

## \* Algoritmo de Bellman - Ford

Não pode ter ciclo negativo    Tem peso negativo     $O(VE)$

Resolve o problema de caminhos mínimos de fonte única no qual o peso das arestas podem ser negativo.

Retorna um valor booleano que indica se existe ou não um ciclo negativo que pode ser alcançado da fonte. Se tal ciclo existe o algoritmo indica que não há solução. Se tal ciclo não existe o algoritmo produz os caminhos mínimos e seus pesos.

Bellman-Ford ( $G, w, s$ )

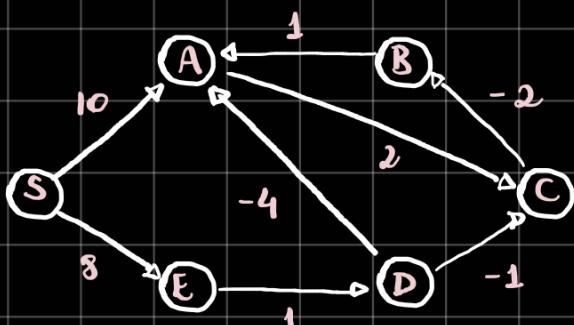
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1 Initialize-Single-Source( $G, s$ )
2 for  $i = 1$  to  $[V[G]] - 1$ 
3   for cada aresta  $(u, v) \in E[G]$ 
4     if  $v.d > u.d + w(u, v)$ 
5        $v.d = u.d + w(u, v)$ 
6        $v.\pi = u$ 
7   for cada aresta  $(u, v) \in E[G]$ 
8     if  $v.d > u.d + w(u, v)$ 
9       return FALSE
10  return TRUE
  
```

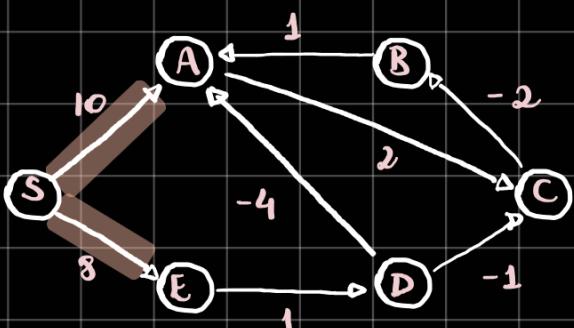
$O(V)$   
 $O(E)$  linha 4 a 6 req.  
 liza o RELAX  
 $O(E)$   
 verifica se há ciclos  
 peso negativo

- Executando o algoritmo

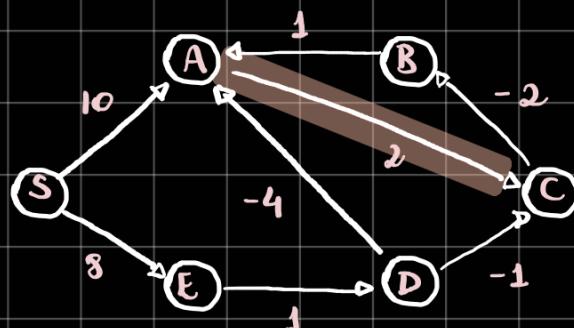
1º Iteração



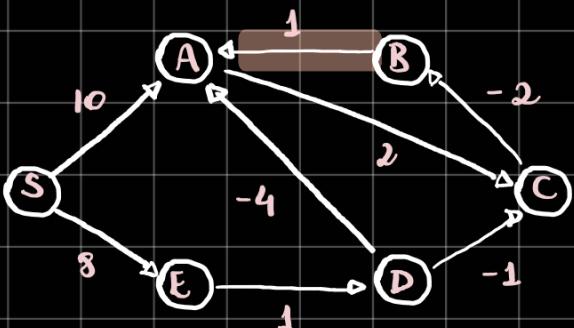
	S	A	B	C	D	E
d	0	$\infty$	$\infty$	$\infty$	$\infty$	$\infty$
$\pi$	-	NIL	NIL	NIL	NIL	NIL



	S	A	B	C	D	E
d	0	10	$\infty$	$\infty$	$\infty$	8
$\pi$	-	S	NIL	NIL	NIL	S

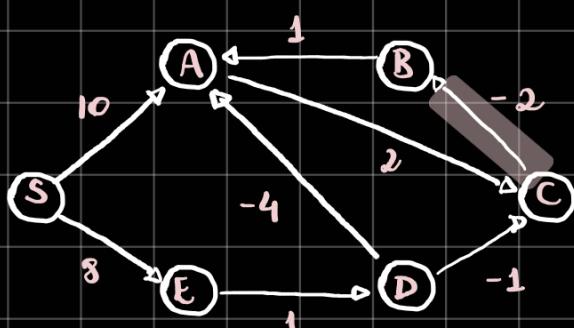


	S	A	B	C	D	E
d	0	10	$\infty$	A	$\infty$	8
$\pi$	-	S	NIL	12	NIL	S

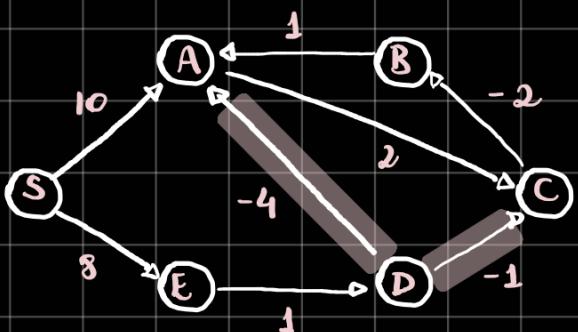


	S	A	B	C	D	E
d	0	10	$\infty$	12	$\infty$	8
$\pi$	-	S	NIL	A	NIL	S

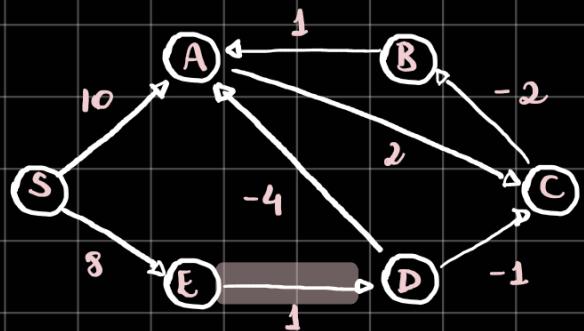
L<sub>D</sub> pula



	S	A	B	C	D	E
d	0	10	10	12	$\infty$	8
$\pi$	-	S	C	A	NIL	S

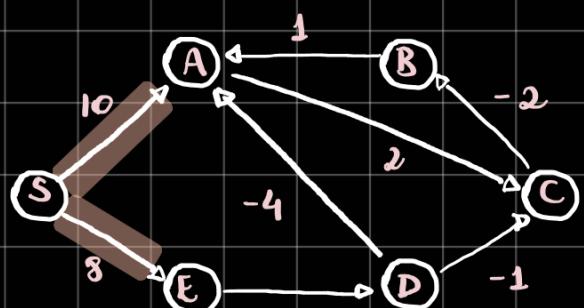


	S	A	B	C	D	E
d	0	10	10	12	$\infty$	8
$\pi$	-	S	C	A	Nil	S
Loopula						

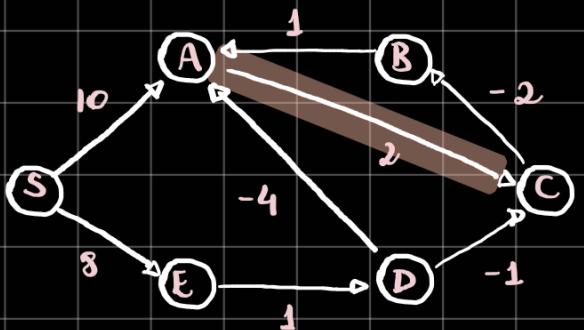


	S	A	B	C	D	E
d	0	10	10	12	9	8
$\pi$	-	S	C	A	E	S

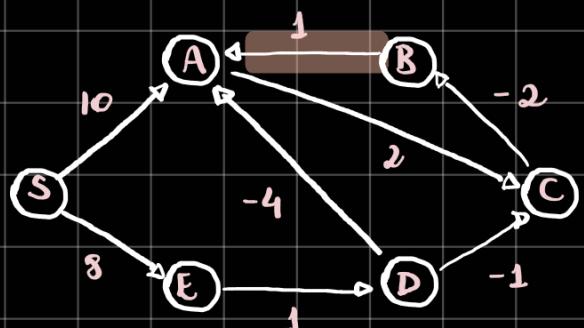
2º Iteração



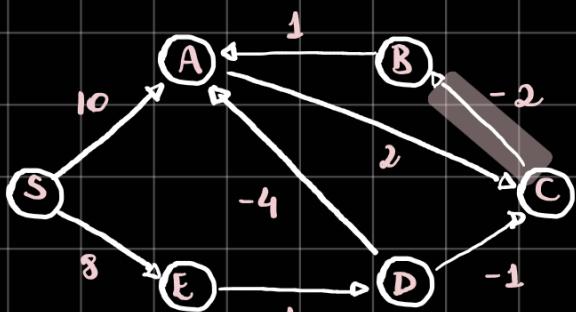
	S	A	B	C	D	E
d	0	10	10	12	9	8
$\pi$	-	S	C	A	E	S



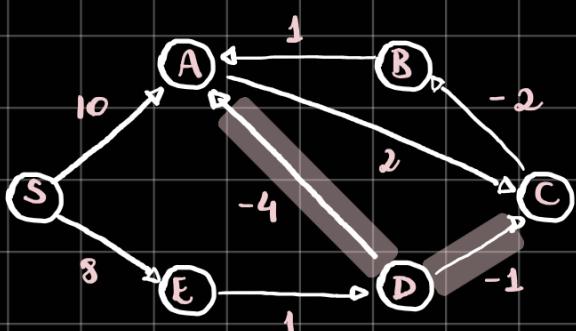
	S	A	B	C	D	E
d	0	10	10	12	9	8
$\pi$	-	S	C	A	E	S



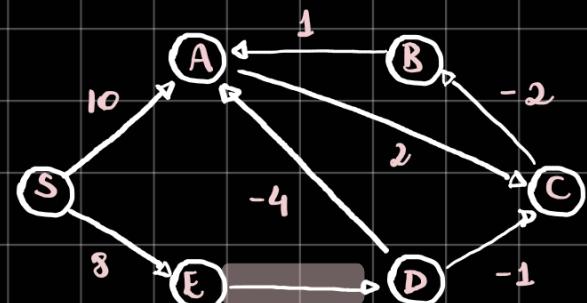
	S	A	B	C	D	E
d	0	10	10	12	9	8
$\pi$	-	S	C	A	E	S



	S	A	B	C	D	E
d	0	10	10	12	9	8
$\pi$	-	S	C	A	E	S

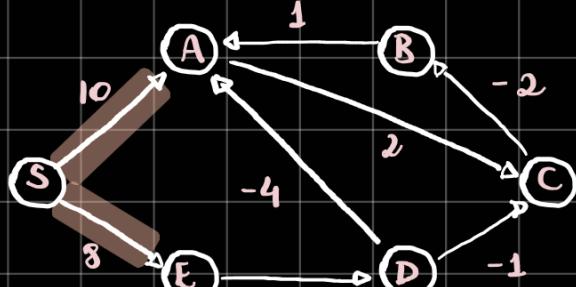


	S	A	B	C	D	E
d	0	5	10	8	9	8
$\pi$	-	D	C	D	E	S

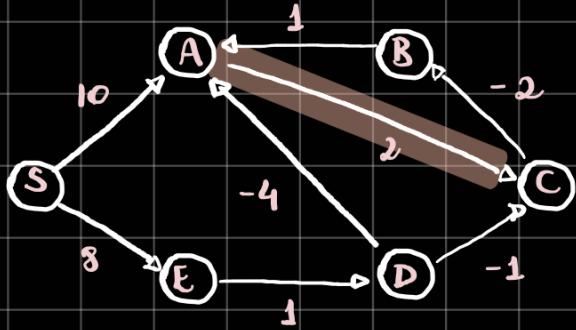


	S	A	B	C	D	E
d	0	5	10	8	9	8
$\pi$	-	D	C	D	E	S

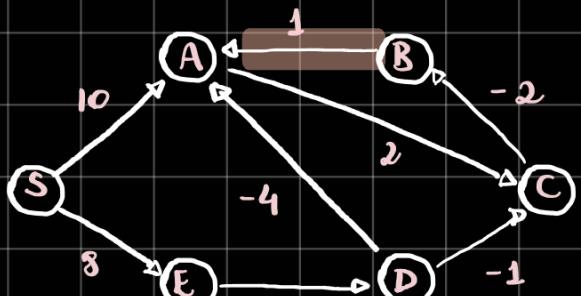
3ª Iteração



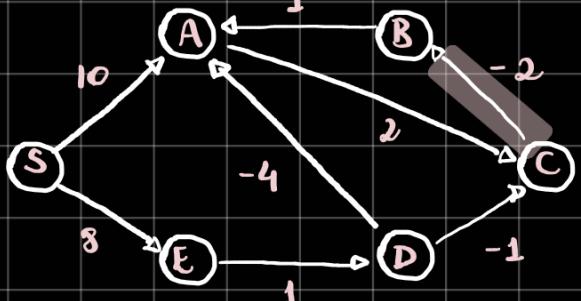
	S	A	B	C	D	E
d	0	5	10	8	9	8
$\pi$	-	D	C	D	E	S



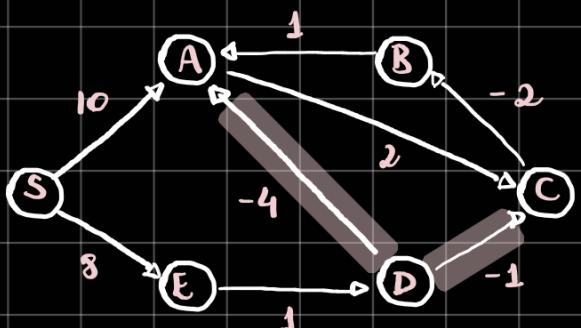
	S	A	B	C	D	E
d	0	5	10	7	9	8
$\pi$	-	D	C	A	E	S



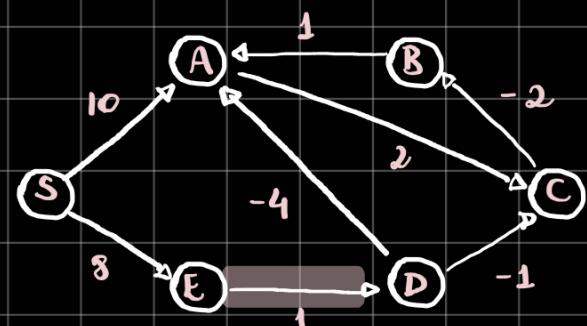
	S	A	<b>B</b>	C	D	E
d	0	5	10	7	9	8
r	-	D	C	A	E	S



	S	A	B	<b>C</b>	D	E
d	0	5	5	7	9	8
r	-	D	C	A	E	S



	S	A	B	C	<b>D</b>	E
d	0	5	5	7	9	8
r	-	D	C	A	E	S



	S	A	B	C	D	<b>E</b>
d	0	5	5	7	9	8
r	-	D	C	A	E	S

Lemma  
(estudar)