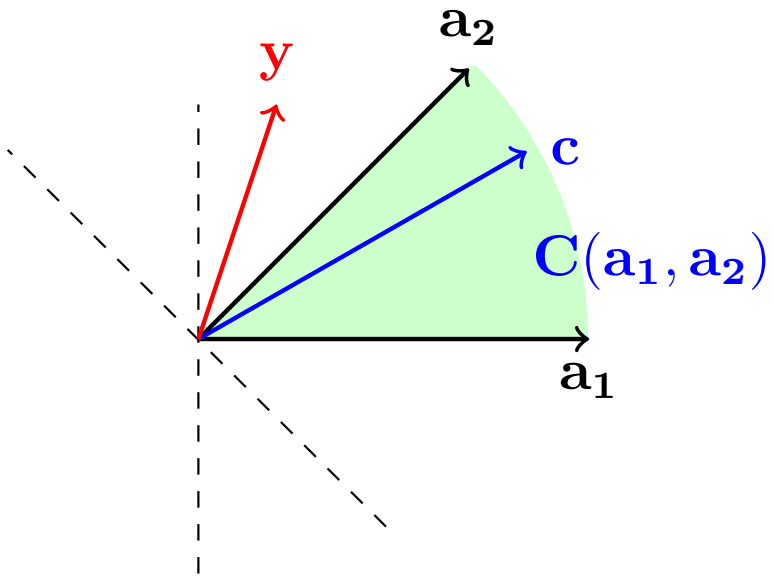
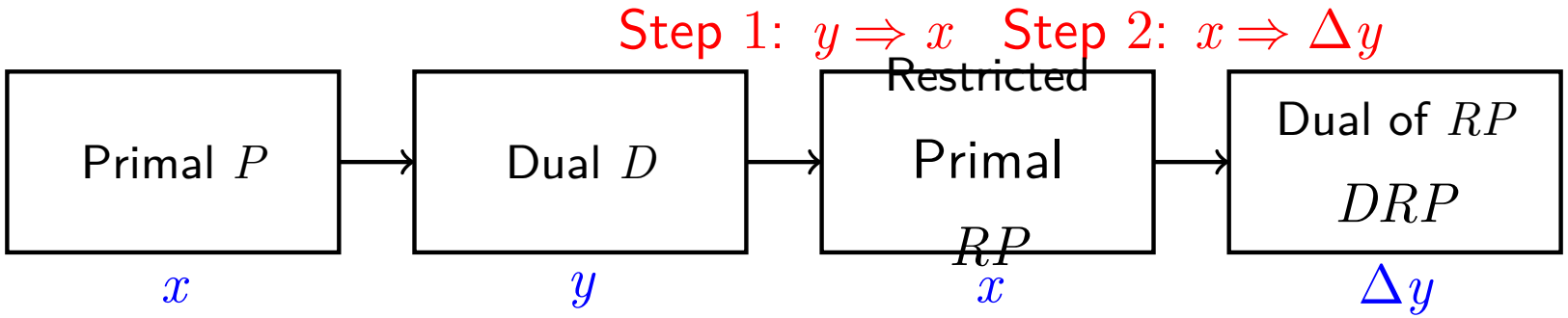
bbbbb;

Farkas lemma

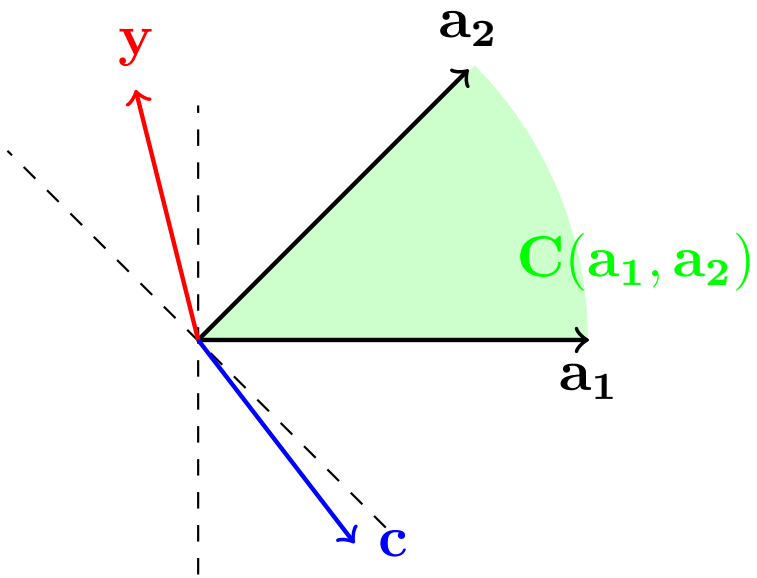


DRP

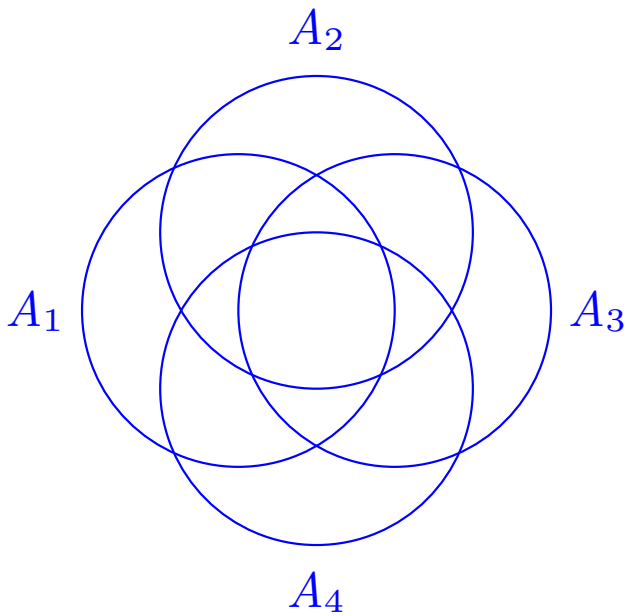


Step 3: $y = y + \theta \times \Delta y$

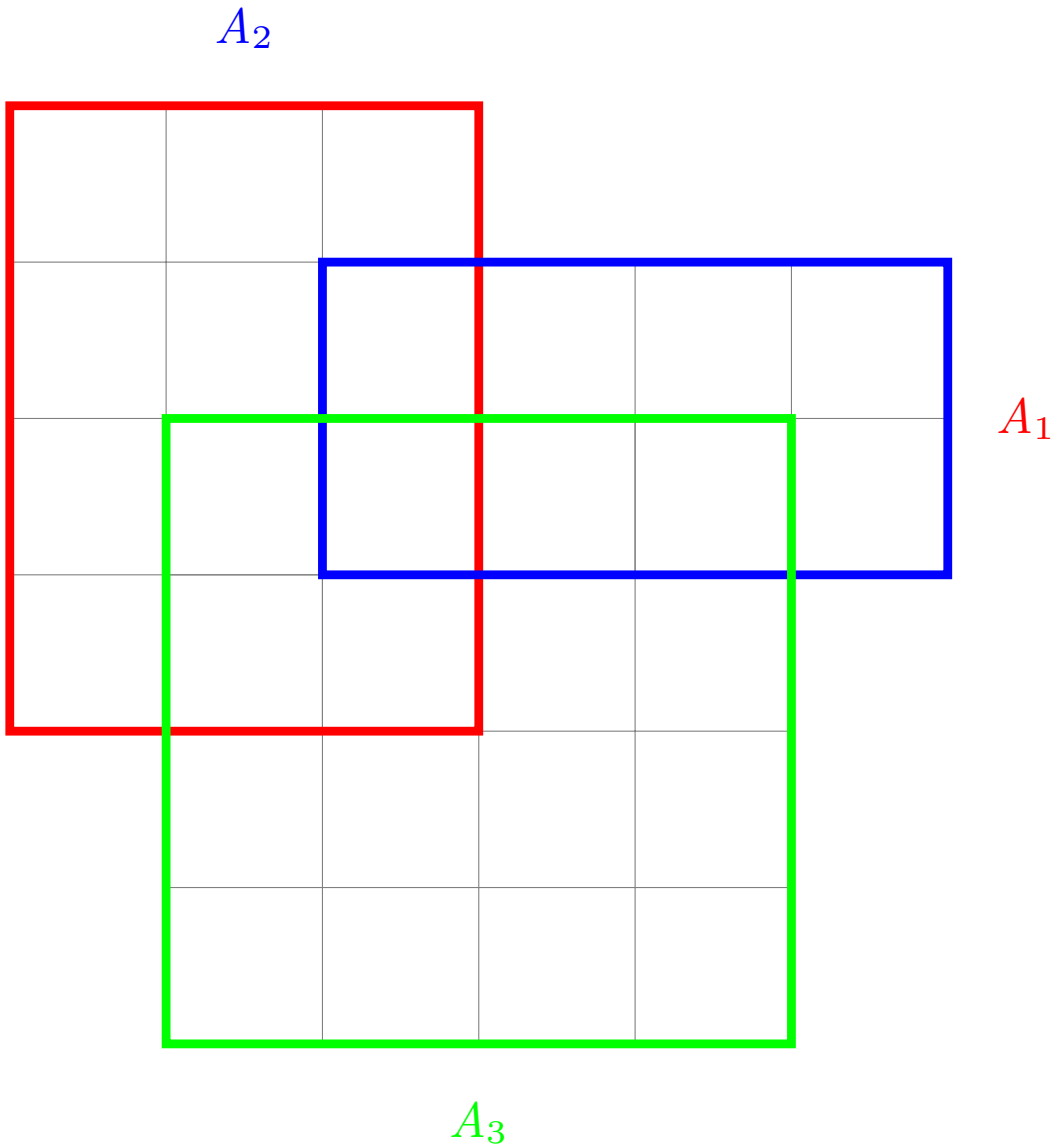
Farkas lemma



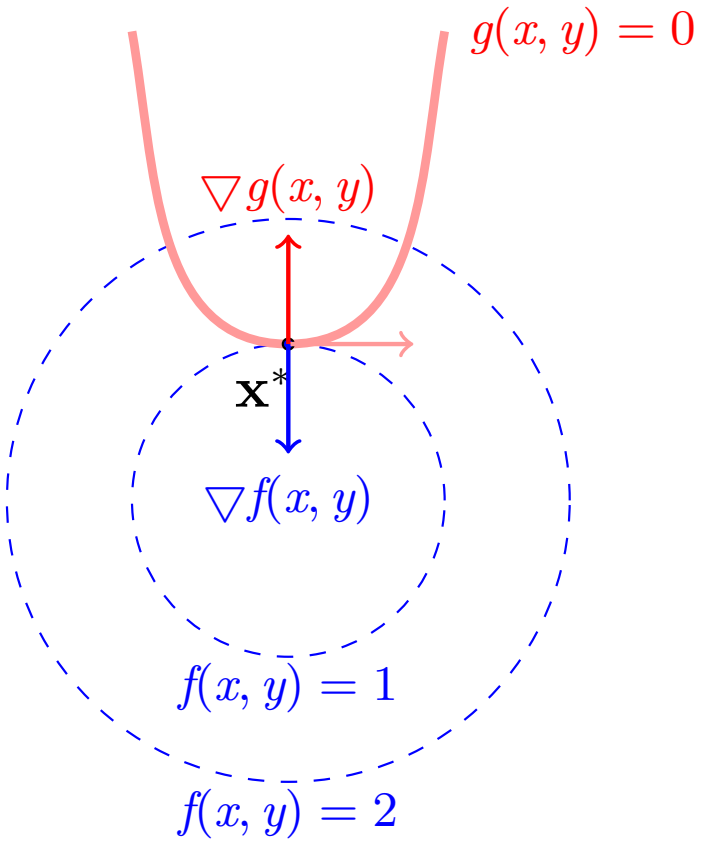
Max Coverage Problem



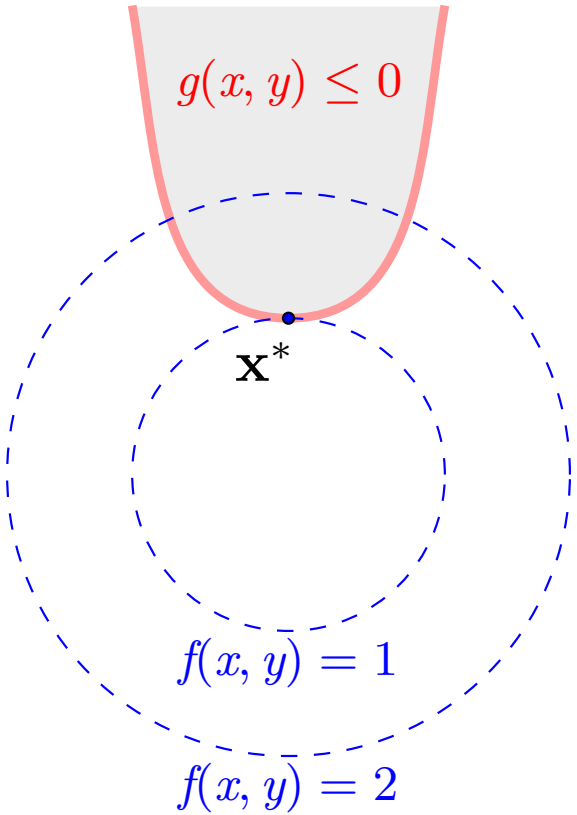
Max Coverage Problem2



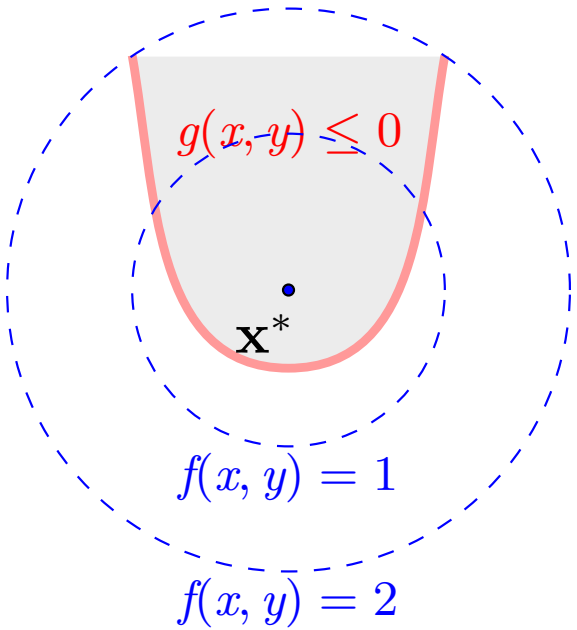
Lagrangian



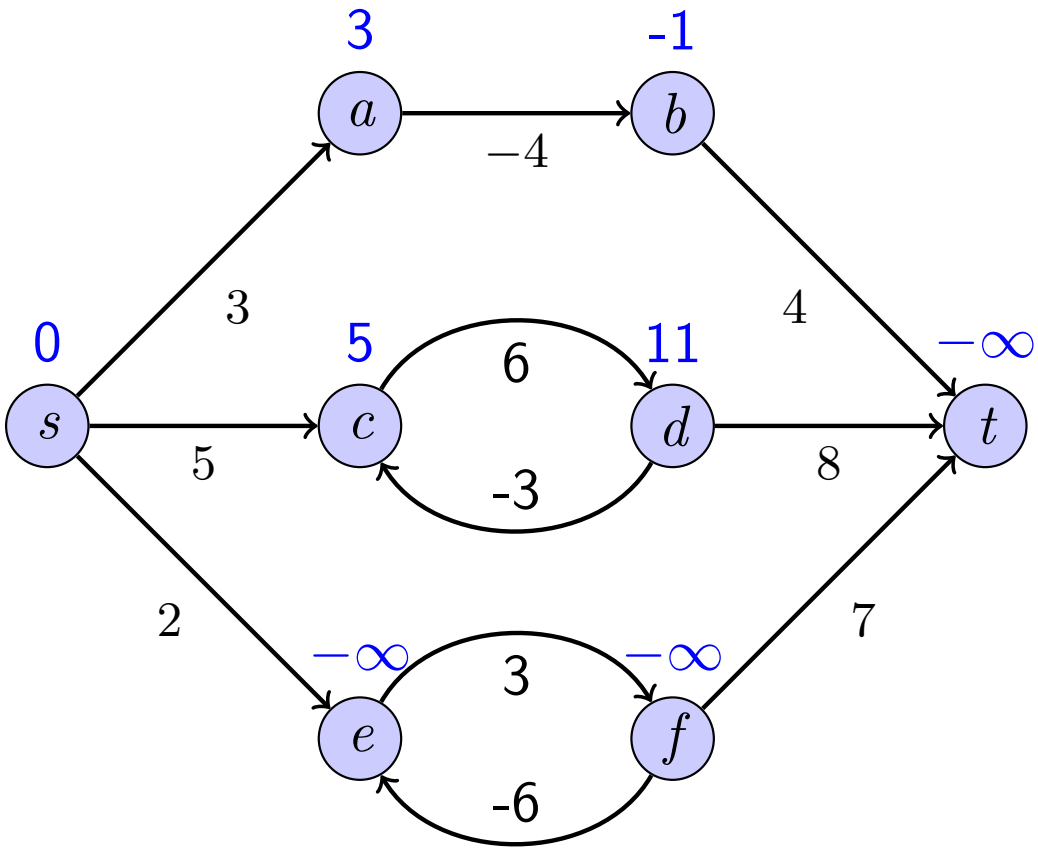
Lagrangian



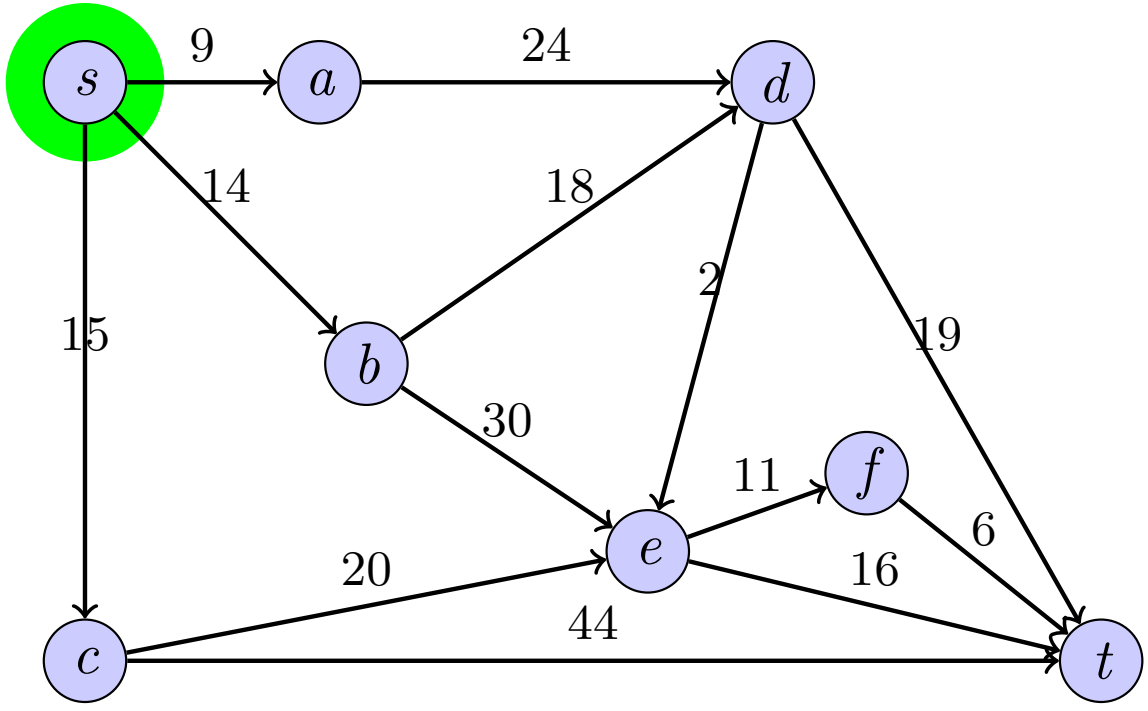
Lagrangian



SP 1



EEE2



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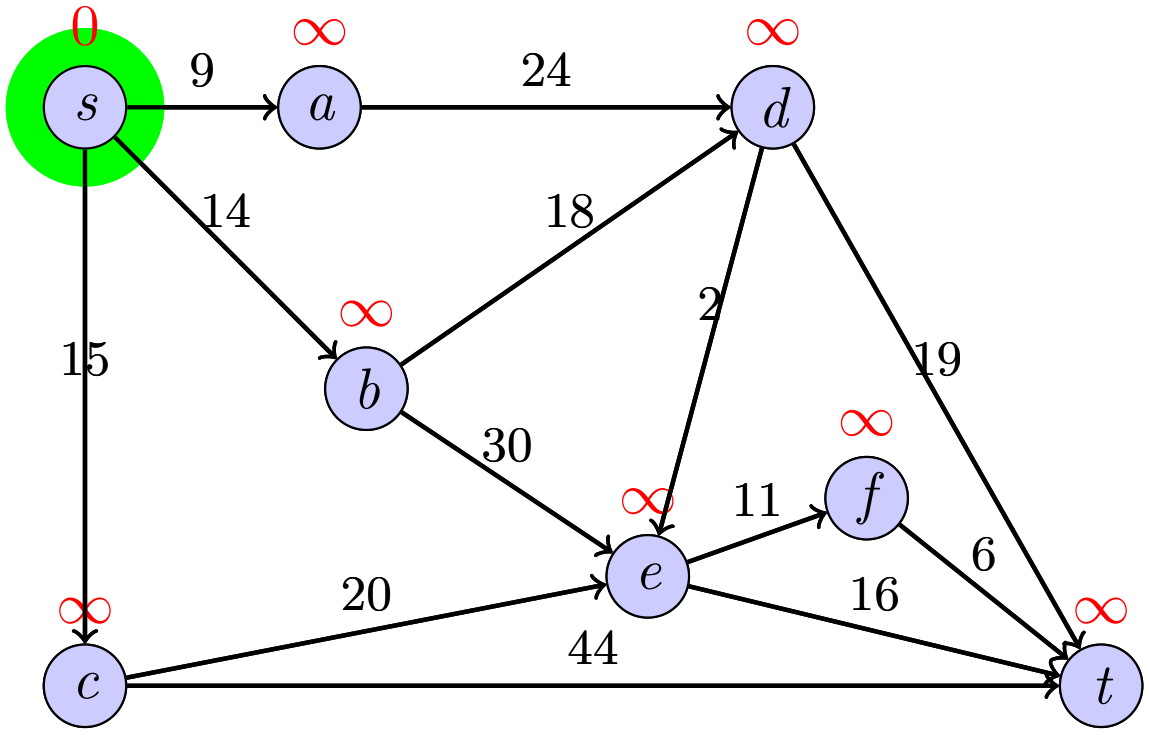

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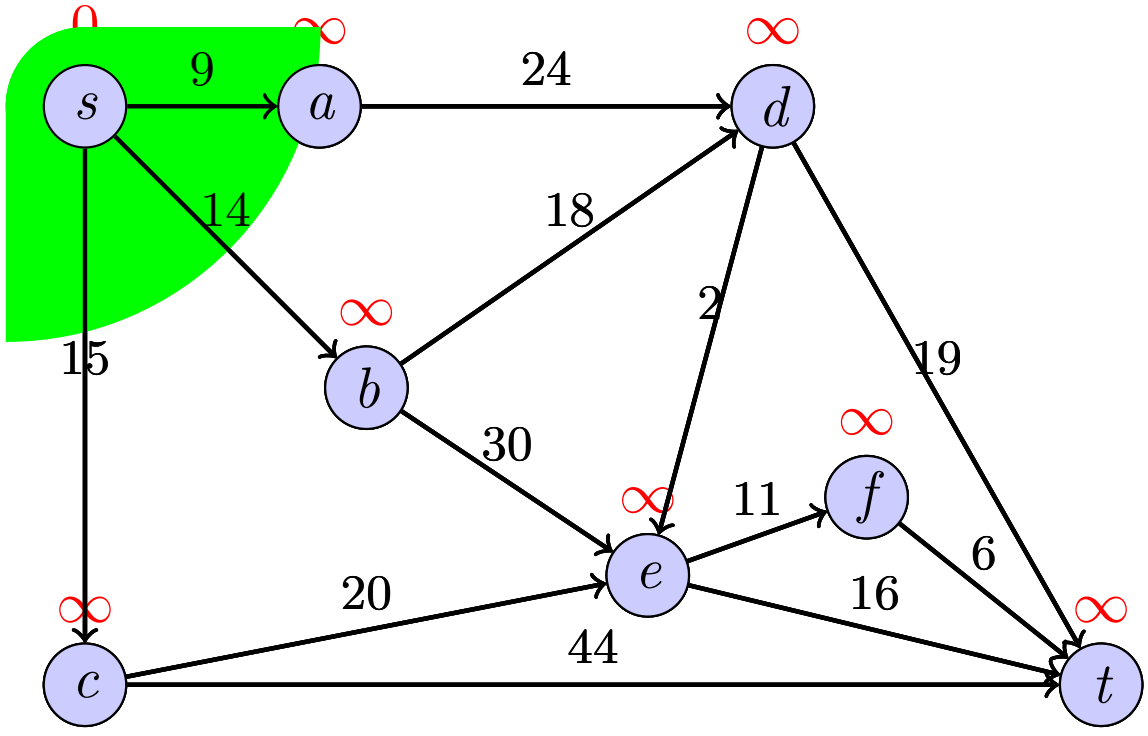

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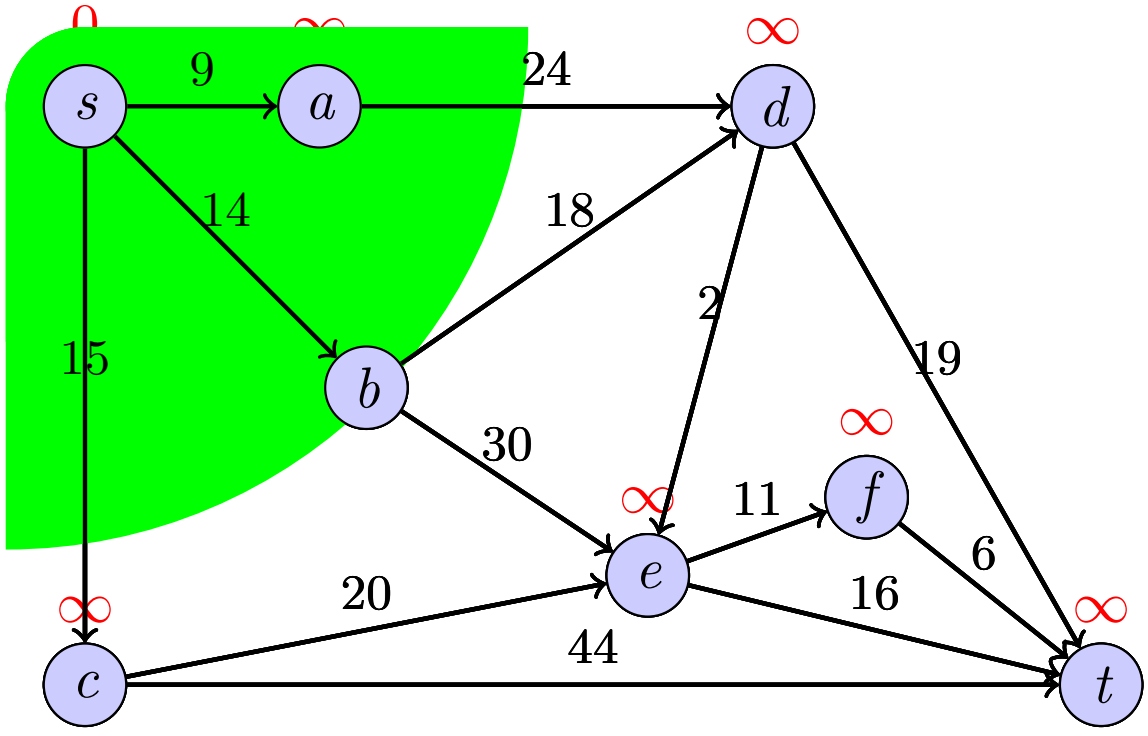

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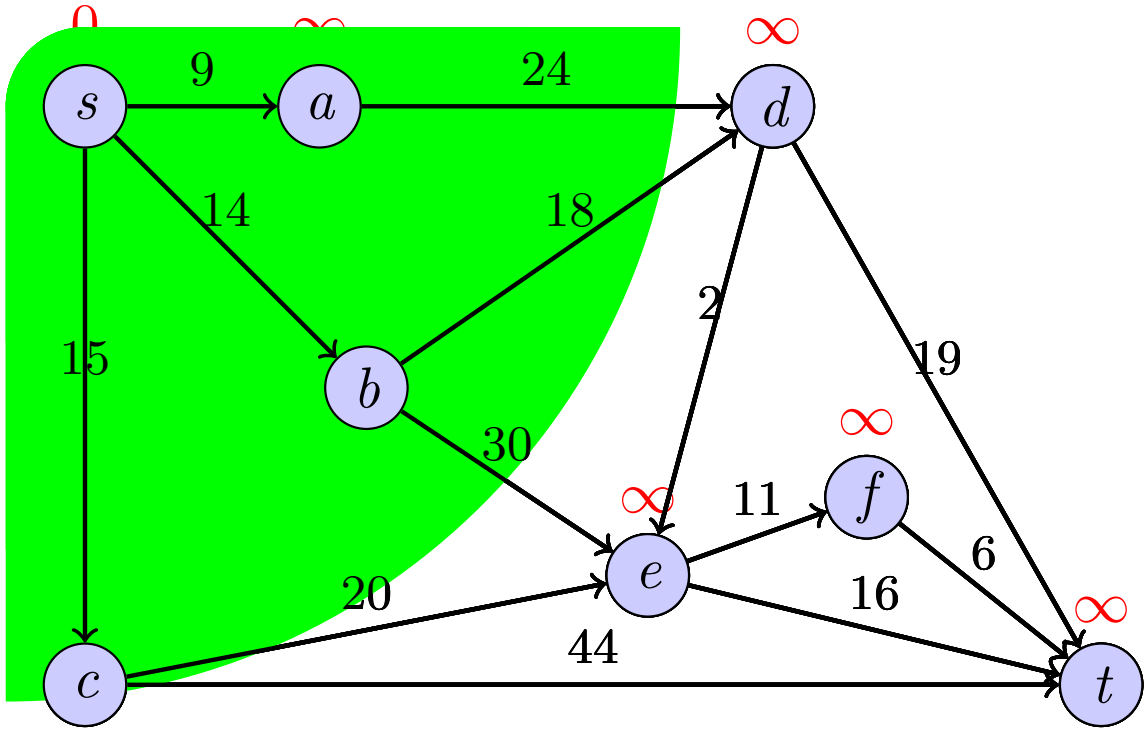

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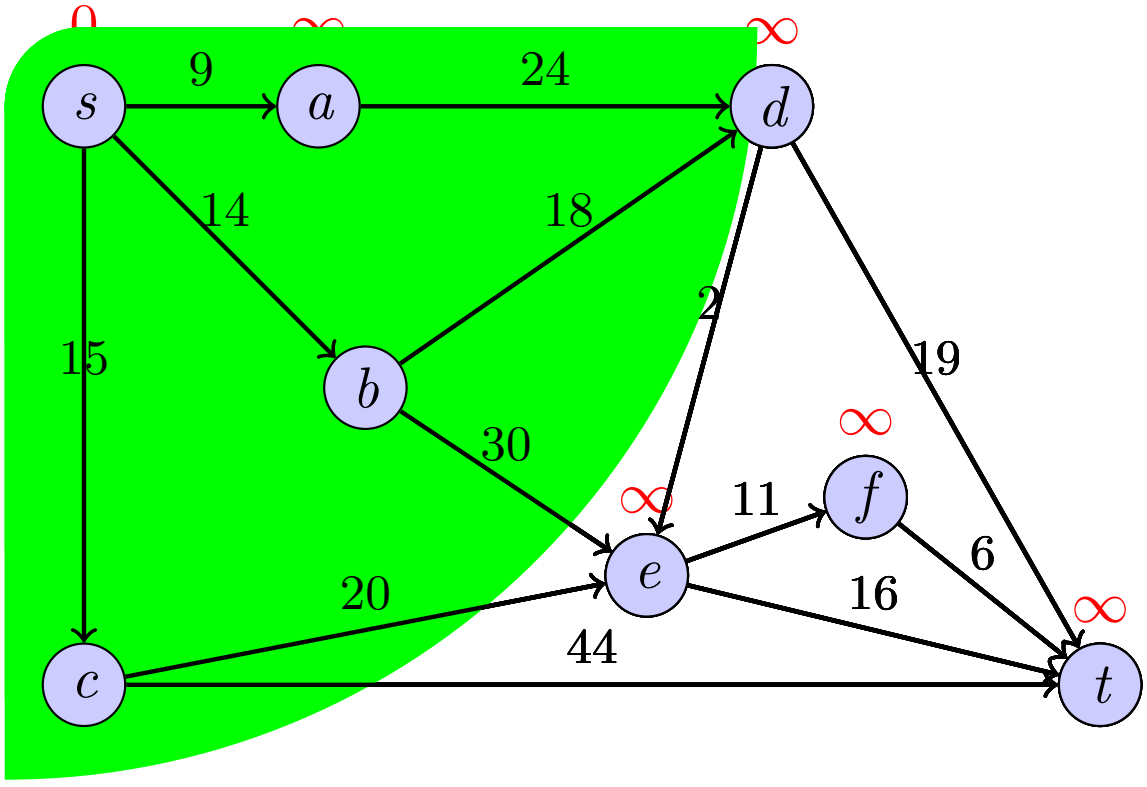

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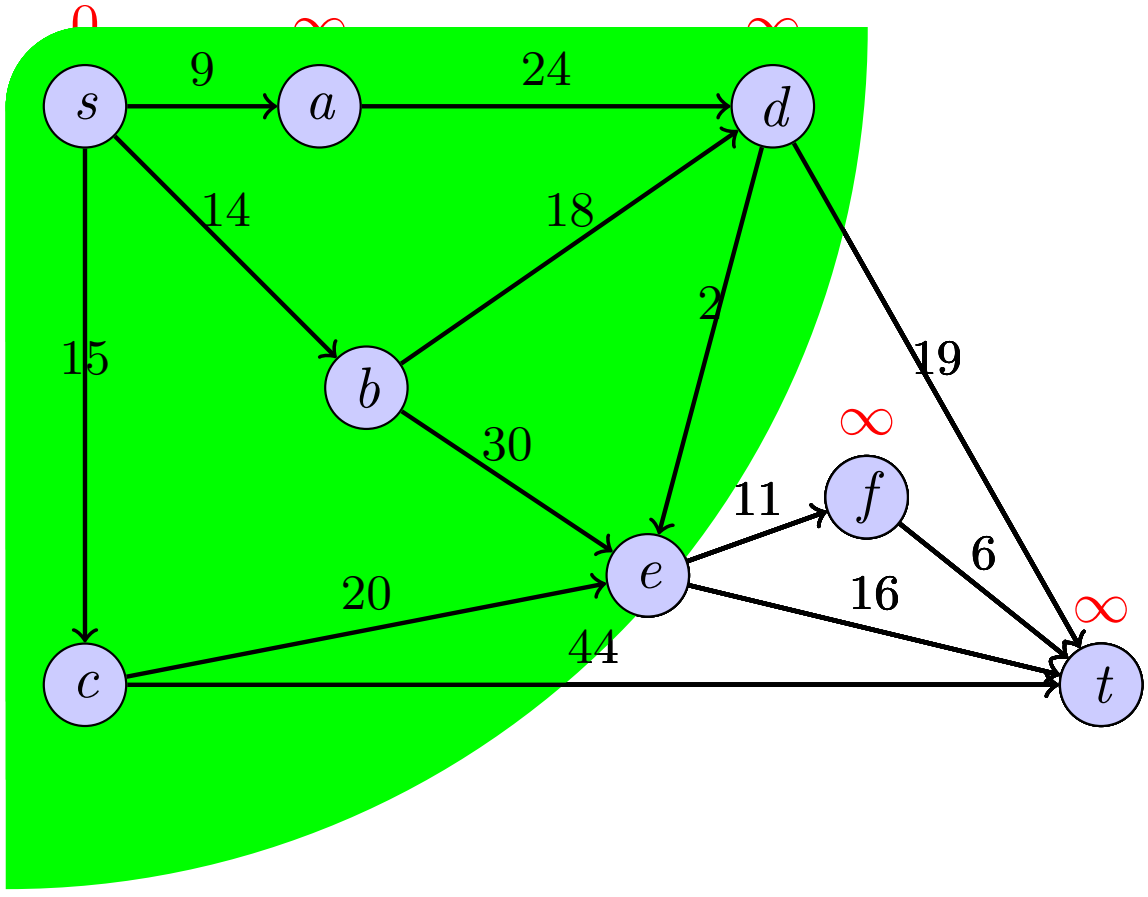

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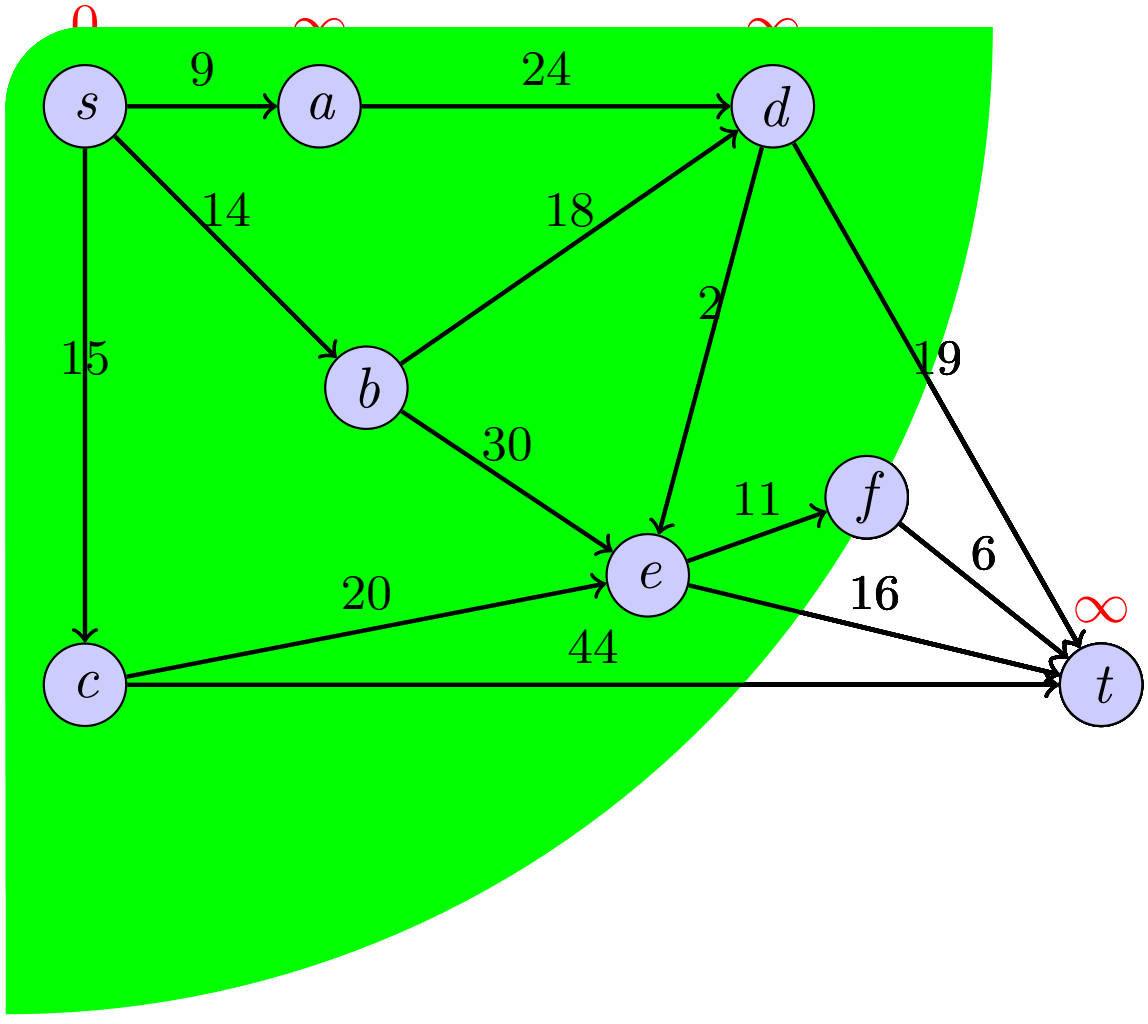

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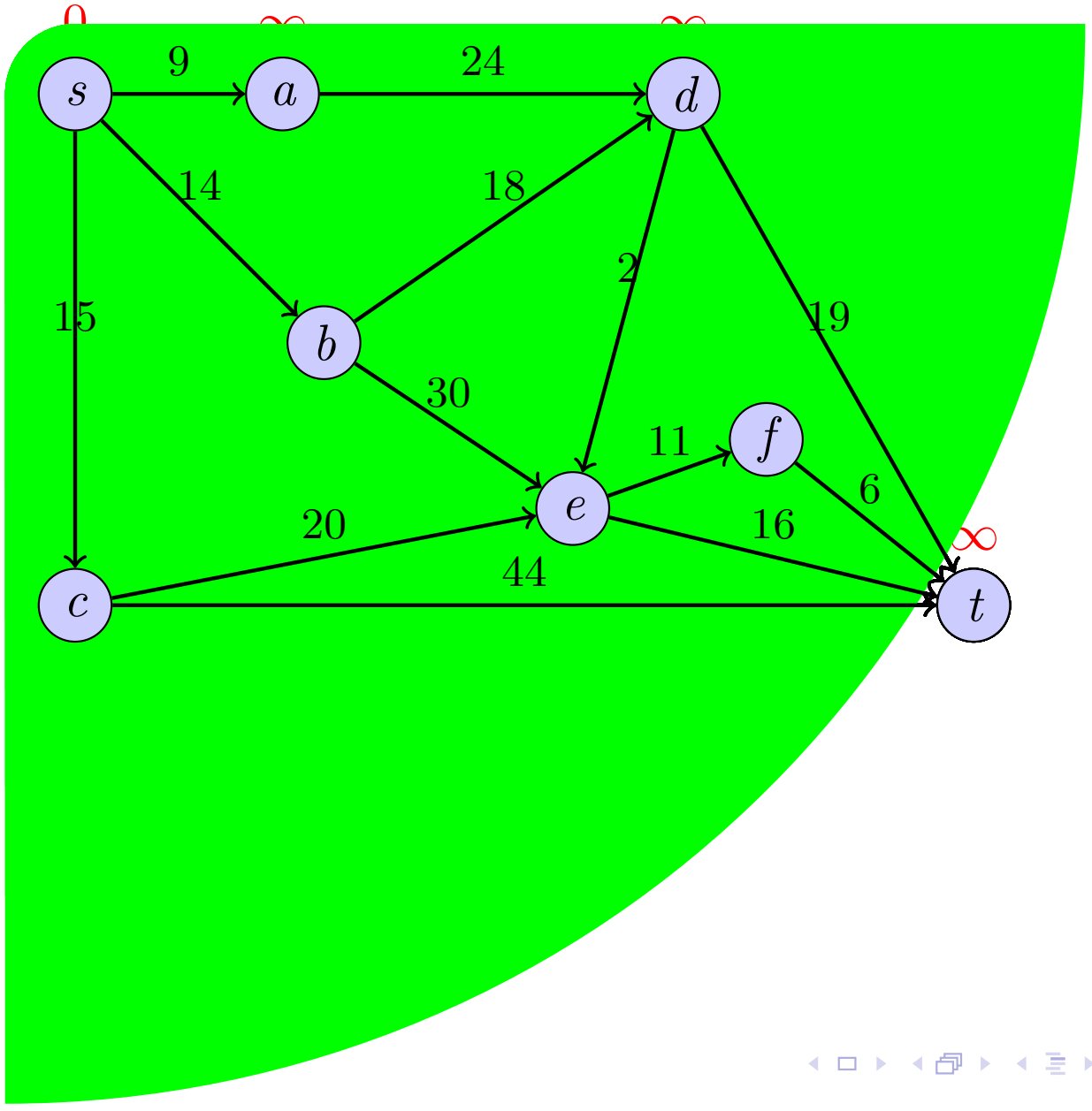
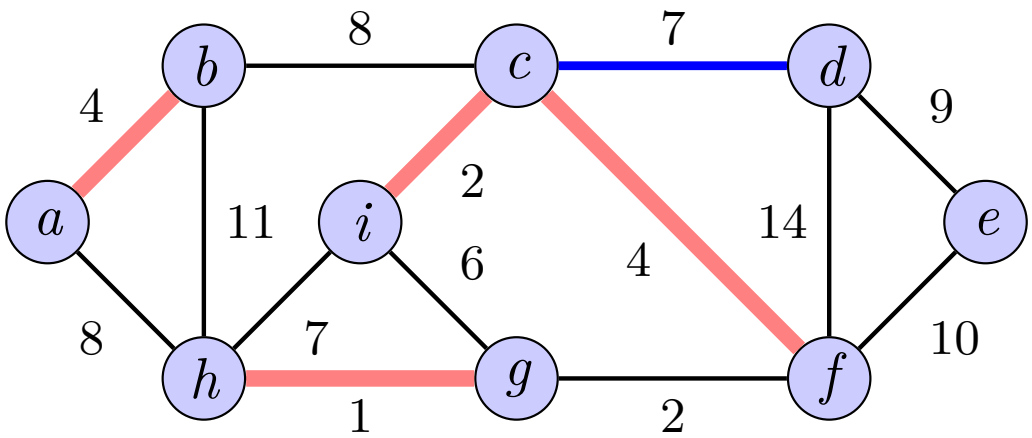
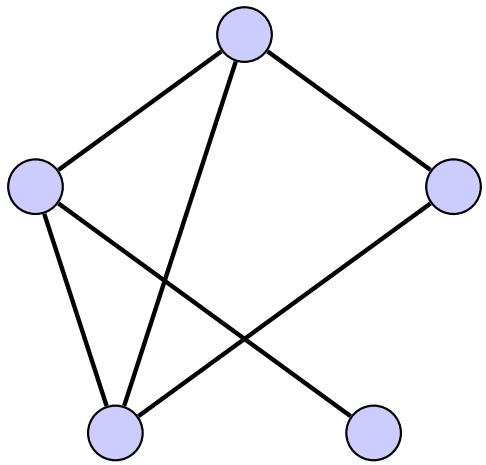


DDD



Pentagon



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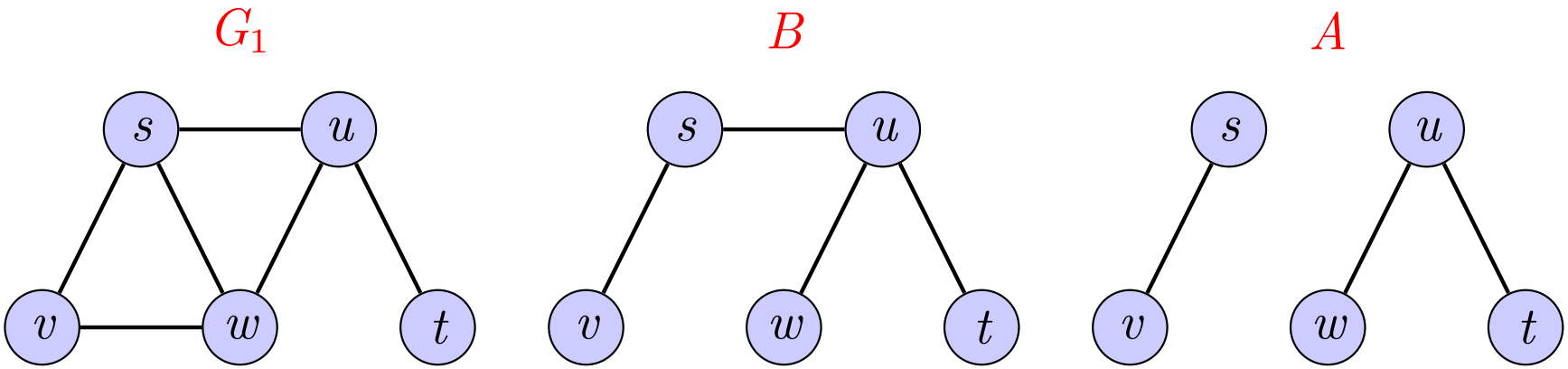

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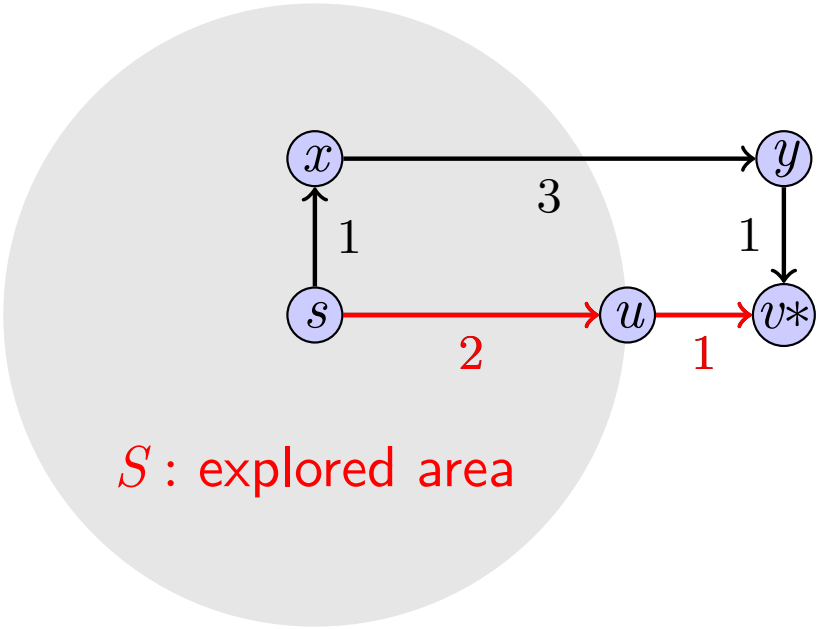

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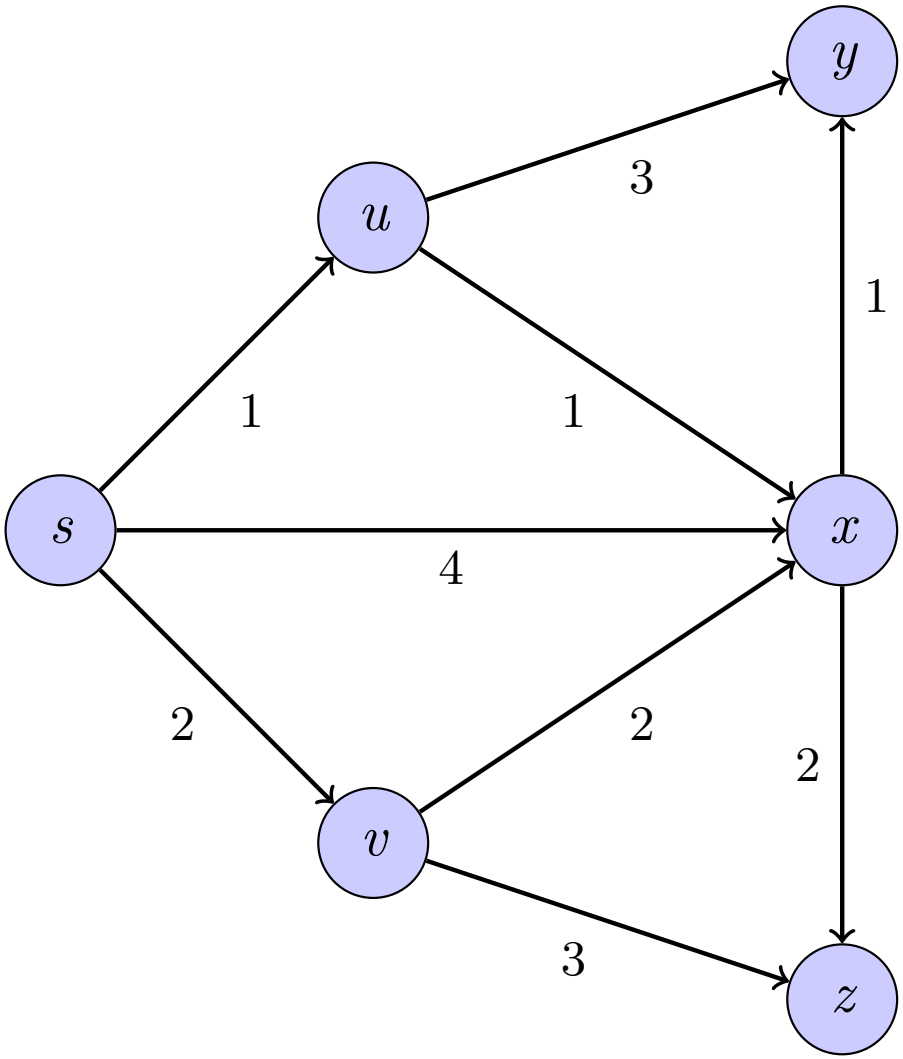

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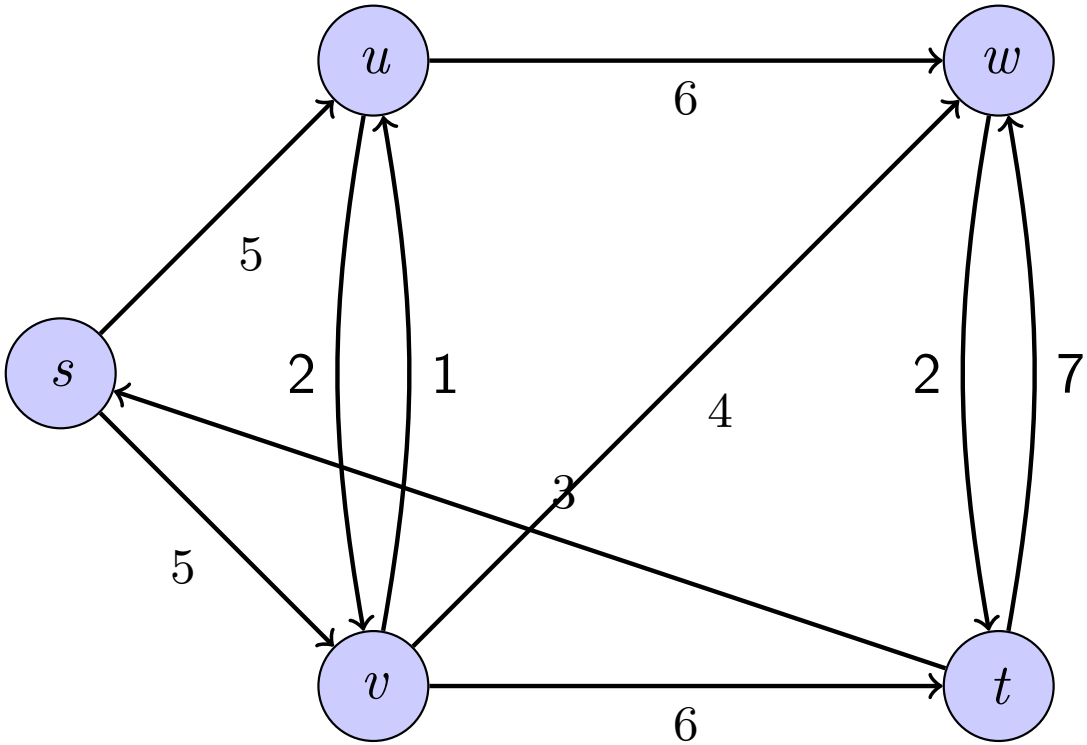


Lec6 Alignment matrix Suffix FULL

4	0	−4	−10	−12	−16	−18	−22	−26	−30	E
5	3	−1	−7	−9	−13	−15	−19	−23	−27	C
3	6	2	−4	−6	−10	−12	−16	−20	−24	N
−1	2	5	−1	−3	−7	−9	−13	−17	−21	E
−5	−2	1	4	0	−4	−6	−10	−14	−18	R
−9	−6	−3	0	3	−1	−3	−7	−11	−15	R
−13	−10	−7	−4	−1	2	0	−4	−8	−12	U
−15	−12	−9	−6	−3	0	3	−1	−5	−9	C
−19	−16	−13	−10	−7	−4	−1	2	−2	−6	C
−23	−20	−17	−14	−11	−8	−5	−2	1	−3	O
−27	−24	−21	−18	−15	−12	−9	−6	−3	0	''

E C N A R R U C O '' S T

Lec6 Alignment matrix Prefix FULL

	S: ''	O	C	U	R	R	A	N	C	E
T:''	0	−3	−6	−9	−12	−15	−18	−21	−24	−27
O	−3	1	−2	−5	−8	−11	−14	−17	−20	−23
C	−6	−2	2	−1	−4	−7	−10	−13	−16	−19
C	−9	−5	−1	1	−2	−5	−8	−11	−12	−15
U	−12	−8	−4	0	0	−3	−6	−9	−12	13
R	−15	−11	−7	−3	1	1	−2	−5	−8	−11
R	−18	−14	−10	−6	−2	2	−	−3	−6	−9
E	−21	−17	−13	−9	−5	−1	1	−1	−4	−5
N	−24	−20	−16	−12	−8	−4	−2	2	−1	−4
C	−27	−23	−19	−15	−11	−7	−5	−1	3	0
E	−30	−26	−22	−18	−14	−10	−8	−4	0	4

Lec7 Shortest Path example FULL

	k=0	1	2	3	4	5
S	0	0	0	0	0	0
U	–	1	1	1	1	1
V	–	2	2	2	2	2
X	–	4	2	2	2	2
Y	–	–	4	3	3	3
Z	–	–	5	4	4	4

Lec6 Alignment matrix Prefix

T: \ S:	''	O	C	U	R	R	A	N	C	E
''	0	−3	−6	−9	−12	−15	−18	−21	−24	−27
O	−3									
C	−6									
C	−9									
U	−12									
R	−15									
R	−18									
E	−21									
N	−24									
C	−27									
E	−30									

Lec6 Step1

OPT

1	2	3	4	
0	6			1
	0	24		2
		0	60	3
			0	4

SPLITTER

1	2	3	4	
	1			1
		2		2
			3	3
				4

Lec6 Step2

OPT

1	2	3	4	
0	6	18		1
	0	24	64	2
		0	60	3
			0	4

SPLITTER

1	2	3	4	
	1	2		1
		2	3	2
			3	3
				4

Lec6 Step3

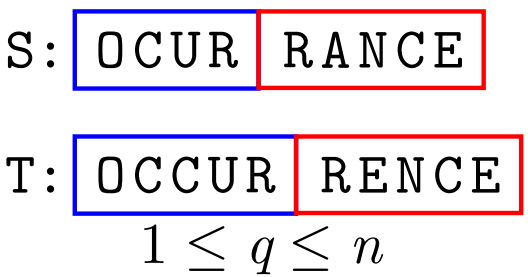
OPT

1	2	3	4	
0	6	18	38	1
	0	24	64	2
		0	60	3
			0	4

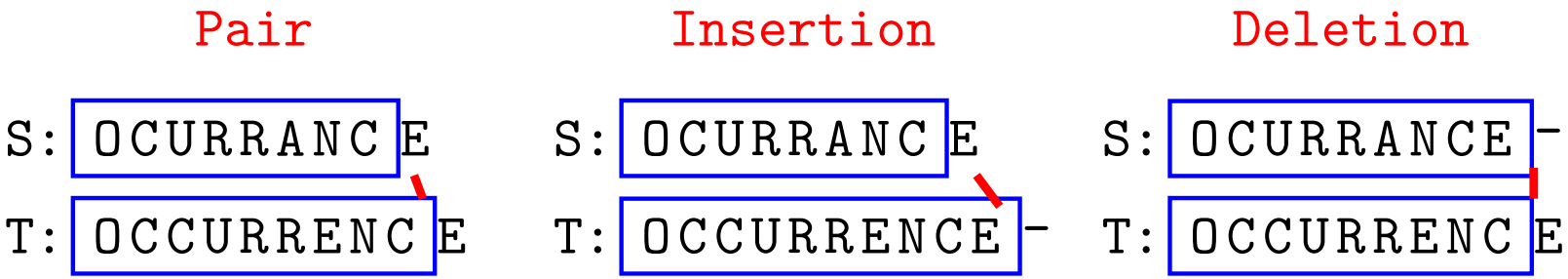
SPLITTER

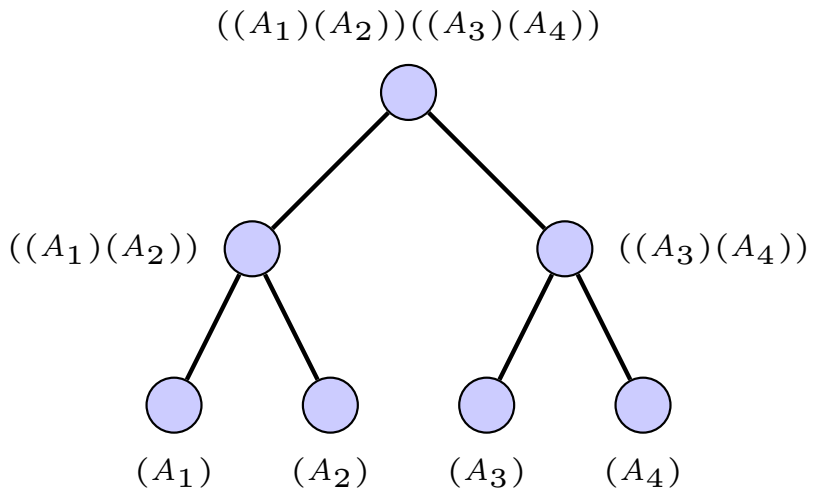
1	2	3	4	
	1	2	3	1
		2	3	2
			3	3
				4

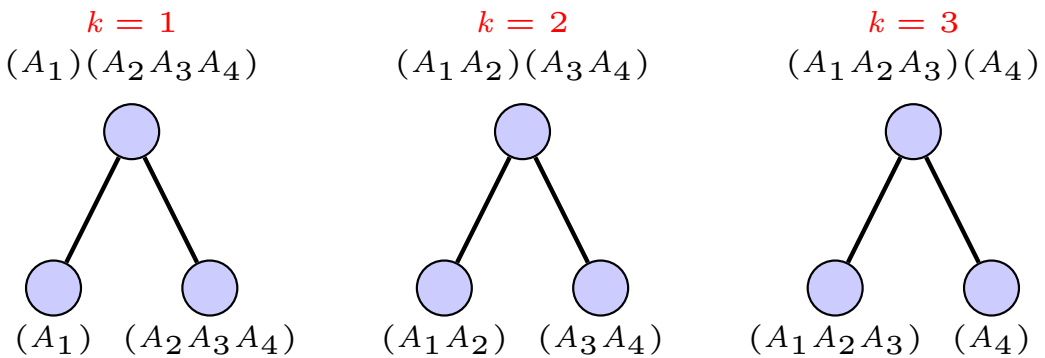
$$\frac{n}{2}$$



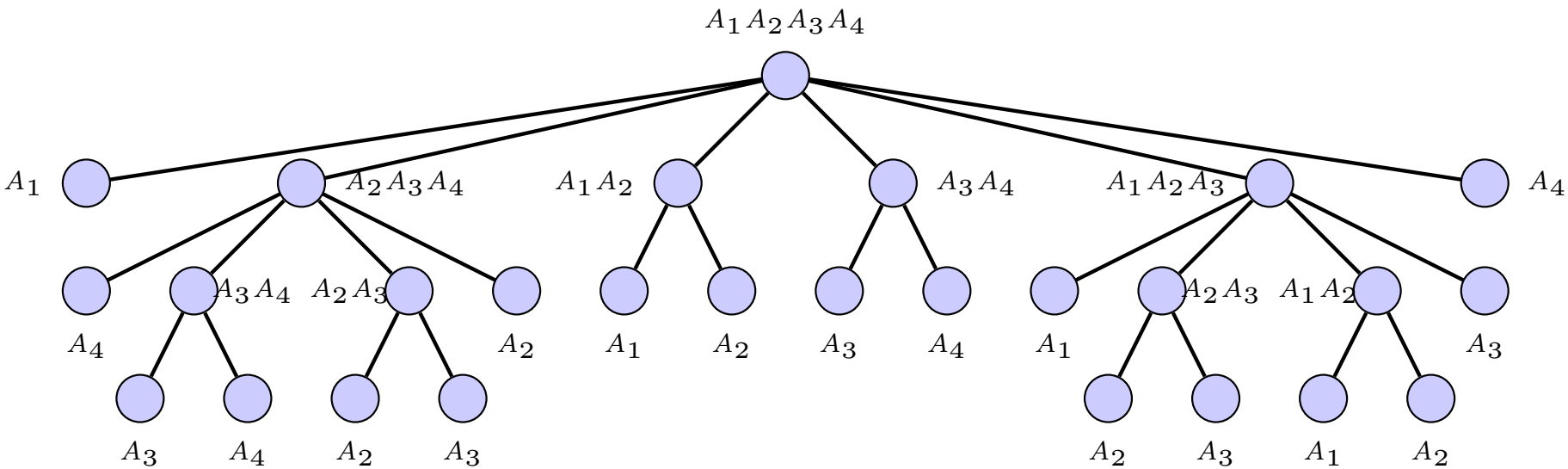
$$1 \leq q \leq n$$

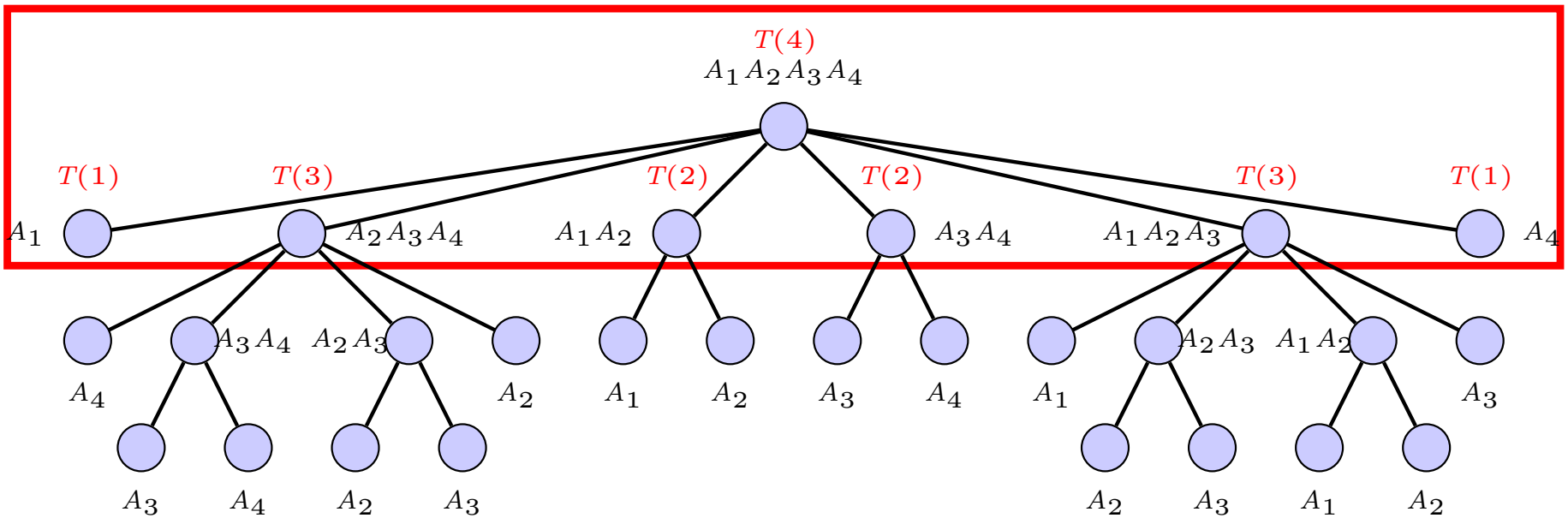

Pair
S: OCURRANC E
T: OCCURRENC E
Insertion
S: OCURRANC E
T: OCCURRENCE -
Deletion
S: OCURRANCE -
T: OCCURRENC E

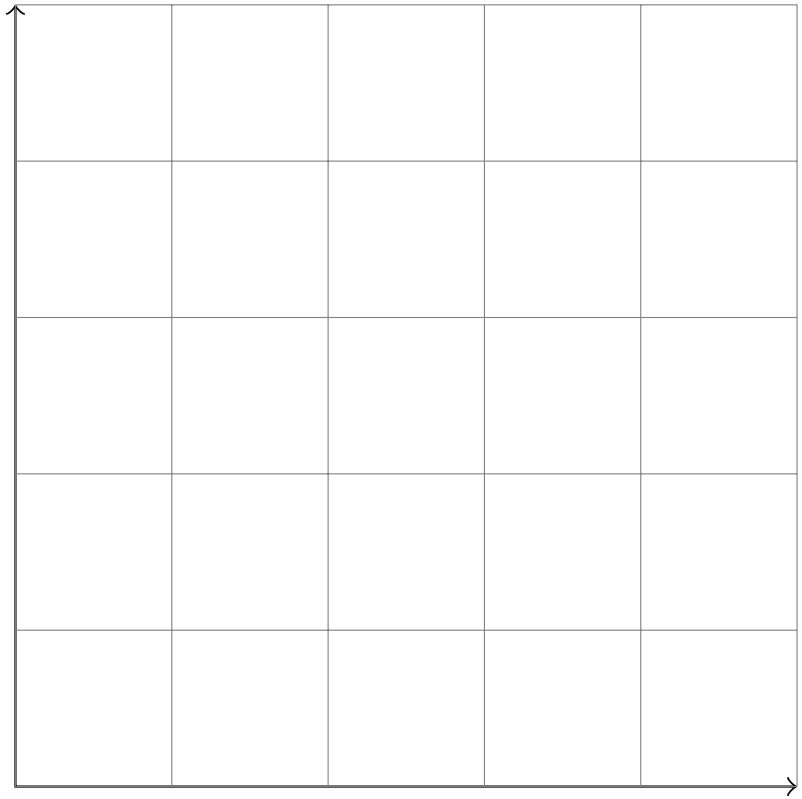

$((A_1)(A_2))((A_3)(A_4))$
$((A_1)(A_2))$
$((A_3)(A_4))$
(A_1)
(A_2)
(A_3)
(A_4)


$k = 1$
$(A_1)(A_2\,A_3\,A_4)$
(A_1)
$(A_2\,A_3\,A_4)$
$k = 2$
$(A_1\,A_2)(A_3\,A_4)$
$(A_1\,A_2)$
$(A_3\,A_4)$
$k = 3$
$(A_1\,A_2\,A_3)(A_4)$
$(A_1\,A_2\,A_3)$
(A_4)

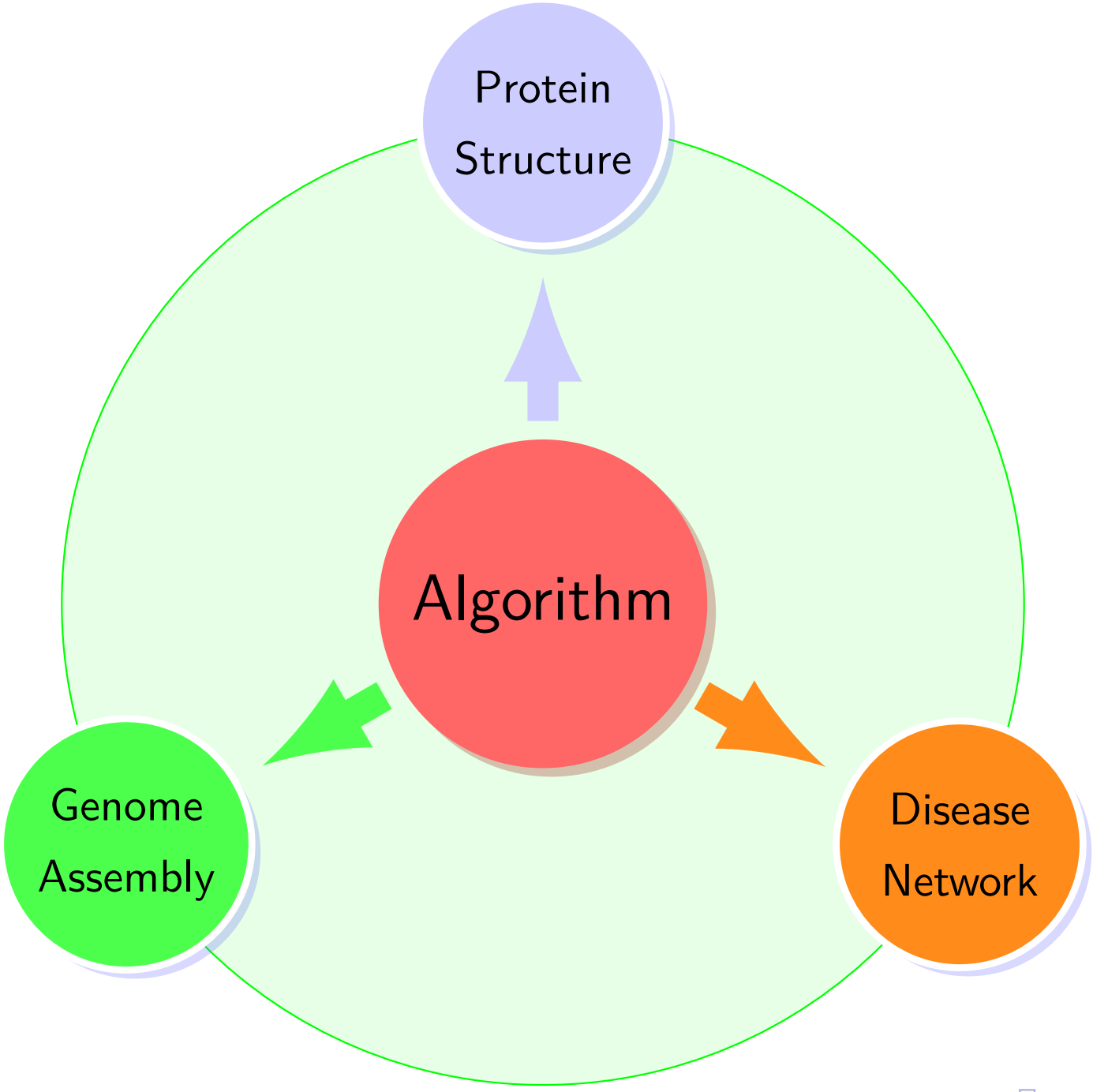
Lec6 DP 3

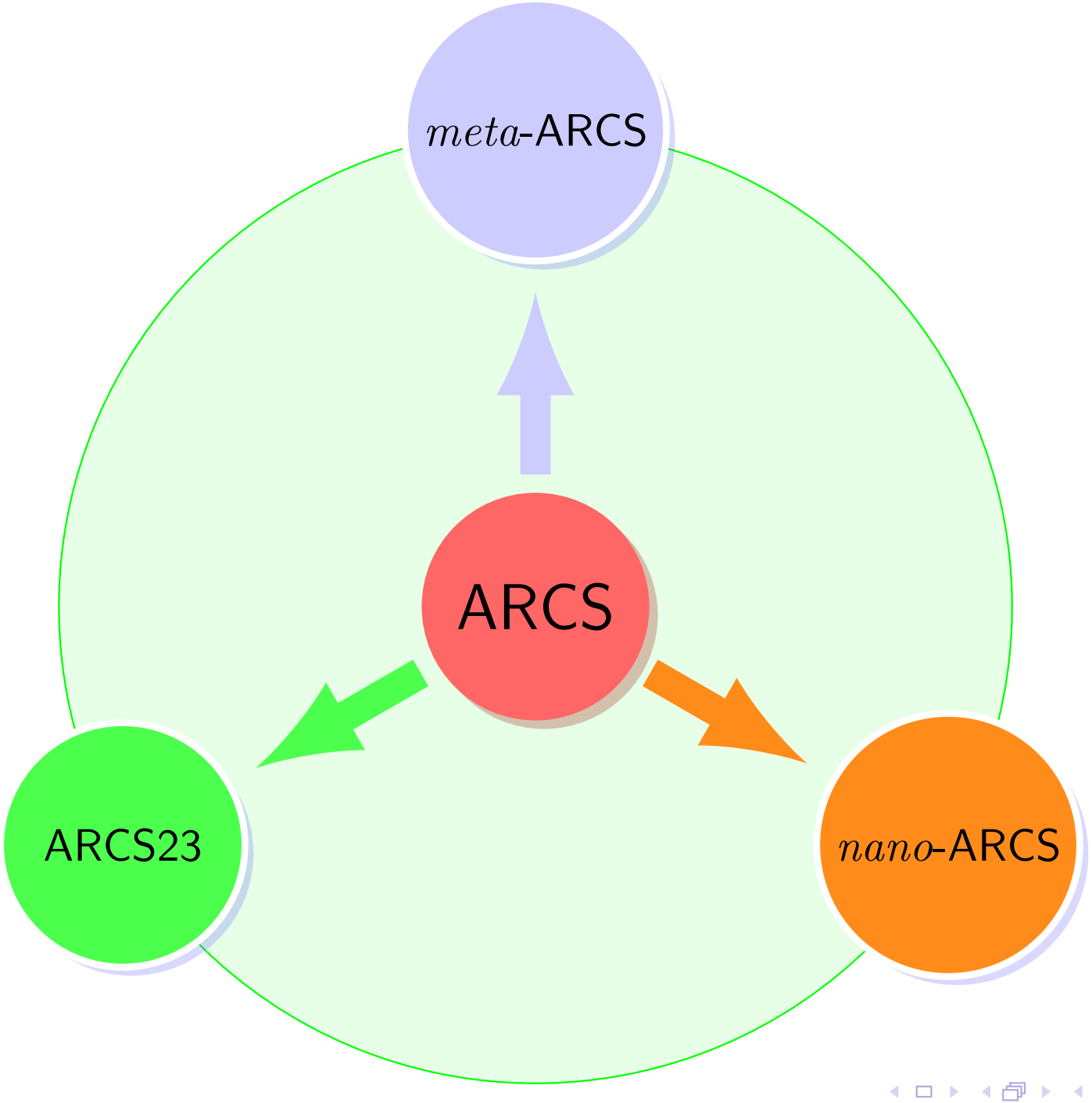

$A_1 A_2 A_3 A_4$
A_1
$A_2 A_3 A_4$
$A_1 A_2$
$A_3 A_4$
$A_1 A_2 A_3$
A_4
A_4
$A_3 A_4$
$A_2 A_3$
A_2
A_1
A_2
A_3
A_4
A_1
$A_2 A_3$
$A_1 A_2$
A_3
A_3
A_4
A_2
A_3
A_2
A_3
A_1
A_2


T(4)
A1 A2 A3 A4
T(1)
T(3)
T(2)
T(2)
T(3)
T(1)
A1
A2 A3 A4
A1 A2
A3 A4
A1 A2 A3
A4
A3 A4
A2 A3
A2
A1
A2
A3
A4
A1
A2 A3
A1 A2
A3
A3
A4
A2
A3
A2
A3
A1
A2

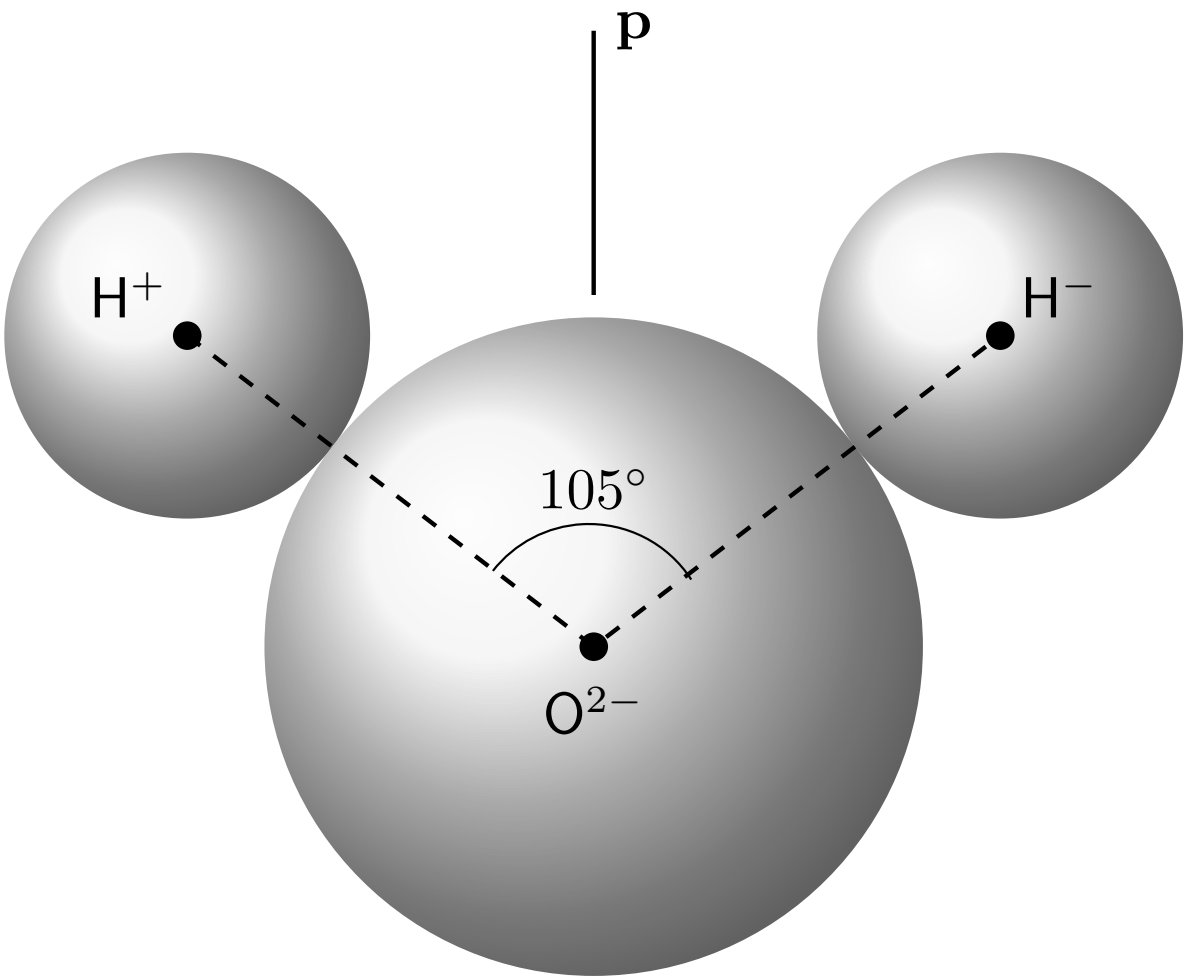


$$
\begin{array}{cccc}
 & 1\times 2 & 2\times 3 & 3\times 4 \qquad\qquad 4\times 5 \\
A_1 = \begin{bmatrix} 1 & 2 \end{bmatrix} & A_2 = \begin{bmatrix} 1 & 2 & 3 \\ 1 & 2 & 3 \end{bmatrix} & A_3 = \begin{bmatrix} 1 & 2 & 3 & 4 \\ 1 & 2 & 3 & 4 \\ 1 & 2 & 3 & 4 \end{bmatrix} & A_4 = \begin{bmatrix} 1 & 2 & 3 & 4 & 5 \\ 1 & 2 & 3 & 4 & 5 \\ 1 & 2 & 3 & 4 & 5 \\ 1 & 2 & 3 & 4 & 5 \end{bmatrix}
\end{array}
$$

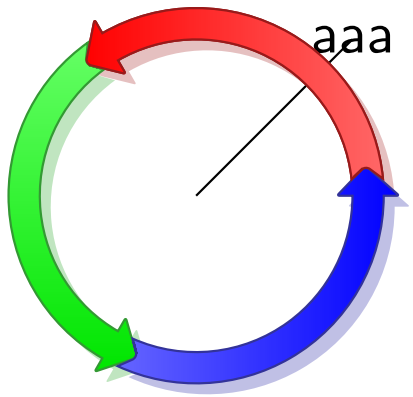

Protein
Structure
Algorithm
Genome
Assembly
Disease
Network


meta-ARCS
ARCS
ARCS23
nano-ARCS

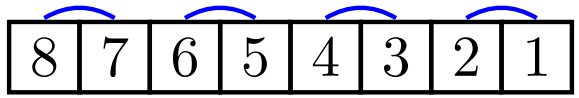
asdf 你好



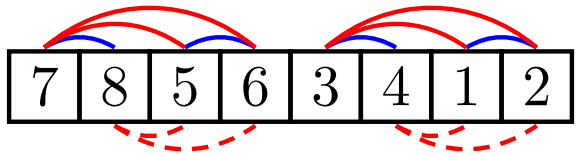
arrow



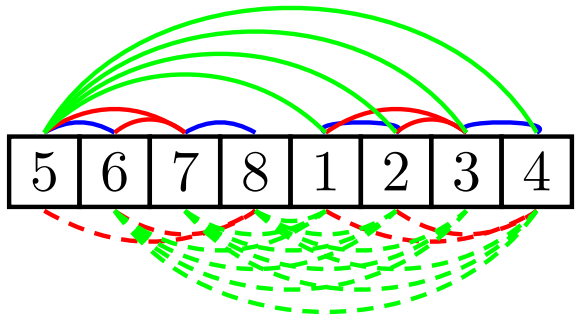
Lec5. Where did we save? Merge sort



MergeSort step 1: 4 ops

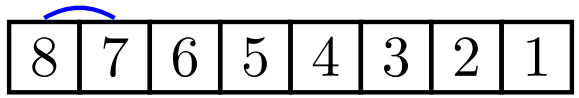


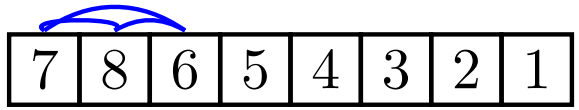
MergeSort step 2: 4 ops, save: 4 ops

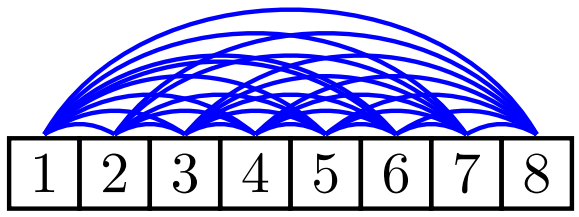


MergeSort step 3: 4 ops, save: 12 ops

Lec5. Where did we save?

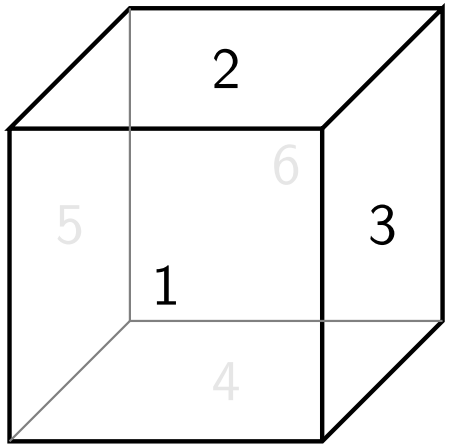




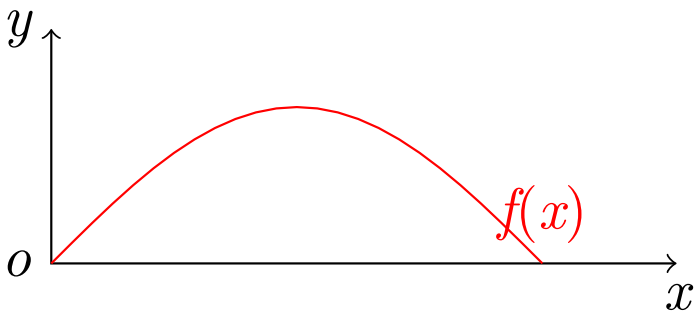


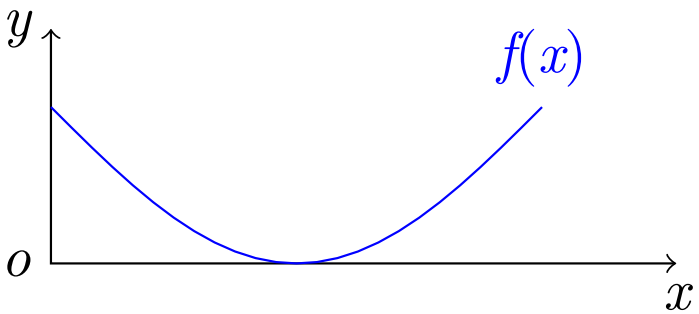
InsertSort: 28 ops

cube

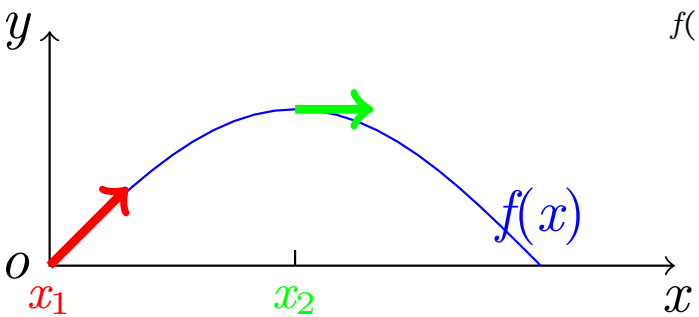


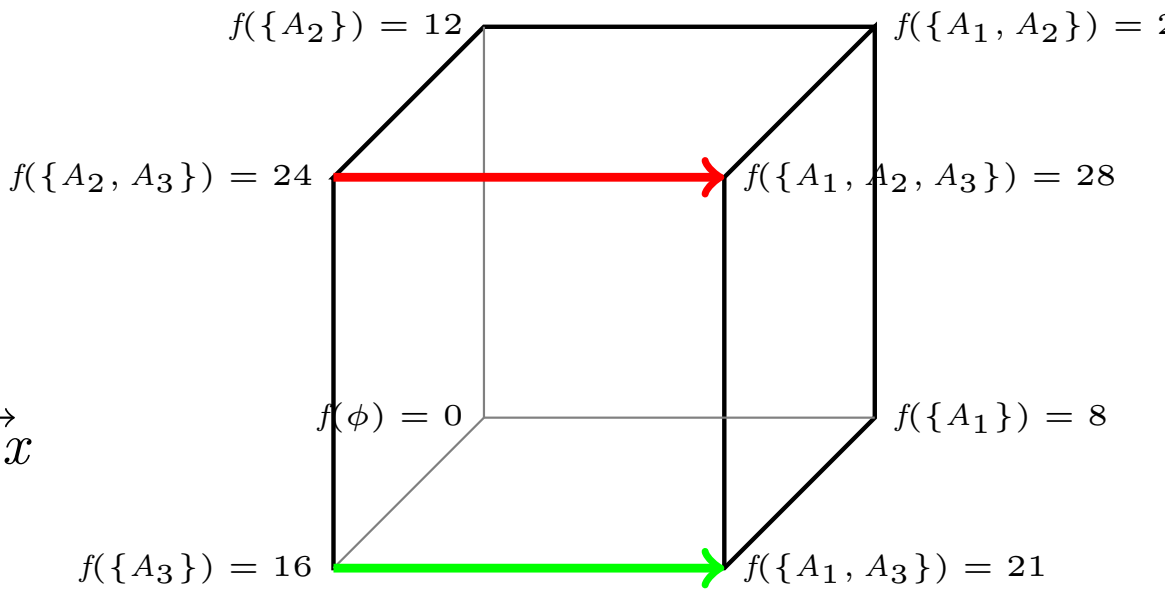
f(x) convex



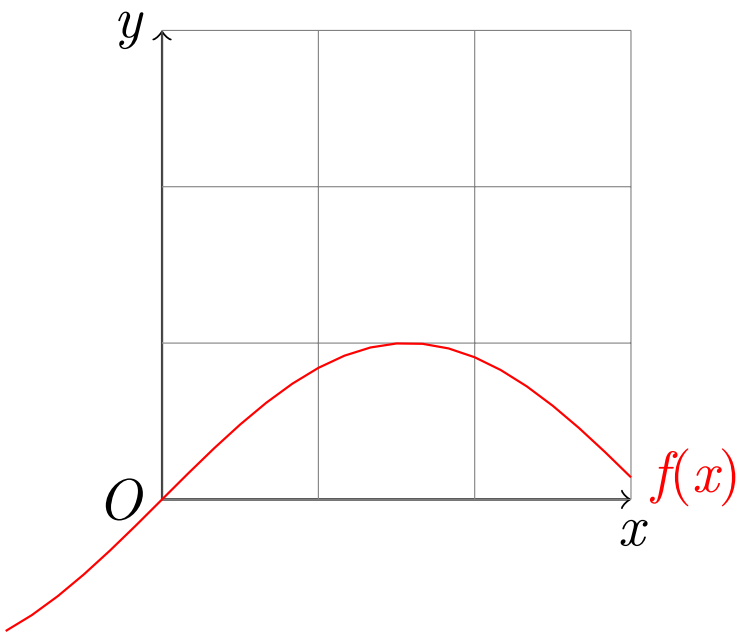


f(x) convex

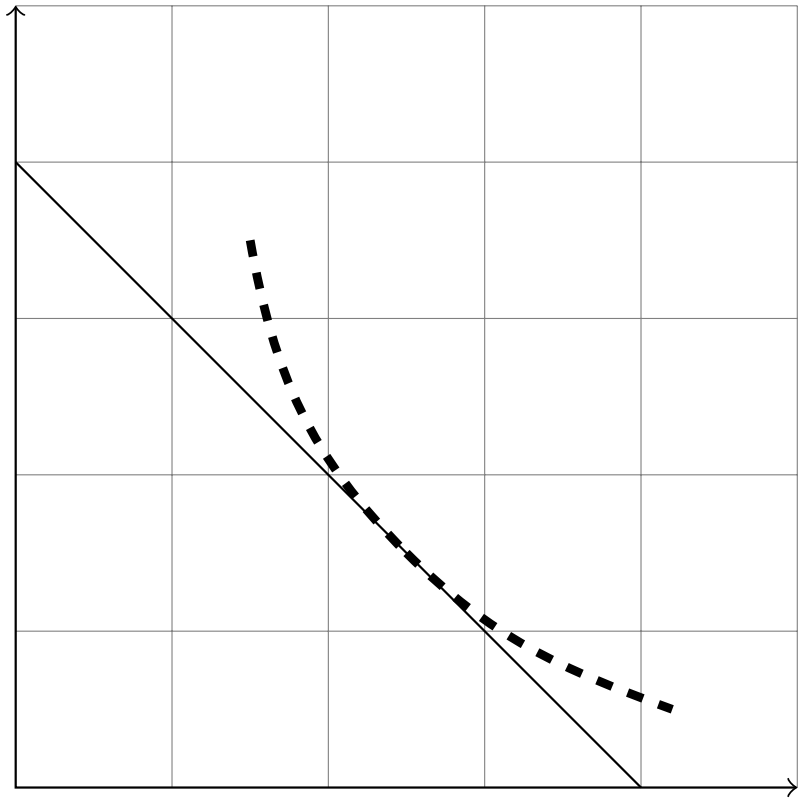

y
o
x_1
x_2
x
$f(x)$


$f(\{A_2\}) = 12$
$f(\{A_1, A_2\}) =$
$f(\{A_2, A_3\}) = 24$
$f(\{A_1, A_2, A_3\}) = 28$
$f(\phi) = 0$
$f(\{A_1\}) = 8$
$f(\{A_3\}) = 16$
$f(\{A_1, A_3\}) = 21$

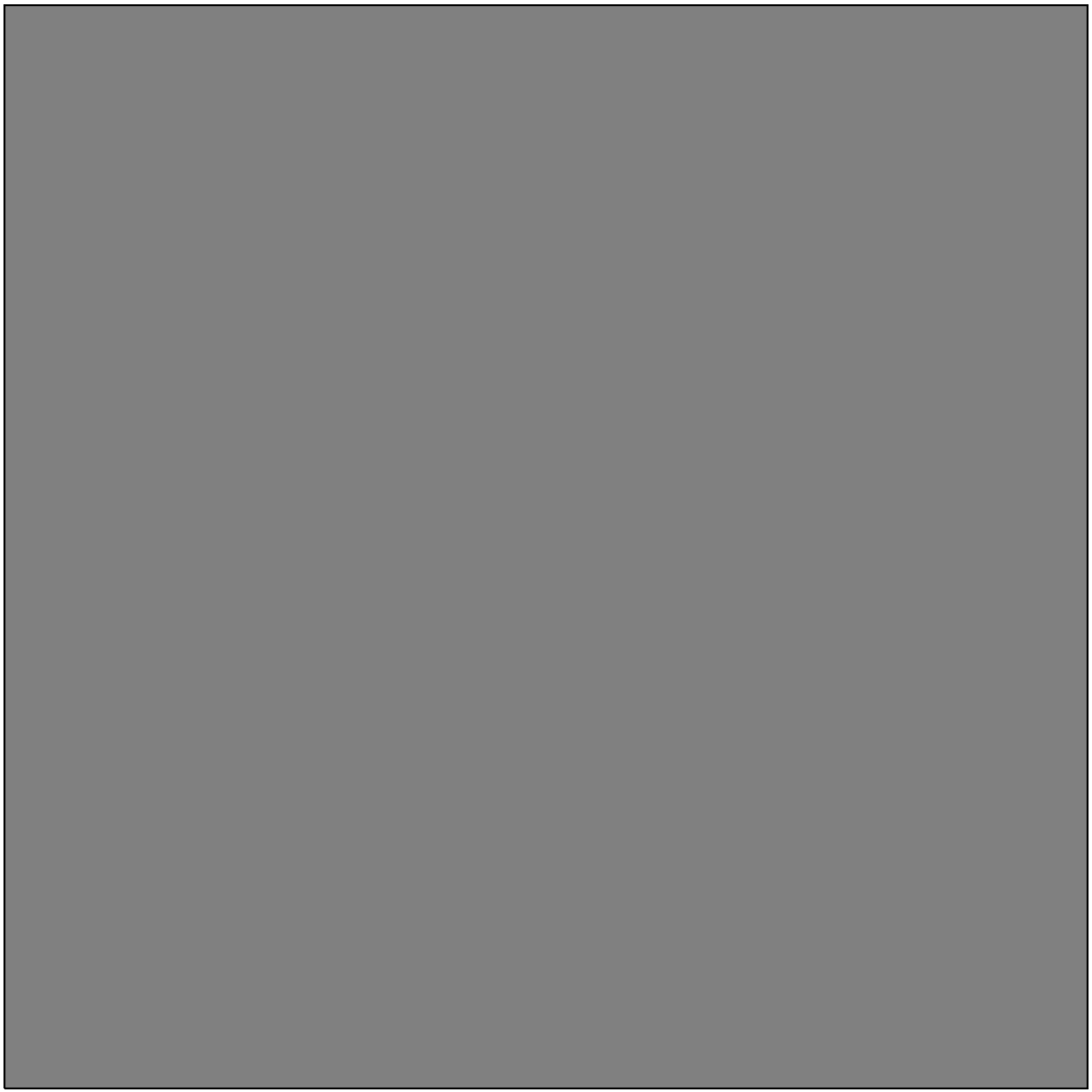
f(x)

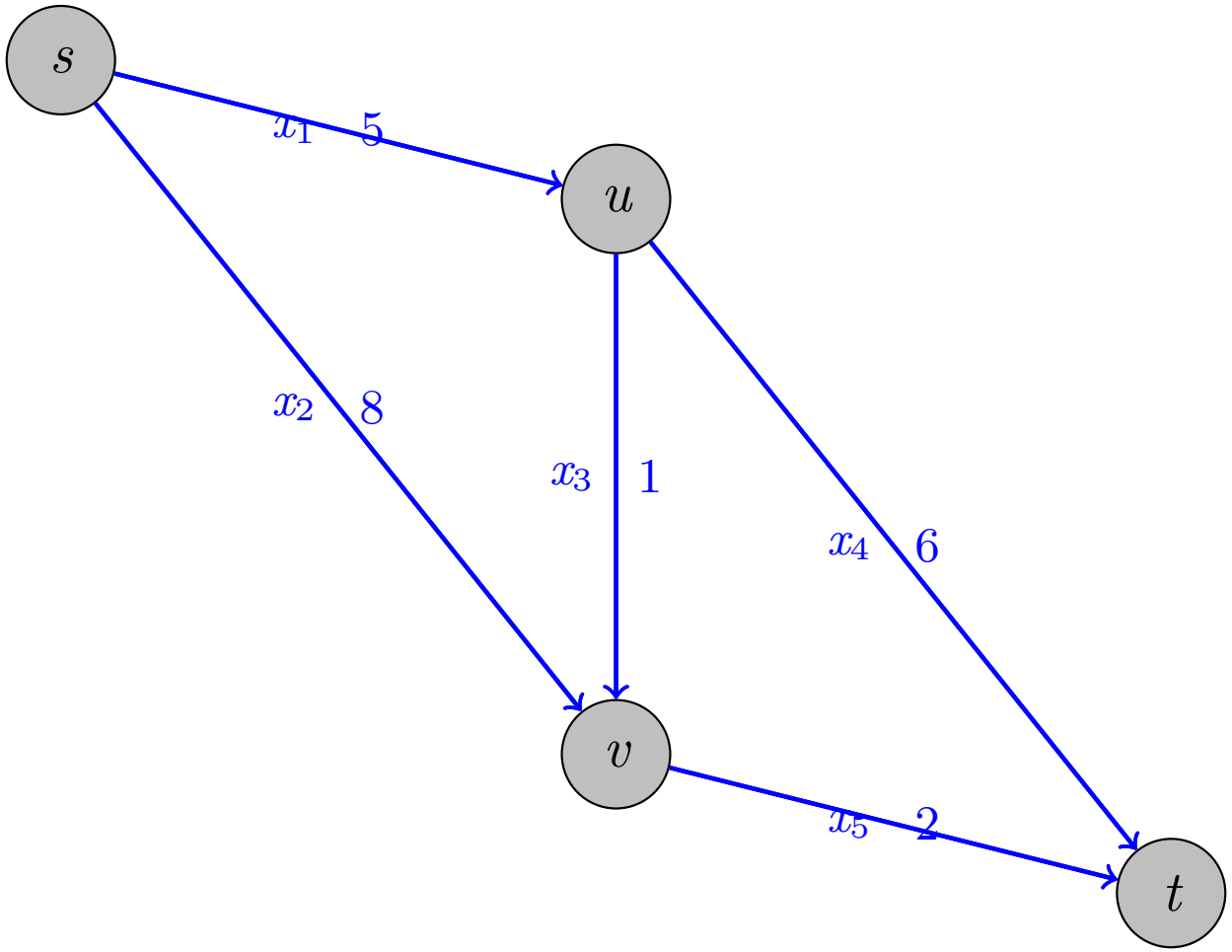


f(x)

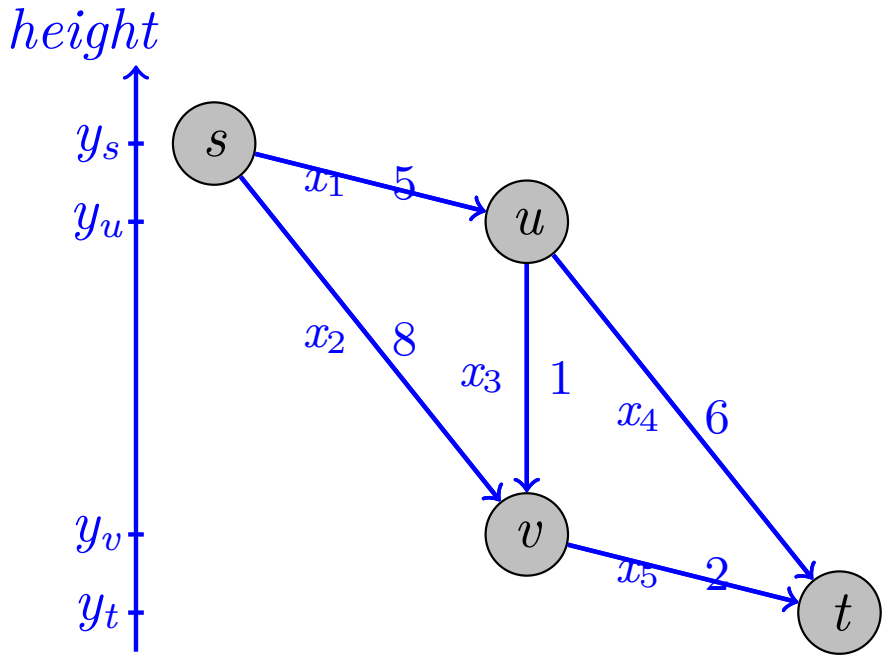


Lec5 Closest Pair n points



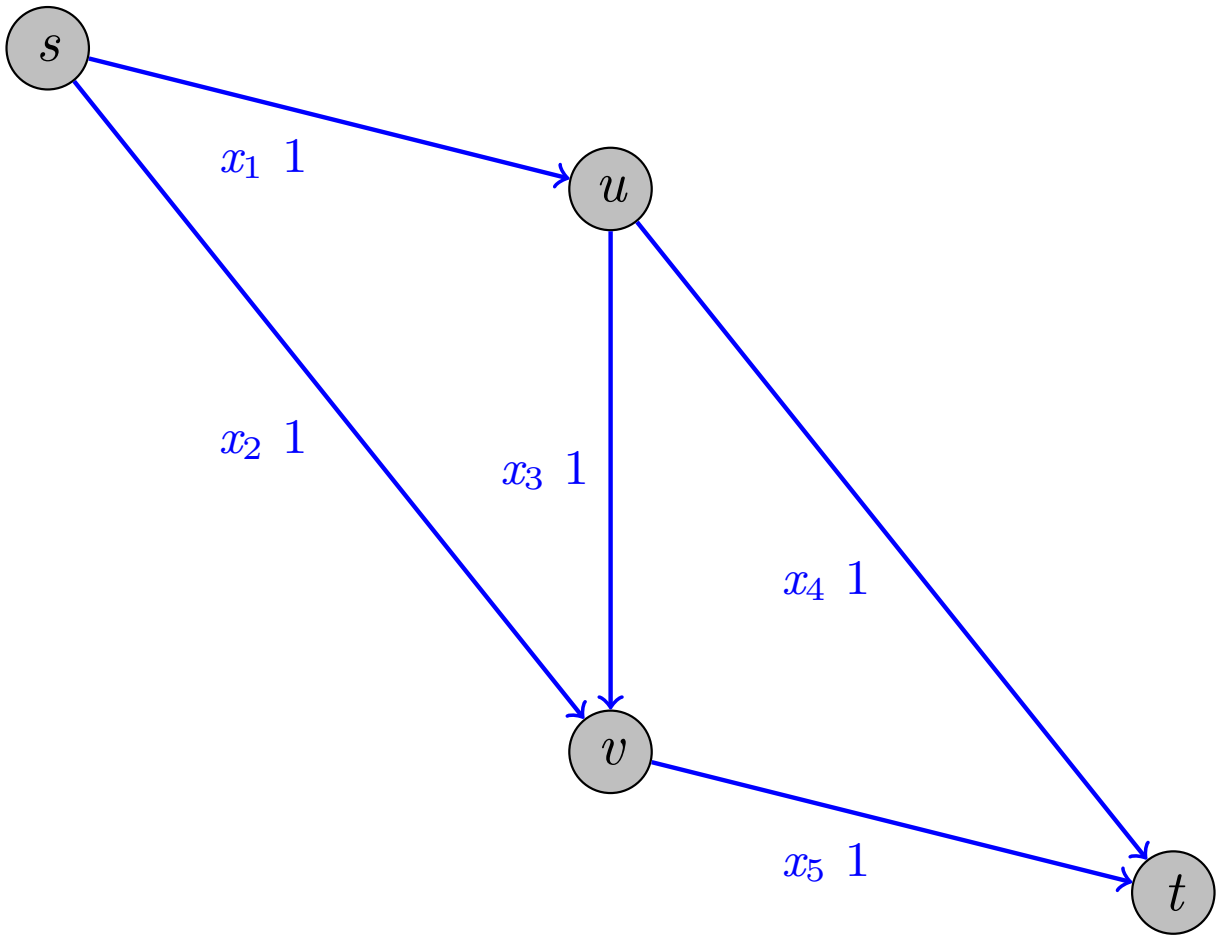

s
u
v
t
x_1 5
x_2 8
x_3 1
x_4 6
x_5 2

Shortest path

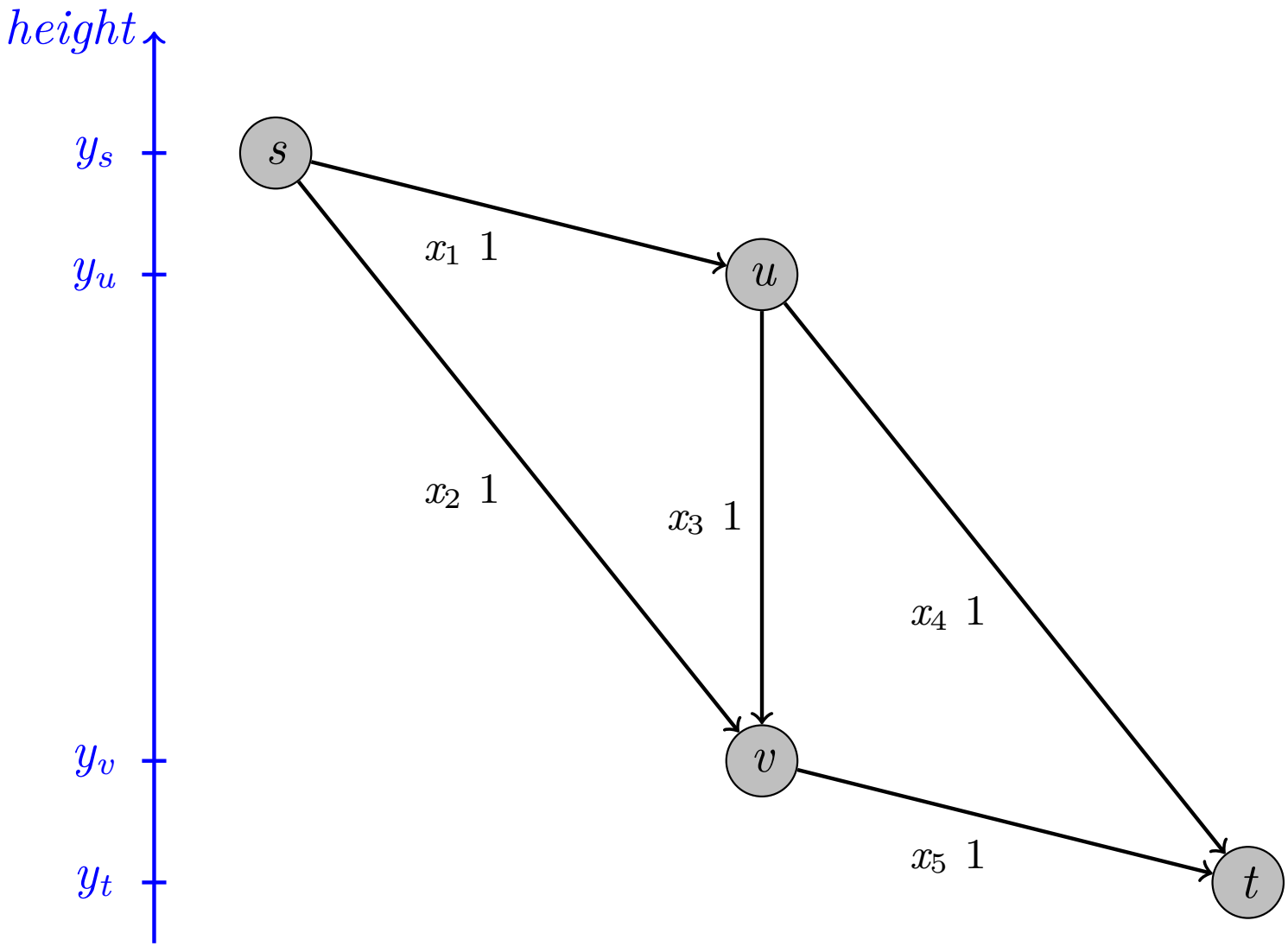


Dual

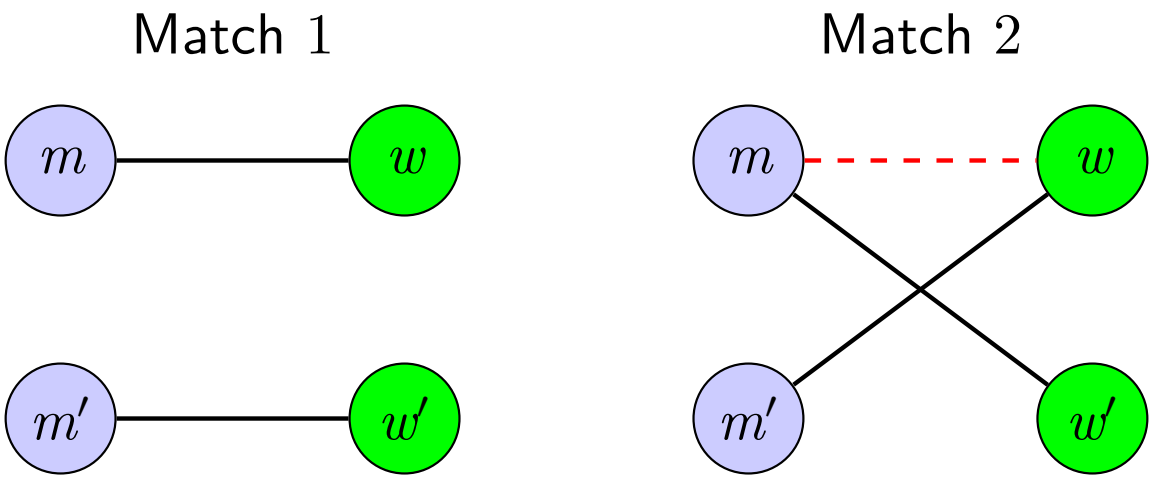
$$
\begin{array}{cccccc}
 & & & x_n = 0 & & \\
 & & & \Uparrow & & \\
c_1 & c_2 & \dots & c_n & & \\
\| & \| & & \vee & \max & \\
y_1\, a_{11} & y_1\, a_{12} & \dots & y_1\, a_{1n} & y_1\, b_1 & \\
+ & + & & + & + & \\
y_2\, a_{21} & y_2\, a_{22} & \dots & y_2\, a_{2n} & y_2\, b_2 & \\
+ & + & & + & + & \\
\vdots & \vdots & \dots & \vdots & \vdots & \\
+ & + & & + & + & \\
y_m\, a_{m1} & y_m\, a_{m2} & \dots & y_m\, a_{mn} & y_m\, b_m &
\end{array}
$$


s
u
v
t
x_1 1
x_2 1
x_3 1
x_4 1
x_5 1

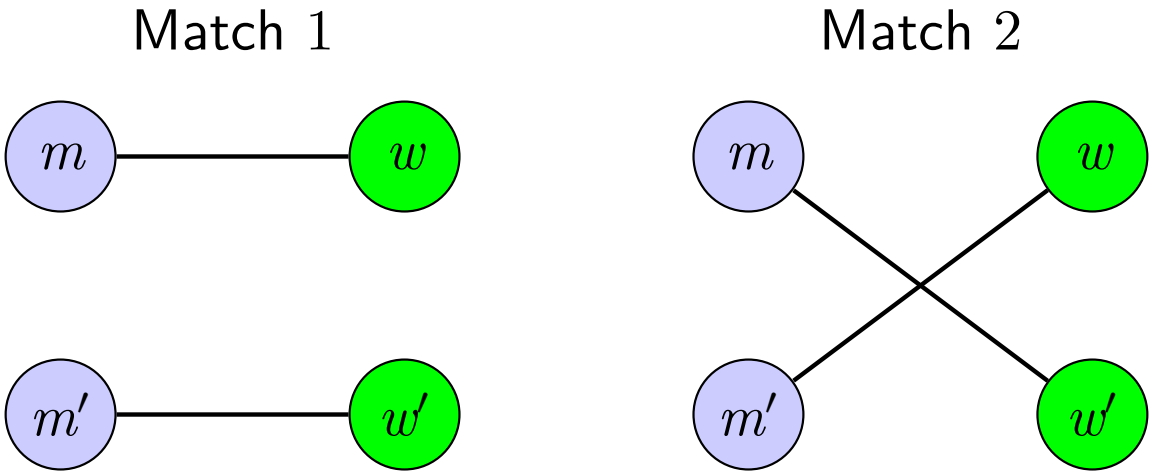
dual of shortest path



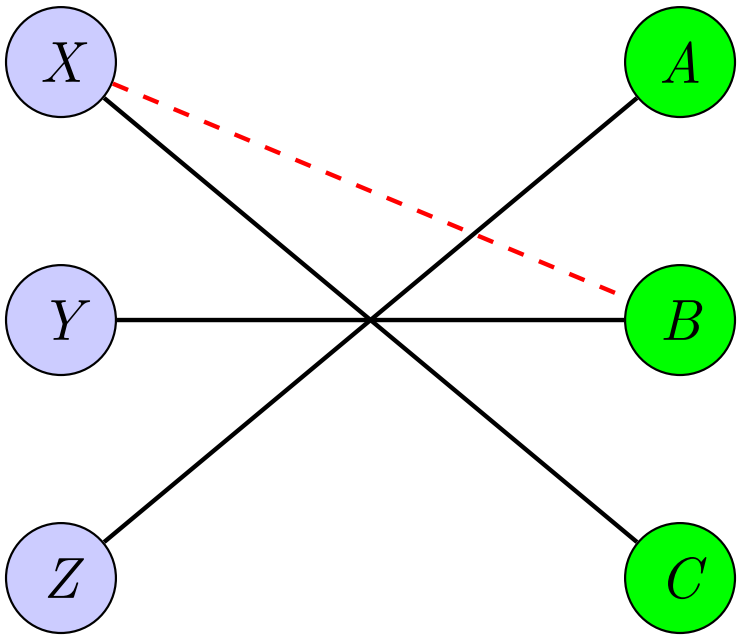
Stable 1



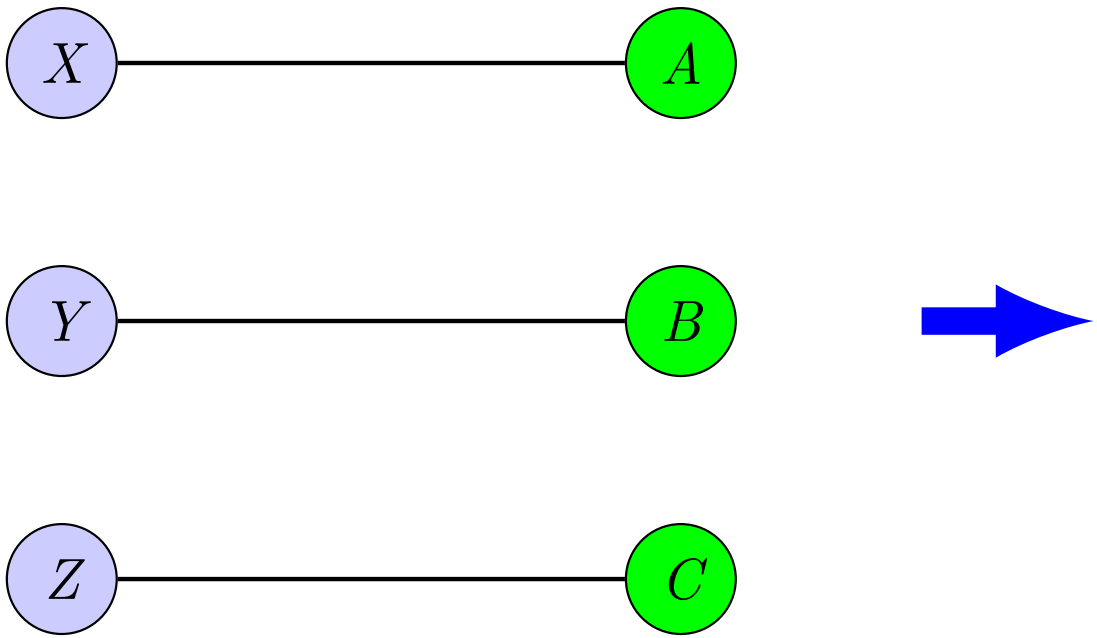
Stable 2



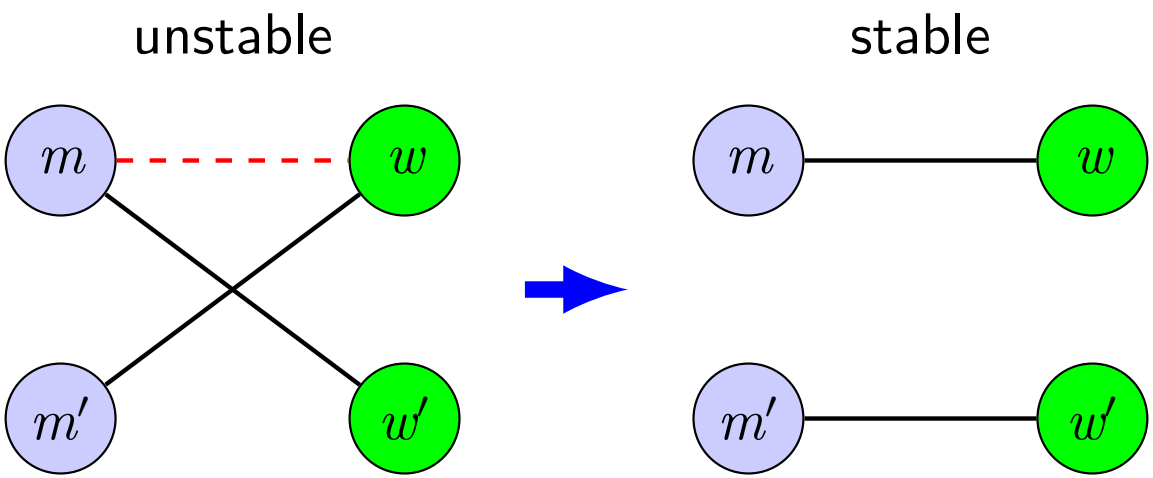
Stable 4



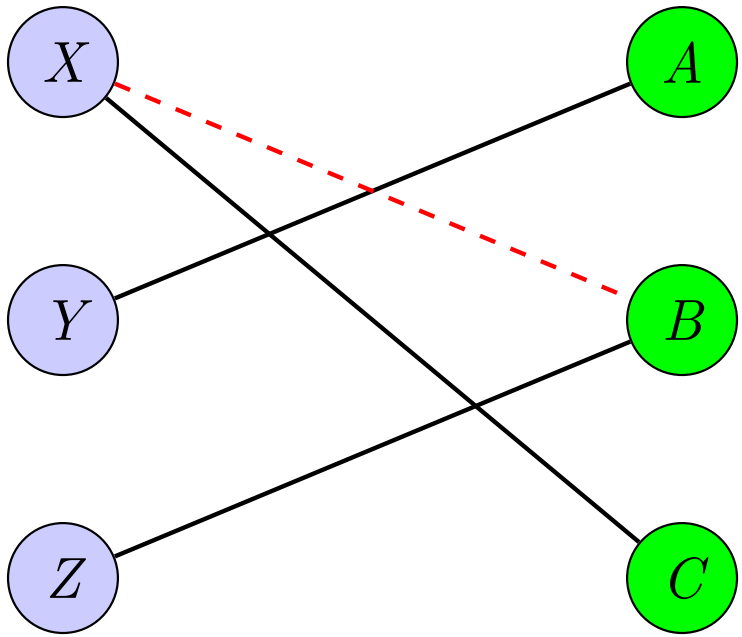
Stable 5



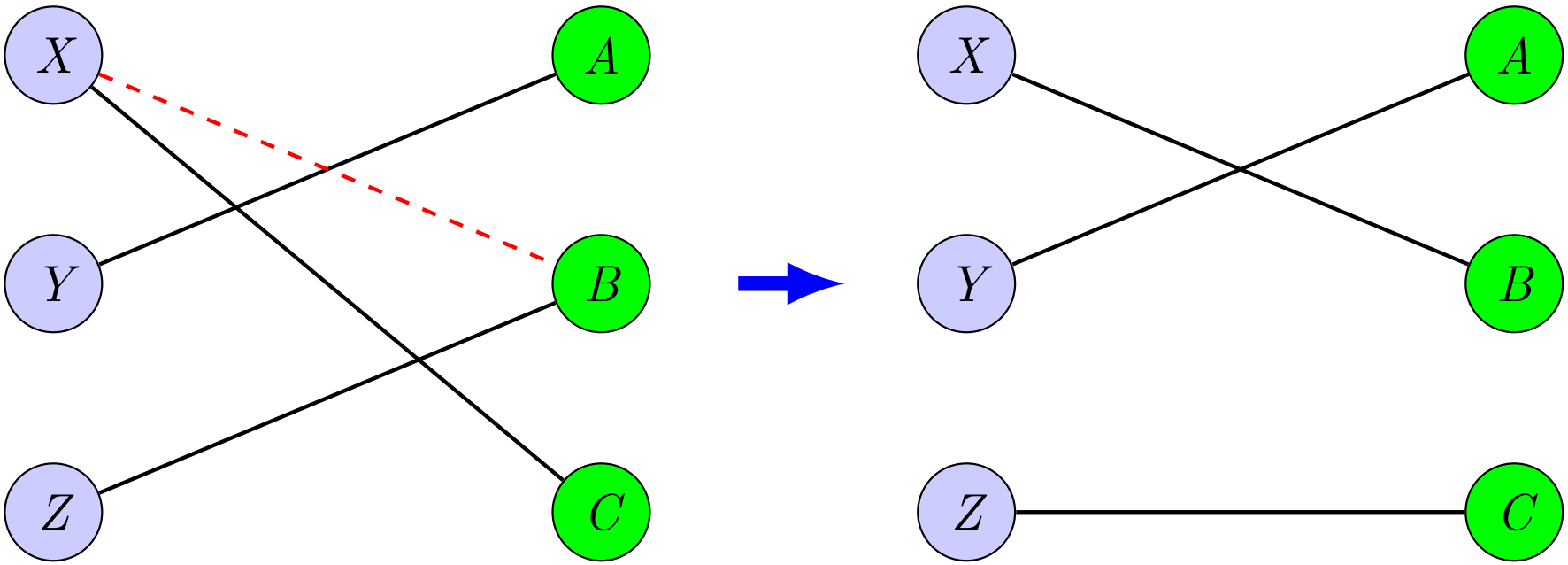
Stable 6



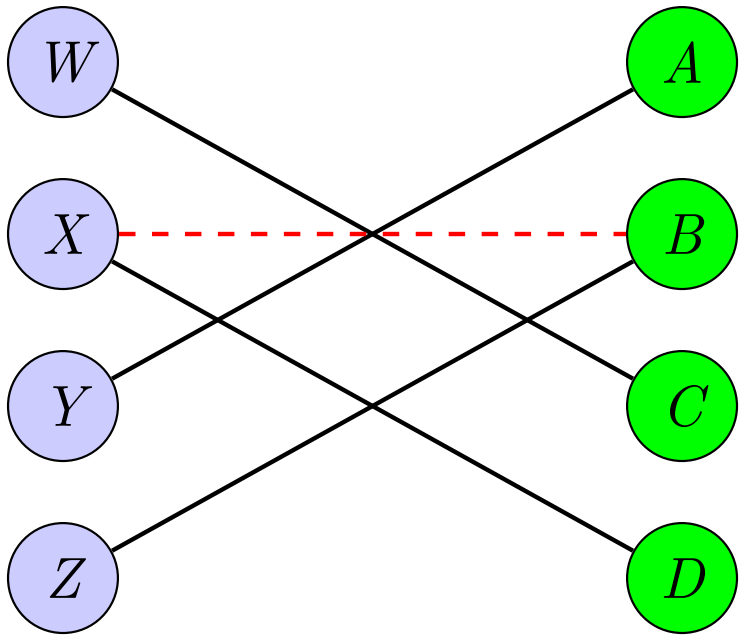
Stable 7



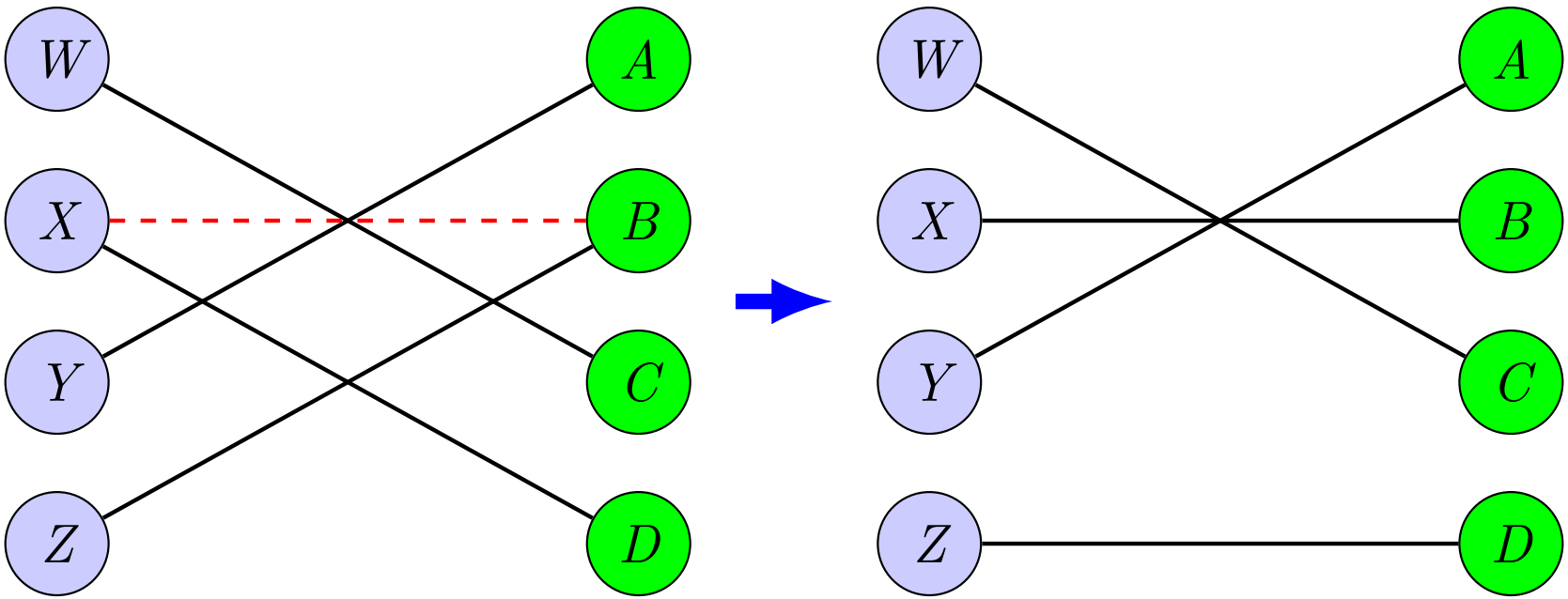
Stable 8



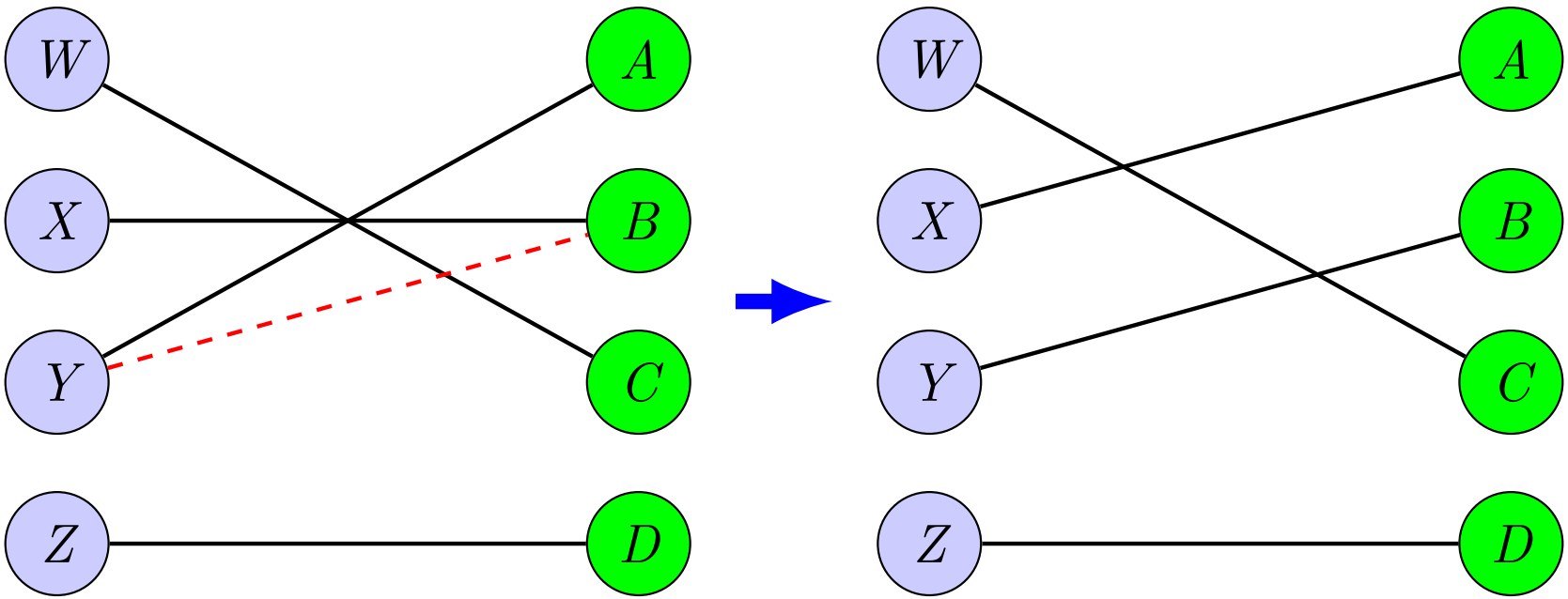
Stable 9



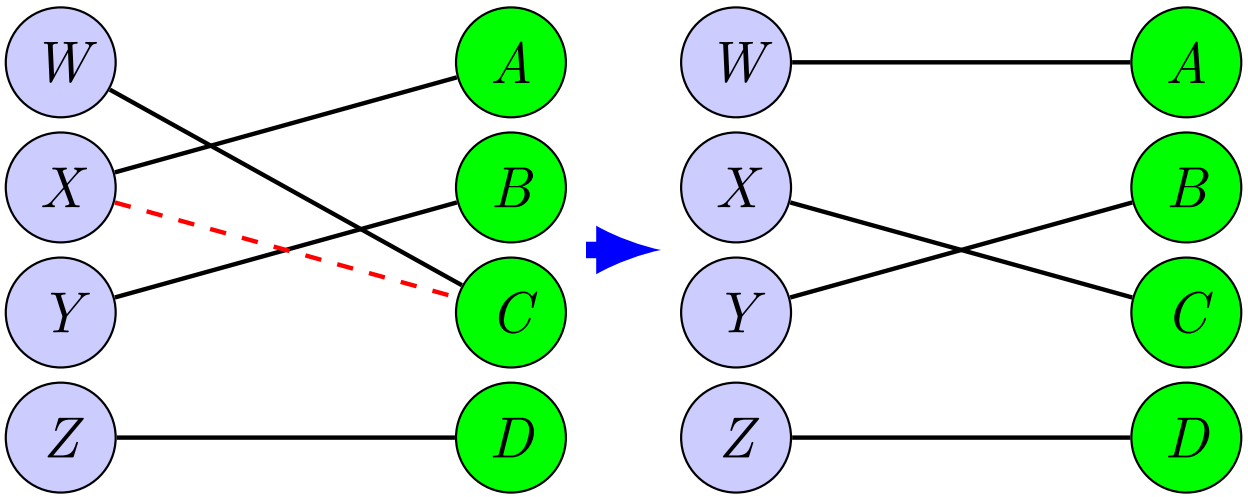
Stable 10



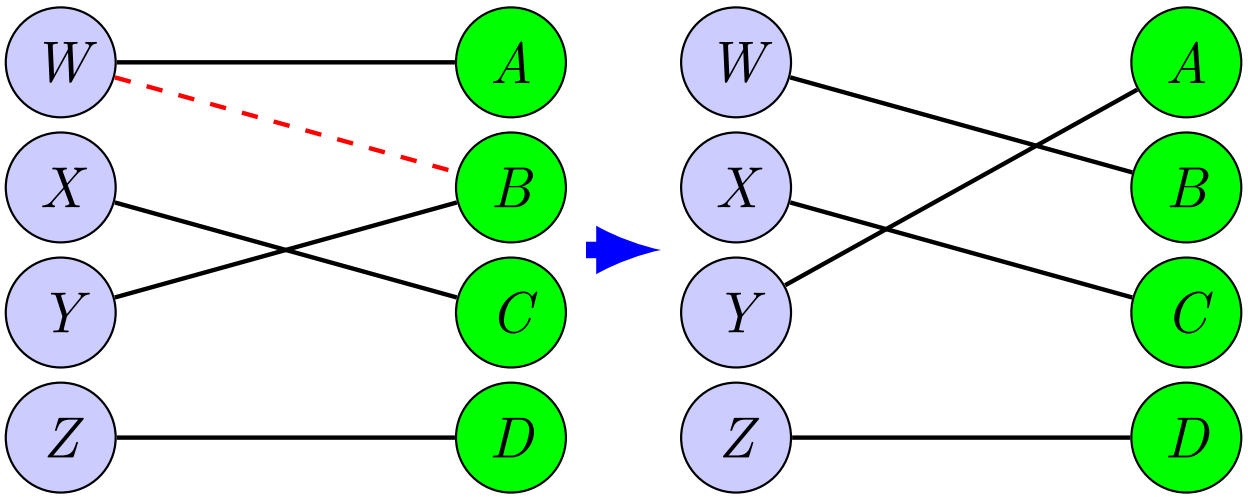
Stable 11



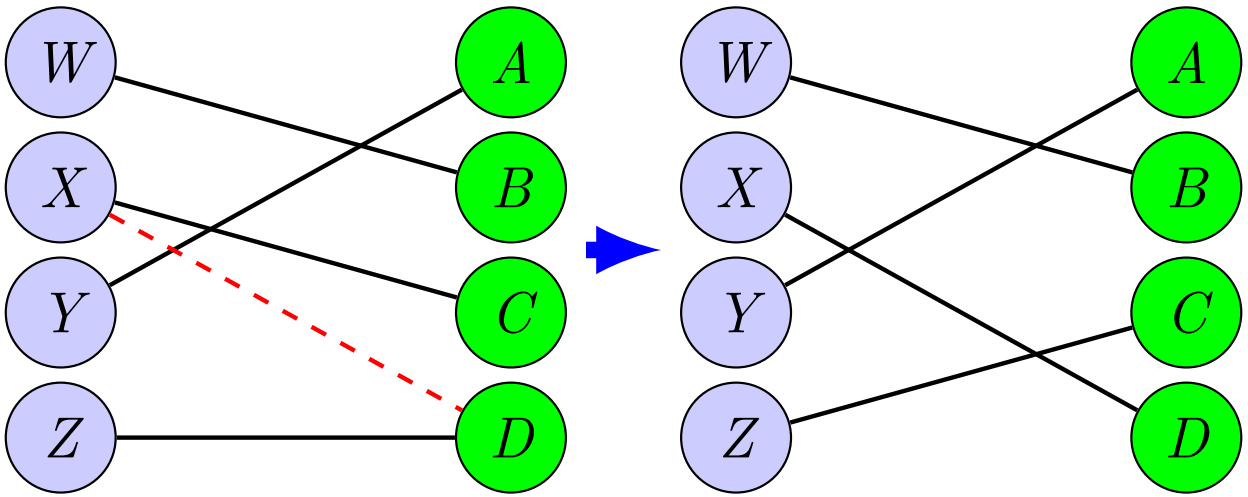
Stable 12



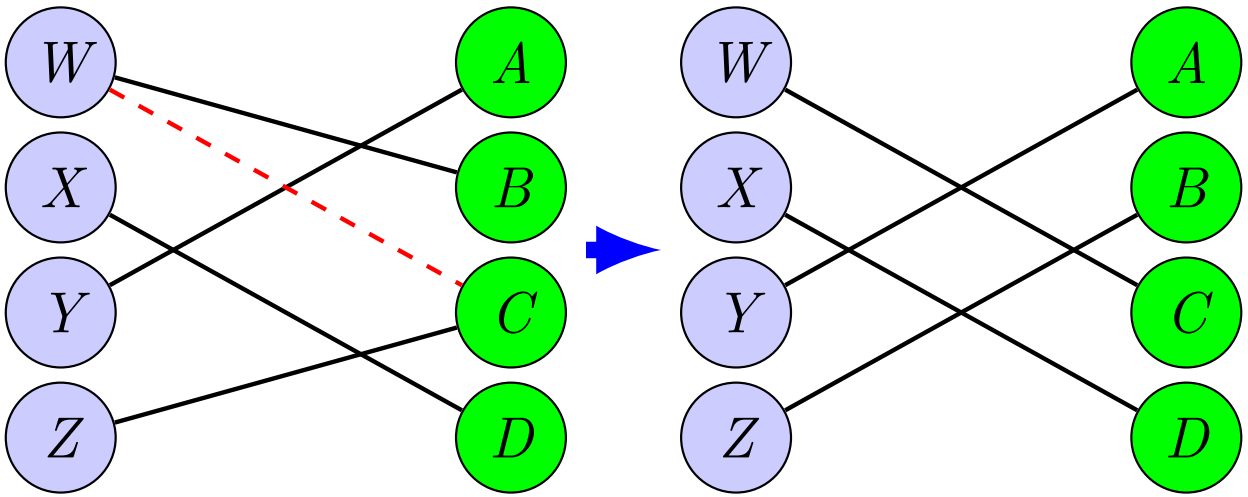
Stable 13



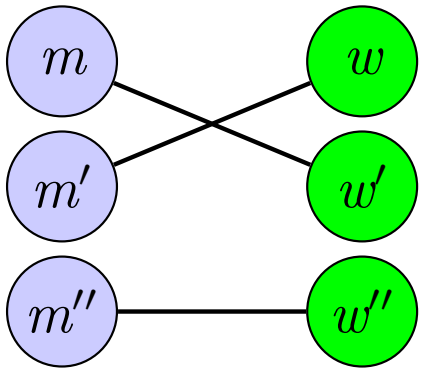
Stable 14



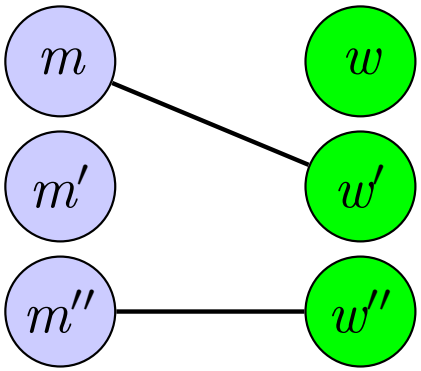
Stable 15



Stable Proof 1

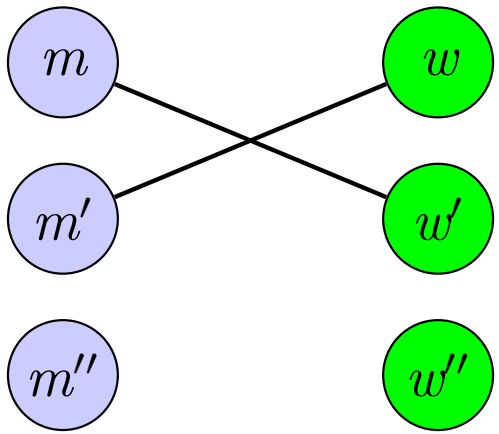


complete solution

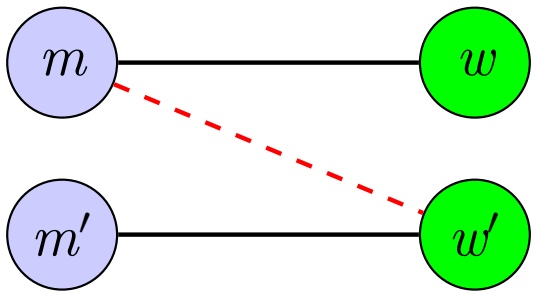


partial solution

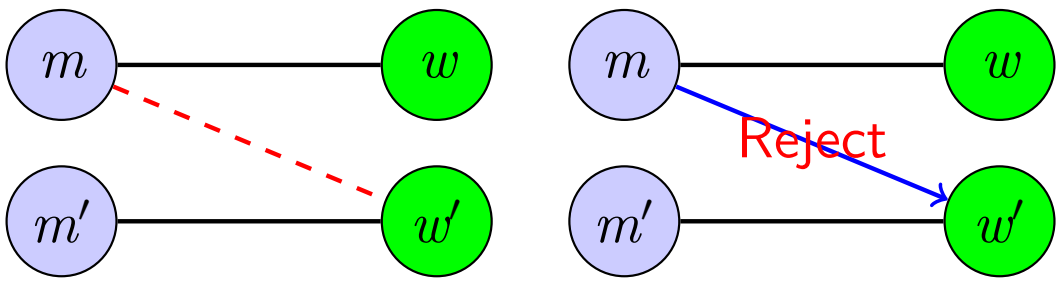
Stable Proof 2



Stable Proof 3



Stable Proof 4



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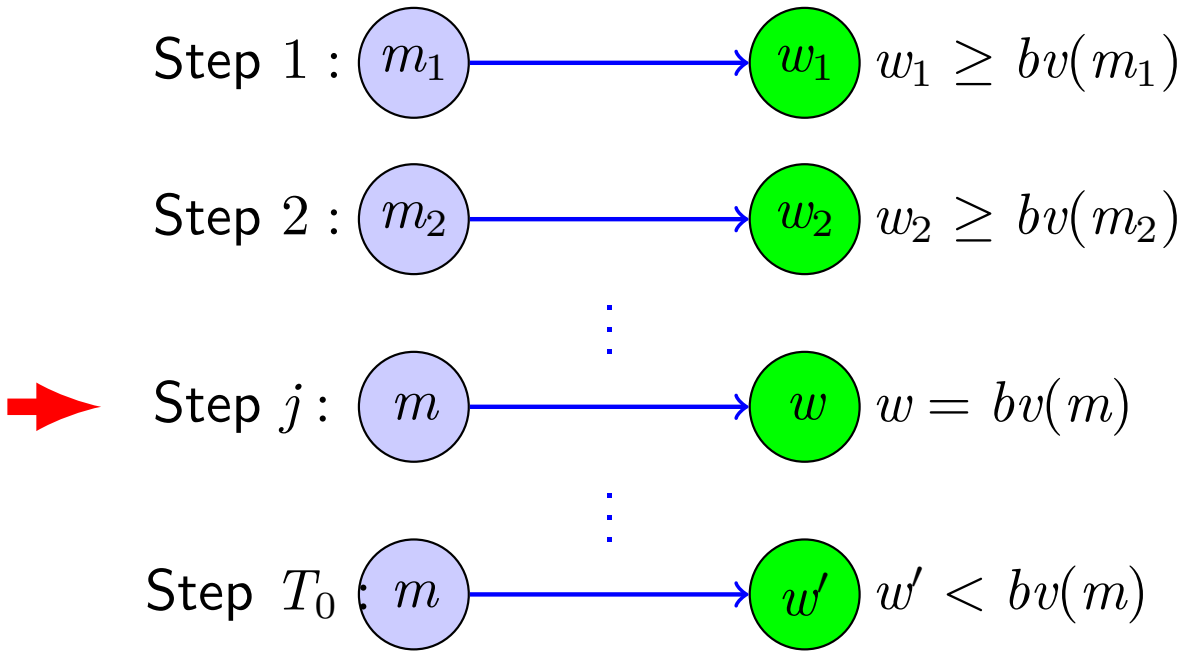
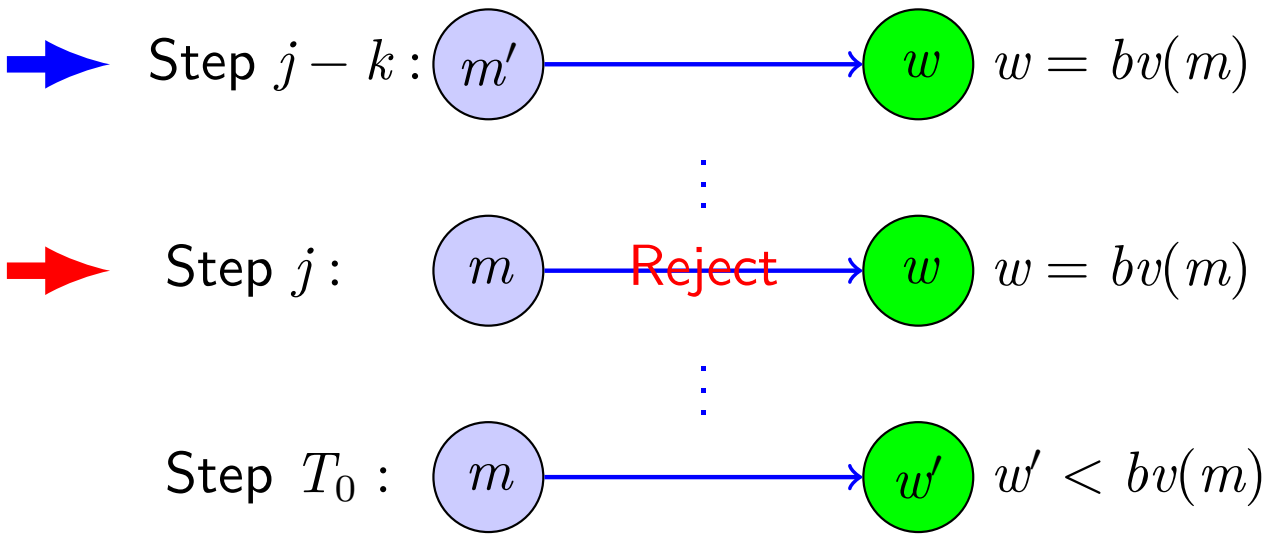
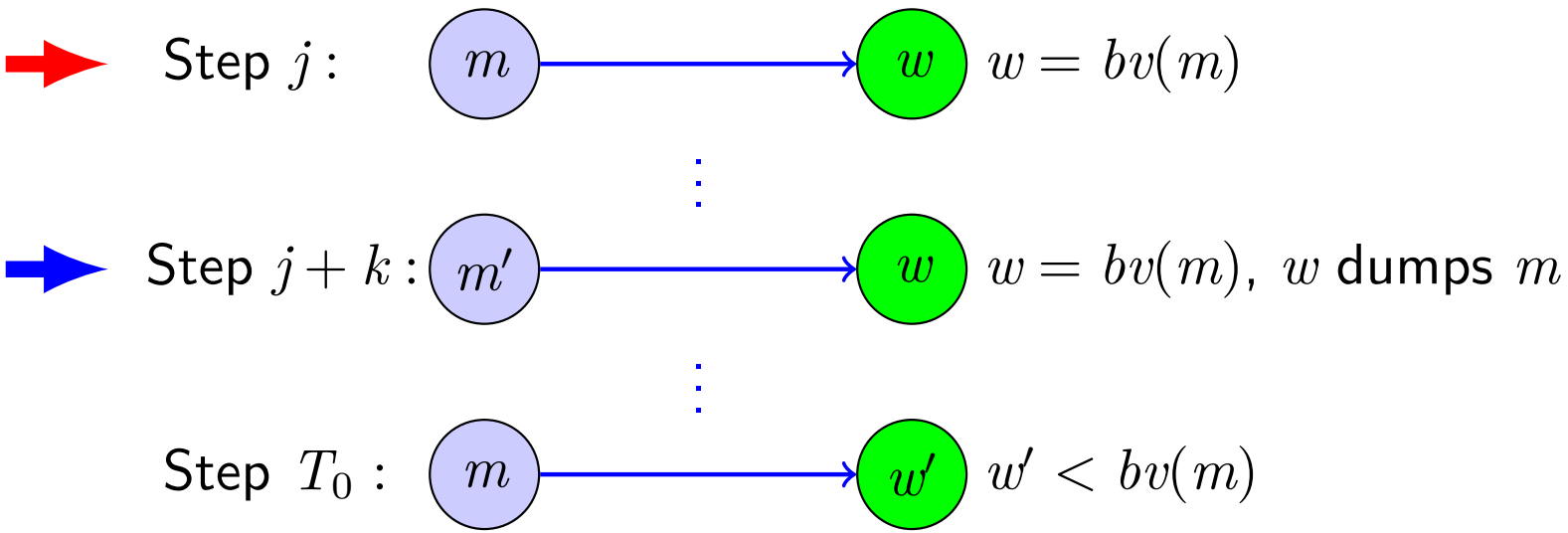


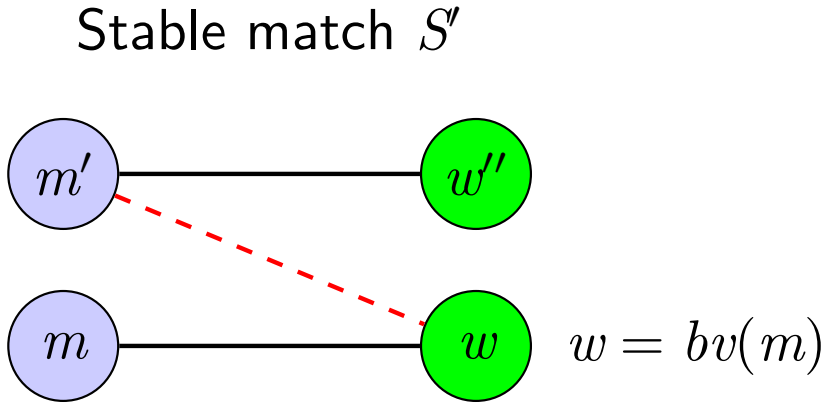
Stable Proof 6



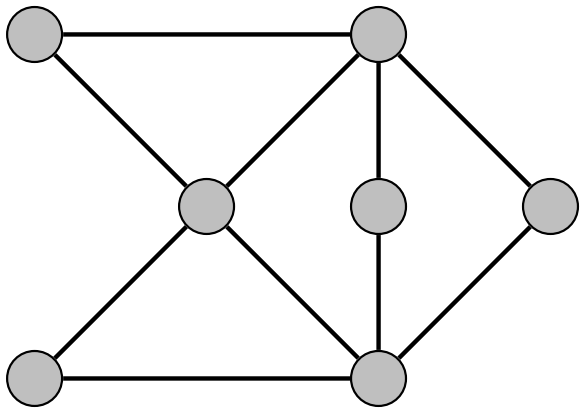
Stable Proof 7

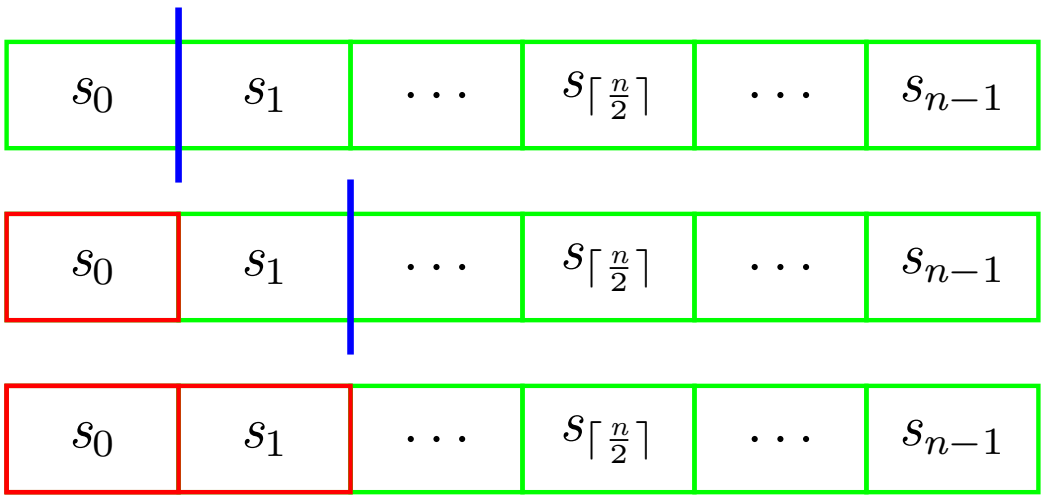


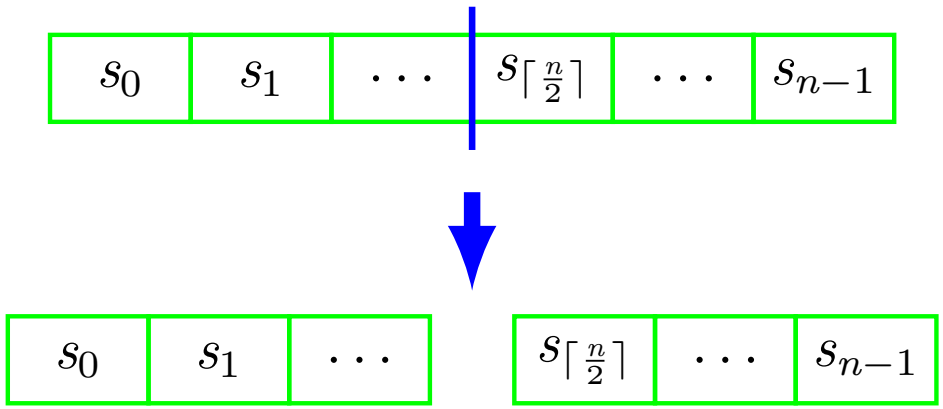
Stable Proof 8



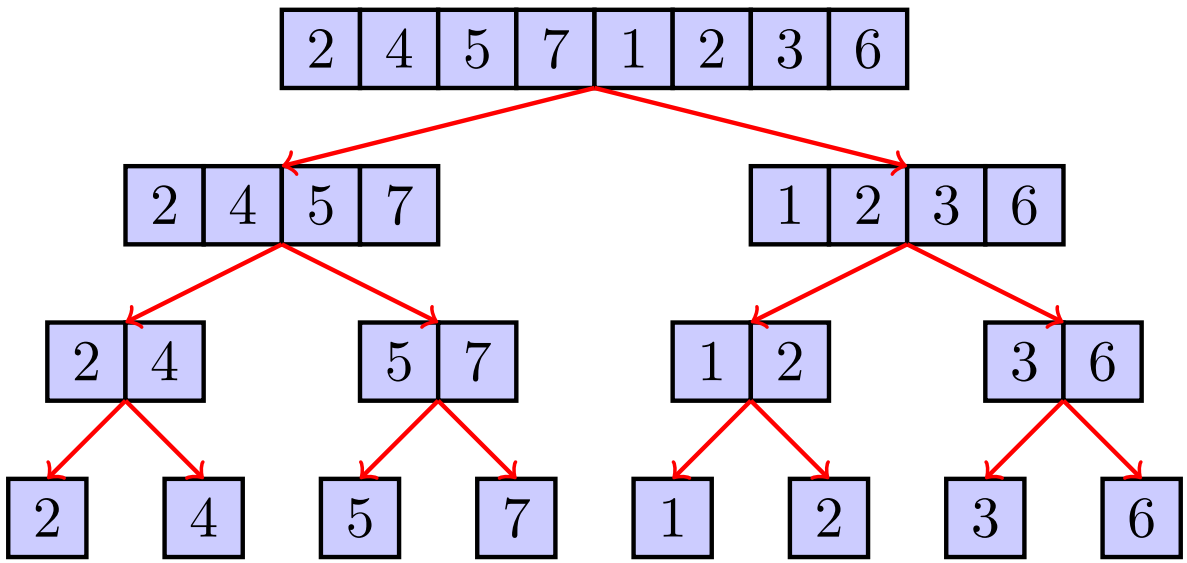
network example



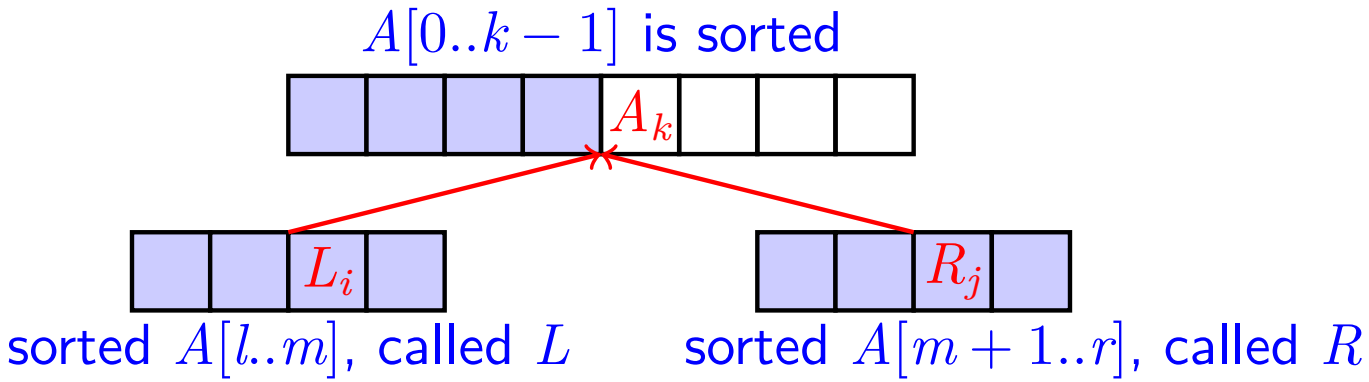

s_0 s_1 $\cdots$ $s_{\lceil \frac{n}{2} \rceil}$ $\cdots$ s_{n-1}
s_0 s_1 $\cdots$ $s_{\lceil \frac{n}{2} \rceil}$ $\cdots$ s_{n-1}
s_0 s_1 $\cdots$ $s_{\lceil \frac{n}{2} \rceil}$ $\cdots$ s_{n-1}


s_0
s_1
$\cdots$
$s_{\lceil \frac{n}{2} \rceil}$
$\cdots$
s_{n-1}
s_0
s_1
$\cdots$
$s_{\lceil \frac{n}{2} \rceil}$
$\cdots$
s_{n-1}

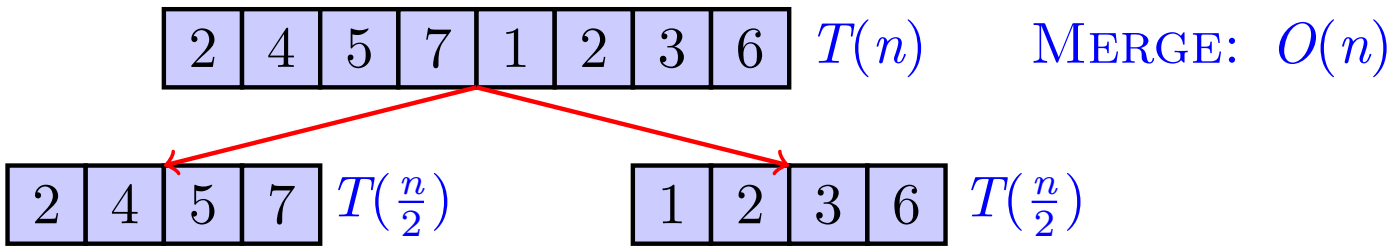
Lec5 how to divide?



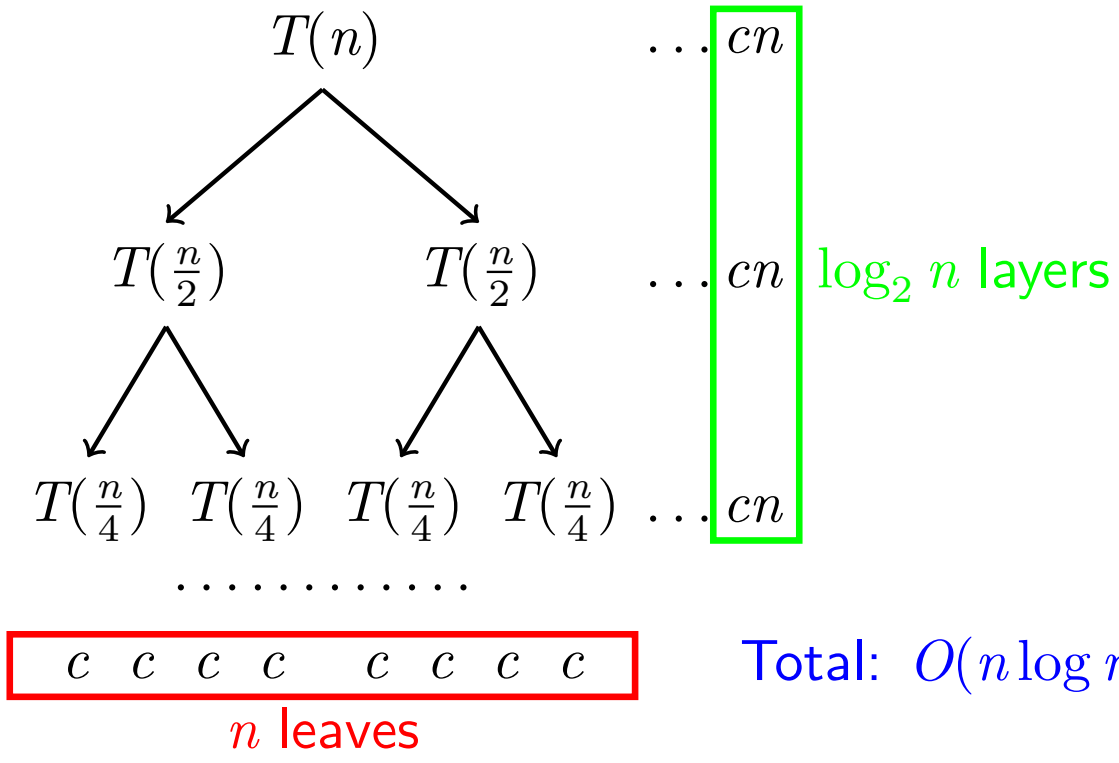
Lec5 how to combine?



Lec5 time complexity?

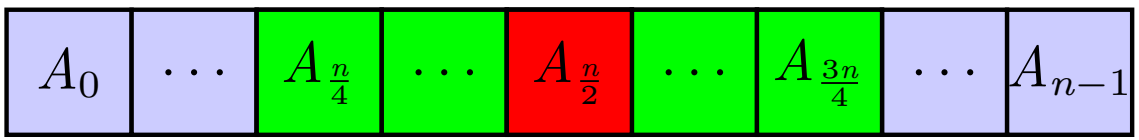


Lec5 tree

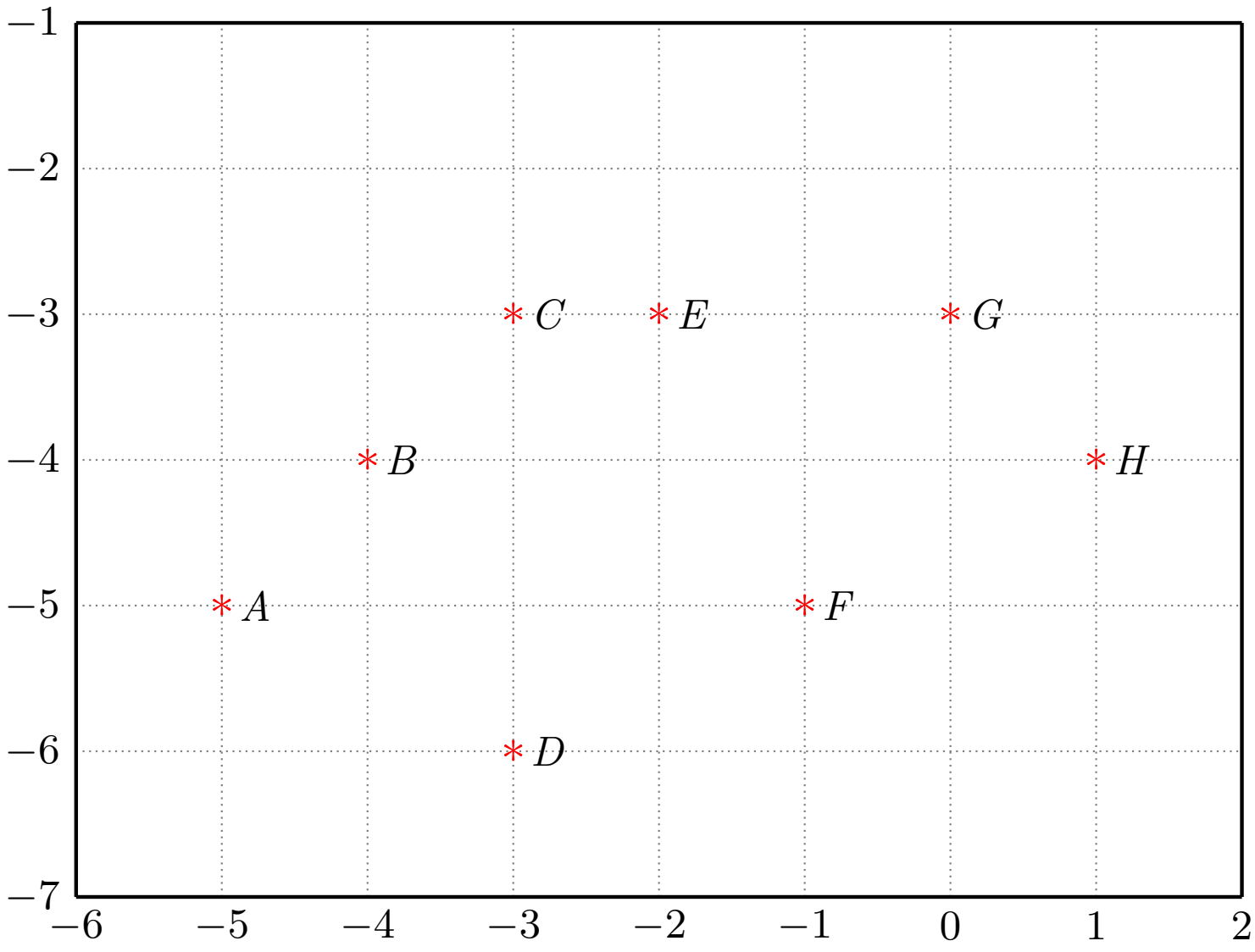

$T(n)$
$T(\frac{n}{2})$ $T(\frac{n}{2})$
$T(\frac{n}{4})$ $T(\frac{n}{4})$ $T(\frac{n}{4})$ $T(\frac{n}{4})$
. . . . . .
c c c c c c c c
n leaves
. . . cn
. . . cn
. . . cn
$\log_2 n$ layers
Total: $O(n \log n)$

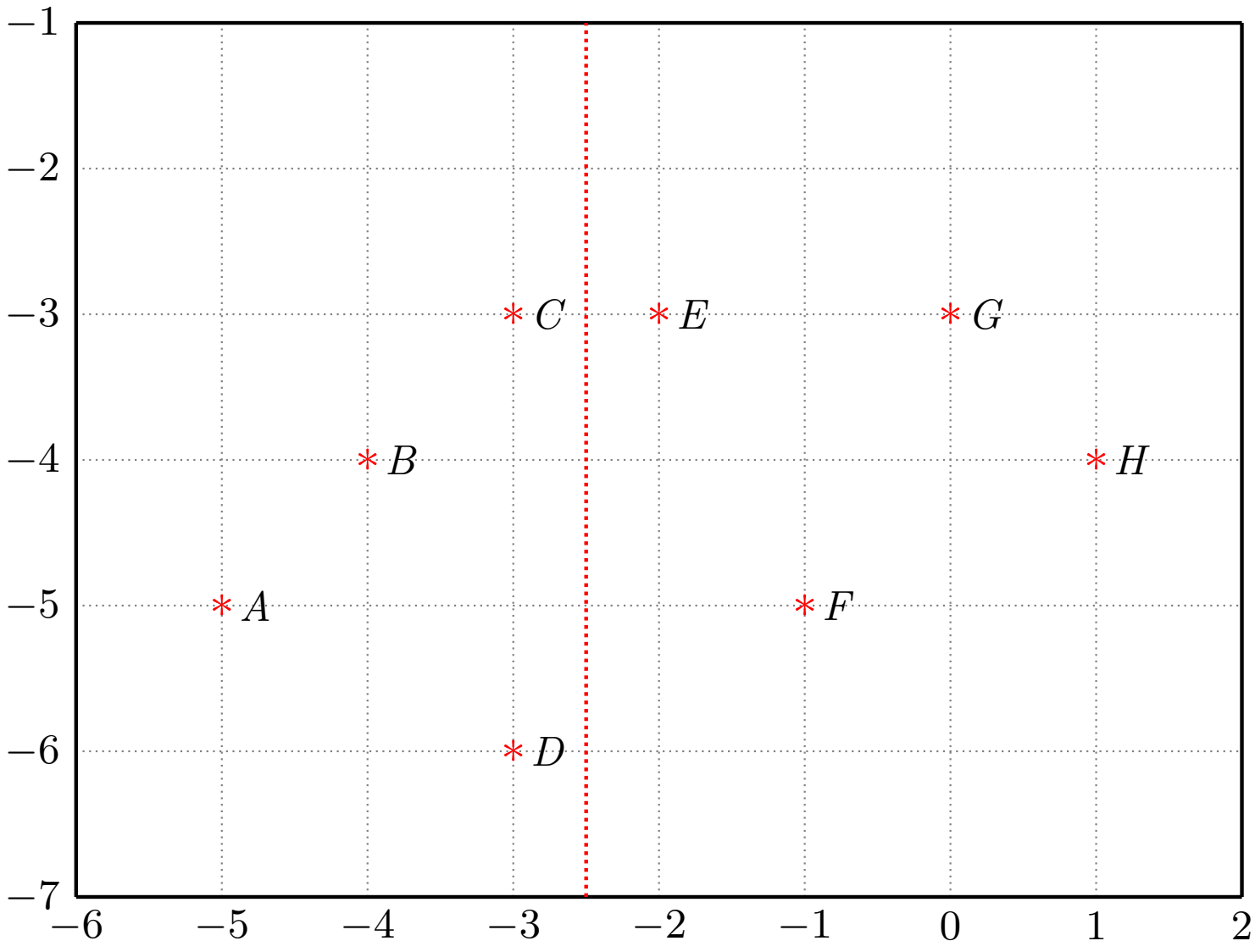
Lec5 Splitter

best splitter

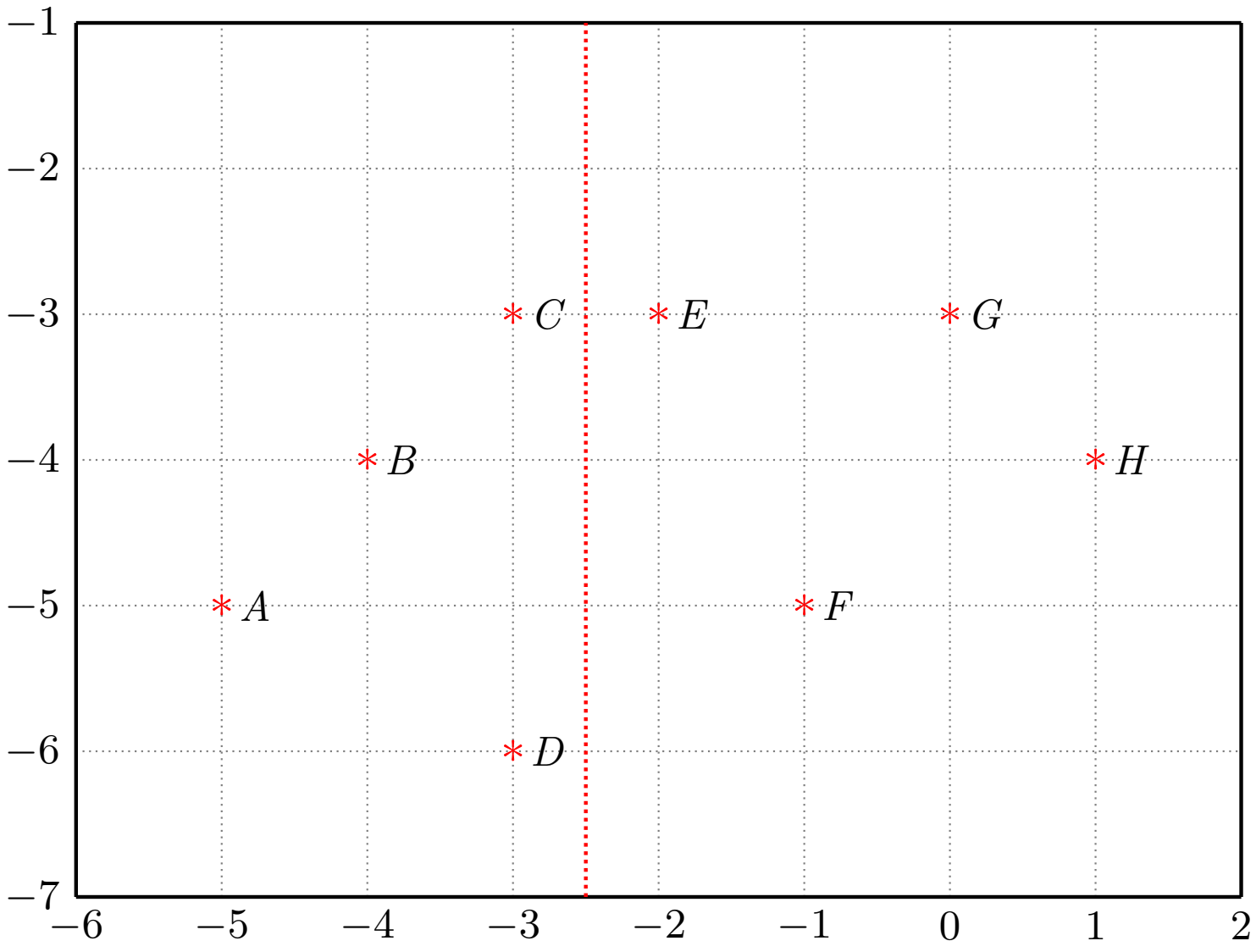


good splitters

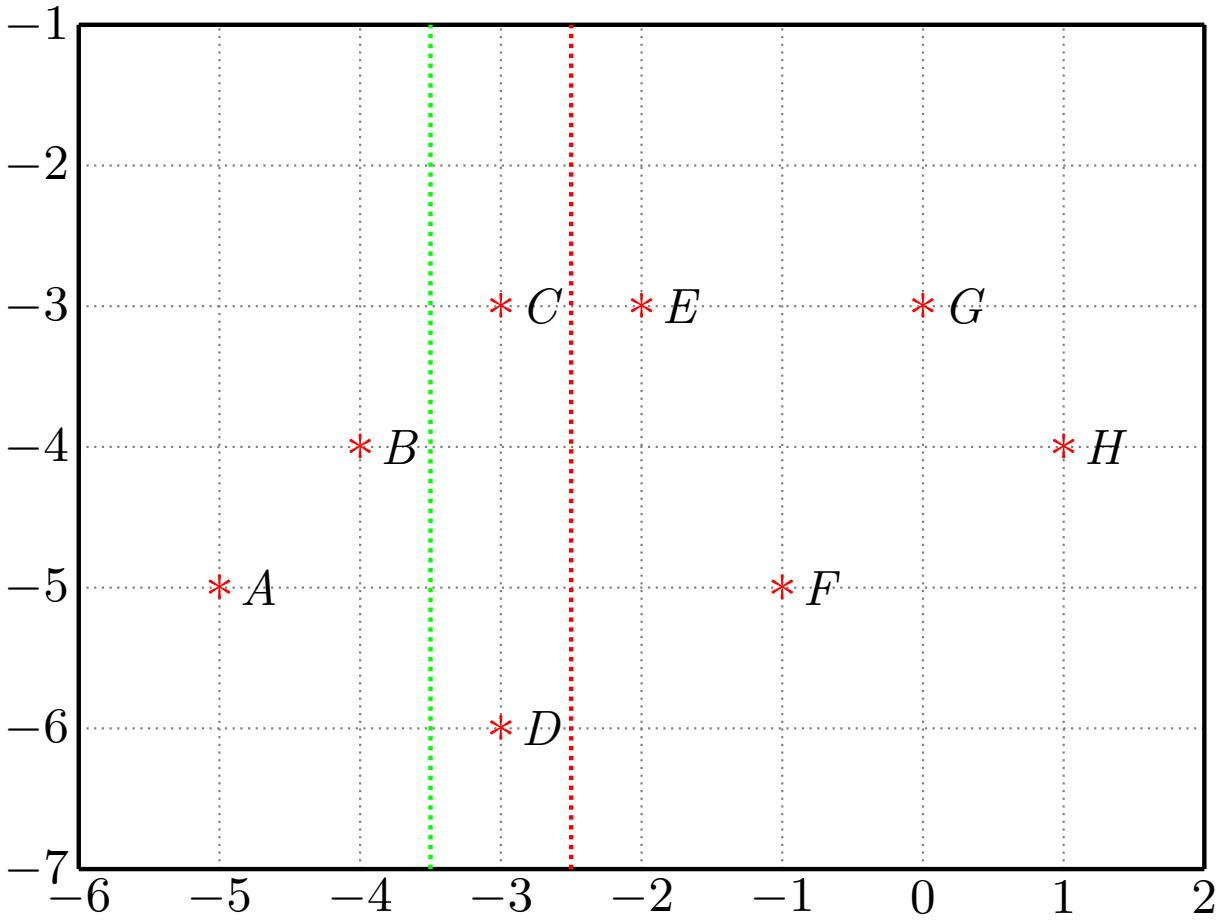

−1
−2
−3
−4
−5
−6
−7
−6
−5
−4
−3
−2
−1
0
1
2
A
B
C
D
E
F
G
H


−1
−2
−3
−4
−5
−6
−7
−6
−5
−4
−3
−2
−1
0
1
2
A
B
C
D
E
F
G
H

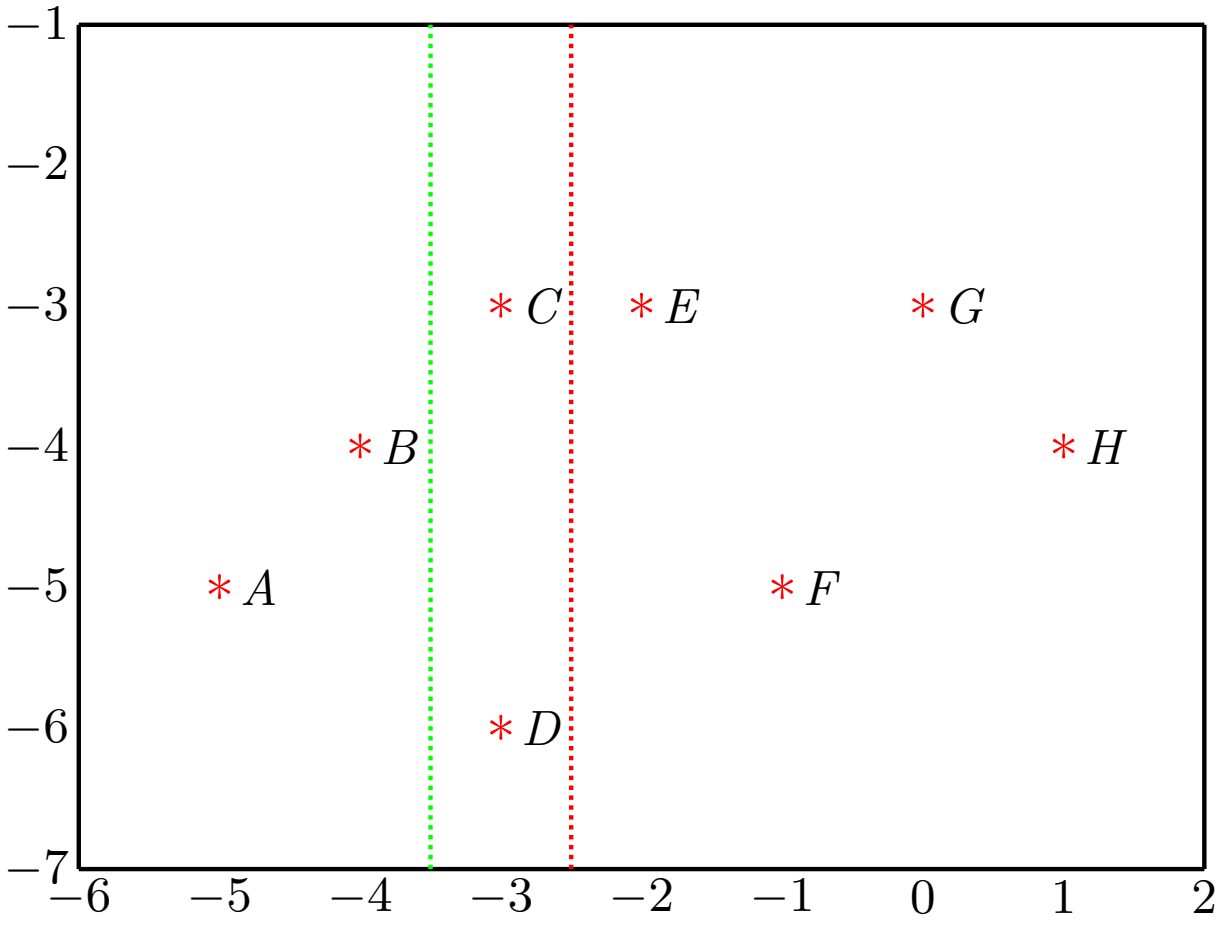
Lec5 Closest Pairs Middle Red Line



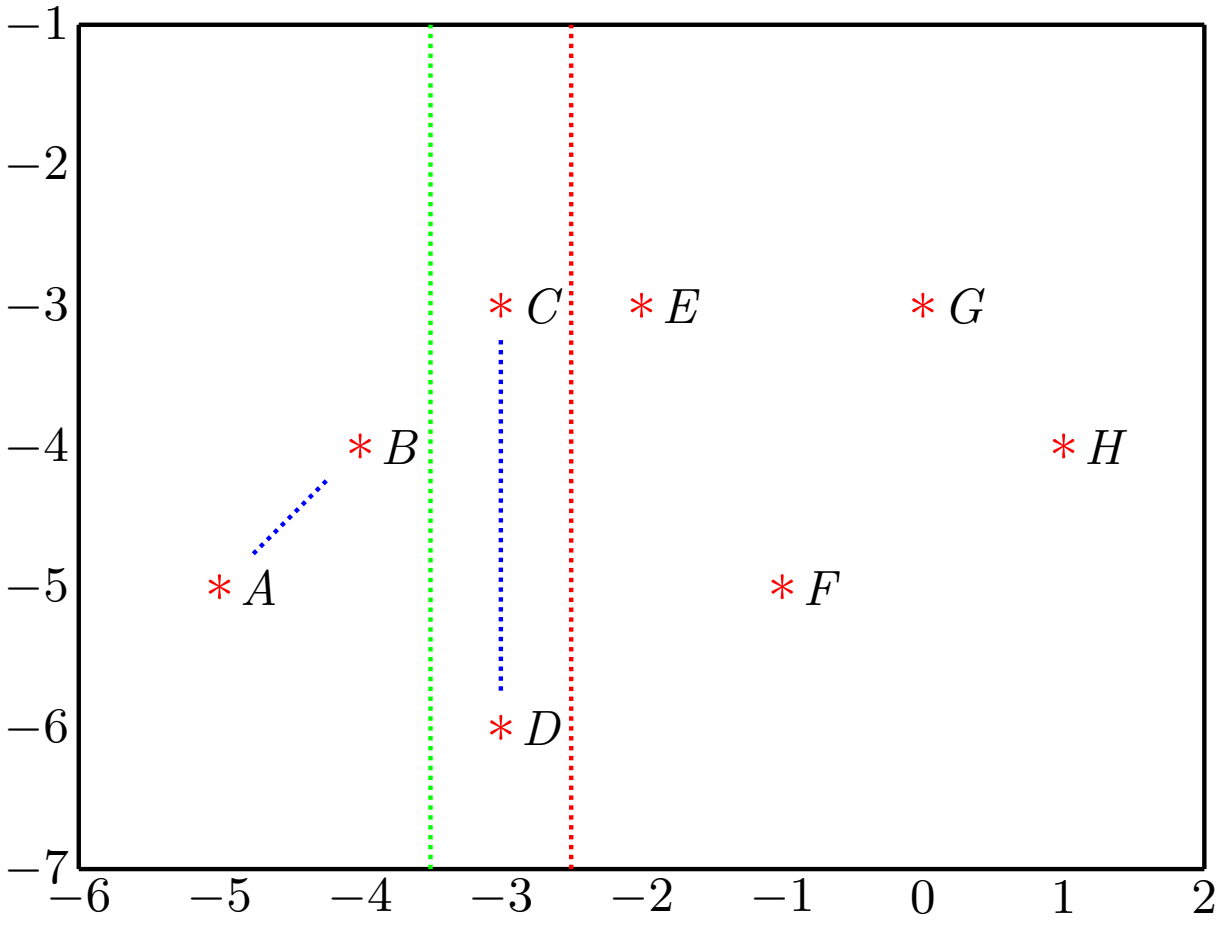
Leech Closest Pairs Left



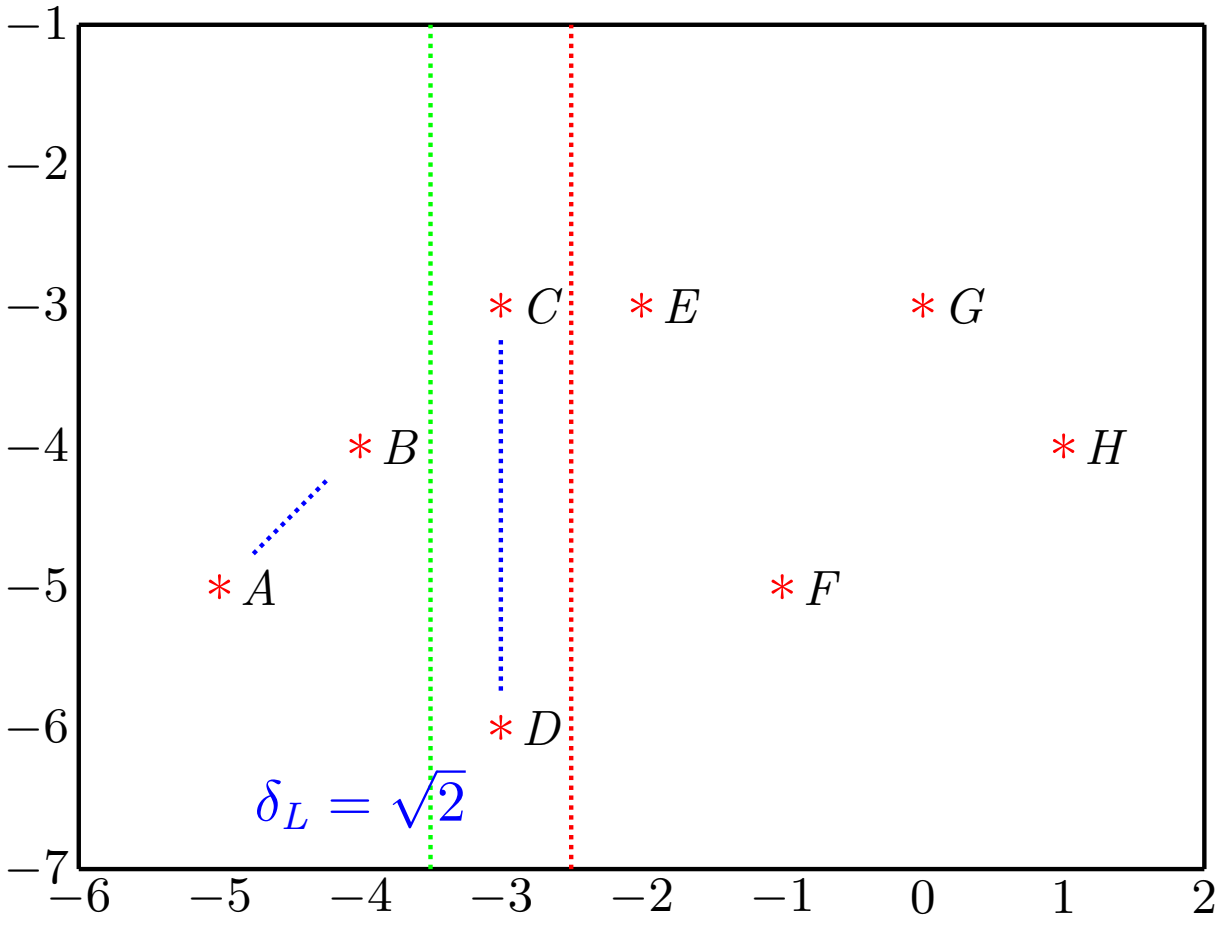
Lec5 Closest Pairs Left Grids



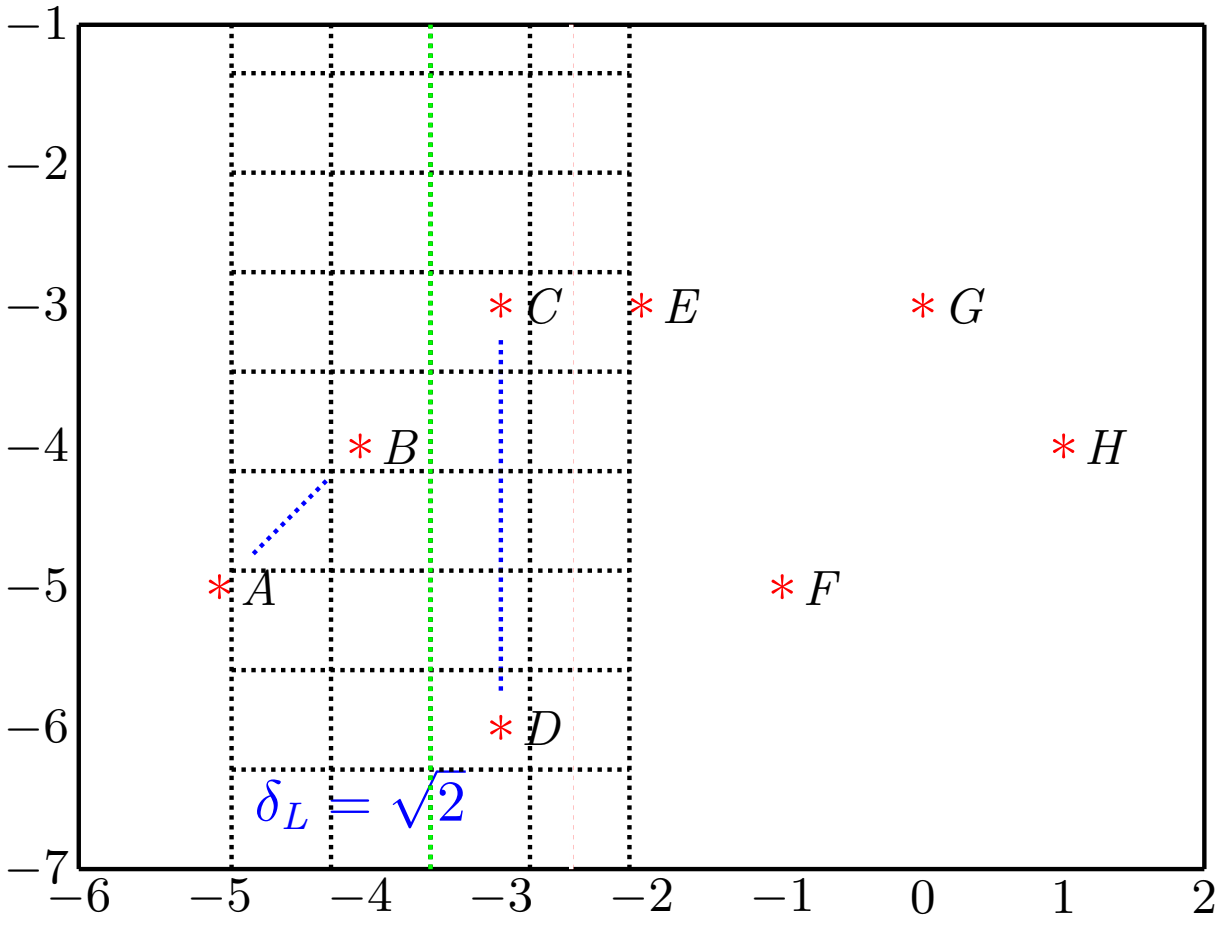
Lec5 Closest Pairs Left Grids



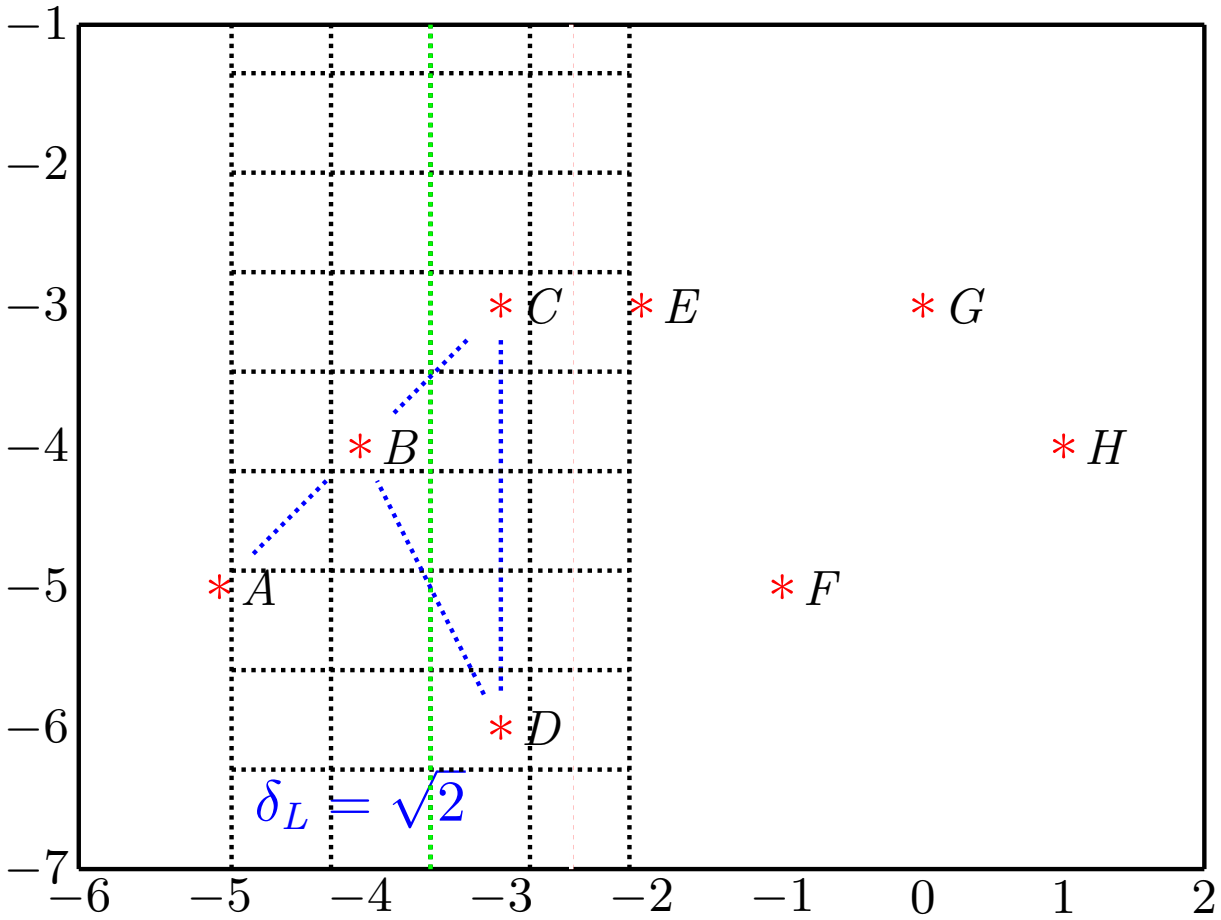
Lec5 Closest Pairs Left Grids



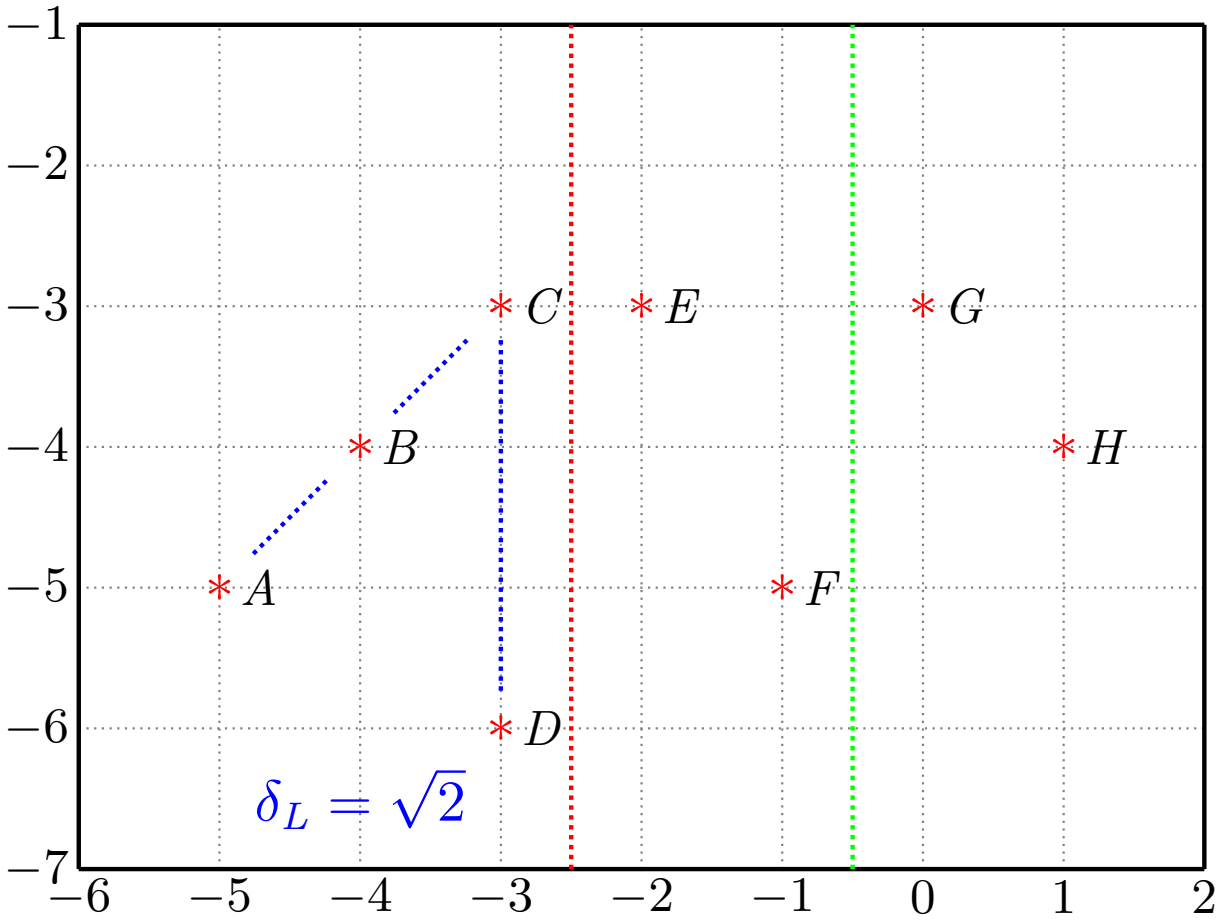
Lec5 Closest Pairs Left Grids



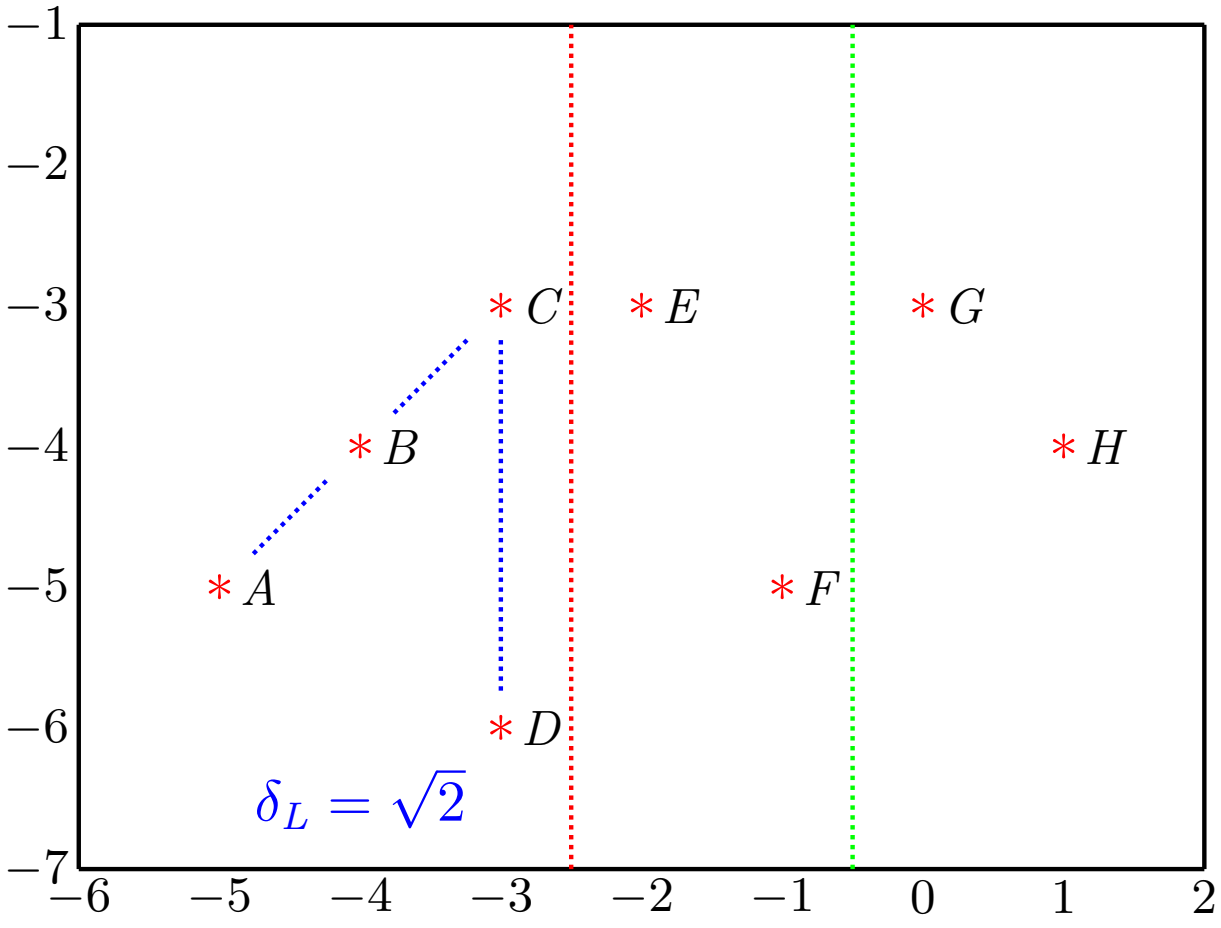
Lec5 Closest Pairs Left Grids



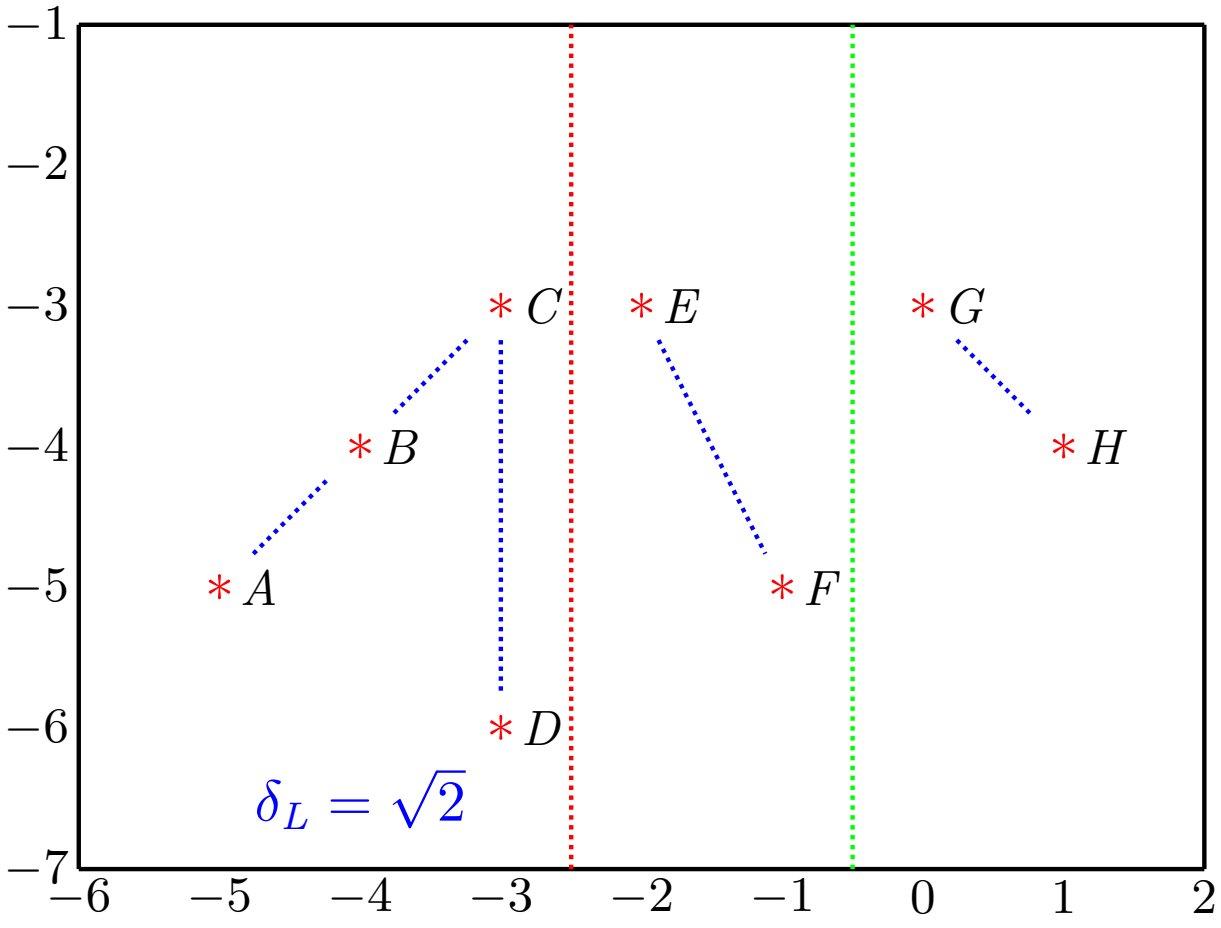
Lec5 Closest Pair Right



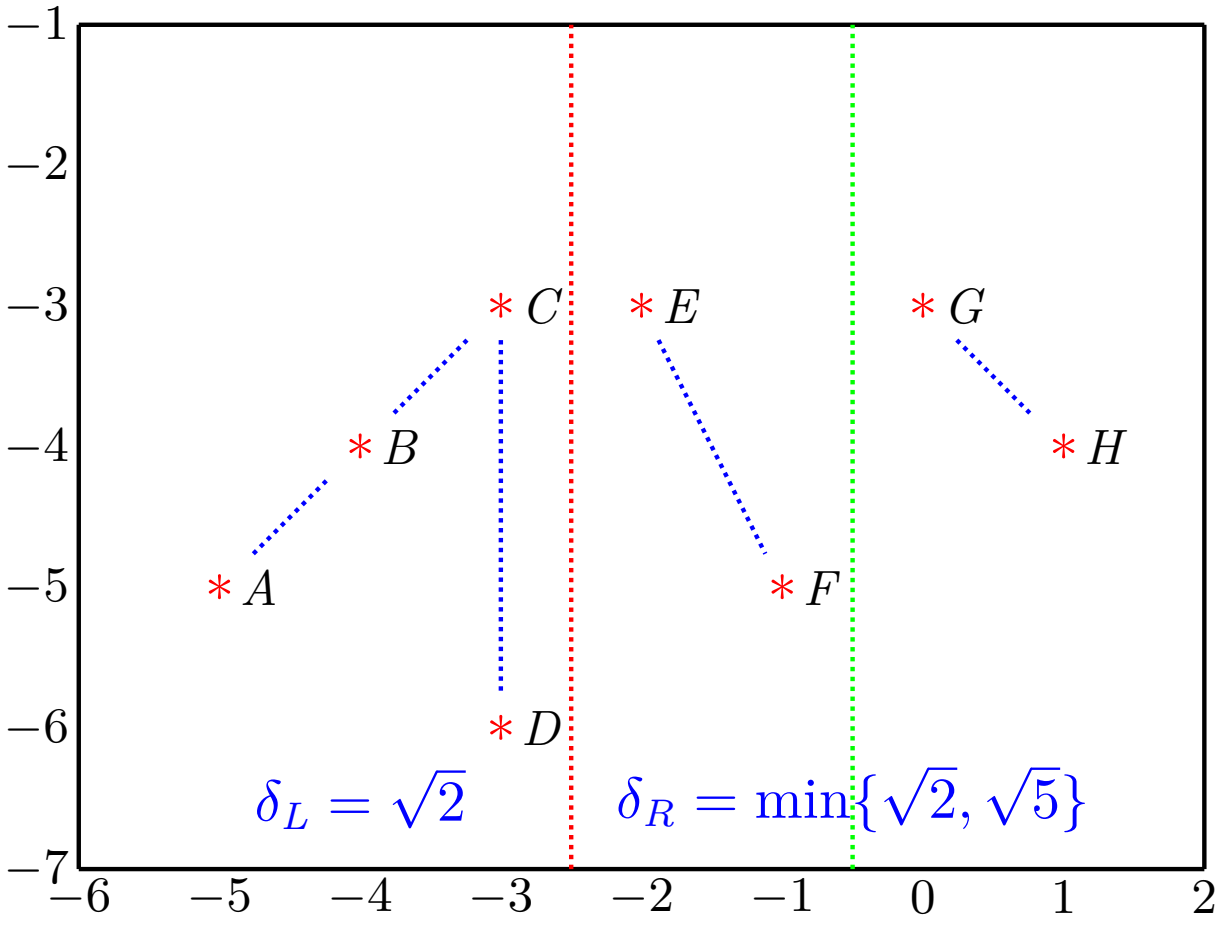
Lec5 Closest Pairs Right Grids



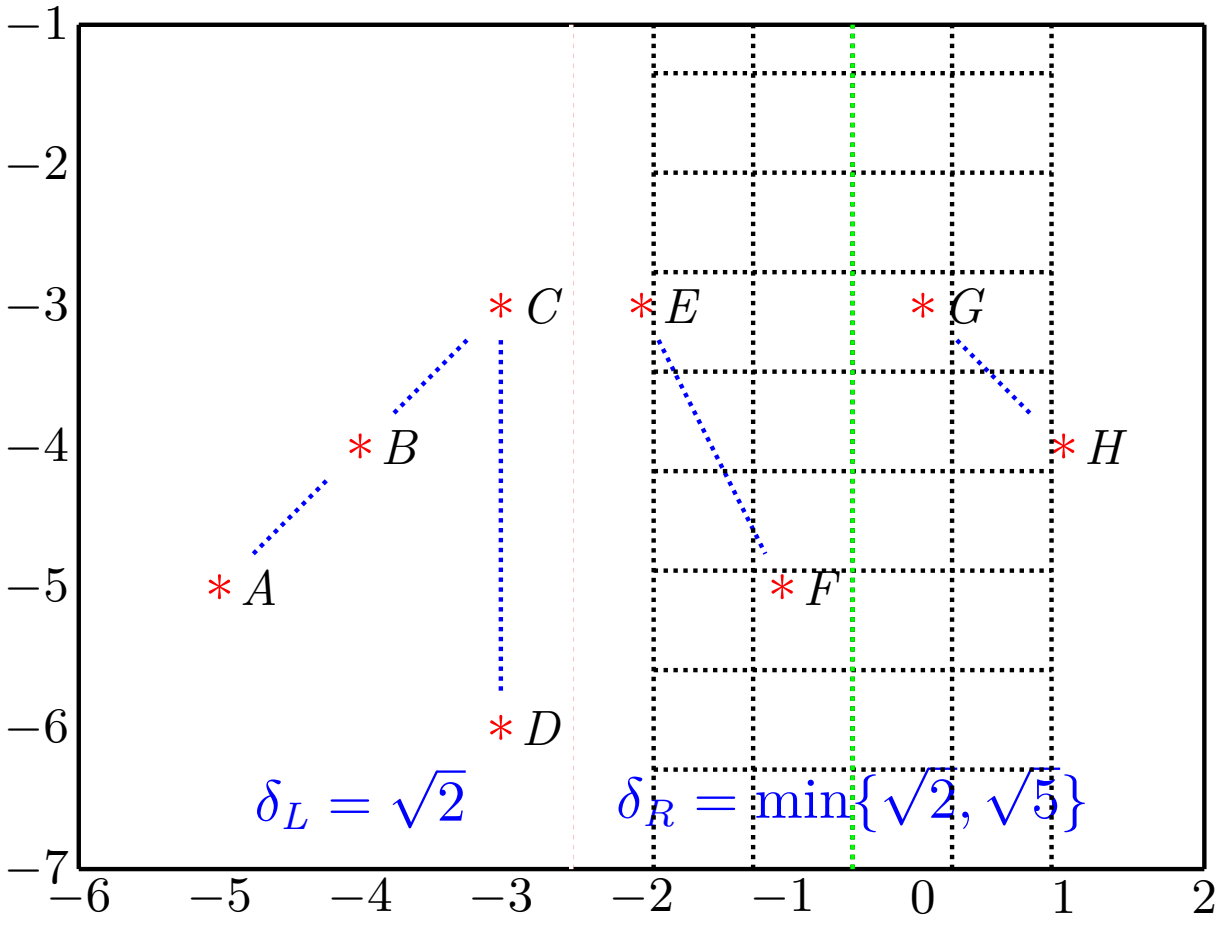
Lec5 Closest Pairs Right Grids



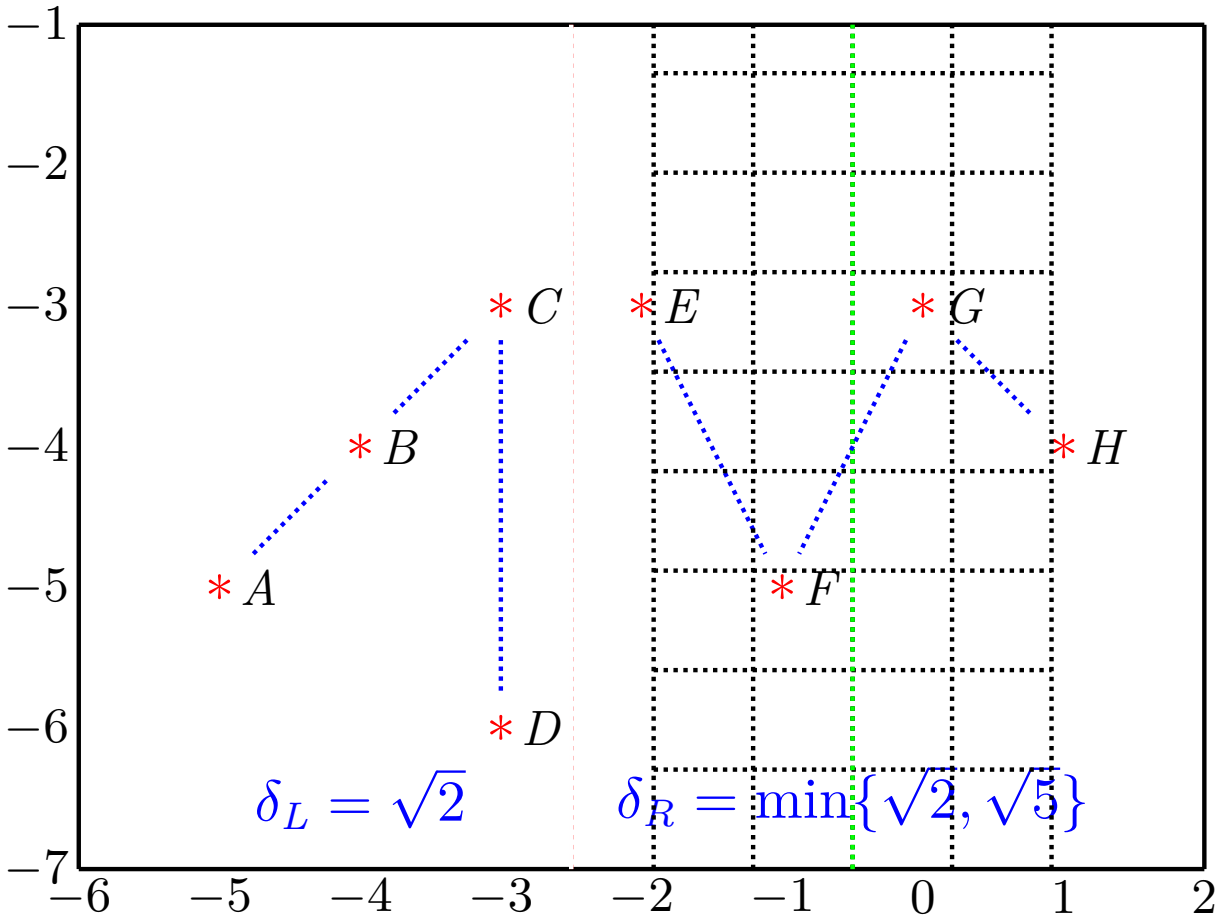
Lec5 Closest Pairs Right Grids



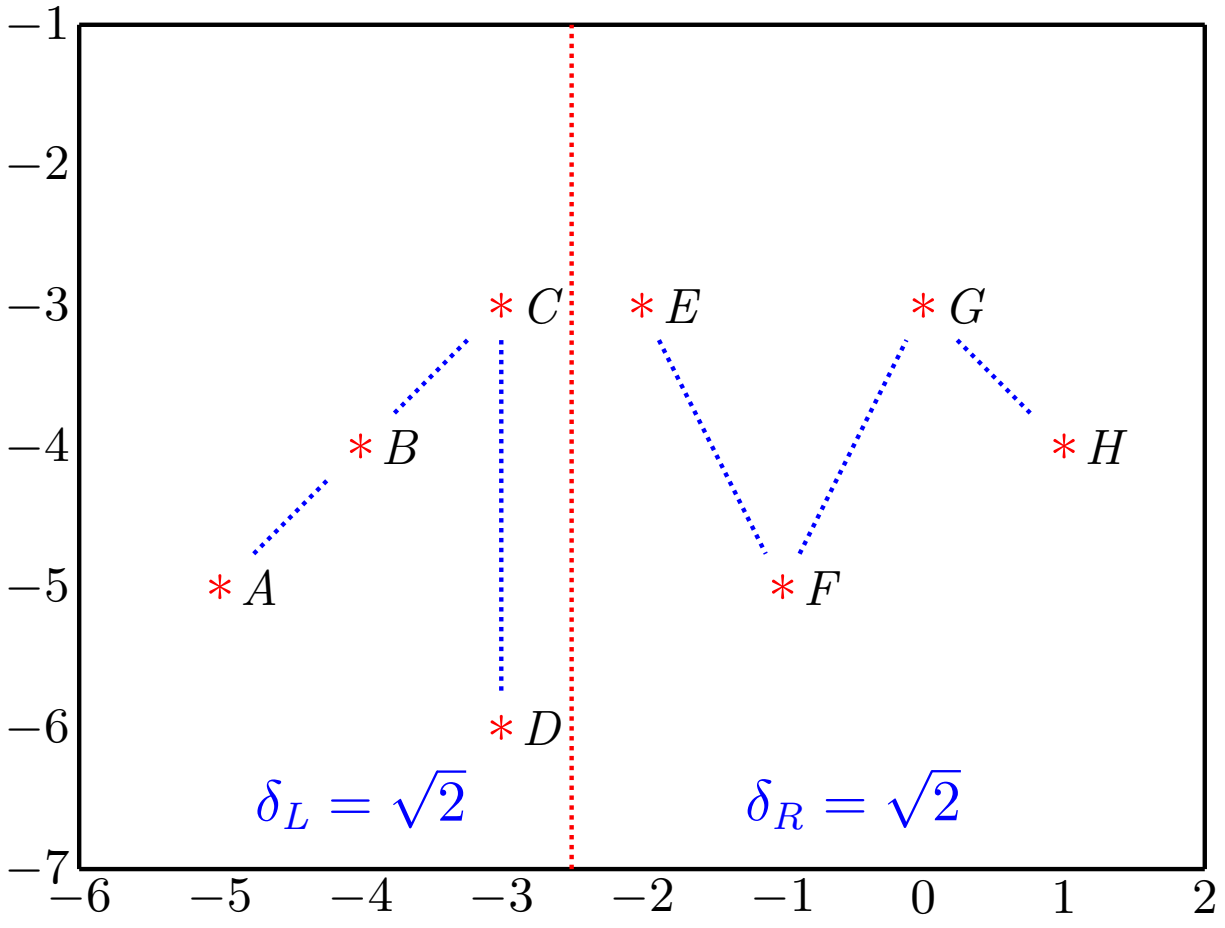
Lec5 Closest Pairs Right Grids



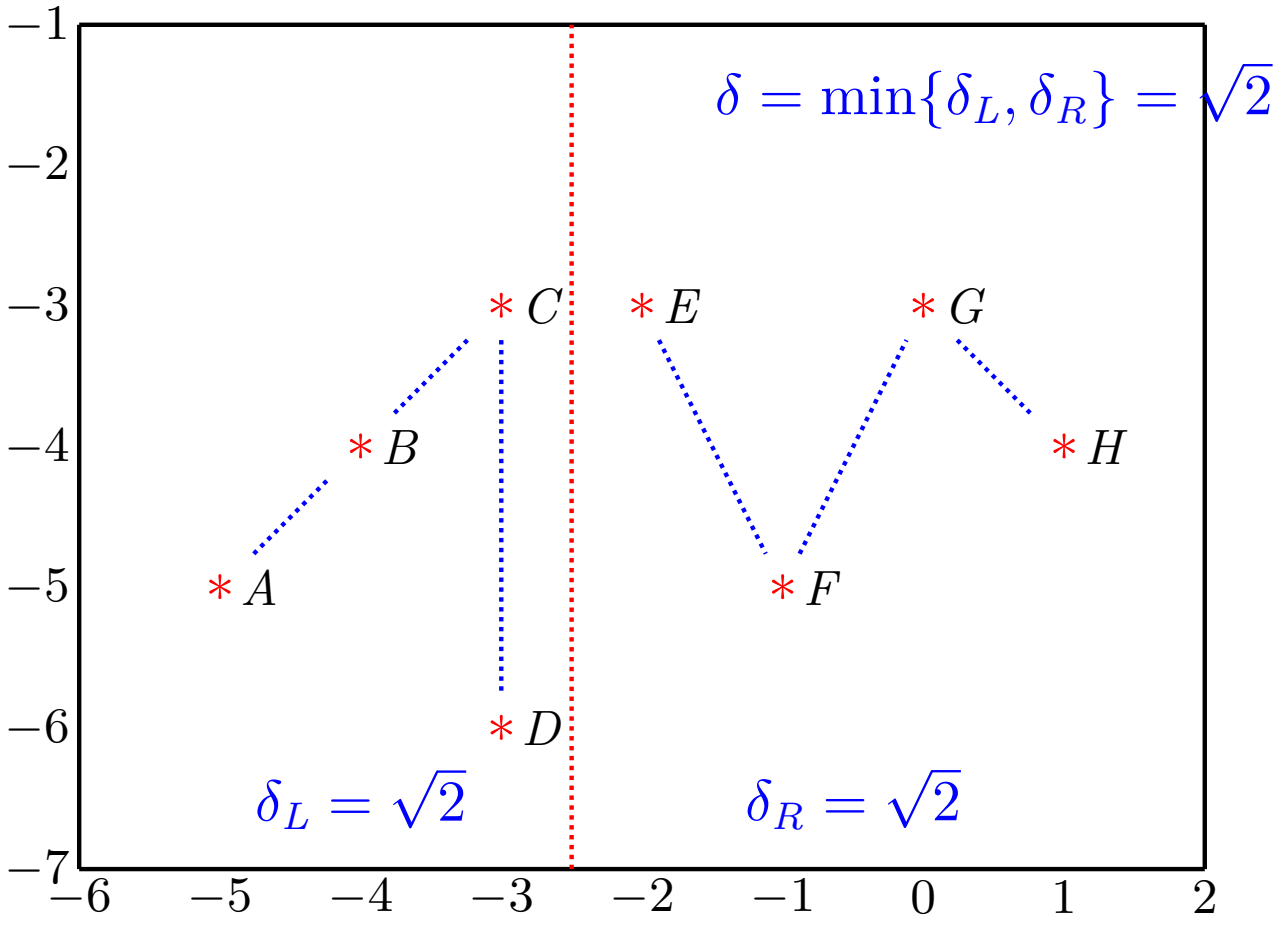
Lec5 Closest Pairs Right Grids



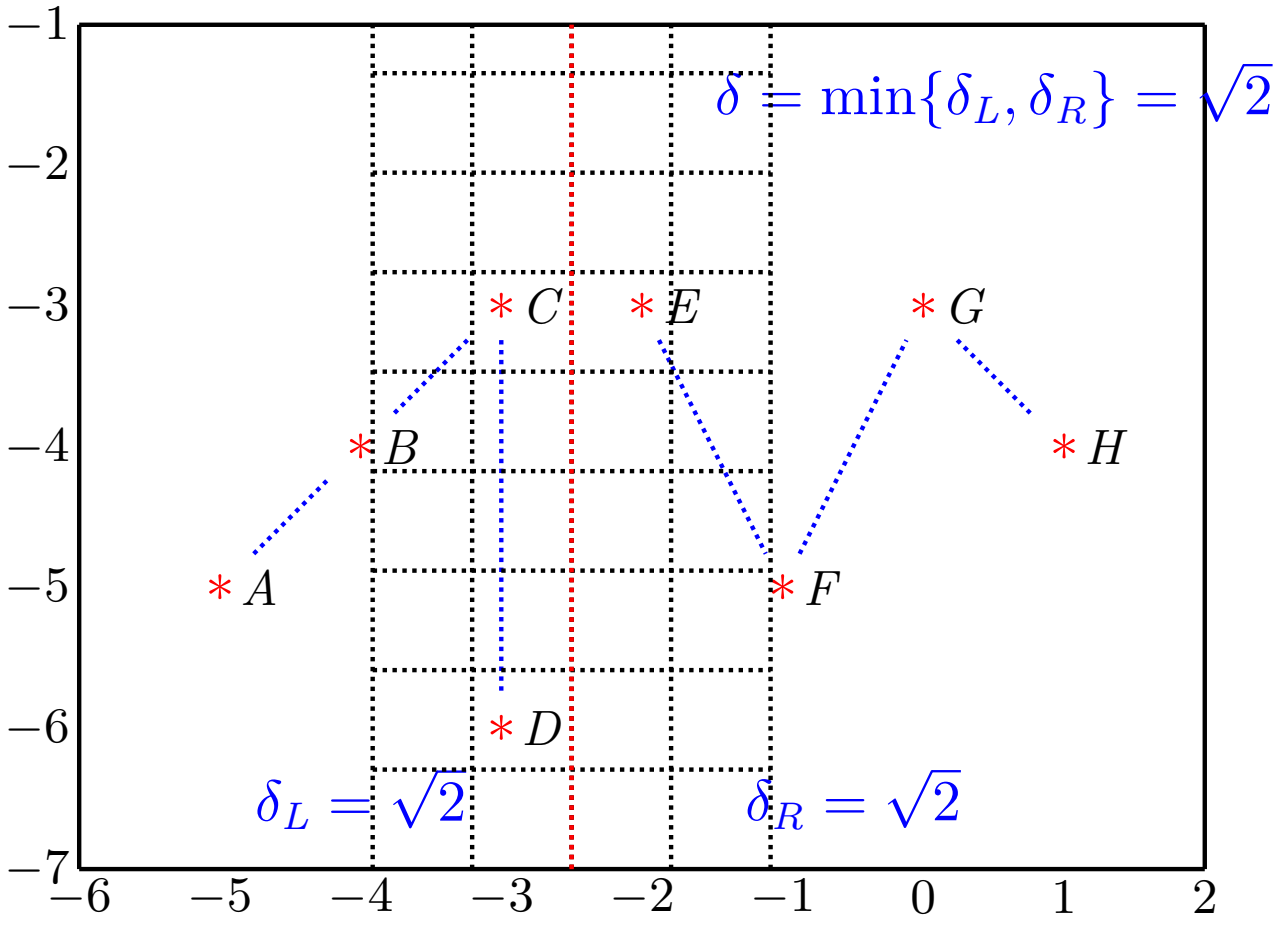
Lec5 Closest Pairs Final



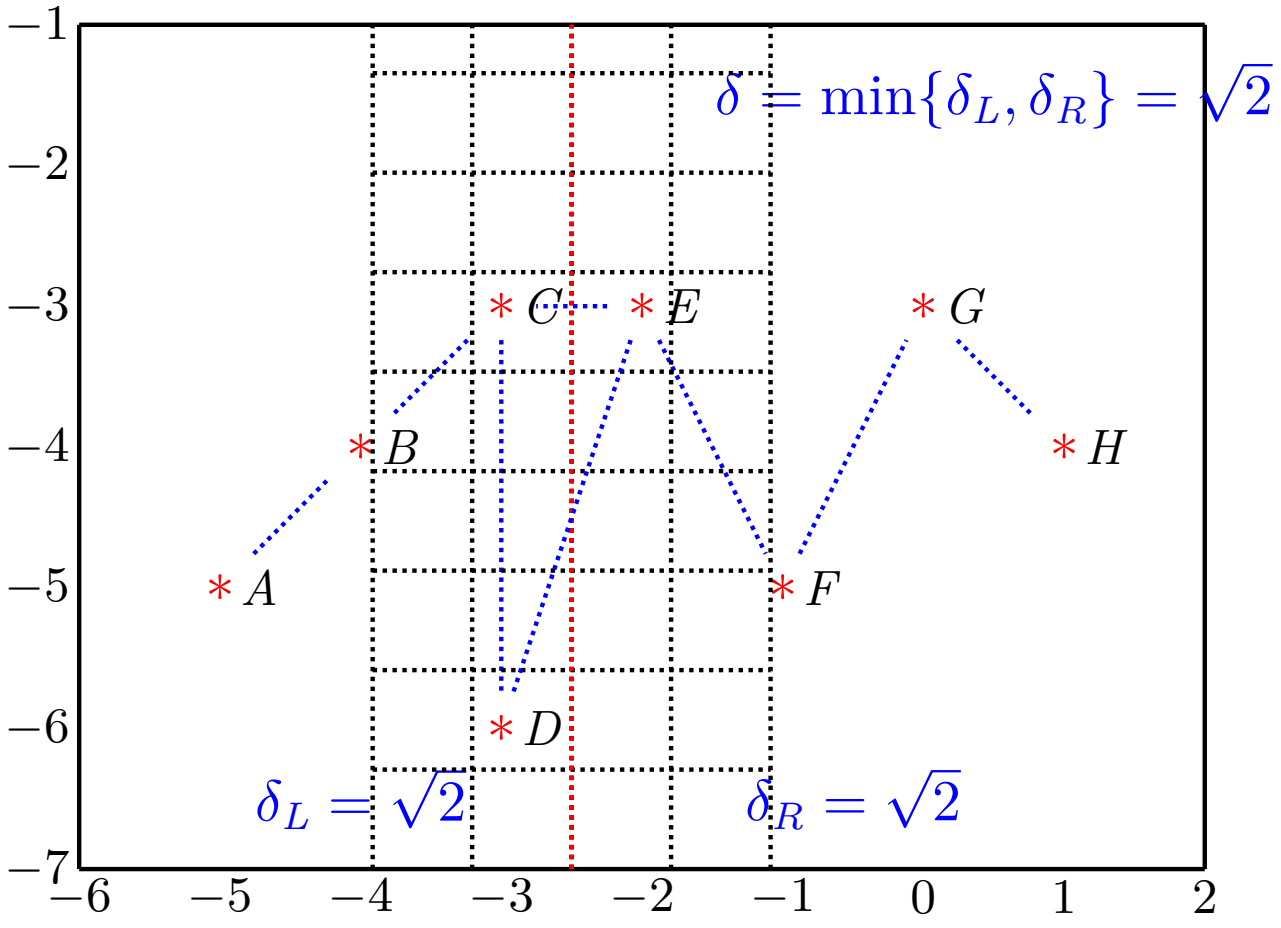
Lec5 Closest Pairs Final



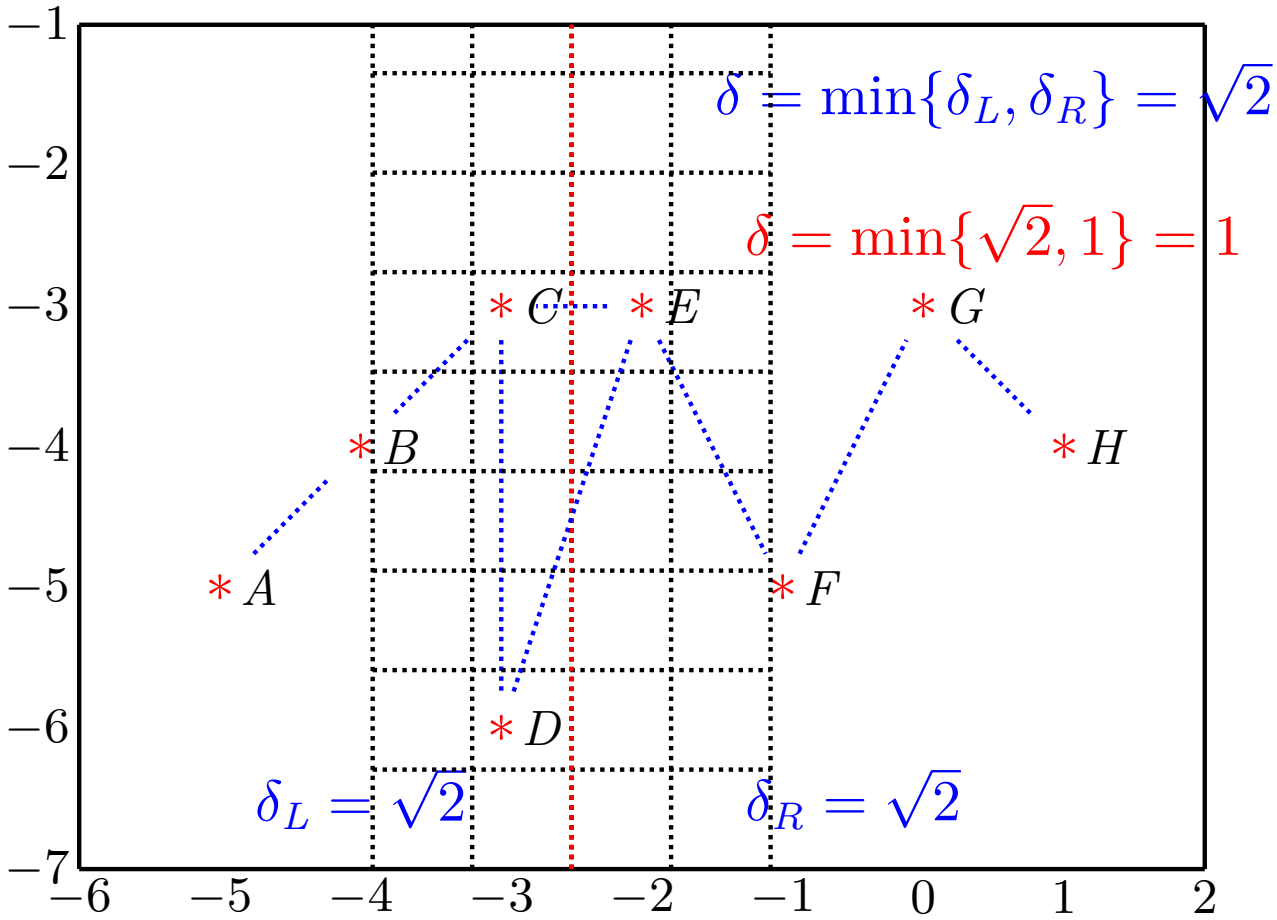
Lec5 Closest Pairs Final



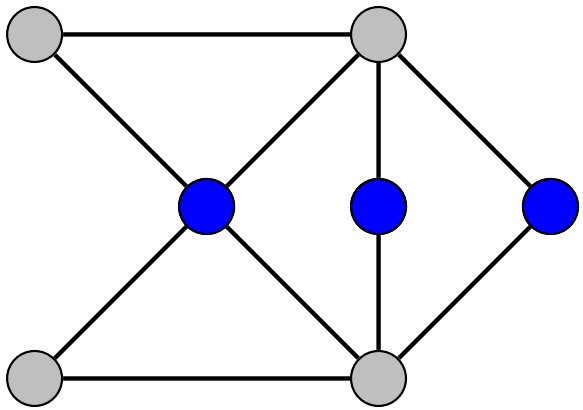
Lec5 Closest Pairs Final



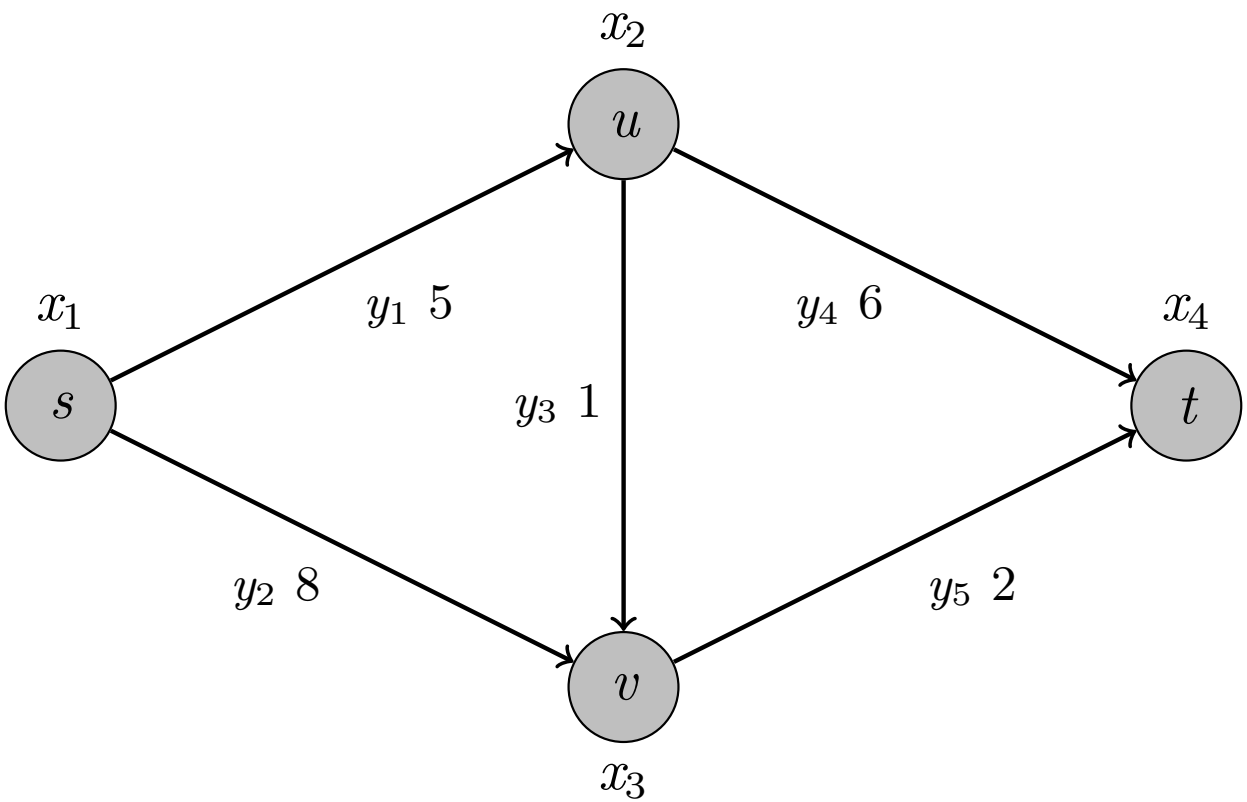
Lec5 Closest Pairs Final



bbb

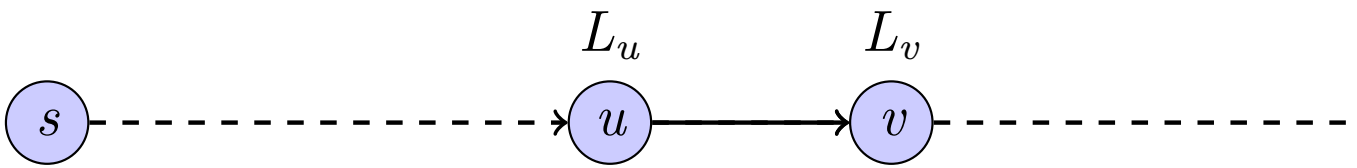


aaa

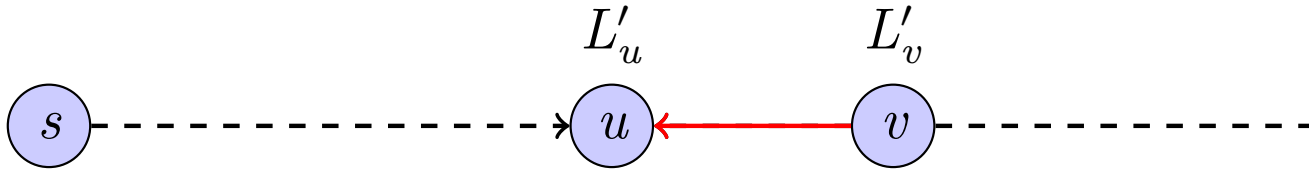


Edmonds Karp

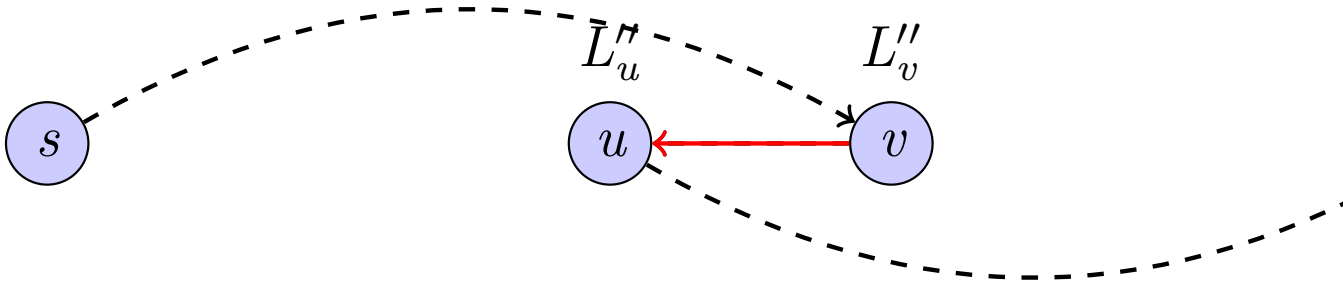
Step k :



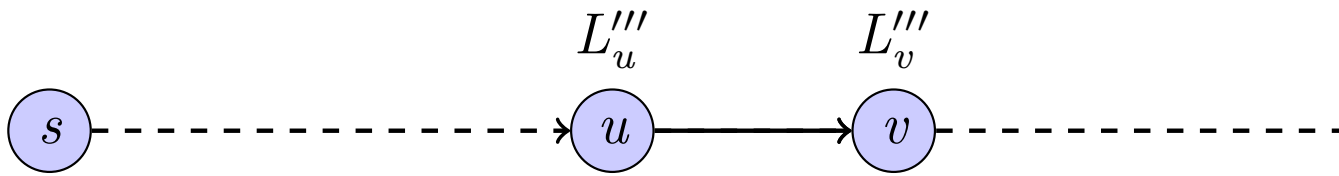
Step $k+1$:

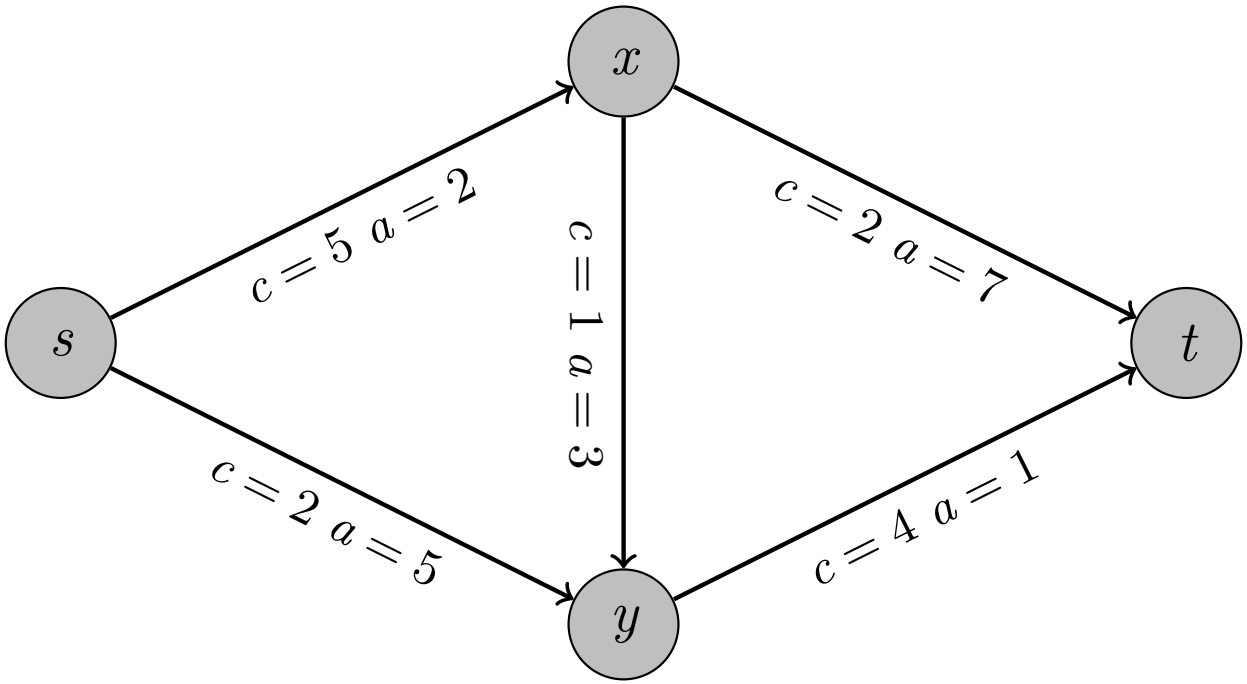


Step k'' :

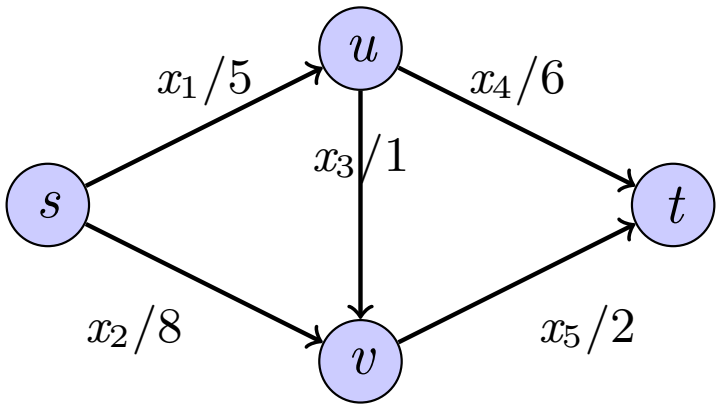


Step k''' :

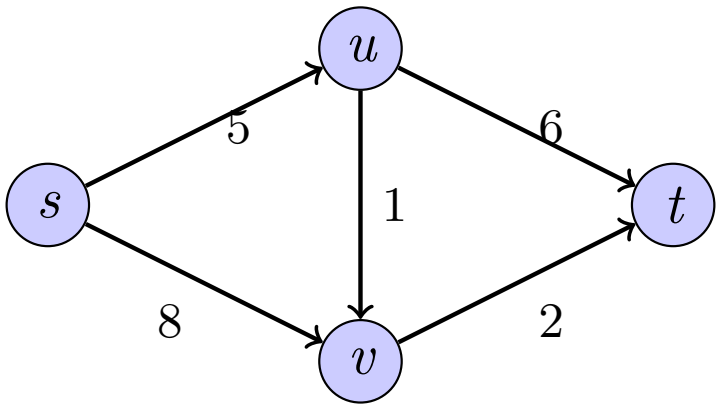


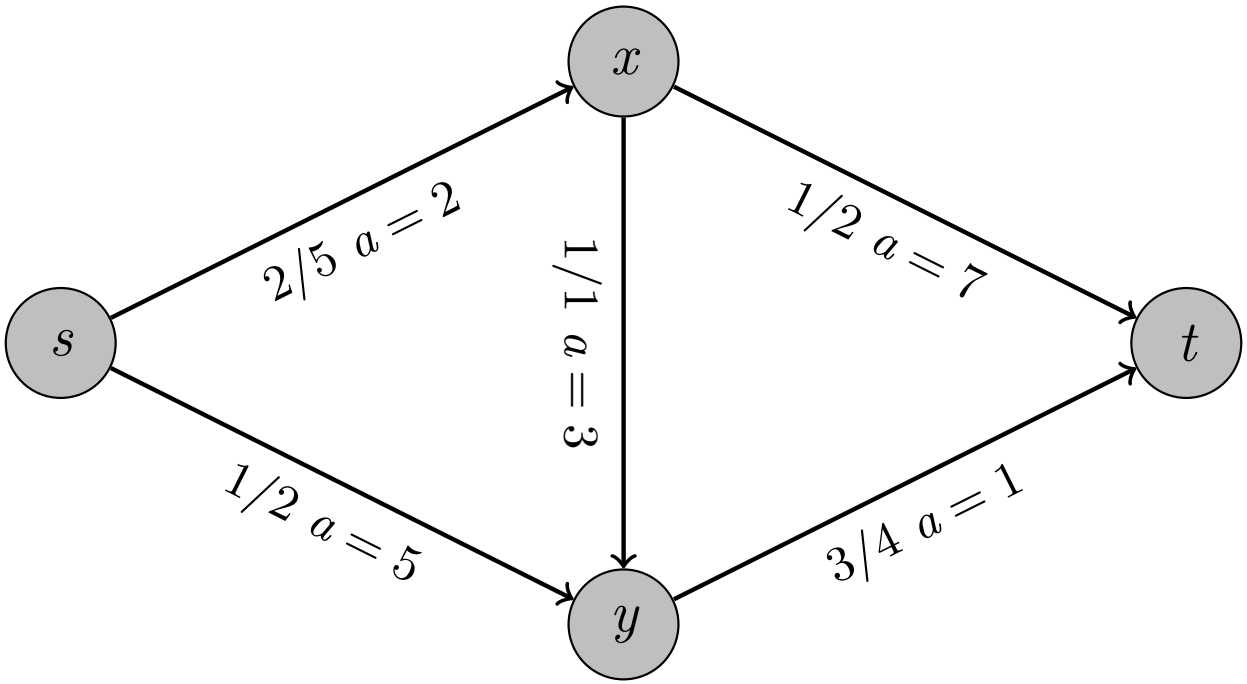

x
s
t
y
c = 5 a = 2
c = 1 a = 3
c = 2 a = 7
c = 2 a = 5
c = 4 a = 1

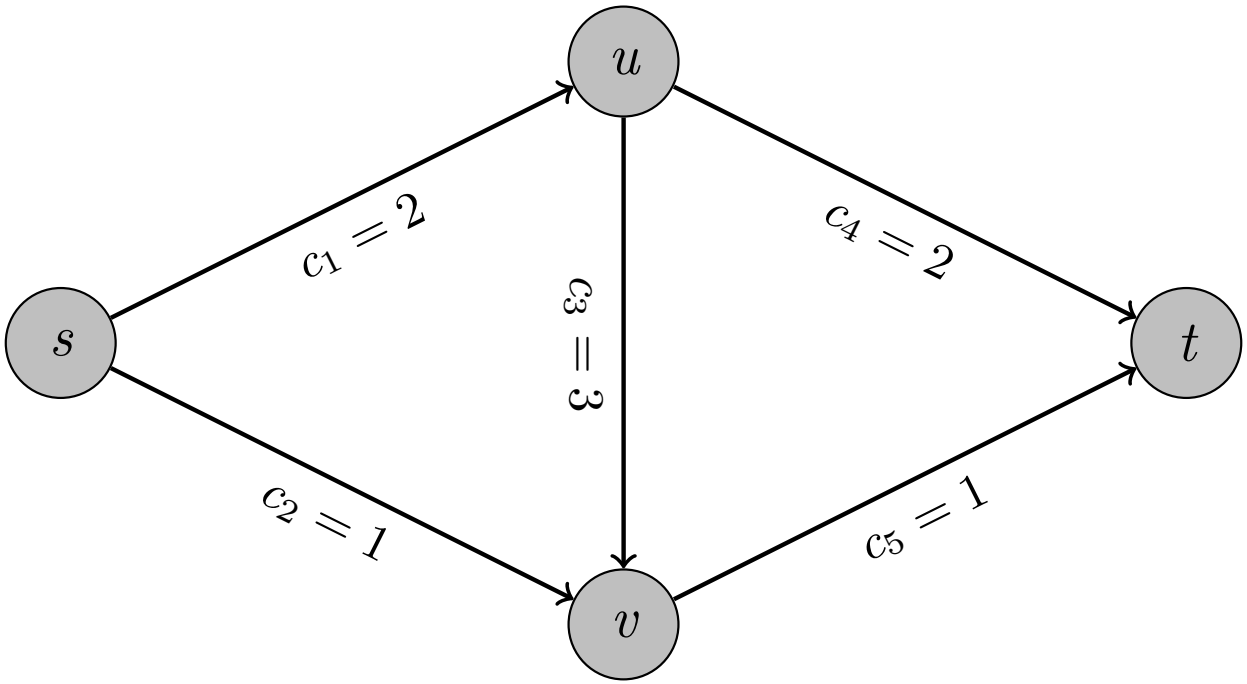
NF2

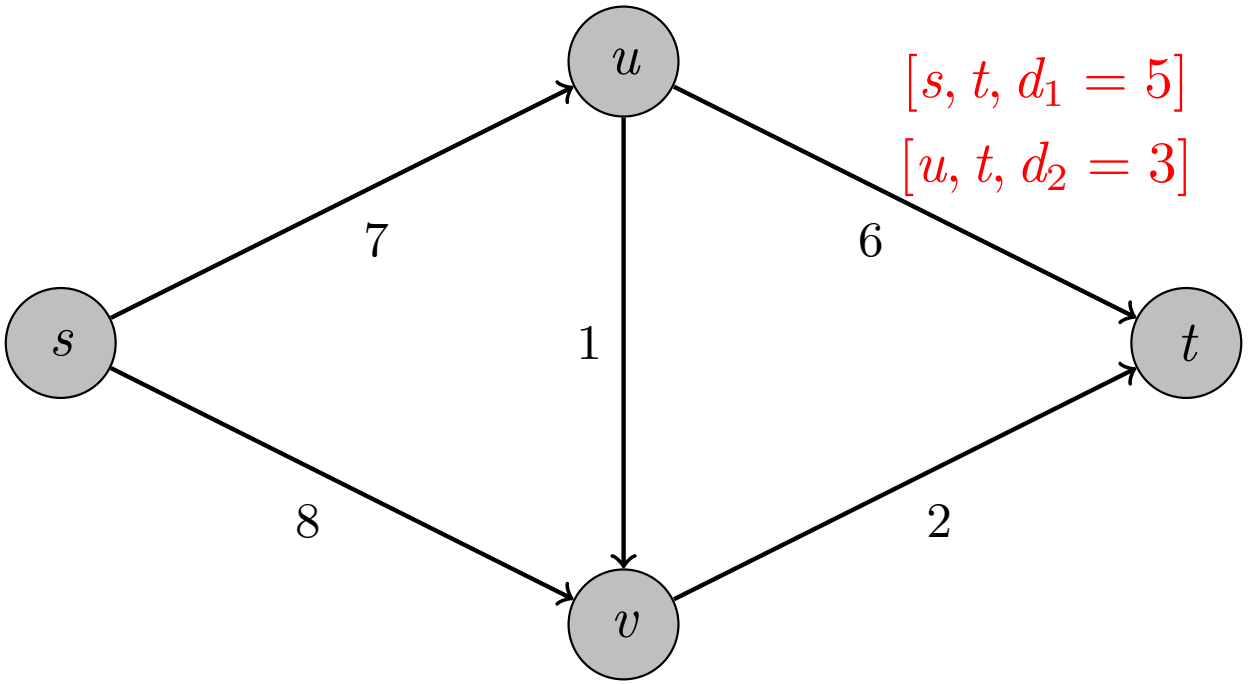


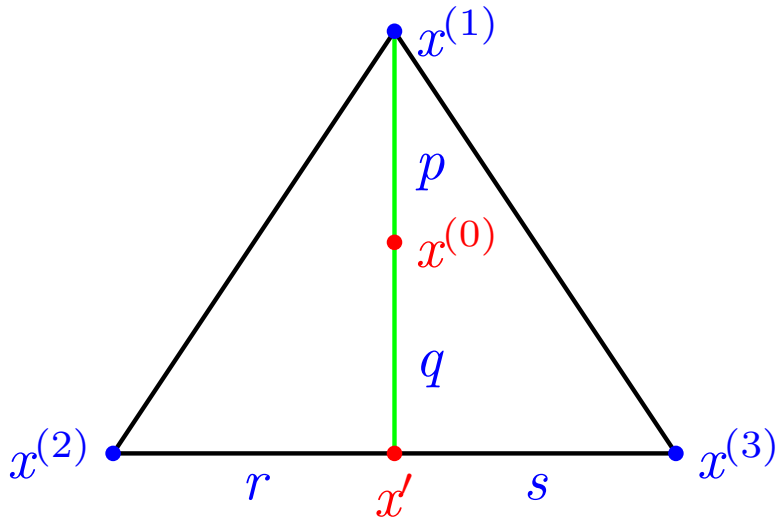
NF1



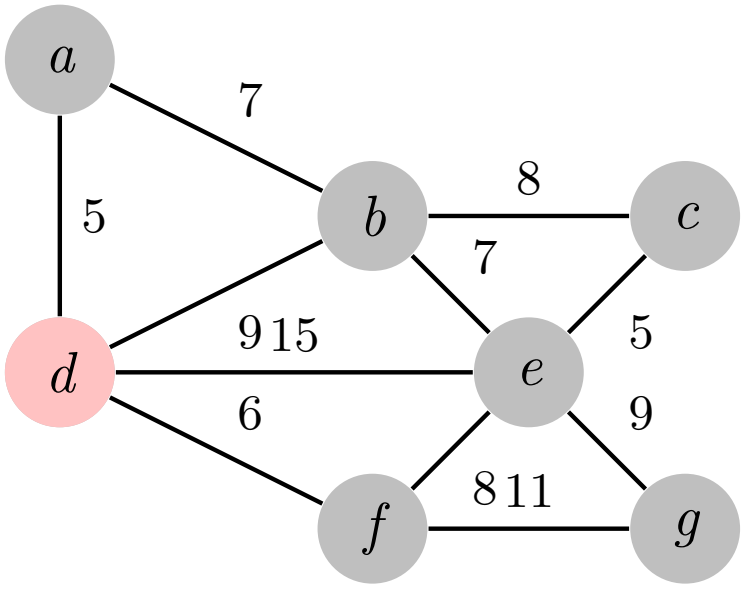

x
s
t
y
2/5 a = 2
1/1 a = 3
1/2 a = 7
1/2 a = 5
3/4 a = 1


u
s
t
v
$c_1 = 2$
$c_2 = 1$
$c_3 = 3$
$c_4 = 2$
$c_5 = 1$

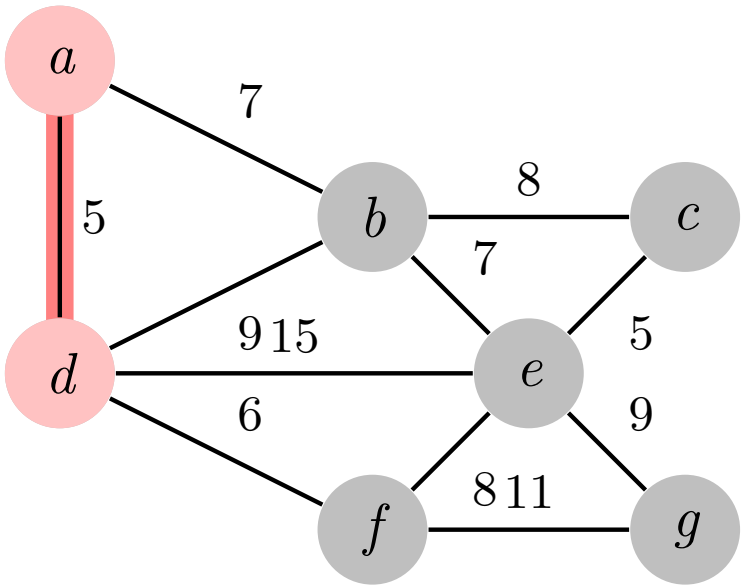

u
$[s, t, d_1 = 5]$
$[u, t, d_2 = 3]$
7
6
s
1
t
8
2
v


$x^{(1)}$
p
$x^{(0)}$
q
$x^{(2)}$
r
x'
s
$x^{(3)}$

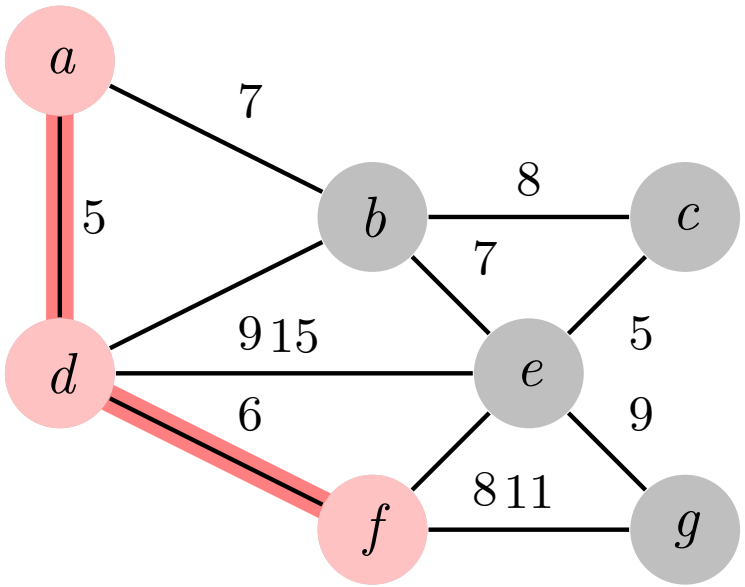
Prim's algorithm



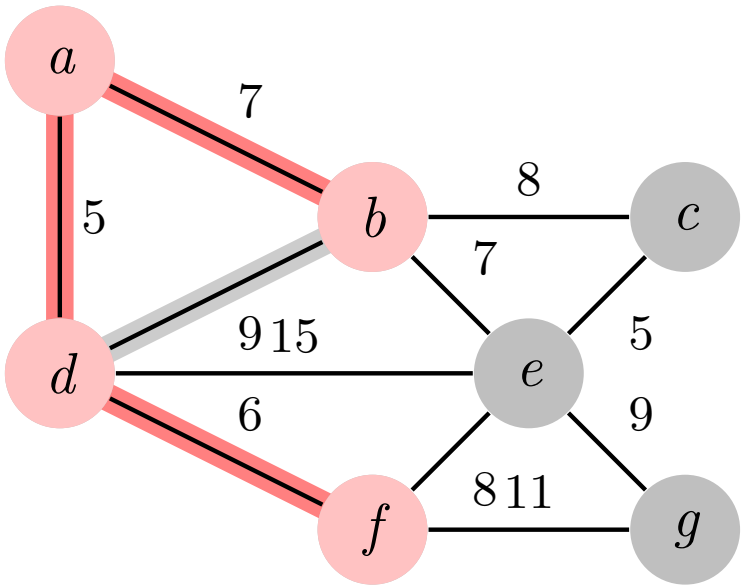
Prim's algorithm



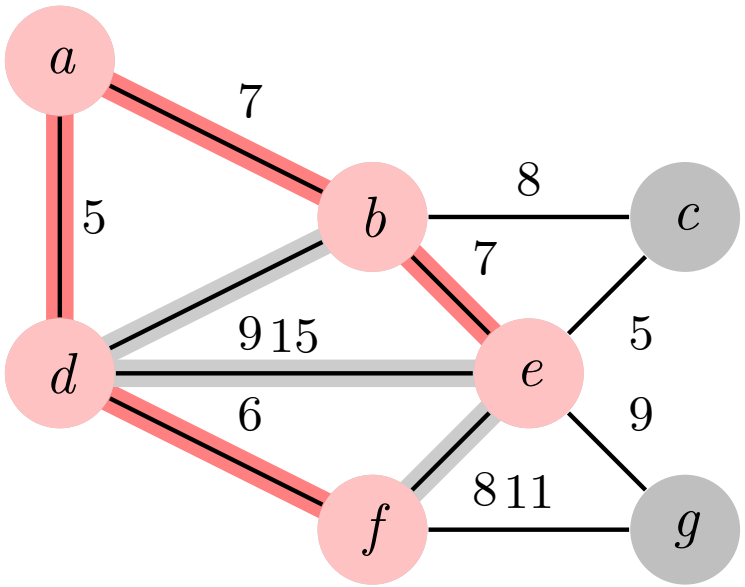
Prim's algorithm



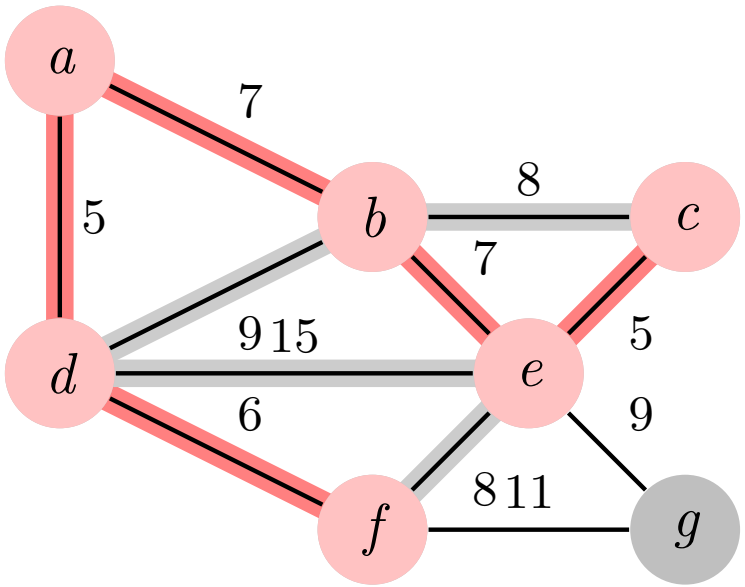
Prim's algorithm



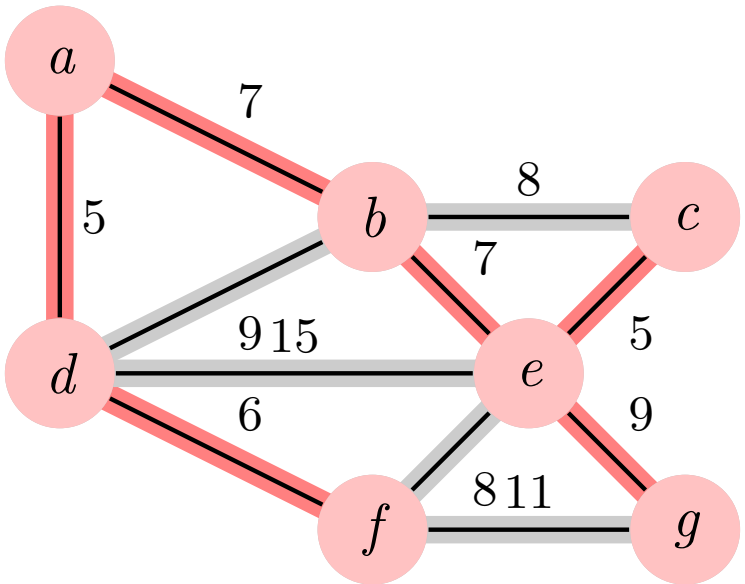
Prim's algorithm



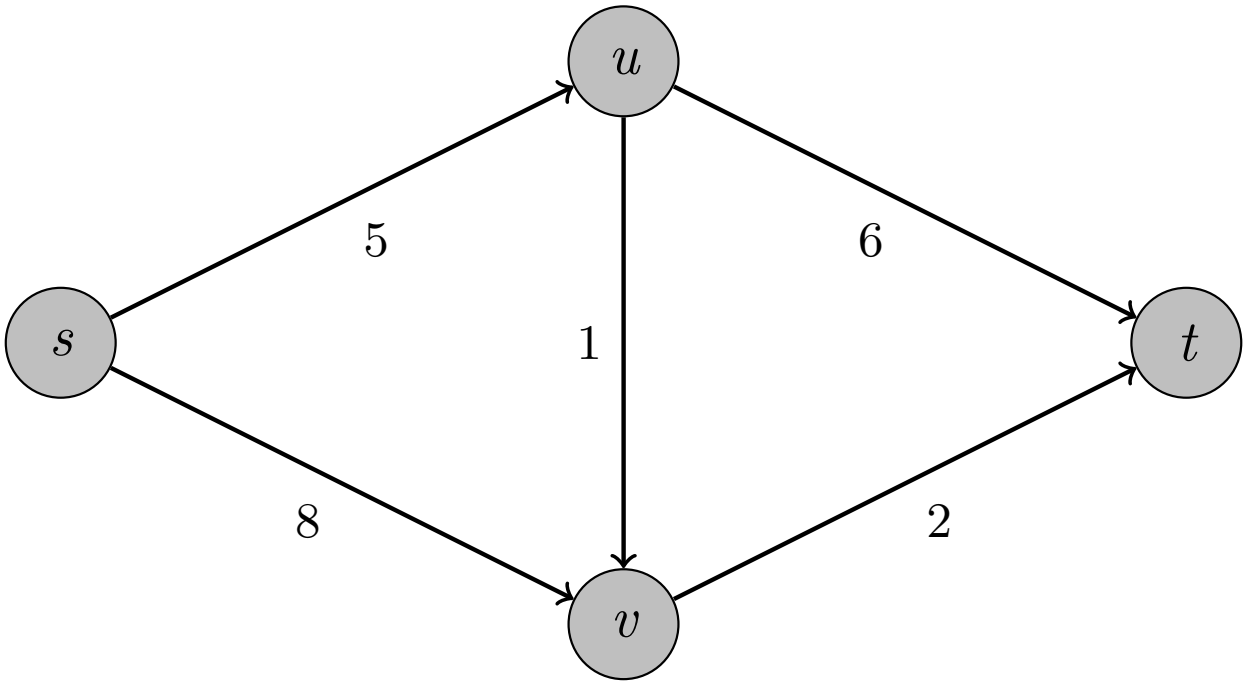
Prim's algorithm



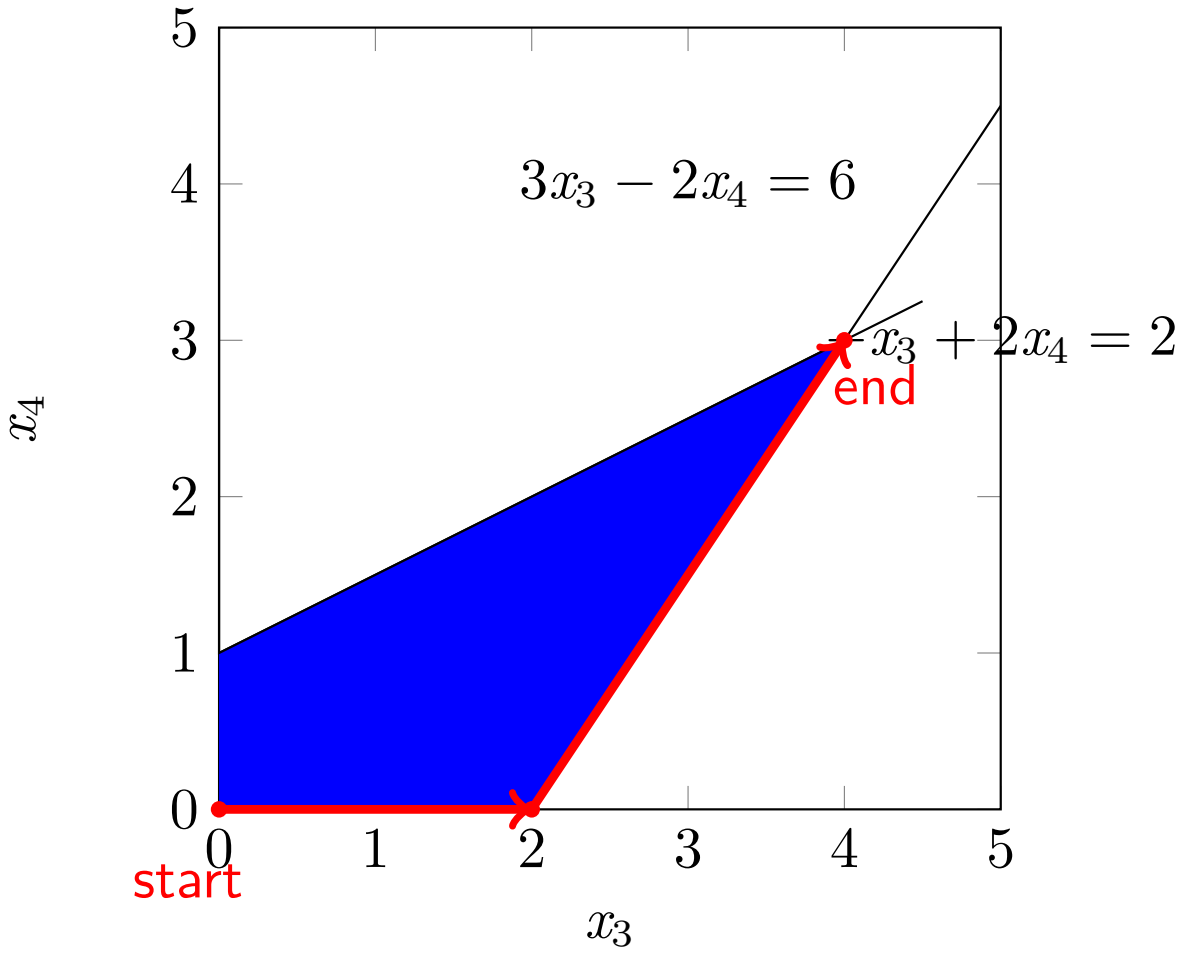
Prim's algorithm

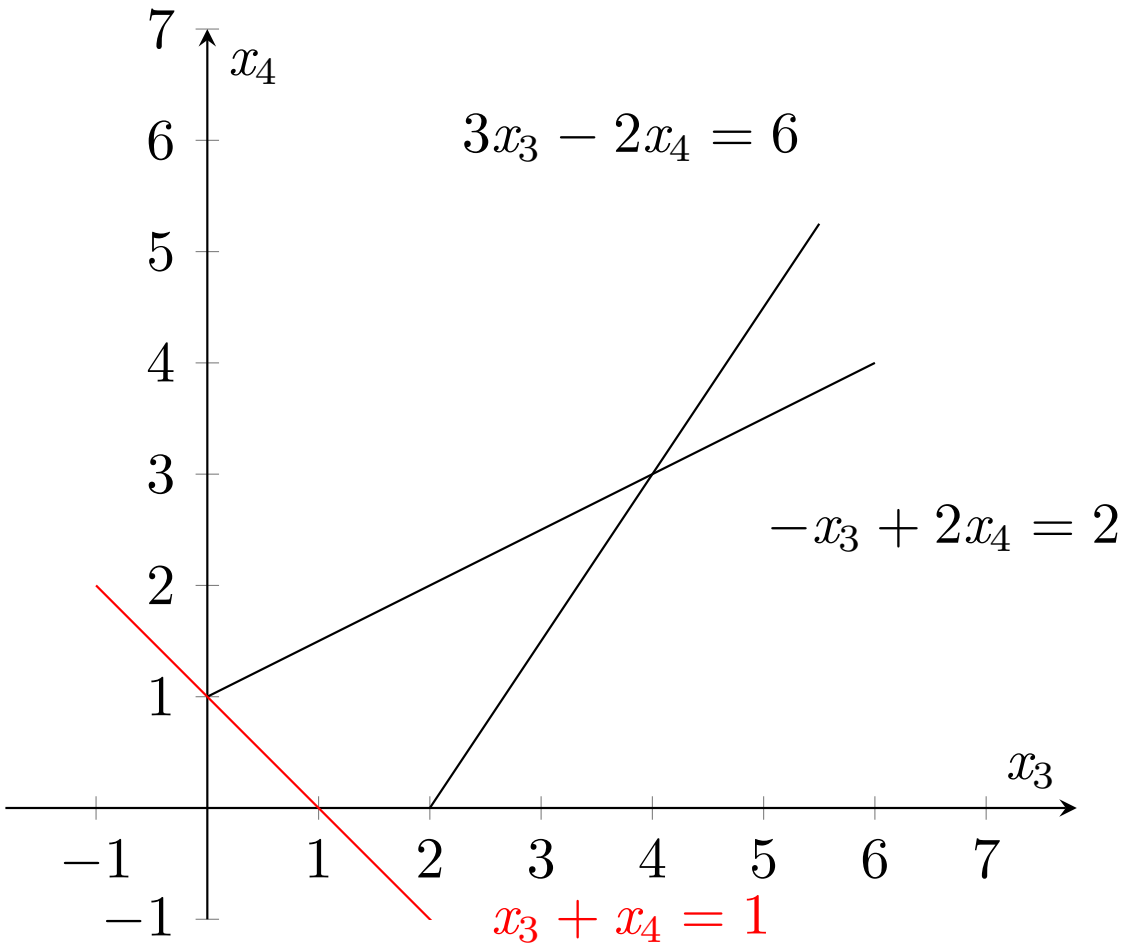


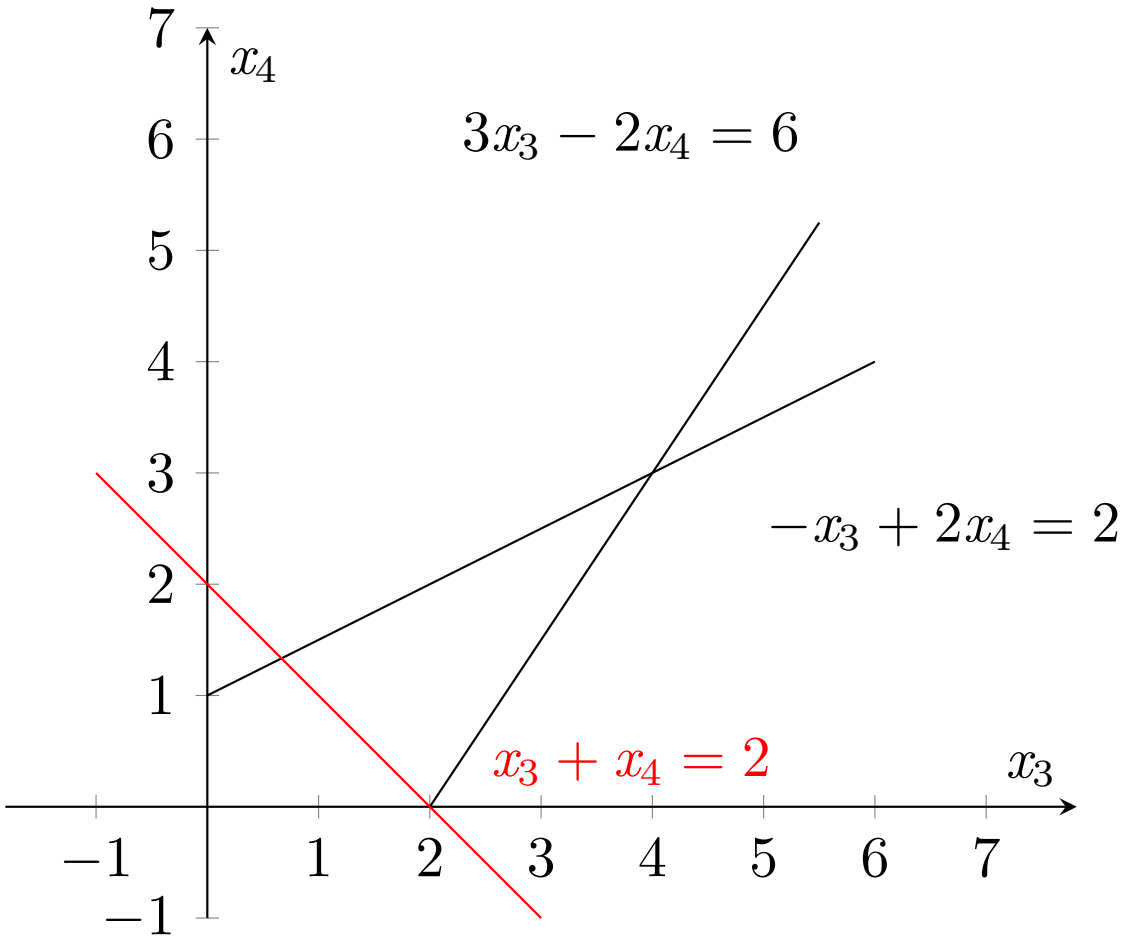
Max Flow

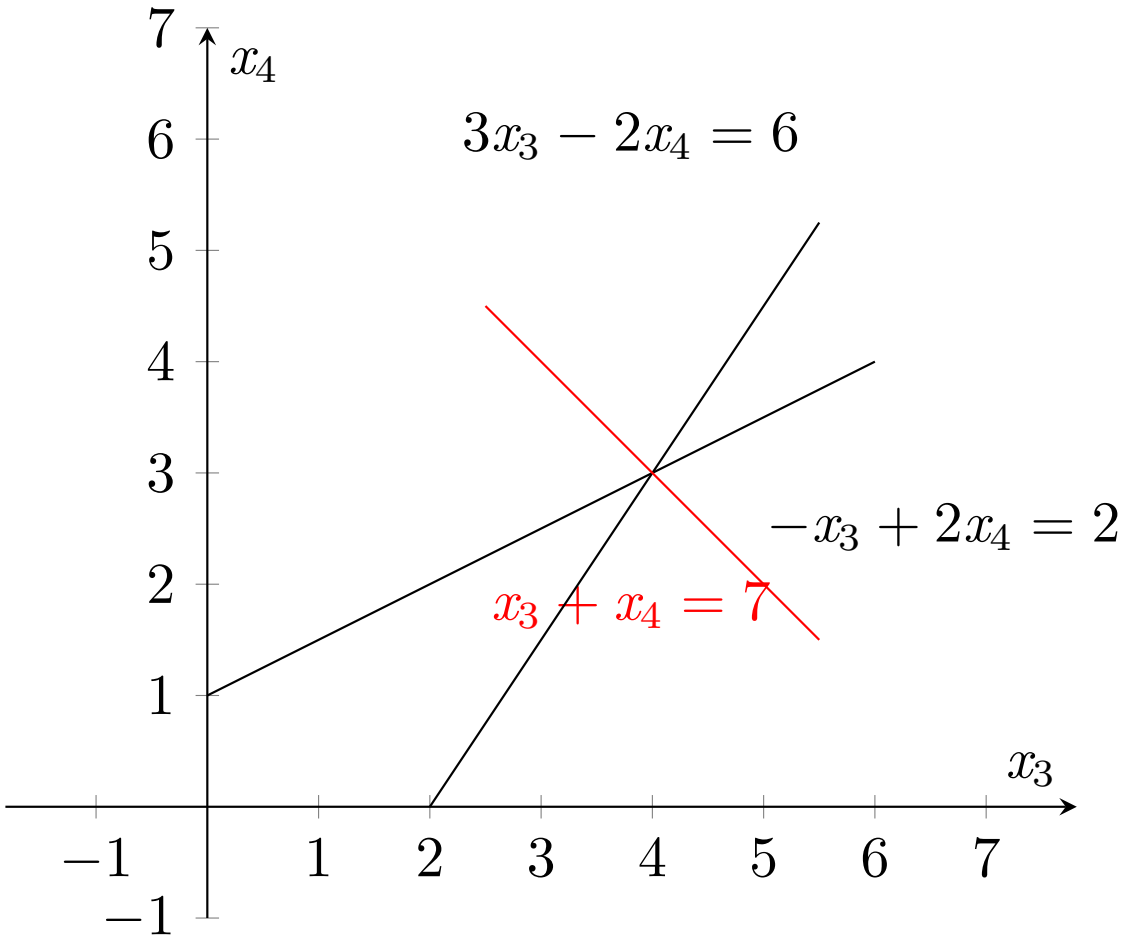


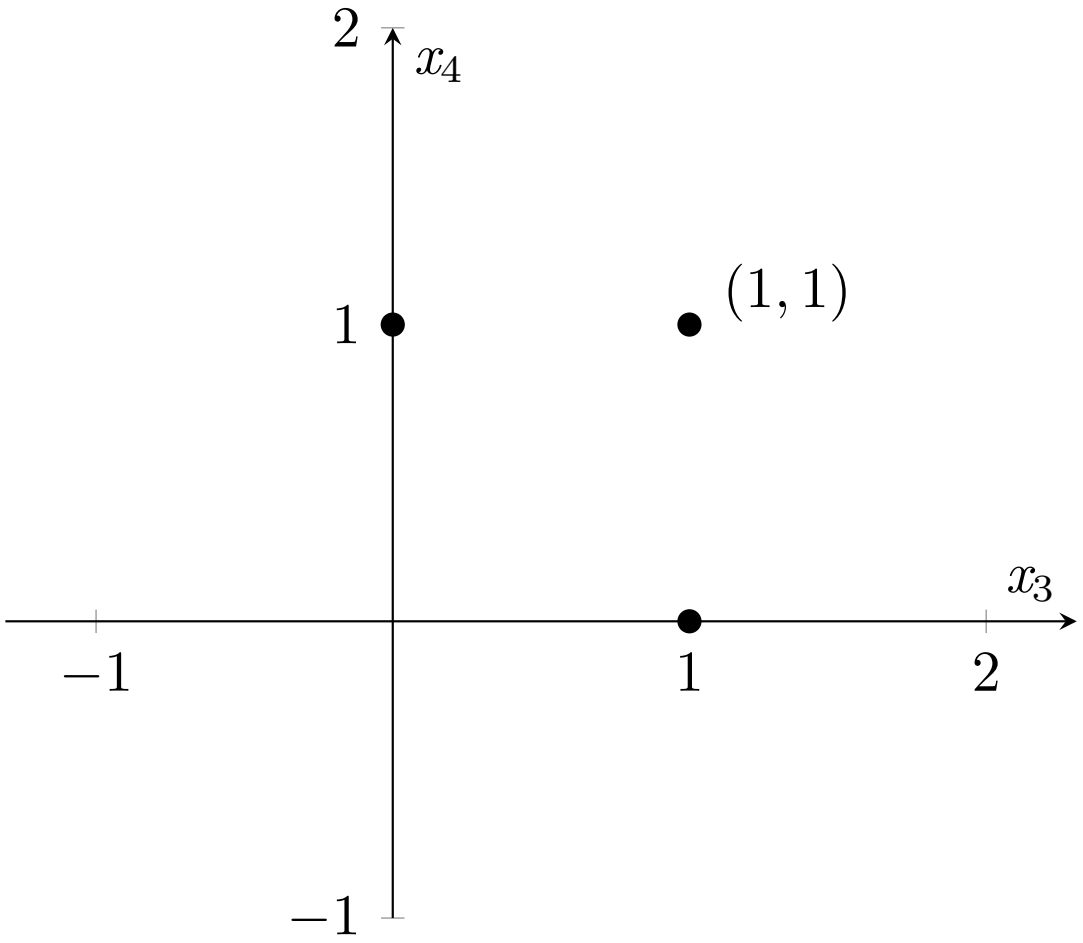
LP example

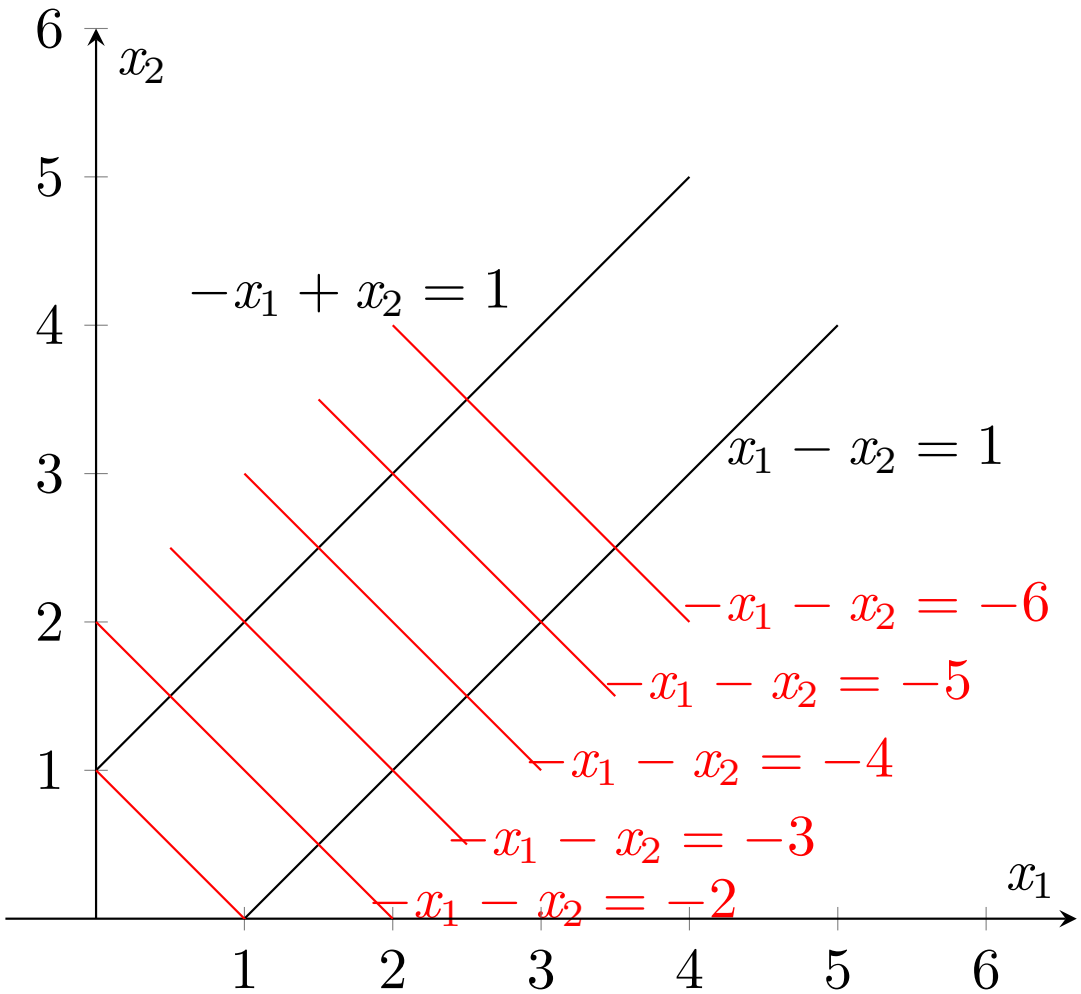


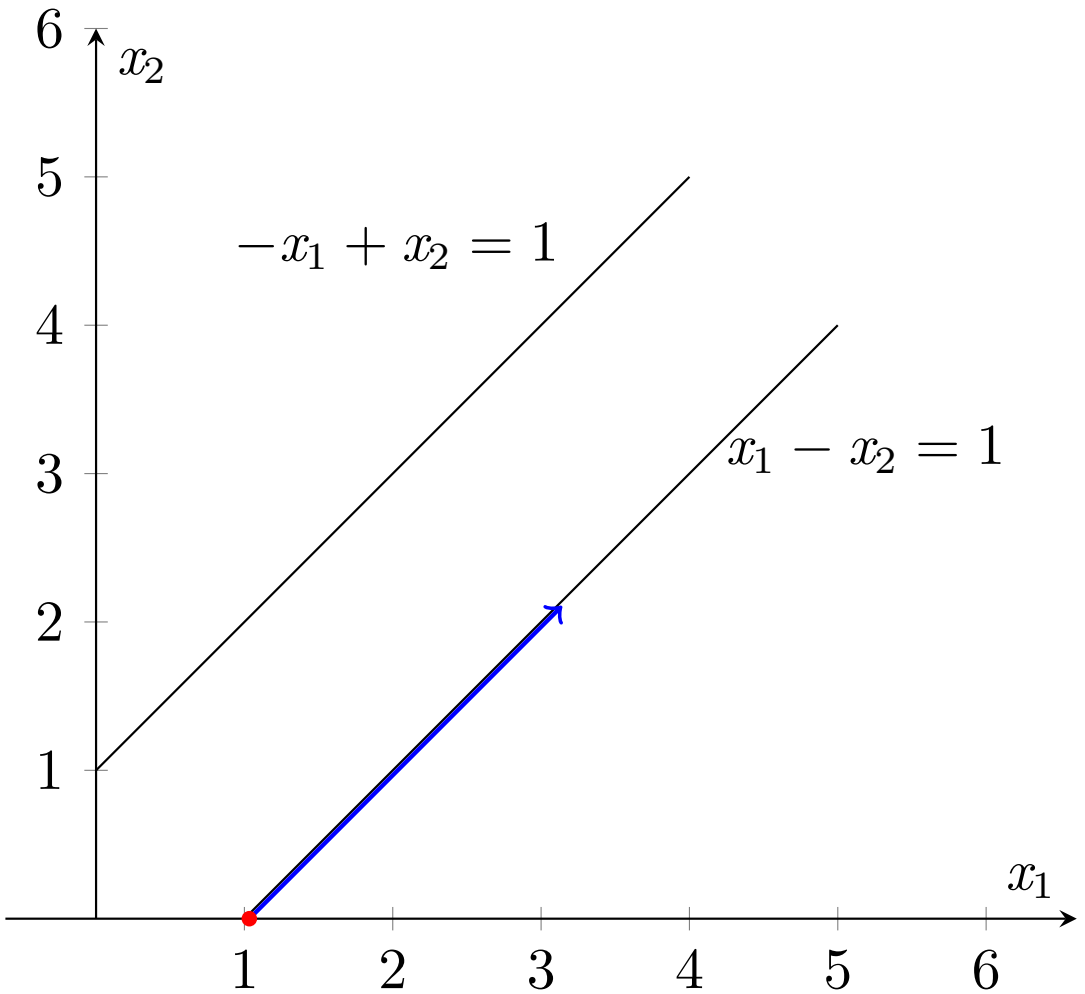

7
6
5
4
3
2
1
−1
x_4
x_3
−1
1
2
3
4
5
6
7
$3x_3 - 2x_4 = 6$
$-x_3 + 2x_4 = 2$
$x_3 + x_4 = 1$

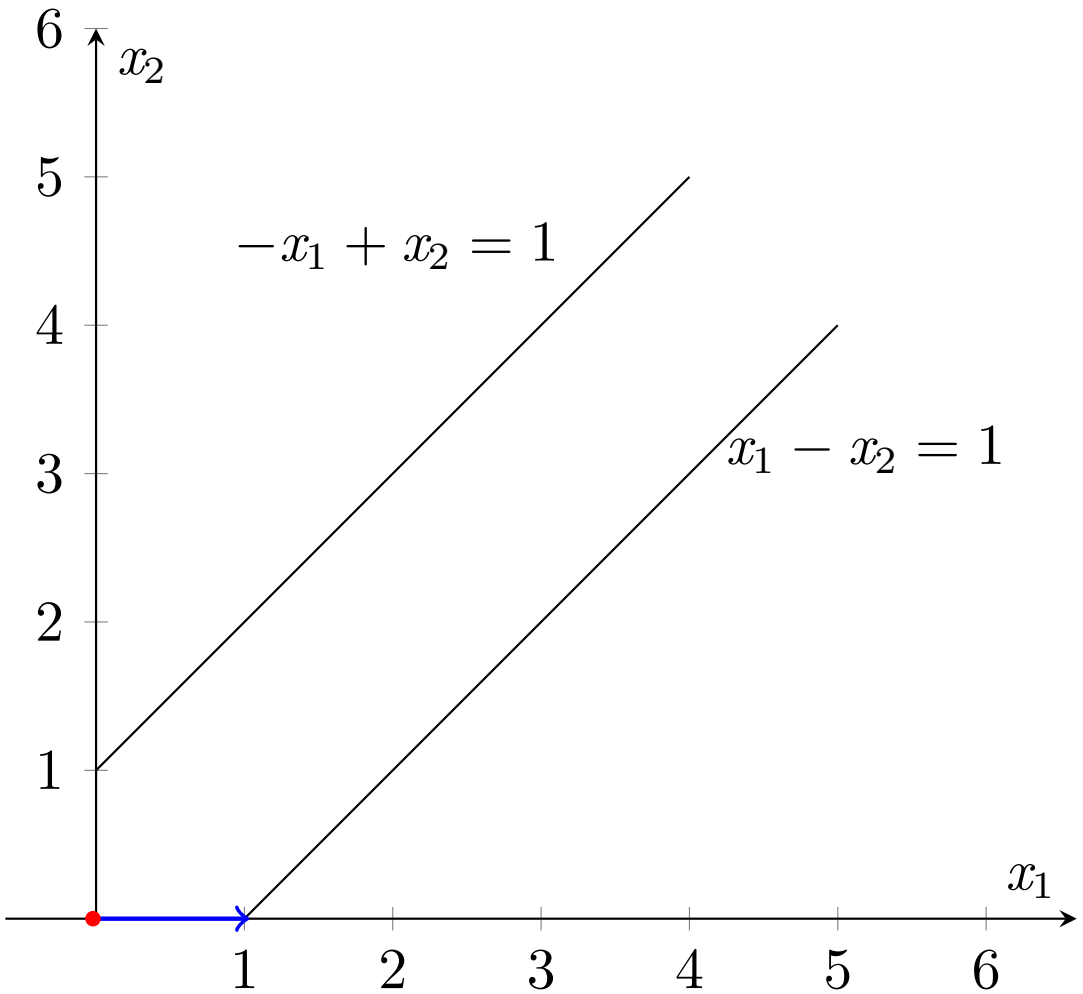

7
6
5
4
3
2
1
−1
−1
1
2
3
4
5
6
7
x_4
x_3
$3x_3 - 2x_4 = 6$
$-x_3 + 2x_4 = 2$
$x_3 + x_4 = 2$


7
6
5
4
3
2
1
−1
−1
1
2
3
4
5
6
7
x_4
x_3
$3x_3 - 2x_4 = 6$
$-x_3 + 2x_4 = 2$
$x_3 + x_4 = 7$


2
x_4
1
$(1, 1)$
x_3
-1
1
2
-1


6
5
4
3
2
1
x_2
x_1
1
2
3
4
5
6
$-x_1 + x_2 = 1$
$x_1 - x_2 = 1$
$-x_1 - x_2 = -6$
$-x_1 - x_2 = -5$
$-x_1 - x_2 = -4$
$-x_1 - x_2 = -3$
$-x_1 - x_2 = -2$

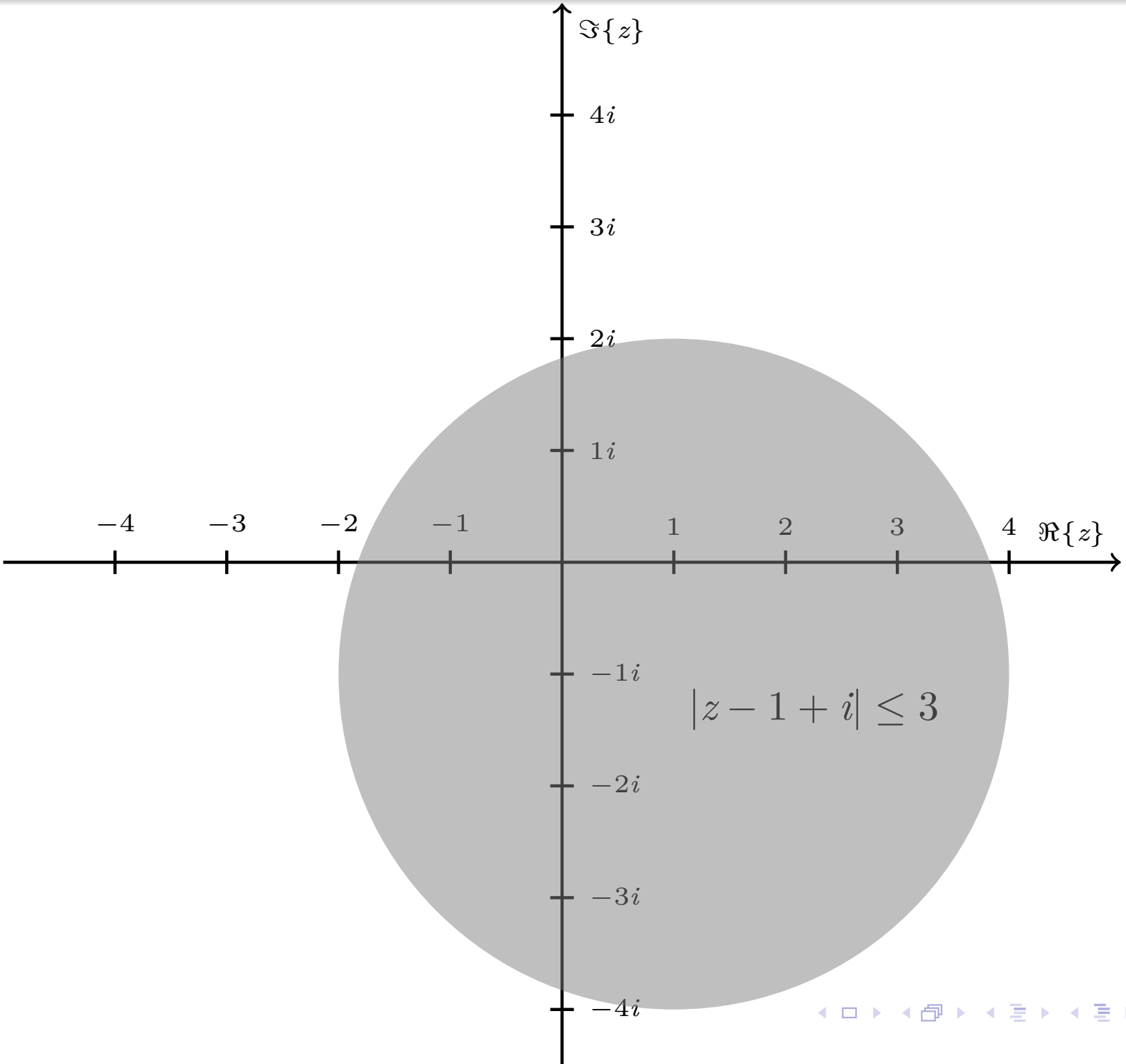

6
5
4
3
2
1
x_2
$-x_1 + x_2 = 1$
$x_1 - x_2 = 1$
x_1
1
2
3
4
5
6


6
5
4
3
2
1
x_2
$-x_1 + x_2 = 1$
$x_1 - x_2 = 1$
x_1
1
2
3
4
5
6

$$
\begin{array}{cccccc}
c_1 & c_2 & \dots & c_n & \\
a_{11} & a_{12} & \dots & a_{1n} & b_1 \\
a_{21} & a_{22} & \dots & a_{2n} & b_2 \\
 & & \dots & & \\
a_{m1} & a_{m2} & \dots & a_{mn} & b_m
\end{array}
$$

$$
\begin{array}{lrcrcccrcl}
\min & c_1 x_1 & + & c_2 x_2 & + & \ldots & + & c_n x_n & & \\
 & a_{11} x_1 & + & a_{12} x_2 & + & \ldots & + & a_{1n} x_n & \geq & b_1 \\
 & a_{21} x_1 & + & a_{22} x_2 & + & \ldots & + & a_{2n} x_n & \geq & b_2 \\
 & & & & & \ldots & & & & \\
 & a_{m1} x_1 & + & a_{m2} x_2 & + & \ldots & + & a_{mn} x_n & \geq & b_m \\
 & & & & & & & x_i & \geq & 0 \quad \text{for each } i
\end{array}
$$

$$
\begin{array}{rrcrcl}
c_1 & c_2 & \cdots & c_n & & \\
\vee| & \vee| & & \vee| & \max & \\
y_1\, a_{11} & y_1\, a_{12} & \cdots & y_1\, a_{1n} & y_1\, b_1 & \\
+ & + & & + & + & \\
y_2\, a_{21} & y_2\, a_{22} & \cdots & y_2\, a_{2n} & y_2\, b_2 & \\
+ & + & & + & + & \\
 & & \cdots & & & \\
+ & + & & + & + & \\
y_m\, a_{m1} & y_m\, a_{m2} & \cdots & y_m\, a_{mn} & y_m\, b_m & \\
 & & & y_j & \geq \quad 0 & \text{for each } j
\end{array}
$$


$\Im\{z\}$
$4i$
$3i$
$2i$
$1i$
$-1i$
$-2i$
$-3i$
$-4i$
-4
-3
-2
-1
1
2
3
4
$\Re\{z\}$
$|z-1+i| \leq 3$

$$\begin{pmatrix} 0 & c_1 & c_2 & \cdots & c_m & \cdots & c_n \\ b_1 & a_{11} & a_{12} & \cdots & a_{1m} & \cdots & a_{1n} \\ b_2 & a_{21} & a_{22} & \cdots & a_{2m} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ b_m & a_{m1} & a_{m2} & \cdots & a_{mm} & \cdots & a_{mn} \end{pmatrix}$$

$\Longrightarrow \times \mathbf{B^{-1}}$

$$\begin{pmatrix} \mathbf{c_B^T B^{-1} b} & 0 & 0 & \cdots & 0 & \mathbf{c_N^T - c_B^T B^{-1} N} \\ & 1 & 0 & \cdots & 0 & \\ \mathbf{B^{-1} b} & 0 & 1 & \cdots & 0 & \mathbf{B^{-1} N} \\ & \vdots & \vdots & \ddots & \vdots & \\ & 0 & 0 & \cdots & 1 & \end{pmatrix}$$

$$\begin{pmatrix} 0 & \dots & 0 & \cdots & c_e & \cdots \\ b_1 & \dots & 0 & \cdots & a_{1e} & \cdots \\ b_2 & \dots & 0 & \cdots & a_{2e} & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ b_l & \dots & 1 & \cdots & a_{le} & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ b_m & \dots & 0 & \cdots & a_{me} & \cdots \end{pmatrix}$$

$\Rightarrow$

$$\begin{pmatrix} -\frac{a_{me}}{a_{le}} b_l & \dots & -\frac{c_e}{a_{le}} & \cdots & 0 & \cdots \\ b_1 - \frac{a_{1e}}{a_{le}} b_l & \dots & -\frac{a_{1e}}{a_{le}} & \cdots & 0 & \cdots \\ b_2 - \frac{a_{2e}}{a_{le}} b_l & \dots & -\frac{a_{2e}}{a_{le}} & \cdots & 0 & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ \frac{1}{a_{le}} b_l & \dots & \frac{1}{a_{le}} & \cdots & 1 & \cdots \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ b_m - \frac{a_{me}}{a_{le}} b_l & \dots & -\frac{a_{me}}{a_{le}} & \cdots & 0 & \cdots \end{pmatrix}$$

LP x1x2-1