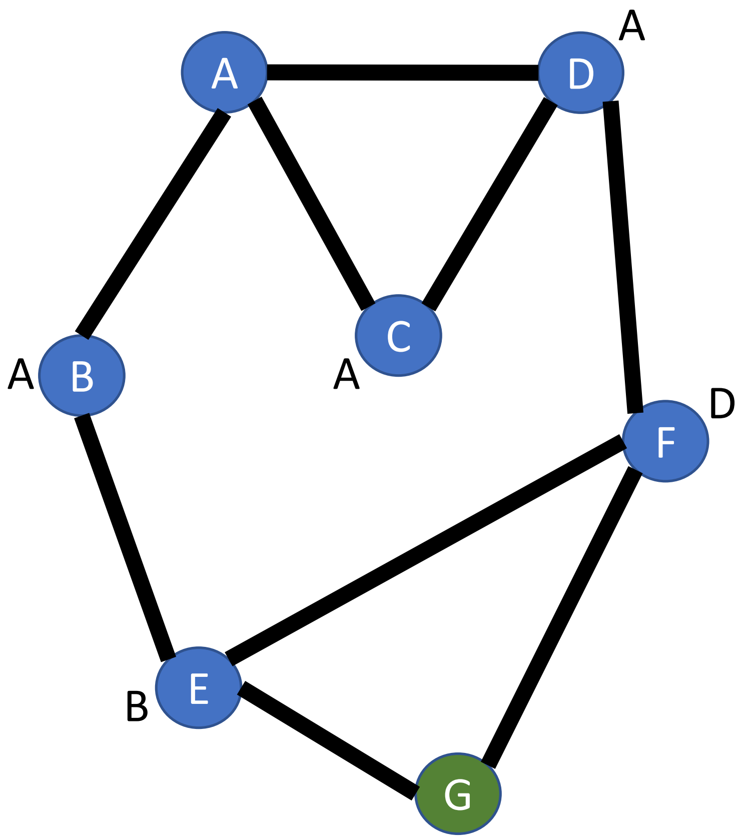
                        //Augment:
                        y.bread = x
```

S = A

x = E

Q

F



```
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        //Step 0: Mark s, put s into a queue
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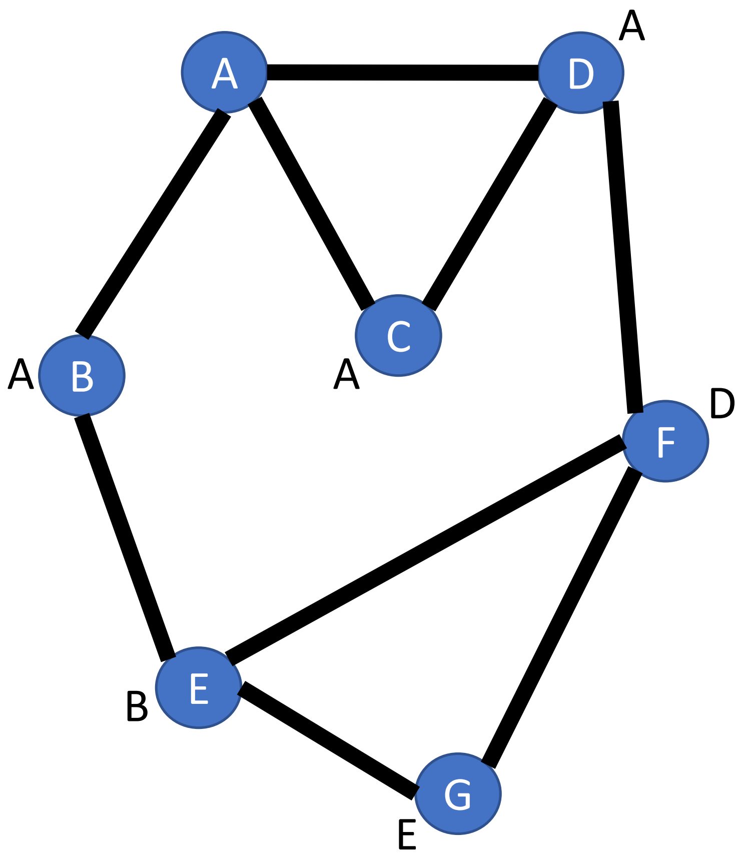
                //unvisited neighbors
                for each unmarked y in x.neighbors()
                        mark y
                        Q.enqueue(y)

                        //Augment:
                        y.bread = x
```

S = A

x = E



Q

F

G

```
Breadth-First-Search( Graph G=(V,E),  s in V )
        //Step 0: Mark s, put s into a queue
        mark s
        Q.enqueue(s)

        //Step 1: Enter BFS loop
        while( Q not empty )
                //Step 1.1: get item from Q
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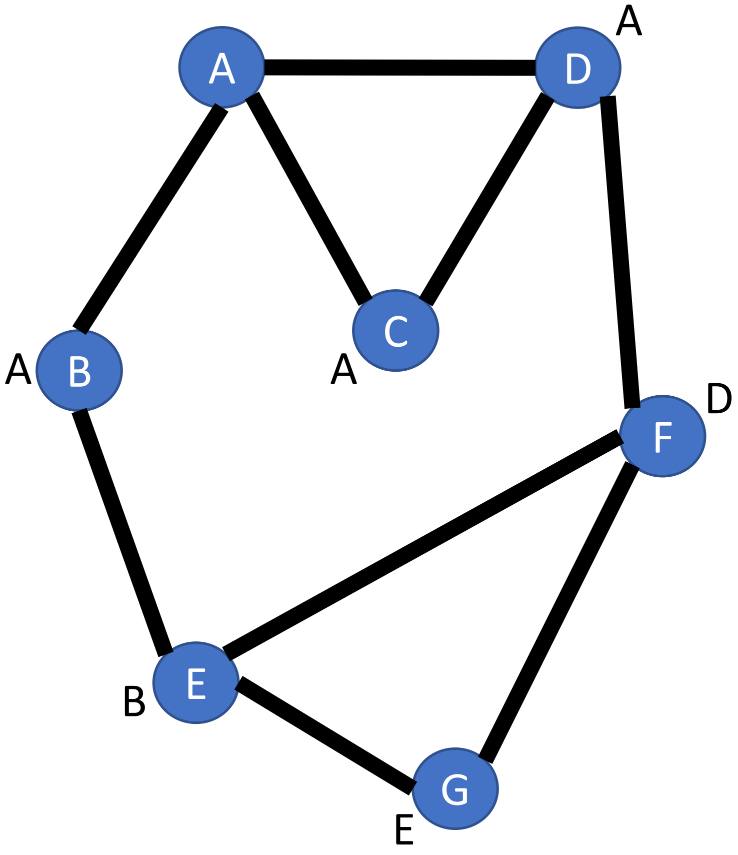
                //Step 1.2: visit all of x's
                //unvisited neighbors
                for each unmarked y in x.neighbors()
                        mark y
                        Q.enqueue(y)

                        //Augment:
                        y.bread = x
```

S = A

x = ?



Q

F

G

```
Breadth-First-Search( Graph G=(V,E),  s in V )
        //Step 0: Mark s, put s into a queue
        mark s
        Q.enqueue(s)

        //Step 1: Enter BFS loop
        while( Q not empty )
            //Step 1.1: get item from Q
            x = Q.dequeue()

            //Step 1.2: visit all of x's
            //unvisited neighbors
            for each unmarked y in x.neighbors()
                mark y
                Q.enqueue(y)

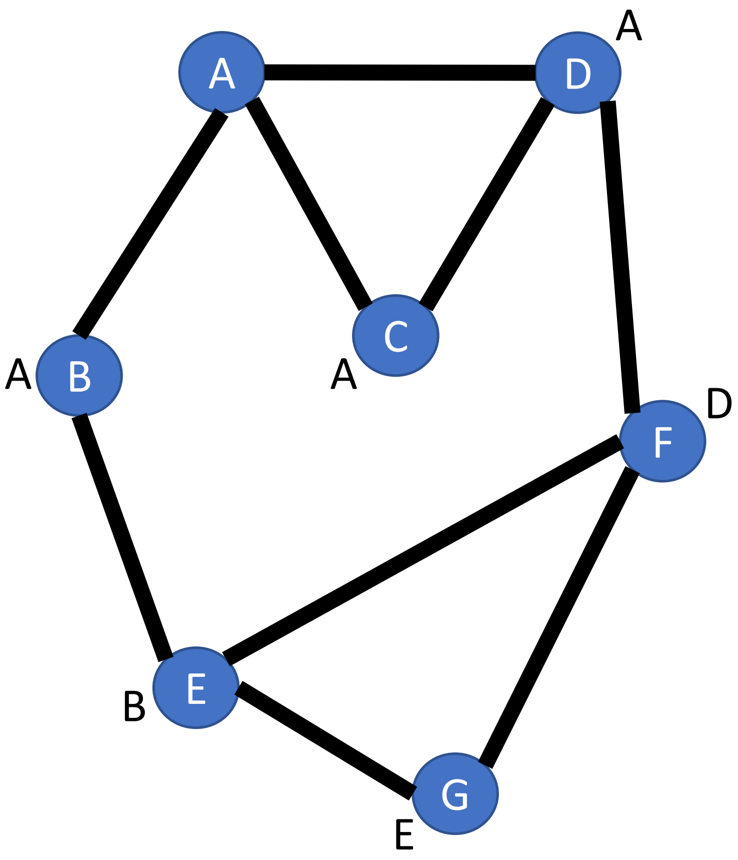
                //Augment:
                y.bread = x
```

S = A

x = F

Q

G



```
Breadth-First-Search( Graph G=(V,E),  s in V )
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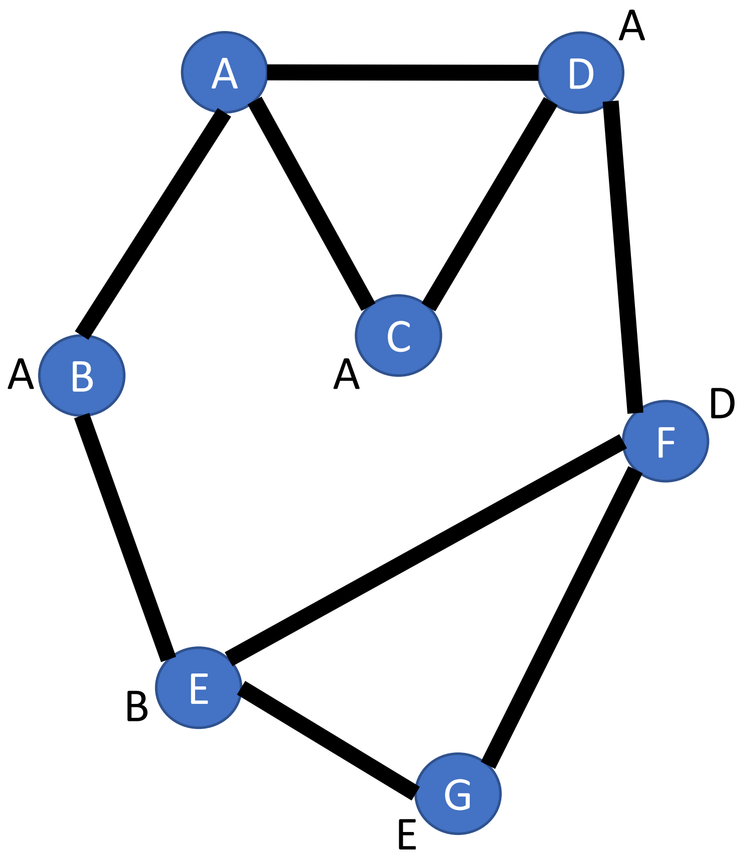
                //unvisited neighbors
                for each unmarked y in x.neighbors()
                        mark y
                        Q.enqueue(y)

                        //Augment:
                        y.bread = x
```

S = A

x = G

Q



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Breadth-First-Search( Graph G=(V,E),  s in V )
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                //unvisited neighbors
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                        mark y
                        Q.enqueue(y)

                        //Augment:
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```
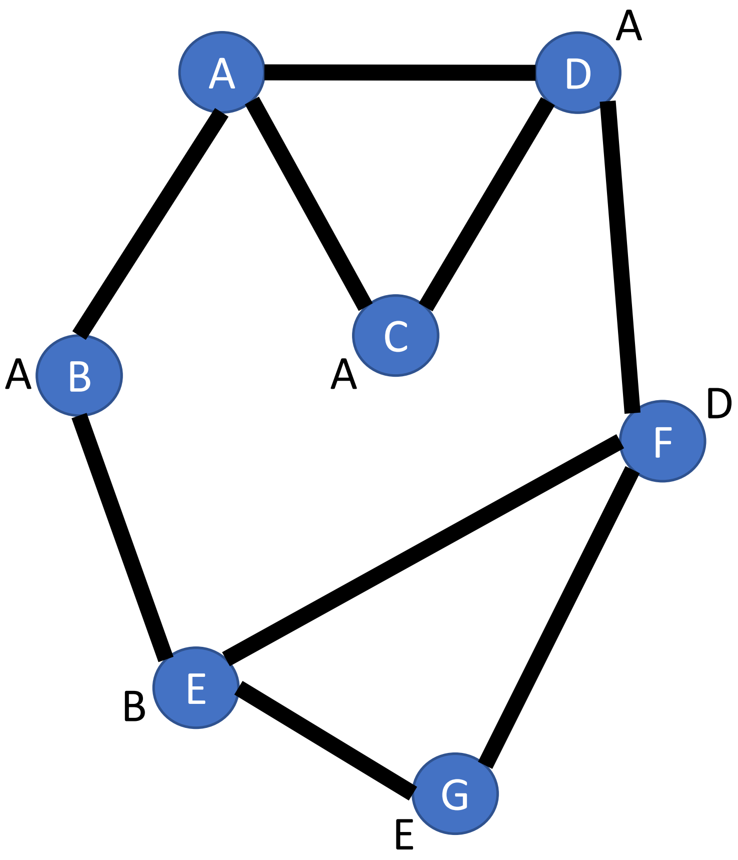

S = A

DONE

Q



```
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                for each unmarked y in x.neighbors()
                        mark y
                        Q.enqueue(y)

                        //Augment:
                        y.bread = x
```
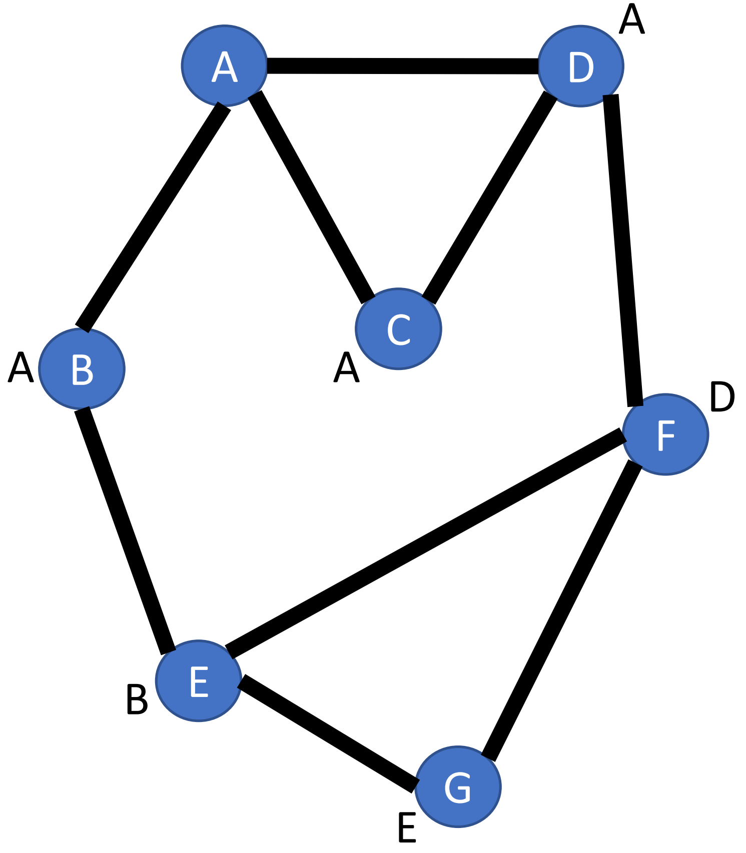

Run time? (In terms of |V| and |E|)

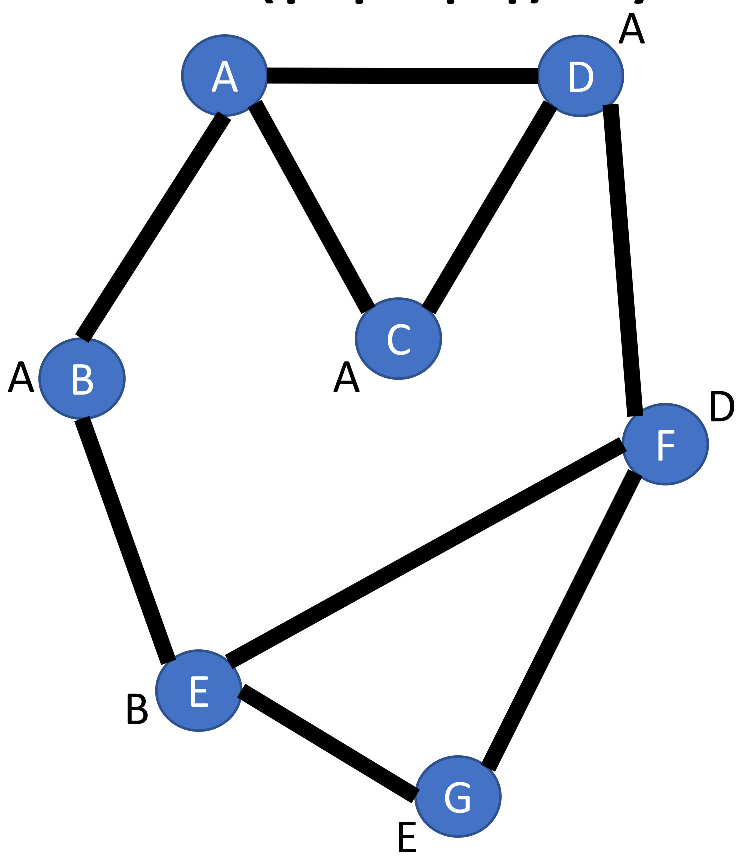


```
Breadth-First-Search( Graph G=(V,E),  s in V )
        //Step 0: Mark s, put s into a queue
        mark s
        Q.enqueue(s)

        //Step 1: Enter BFS loop
        while( Q not empty )
                //Step 1.1: get item from Q
  O(1)          x = Q.dequeue()

                //Step 1.2: visit all of x's
                //unvisited neighbors
                for each unmarked y in x.neighbors()
                        mark y
                        Q.enqueue(y)
            O(1)
                        //Augment:
                        y.bread = x
```

Run time?

O(|E|)

Or O(|V| + |E|) if you want to visit all vertices.



Breadth-First-Search(Graph G=(V,E), s in V)

```
    //Step 0: Mark s, put s into a queue
    mark s
    Q.enqueue(s)

    //Step 1: Enter BFS loop
    while( Q not empty )
        //Step 1.1: get item from Q
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        for each unmarked y in x.neighbors()
            mark y
            Q.enqueue(y)
O(1)
            //Augment:
            y.bread = x
```