DIJKSTRA'S ALGORITHM

Dijkstra's Algorithm

$l(v_0) := 0$; FOR $v \in V \setminus \{v_0\}$ DO: $l(v) := \infty$; END; $U := \{v_0\}$; $u := v_0$;

DO:

  $C :=$ false;

  FOR $v \in V \setminus U$ DO:

    IF $(u, v) \in E$ AND $l(v) > l(u) + w(u, v)$ THEN

      $p(v) := u$;

      $l(v) := l(u) + w(u, v)$;

    END IF;

  END;

  IF $\exists v \in V \setminus U : l(v) < \infty$ THEN

    C:=true;

    choose node $z \in V \setminus U$ with $l(z) = \min_{v \in V \setminus U} l(v)$;

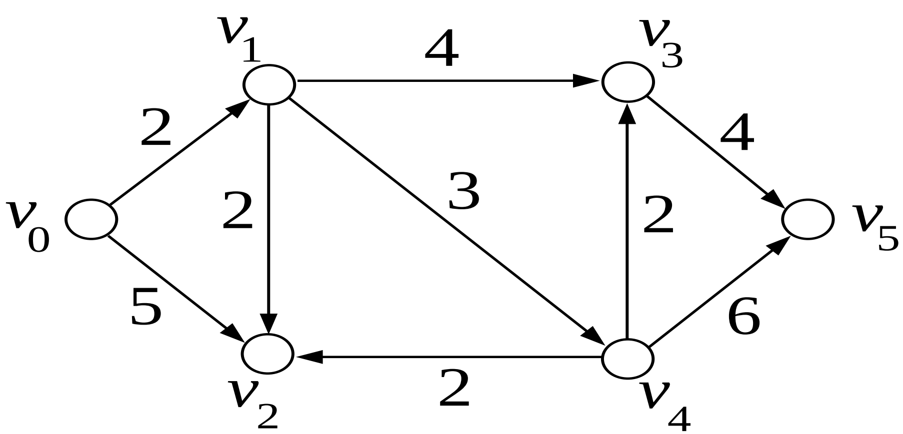
    $U := U \cup \{z\}$;

    $u := z$;

  END IF

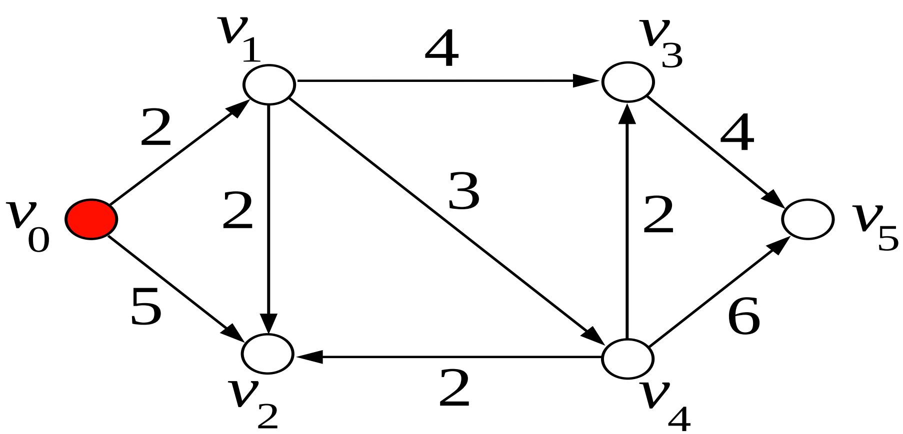
WHILE $U \neq V$ AND $C =$ true;

Dijkstra's Algorithm



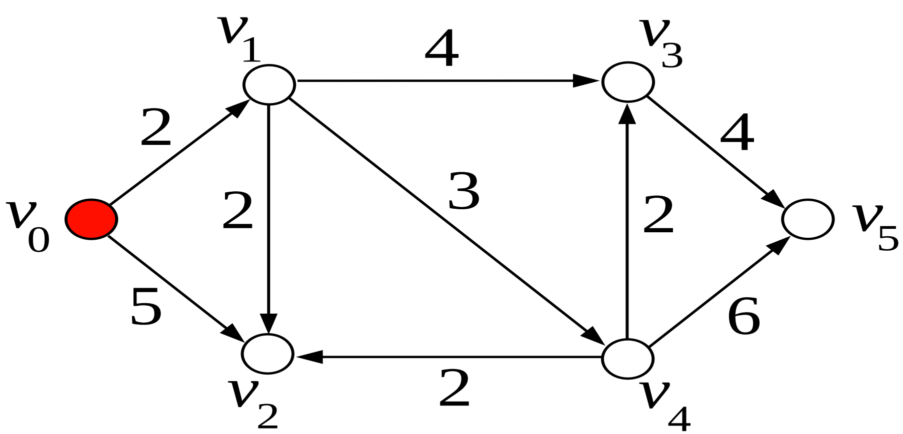
	v_0	v_1	v_2	v_3	v_4	v_5	chosen node
0	0	∞	∞	∞	∞	∞	

Dijkstra's Algorithm



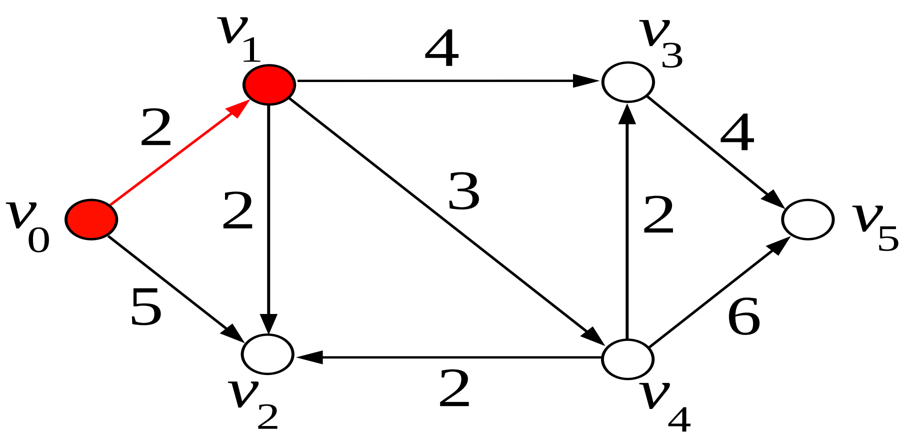
	v_0	v_1	v_2	v_3	v_4	v_5	chosen node
0	$\boxed{0}$	∞	∞	∞	∞	∞	v_0

Dijkstra's Algorithm



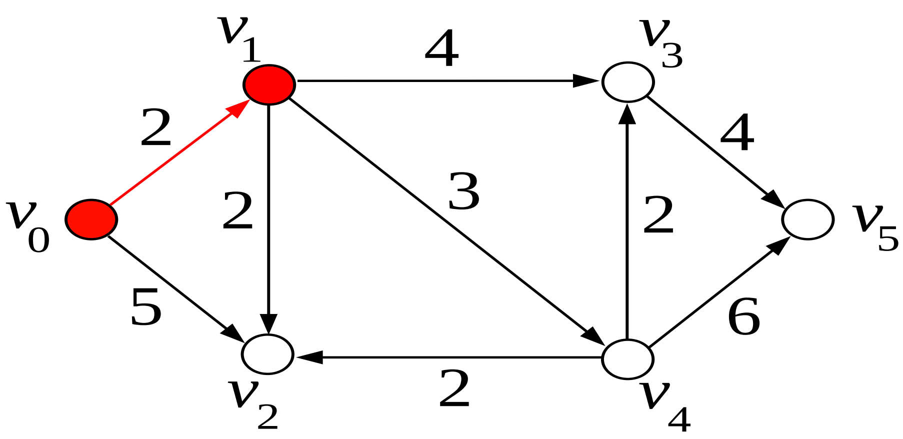
	v_0	v_1	v_2	v_3	v_4	v_5	chosen node
0	$\boxed{0}$	∞	∞	∞	∞	∞	v_0
1		$2/v_0$	$5/v_0$	∞	∞	∞	

Dijkstra's Algorithm



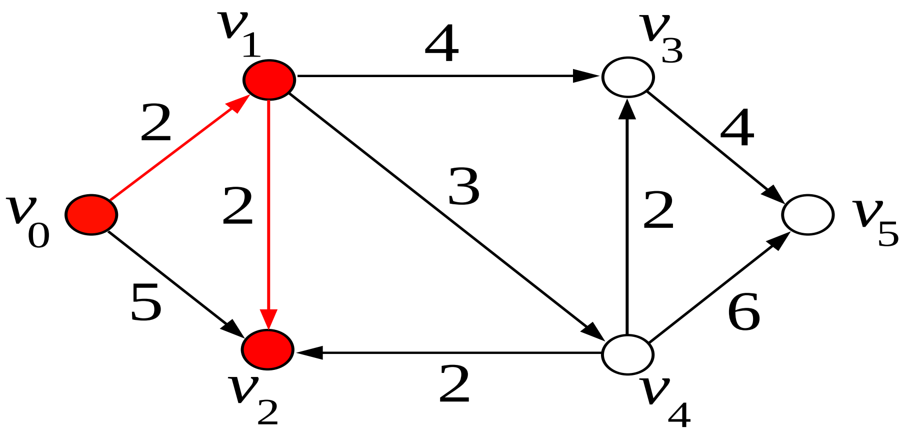
	v_0	v_1	v_2	v_3	v_4	v_5	chosen node
0	$\boxed{0}$	∞	∞	∞	∞	∞	v_0
1		$\boxed{2/v_0}$	$5/v_0$	∞	∞	∞	v_1

Dijkstra's Algorithm



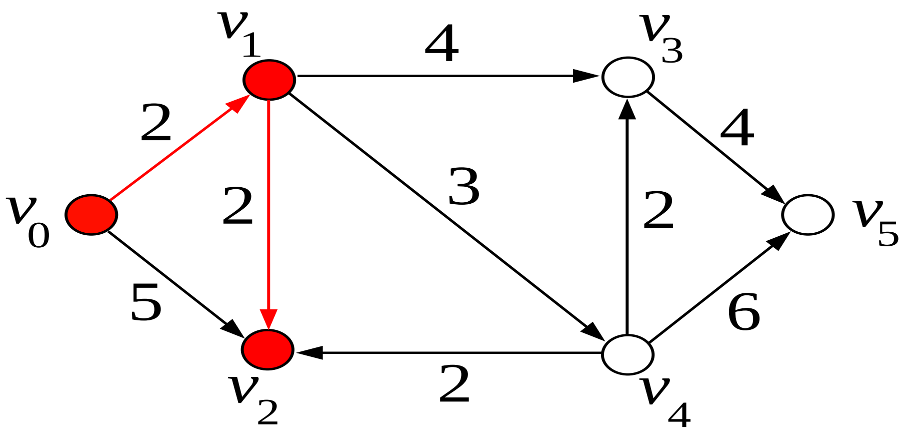
	v_0	v_1	v_2	v_3	v_4	v_5	chosen node
0	$\boxed{0}$	∞	∞	∞	∞	∞	v_0
1		$\boxed{2/v_0}$	$5/v_0$	∞	∞	∞	v_1
2			$4/v_1$	$6/v_1$	$5/v_1$	∞	

Dijkstra's Algorithm



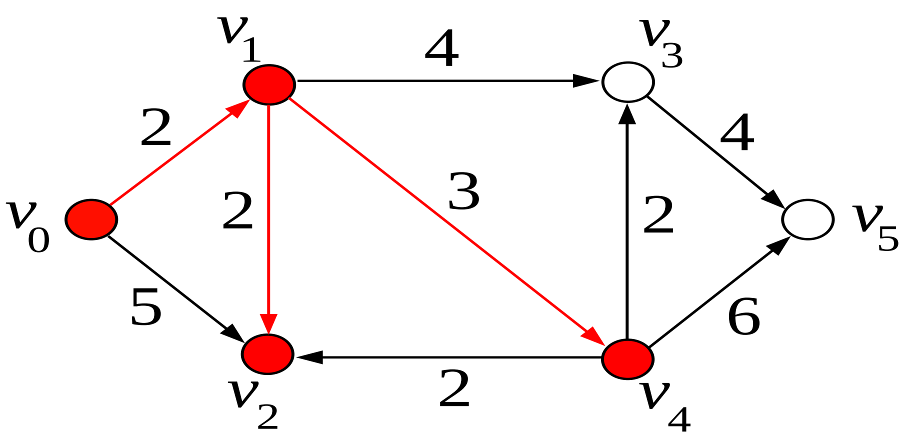
	v_0	v_1	v_2	v_3	v_4	v_5	chosen node
0	$\boxed{0}$	∞	∞	∞	∞	∞	v_0
1		$\boxed{2/v_0}$	$5/v_0$	∞	∞	∞	v_1
2			$\boxed{4/v_1}$	$6/v_1$	$5/v_1$	∞	v_2

Dijkstra's Algorithm



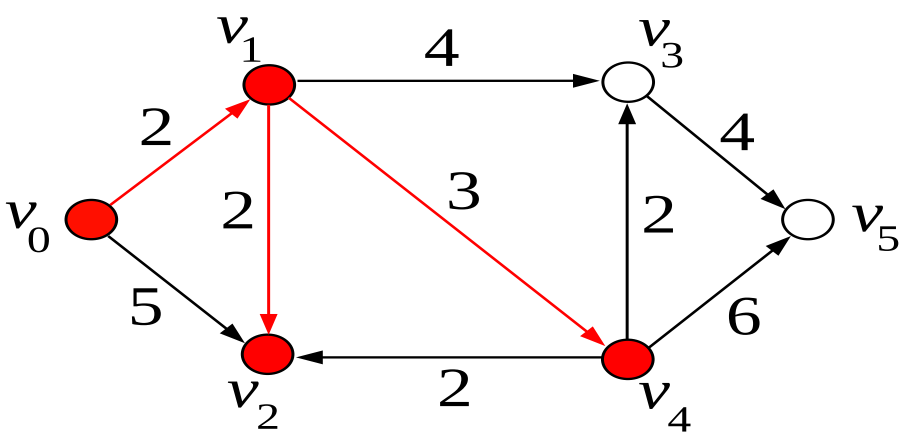
	v_0	v_1	v_2	v_3	v_4	v_5	chosen node
0	$\boxed{0}$	∞	∞	∞	∞	∞	v_0
1		$\boxed{2/v_0}$	$5/v_0$	∞	∞	∞	v_1
2			$\boxed{4/v_1}$	$6/v_1$	$5/v_1$	∞	v_2
3				$6/v_1$	$5/v_1$	∞	

Dijkstra's Algorithm



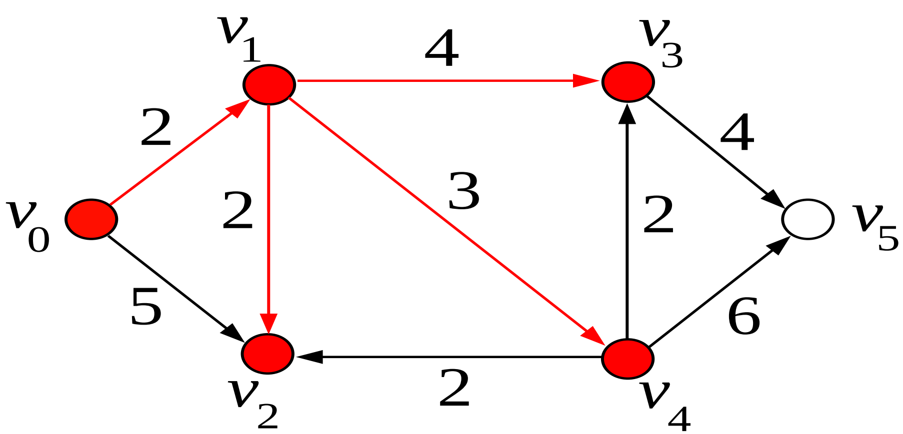
	v_0	v_1	v_2	v_3	v_4	v_5	chosen node
0	$\boxed{0}$	∞	∞	∞	∞	∞	v_0
1		$\boxed{2/v_0}$	$5/v_0$	∞	∞	∞	v_1
2			$\boxed{4/v_1}$	$6/v_1$	$5/v_1$	∞	v_2
3				$6/v_1$	$\boxed{5/v_1}$	∞	v_4

Dijkstra's Algorithm



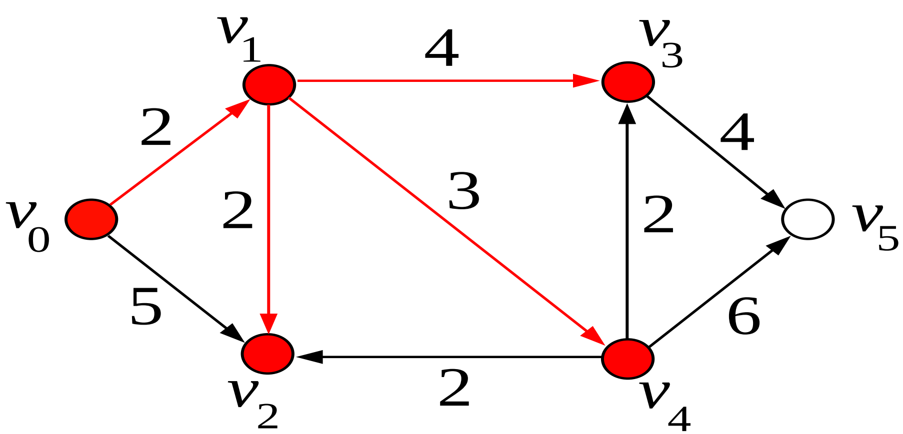
	v_0	v_1	v_2	v_3	v_4	v_5	chosen node
0	$\boxed{0}$	∞	∞	∞	∞	∞	v_0
1		$\boxed{2/v_0}$	$5/v_0$	∞	∞	∞	v_1
2			$\boxed{4/v_1}$	$6/v_1$	$5/v_1$	∞	v_2
3				$6/v_1$	$\boxed{5/v_1}$	∞	v_4
4				$6/v_1$		$11/v_4$	

Dijkstra's Algorithm



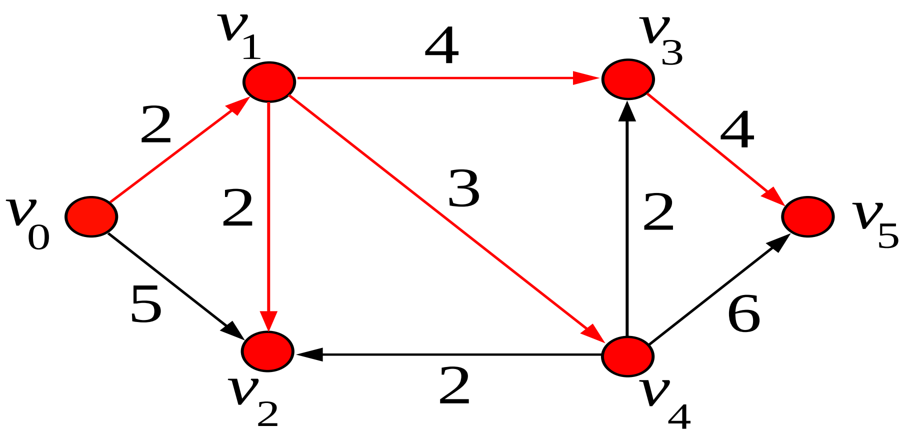
	v_0	v_1	v_2	v_3	v_4	v_5	chosen node
0	0	∞	∞	∞	∞	∞	v_0
1		$2/v_0$	$5/v_0$	∞	∞	∞	v_1
2			$4/v_1$	$6/v_1$	$5/v_1$	∞	v_2
3				$6/v_1$	$5/v_1$	∞	v_4
4				$6/v_1$		$11/v_4$	v_3

Dijkstra's Algorithm



	v_0	v_1	v_2	v_3	v_4	v_5	chosen node
0	$\boxed{0}$	∞	∞	∞	∞	∞	v_0
1		$\boxed{2/v_0}$	$5/v_0$	∞	∞	∞	v_1
2			$\boxed{4/v_1}$	$6/v_1$	$5/v_1$	∞	v_2
3				$6/v_1$	$\boxed{5/v_1}$	∞	v_4
4				$\boxed{6/v_1}$		$11/v_4$	v_3
5						$10/v_3$	

Dijkstra's Algorithm



	v_0	v_1	v_2	v_3	v_4	v_5	chosen node
0	$\boxed{0}$	∞	∞	∞	∞	∞	v_0
1		$\boxed{2/v_0}$	$5/v_0$	∞	∞	∞	v_1
2			$\boxed{4/v_1}$	$6/v_1$	$5/v_1$	∞	v_2
3				$6/v_1$	$\boxed{5/v_1}$	∞	v_4
4				$\boxed{6/v_1}$		$11/v_4$	v_3
5						$\boxed{10/v_3}$	v_5

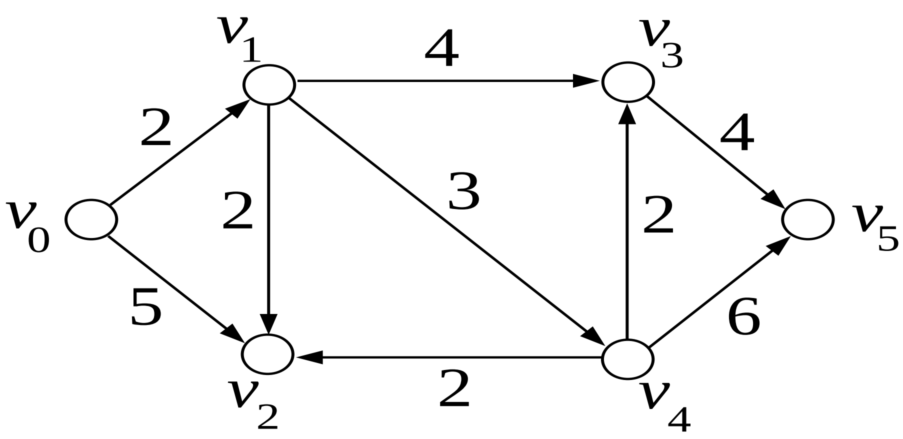
MOORE’S ALGORITHM

Moore's Algorithm

$\ell(v_0) := 0$; $a(v_0) := 0$; $p(v_0) := *$; $S := 0$; $I := 1$;
FOR $v \in V \setminus \{v_0\}$ DO: $l(v) := \infty$; $a(v) := \infty$; $p(v) := *$; END;

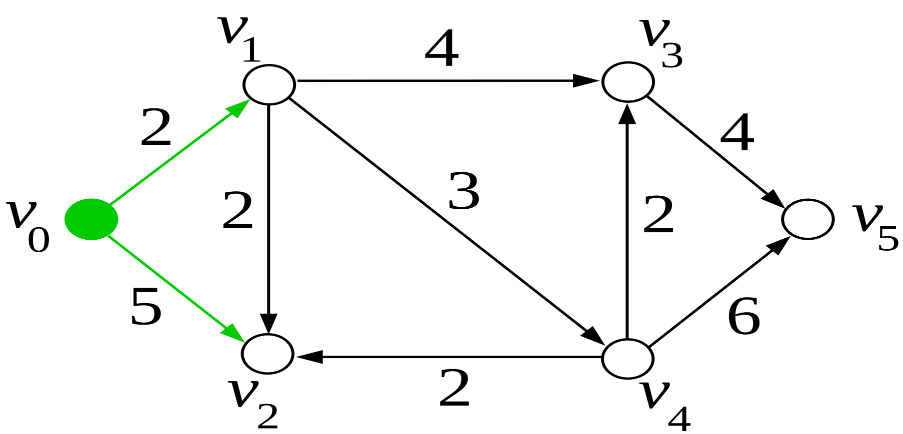
```
WHILE I = 1 DO:
   I := 0;
   FOR  v ∈ V  DO:
     IF a(v) = S THEN
       FOR  v̄ ∈ A_v DO
         IF ℓ(v̄) > ℓ(v) + w(v, v̄) THEN
            I := 1; ℓ(v̄) := ℓ(v)+w(v, v̄); a(v̄) := a(v)+1; p(v̄) := v;
         END IF;
       END;
     END IF;
   END;
   S := S + 1;
END;
```

Moore's Algorithm



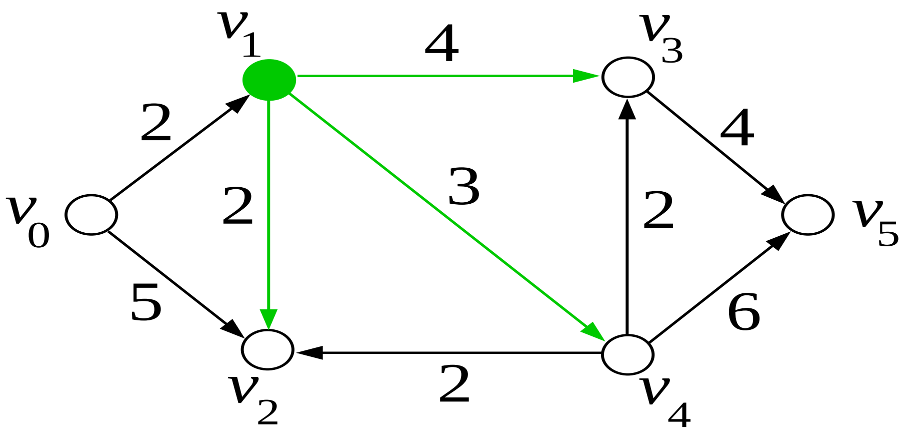
v / ℓ/a	v_0	v_1	v_2	v_3	v_4	v_5	S	I
	0/0	∞/∞	∞/∞	∞/∞	∞/∞	∞/∞	0	0

Moore's Algorithm



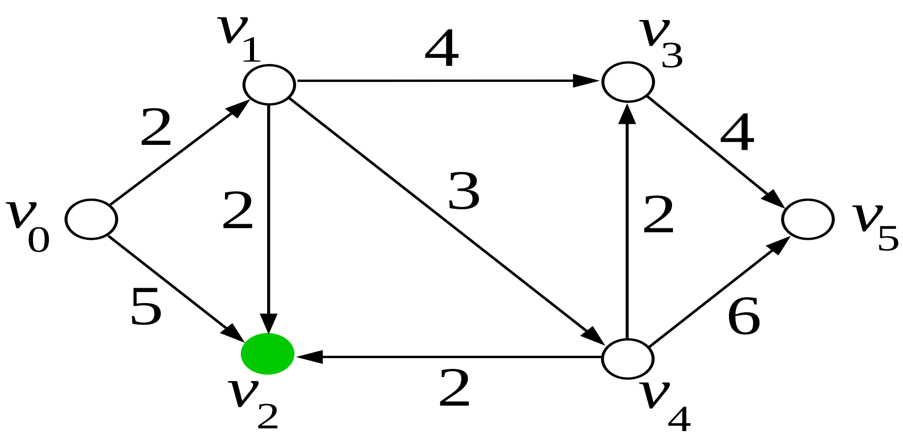
v / ℓ/a	v_0	v_1	v_2	v_3	v_4	v_5	S	I
	$0/0$	∞/∞	∞/∞	∞/∞	∞/∞	∞/∞	0	0
v_0		$2/1$	$5/1$	∞/∞	∞/∞	∞/∞	$0 \to 1$	$0 \to 1$

Moore's Algorithm



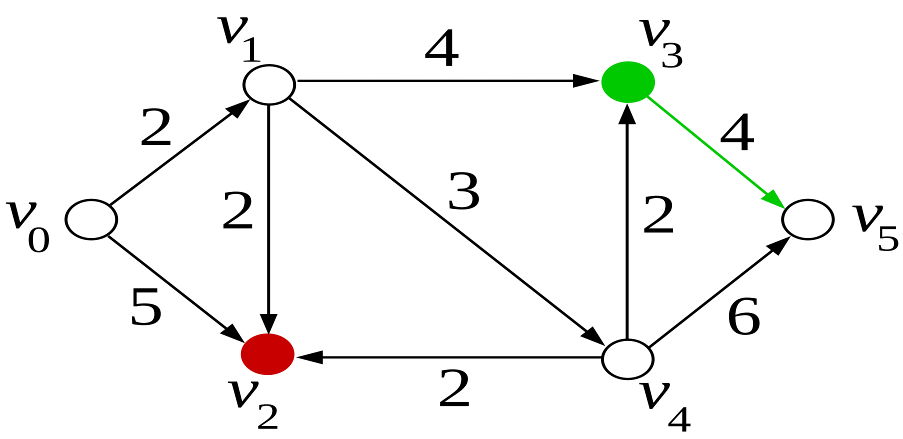
v / ℓ/a	v_0	v_1	v_2	v_3	v_4	v_5	S	I
	0/0	∞/∞	∞/∞	∞/∞	∞/∞	∞/∞	0	0
v_0		2/1	5/1	∞/∞	∞/∞	∞/∞	$0 \to 1$	$0 \to 1$
v_1		2/1	4/2	6/2	5/2	∞/∞	$1 \to 2$	$0 \to 1$

Moore's Algorithm



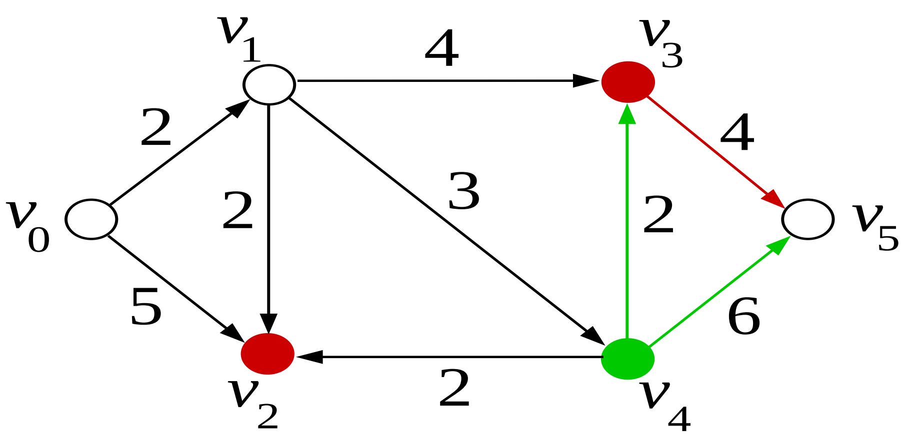
v / ℓ/a	v_0	v_1	v_2	v_3	v_4	v_5	S	I
	0/0	∞/∞	∞/∞	∞/∞	∞/∞	∞/∞	0	0
v_0		2/1	5/1	∞/∞	∞/∞	∞/∞	$0 \to 1$	$0 \to 1$
v_1		2/1	4/2	6/2	5/2	∞/∞	$1 \to 2$	$0 \to 1$
v_2		2/1	4/2	6/2	5/2	∞/∞	2	0

Moore's Algorithm



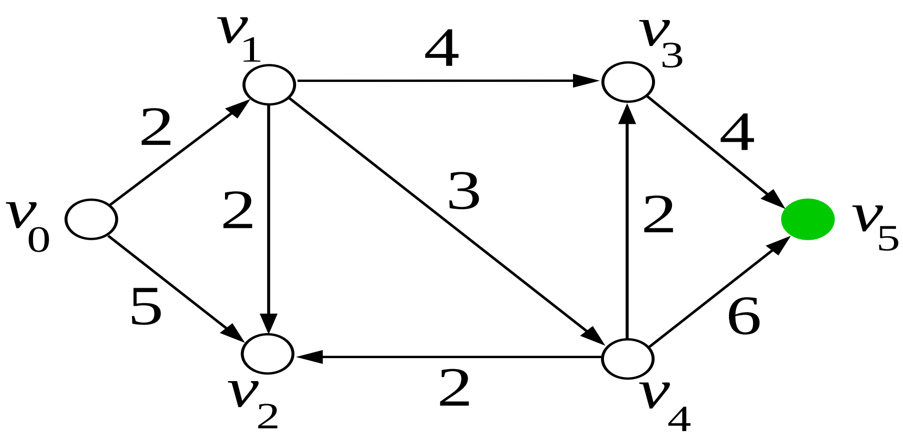
v / ℓ/a	v_0	v_1	v_2	v_3	v_4	v_5	S	I
	$0/0$	∞/∞	∞/∞	∞/∞	∞/∞	∞/∞	0	0
v_0		$2/1$	$5/1$	∞/∞	∞/∞	∞/∞	$0 \to 1$	$0 \to 1$
v_1		$2/1$	$4/2$	$6/2$	$5/2$	∞/∞	$1 \to 2$	$0 \to 1$
v_2		$2/1$	$4/2$	$6/2$	$5/2$	∞/∞	2	0
v_3		$2/1$	$4/2$	$6/2$	$5/2$	$10/3$	2	$0 \to 1$

Moore's Algorithm



v / ℓ/a	v_0	v_1	v_2	v_3	v_4	v_5	S	I
	$0/0$	∞/∞	∞/∞	∞/∞	∞/∞	∞/∞	0	0
v_0		$2/1$	$5/1$	∞/∞	∞/∞	∞/∞	$0 \to 1$	$0 \to 1$
v_1		$2/1$	$4/2$	$6/2$	$5/2$	∞/∞	$1 \to 2$	$0 \to 1$
v_2		$2/1$	$4/2$	$6/2$	$5/2$	∞/∞	2	0
v_3		$2/1$	$4/2$	$6/2$	$5/2$	$10/3$	2	$0 \to 1$
v_4		$2/1$	$4/2$	$6/2$	$5/2$	$10/3$	$2 \to 3$	1

Moore's Algorithm



v / ℓ/a	v_0	v_1	v_2	v_3	v_4	v_5	S	I
	0/0	∞/∞	∞/∞	∞/∞	∞/∞	∞/∞	0	0
v_0		2/1	5/1	∞/∞	∞/∞	∞/∞	$0 \to 1$	$0 \to 1$
v_1		2/1	4/2	6/2	5/2	∞/∞	$1 \to 2$	$0 \to 1$
v_2		2/1	4/2	6/2	5/2	∞/∞	2	0
v_3		2/1	4/2	6/2	5/2	10/3	2	$0 \to 1$
v_4		2/1	4/2	6/2	5/2	10/3	$2 \to 3$	1
v_5		2/1	4/2	6/2	5/2	10/3	3	0

FLOYD-WARSHALL ALGORITHM

Floyd-Warshall Algorithm

$$V = \{v_1, v_2, \ldots, v_n\}, \quad W = (w_{ij})_{1 \le i,j \le n}, \quad w_{ij} = w(v_i, v_j)$$

1. $\ell_{ij} := w_{ij}$

2.
```
for i=1 to n do
  for j=1 to n do
   for k=1 to n do
    ℓ_jk := min(ℓ_jk, ℓ_ji + ℓ_ik)
   end
   if  ℓ_jj < 0 then STOP (Cycle of negative length!)
  end
end
```

Floyd-Warshall Algorithm

$$L_0 = \begin{pmatrix} 0 & 2 & 4 & \infty & 3 \\ 2 & 0 & 8 & \infty & 1 \\ 6 & 2 & 0 & 4 & 3 \\ 1 & \infty & \infty & 0 & 5 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

for i=1 **to** n **do**
  for j=1 **to** n **do**
    for k=1 **to** n **do**
      $\ell_{jk} := \min(\ell_{jk}, \ell_{ji} + \ell_{ik})$
    end
    if $\ell_{jj} < 0$ **then** STOP (Cycle of negative length!)
  end
end

Floyd-Warshall Algorithm

$i = 1, j = 2$

$$L_0 \longrightarrow L_1 = \begin{pmatrix} 0 & 2 & 4 & \infty & 3 \\ 2 & 0 & 8 & \infty & 1 \\ 6 & 2 & 0 & 4 & 3 \\ 1 & \infty & \infty & 0 & 5 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

for i=1 **to** n **do**
  for j=1 **to** n **do**
    for k=1 **to** n **do**
      $\ell_{jk} := \min(\ell_{jk}, \ell_{ji} + \ell_{ik})$
    end
    if $\ell_{jj} < 0$ **then** STOP (Cycle of negative length!)
  end
end

Floyd-Warshall Algorithm

$i = 1, j = 2$

$$L_0 \longrightarrow L_1 = \begin{pmatrix} 0 & 2 & 4 & \infty & 3 \\ \mathbf{2} & 0 & 8 & \infty & 1 \\ 6 & 2 & 0 & 4 & 3 \\ 1 & \infty & \infty & 0 & 5 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

for i=1 **to** n **do**

  for j=1 **to** n **do**

   for k=1 **to** n **do**

    $\ell_{jk} := \min(\ell_{jk}, \ell_{ji} + \ell_{ik})$

   end

   if $\ell_{jj} < 0$ **then** STOP (Cycle of negative length!)

  end

end

Floyd-Warshall Algorithm

$i = 1, j = 2$

$$L_0 \longrightarrow L_1 = \begin{pmatrix} \mathbf{0} & 2 & 4 & \infty & 3 \\ \underline{\mathbf{2}} & 0 & 8 & \infty & 1 \\ 6 & 2 & 0 & 4 & 3 \\ 1 & \infty & \infty & 0 & 5 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

```
for i=1 to n do
  for j=1 to n do
    for k=1 to n do
      ℓ_jk := min(ℓ_jk, ℓ_ji + ℓ_ik)
    end
    if  ℓ_jj < 0 then STOP (Cycle of negative length!)
  end
end
```

Floyd-Warshall Algorithm

$i = 1, j = 2$

$$L_0 \longrightarrow L_1 = \begin{pmatrix} 0 & \mathbf{2} & 4 & \infty & 3 \\ \mathbf{2} & \underline{0} & 8 & \infty & 1 \\ 6 & 2 & 0 & 4 & 3 \\ 1 & \infty & \infty & 0 & 5 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

```
for i=1 to n do
  for j=1 to n do
    for k=1 to n do
      ℓ_jk := min(ℓ_jk, ℓ_ji + ℓ_ik)
    end
    if  ℓ_jj < 0 then STOP (Cycle of negative length!)
  end
end
```

Floyd-Warshall Algorithm

$i = 1, j = 2$

$$L_0 \longrightarrow L_1 = \begin{pmatrix} 0 & 2 & 4 & \infty & 3 \\ \mathbf{2} & 0 & \underline{8} & \infty & 1 \\ 6 & 2 & 0 & 4 & 3 \\ 1 & \infty & \infty & 0 & 5 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

```
for i=1 to n do
  for j=1 to n do
   for k=1 to n do
    ℓ_jk := min(ℓ_jk, ℓ_ji + ℓ_ik)
   end
   if  ℓ_jj < 0 then STOP (Cycle of negative length!)
  end
end
```

Floyd-Warshall Algorithm

$i = 1, j = 2$

$$L_0 \longrightarrow L_1 = \begin{pmatrix} 0 & 2 & 4 & \infty & 3 \\ 2 & 0 & 6 & \underline{\infty} & 1 \\ 6 & 2 & 0 & 4 & 3 \\ 1 & \infty & \infty & 0 & 5 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

for i=1 **to** n **do**
  for j=1 **to** n **do**
   for k=1 **to** n **do**
    $\ell_{jk} := \min(\ell_{jk}, \ell_{ji} + \ell_{ik})$
   end
   if $\ell_{jj} < 0$ **then** STOP (Cycle of negative length!)
  end
end

Floyd-Warshall Algorithm

$i = 1, j = 2$

$$L_0 \longrightarrow L_1 = \begin{pmatrix} 0 & 2 & 4 & \infty & \mathbf{3} \\ \mathbf{2} & 0 & 6 & \infty & \underline{1} \\ 6 & 2 & 0 & 4 & 3 \\ 1 & \infty & \infty & 0 & 5 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

```
for i=1 to n do
  for j=1 to n do
    for k=1 to n do
      ℓ_jk := min(ℓ_jk, ℓ_ji + ℓ_ik)
    end
    if ℓ_jj < 0 then STOP (Cycle of negative length!)
  end
end
```

Floyd-Warshall Algorithm

$i = 1, j = 2$

$$L_0 \longrightarrow L_1 = \begin{pmatrix} 0 & 2 & 4 & \infty & 3 \\ \mathbf{2} & 0 & 6 & \infty & 1 \\ 6 & 2 & 0 & 4 & 3 \\ 1 & \infty & \infty & 0 & 5 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

```
for i=1 to n do
  for j=1 to n do
    for k=1 to n do
      ℓ_jk := min(ℓ_jk, ℓ_ji + ℓ_ik)
    end
    if  ℓ_jj < 0 then STOP (Cycle of negative length!)
  end
end
```

Floyd-Warshall Algorithm

$i = 1, j = 3$

$$L_0 \longrightarrow L_1 = \begin{pmatrix} 0 & 2 & 4 & \infty & 3 \\ 2 & 0 & 6 & \infty & 1 \\ 6 & 2 & 0 & 4 & 3 \\ 1 & \infty & \infty & 0 & 5 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

for i=1 **to** n **do**

  for j=1 **to** n **do**

   for k=1 **to** n **do**

    $\ell_{jk} := \min(\ell_{jk}, \ell_{ji} + \ell_{ik})$

   end

   if $\ell_{jj} < 0$ **then** STOP (Cycle of negative length!)

  end

end

Floyd-Warshall Algorithm

$i = 1, j = 3$ no improvement!

$$L_0 \longrightarrow L_1 = \begin{pmatrix} 0 & 2 & 4 & \infty & 3 \\ 2 & 0 & 6 & \infty & 1 \\ \mathbf{6} & 2 & 0 & 4 & 3 \\ 1 & \infty & \infty & 0 & 5 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

for i=1 **to** n **do**
  for j=1 **to** n **do**
    for k=1 **to** n **do**
      $\ell_{jk} := \min(\ell_{jk}, \ell_{ji} + \ell_{ik})$
    end
    if $\ell_{jj} < 0$ **then** STOP (Cycle of negative length!)
  end
end

Floyd-Warshall Algorithm

$i = 1, j = 4$

$$L_0 \longrightarrow L_1 = \begin{pmatrix} 0 & 2 & 4 & \infty & 3 \\ 2 & 0 & 6 & \infty & 1 \\ 6 & 2 & 0 & 4 & 3 \\ \underline{1} & \infty & \infty & 0 & 5 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

```
for i=1 to n do
  for j=1 to n do
    for k=1 to n do
      ℓ_jk := min(ℓ_jk, ℓ_ji + ℓ_ik)
    end
    if  ℓ_jj < 0 then STOP (Cycle of negative length!)
  end
end
```

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$i = 1, j = 4$

$$L_0 \longrightarrow L_1 = \begin{pmatrix} 0 & \mathbf{2} & 4 & \infty & 3 \\ 2 & 0 & 6 & \infty & 1 \\ 6 & 2 & 0 & 4 & 3 \\ \mathbf{1} & \underline{\infty} & \infty & 0 & 5 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

```
for i=1 to n do
  for j=1 to n do
    for k=1 to n do
      ℓ_jk := min(ℓ_jk, ℓ_ji + ℓ_ik)
    end
    if ℓ_jj < 0 then STOP (Cycle of negative length!)
  end
end
```

Floyd-Warshall Algorithm

$i = 1, j = 4$

$$L_0 \longrightarrow L_1 = \begin{pmatrix} 0 & 2 & 4 & \infty & 3 \\ 2 & 0 & 6 & \infty & 1 \\ 6 & 2 & 0 & 4 & 3 \\ 1 & 3 & \underline{\infty} & 0 & 5 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

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for i=1 to n do
  for j=1 to n do
    for k=1 to n do
      ℓ_jk := min(ℓ_jk, ℓ_ji + ℓ_ik)
    end
    if  ℓ_jj < 0 then STOP (Cycle of negative length!)
  end
end
```

Floyd-Warshall Algorithm

$i = 1, j = 4$

$$L_0 \longrightarrow L_1 = \begin{pmatrix} 0 & 2 & 4 & \infty & 3 \\ 2 & 0 & 6 & \infty & 1 \\ 6 & 2 & 0 & 4 & 3 \\ 1 & 3 & 5 & \underline{0} & 5 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

for i=1 **to** n **do**

  for j=1 **to** n **do**

   for k=1 **to** n **do**

    $\ell_{jk} := \min(\ell_{jk}, \ell_{ji} + \ell_{ik})$

   end

   if $\ell_{jj} < 0$ **then** STOP (Cycle of negative length!)

  end

end

Floyd-Warshall Algorithm

$i = 1, j = 4$

$$L_0 \longrightarrow L_1 = \begin{pmatrix} 0 & 2 & 4 & \infty & \mathbf{3} \\ 2 & 0 & 6 & \infty & 1 \\ 6 & 2 & 0 & 4 & 3 \\ 1 & 3 & 5 & 0 & \underline{5} \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

for i=1 **to** n **do**
  for j=1 **to** n **do**
   for k=1 **to** n **do**
    $\ell_{jk} := \min(\ell_{jk}, \ell_{ji} + \ell_{ik})$
   end
   if $\ell_{jj} < 0$ **then** STOP (Cycle of negative length!)
  end
end

Floyd-Warshall Algorithm

$i = 1, j = 4$

$$L_0 \longrightarrow L_1 = \begin{pmatrix} 0 & 2 & 4 & \infty & 3 \\ 2 & 0 & 6 & \infty & 1 \\ 6 & 2 & 0 & 4 & 3 \\ 1 & 3 & 5 & 0 & 4 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

```
for i=1 to n do
  for j=1 to n do
   for k=1 to n do
    ℓ_jk := min(ℓ_jk, ℓ_ji + ℓ_ik)
   end
   if  ℓ_jj < 0 then STOP (Cycle of negative length!)
  end
end
```

Floyd-Warshall Algorithm

$$L_1 = \begin{pmatrix} 0 & 2 & 4 & \infty & 3 \\ 2 & 0 & 6 & \infty & 1 \\ 6 & 2 & 0 & 4 & 3 \\ 1 & 3 & 5 & 0 & 4 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

```
for i=1 to n do
  for j=1 to n do
   for k=1 to n do
    ℓ_jk := min(ℓ_jk, ℓ_ji + ℓ_ik)
   end
   if  ℓ_jj < 0 then STOP (Cycle of negative length!)
  end
end
```

Floyd-Warshall Algorithm

$i = 2, j = 3$

$$L_1 \longrightarrow L_2 = \begin{pmatrix} 0 & 2 & 4 & \infty & 3 \\ \mathbf{2} & 0 & 6 & \infty & 1 \\ \underline{6} & \mathbf{2} & 0 & 4 & 3 \\ 1 & 3 & 5 & 0 & 4 \\ \infty & \infty & \infty & 1 & 0 \end{pmatrix}$$

for i=1 to n do

  for j=1 to n do

   for k=1 to n do

    $\ell_{jk} := \min(\ell_{jk}, \ell_{ji} + \ell_{ik})$

   end

   if $\ell_{jj} < 0$ then STOP (Cycle of negative length!)

  end

end

Floyd-Warshall Algorithm

Result:

$$L_5 = \begin{pmatrix} 0 & 2 & 4 & 4 & 3 \\ 2 & 0 & 6 & 2 & 1 \\ 4 & 2 & 0 & 4 & 3 \\ 1 & 3 & 5 & 0 & 4 \\ 2 & 4 & 6 & 1 & 0 \end{pmatrix}$$

```
for i=1 to n do
  for j=1 to n do
   for k=1 to n do
    ℓ_jk := min(ℓ_jk, ℓ_ji + ℓ_ik)
   end
   if  ℓ_jj < 0 then STOP (Cycle of negative length!)
  end
end
```