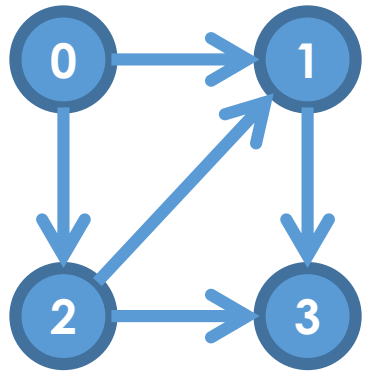


Finding Two-Hop Neighbors



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by Christine Alvarado, Mia Minnes, and Leo Porter, 2015.

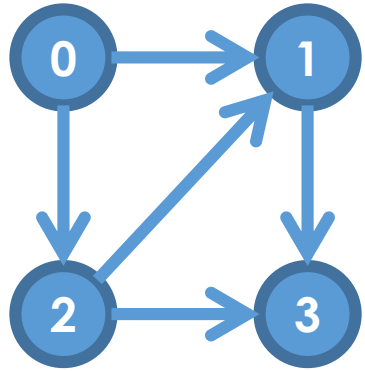


$V = \{0, 1, 2, 3\}$

0	1	1	0
0	0	0	1
0	1	0	1
0	0	0	0

Assignment: Find all two-hop neighbors from given vertex (Adjacency Matrix)

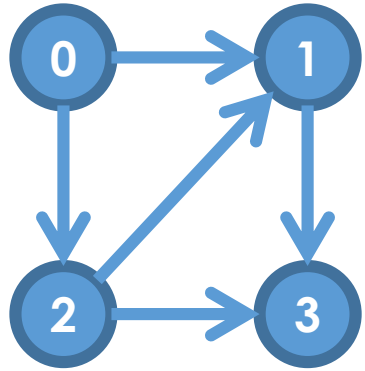
```
public List<Integer> getDistance2(int v) {  
    List<Integer> twoHop = new ArrayList<Integer>();  
    for (int i = 0; i < getNumVertices(); i++) {  
        for (int j=0; j< adjMatrix[v][i]; j++) {  
            // Instead of adding i directly, add the  
            // neighbors of i  
        }  
    }  
    return twoHop;  
}
```



$V = \{0, 1, 2, 3\}$

0	1	1	0
0	0	0	1
0	1	0	1
0	0	0	0

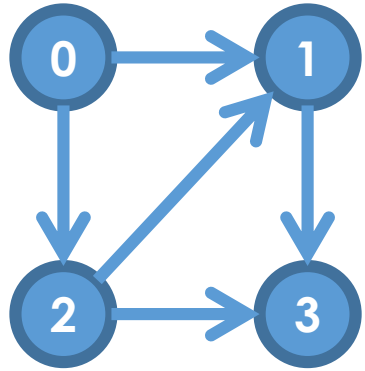
**Matrix multiplication for
finding two-hop neighbors**



$V = \{0, 1, 2, 3\}$

$$\begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

**Matrix multiplication for
finding two-hop neighbors**

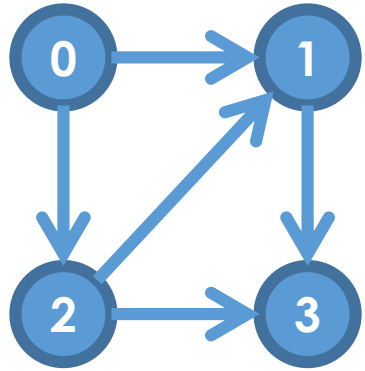


$V = \{0, 1, 2, 3\}$

$$\begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix}^2 =$$

**Matrix multiplication for
finding two-hop neighbors**

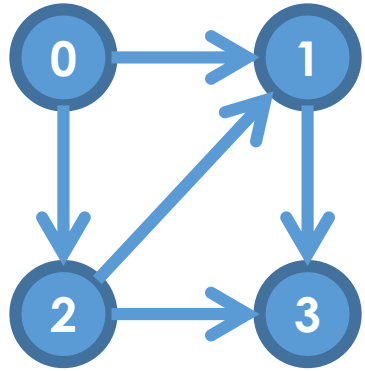
**matrix whose entries are
two-hop neighbors!**



$V = \{0, 1, 2, 3\}$

**Matrix multiplication for
finding two-hop neighbors**

$$\begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} = \begin{pmatrix} & & & \\ & & & \\ & & & \\ & & & \end{pmatrix}$$

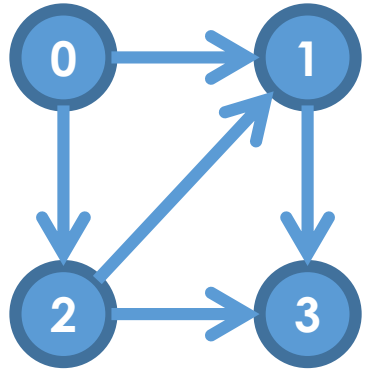


$V = \{0, 1, 2, 3\}$

**Matrix multiplication for
finding two-hop neighbors**

$$\begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} = \begin{pmatrix} \square & & & \\ & & & \\ & & & \\ & & & \end{pmatrix}$$

$$0 * 0 + 1 * 0 + 1 * 0 + 0 * 0 = 0$$

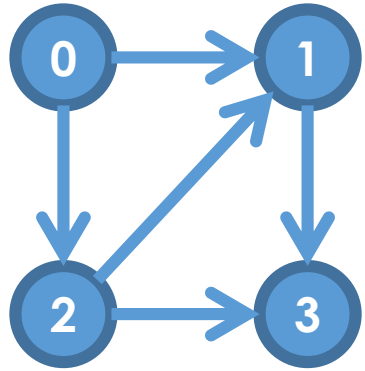


$V = \{0, 1, 2, 3\}$

**Matrix multiplication for
finding two-hop neighbors**

$$\begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} = \begin{pmatrix} 0 & & & \end{pmatrix}$$

$$0 * 0 + 1 * 0 + 1 * 0 + 0 * 0 = 0$$

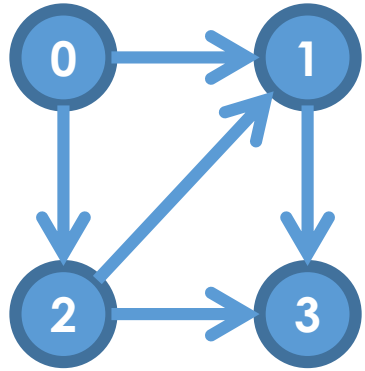


$V = \{0, 1, 2, 3\}$

**Matrix multiplication for
finding two-hop neighbors**

$$\begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} = \begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

$$0 * 1 + 1 * 0 + 1 * 1 + 0 * 0 = 1$$

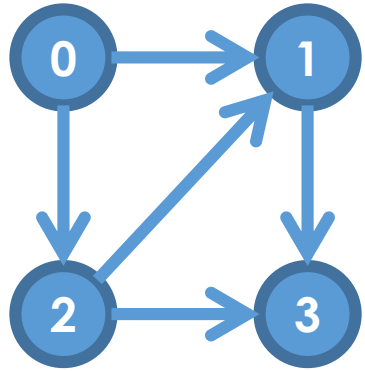


$V = \{0, 1, 2, 3\}$

Matrix multiplication for
finding two-hop neighbors

$$\begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} = \begin{pmatrix} 0 & 1 & 0 & \\ & & & \\ & & & \\ & & & \end{pmatrix}$$

$$0 * 1 + 1 * 0 + 1 * 0 + 0 * 0 = 0$$

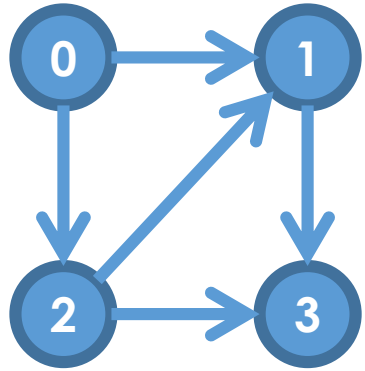


$V = \{0, 1, 2, 3\}$

**Matrix multiplication for
finding two-hop neighbors**

$$\begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} = \begin{pmatrix} 0 & 1 & 0 & 2 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$

$$0 * 0 + 1 * 1 + 1 * 1 + 0 * 0 = 2$$

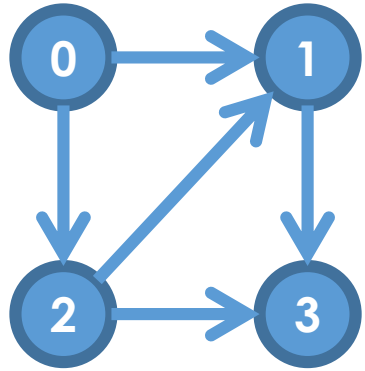


$V = \{0, 1, 2, 3\}$

**Matrix multiplication for
finding two-hop neighbors**

$$\begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} = \begin{pmatrix} 0 & 1 & 0 & 2 \\ 0 & & & \end{pmatrix}$$

$$0 * 0 + 0 * 0 + 0 * 0 + 1 * 0 = 0$$



$V = \{0, 1, 2, 3\}$

**Matrix multiplication for
finding two-hop neighbors**

$$\begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} \begin{pmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix} = \begin{pmatrix} 0 & 1 & 0 & 2 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{pmatrix}$$