Edit Distance

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Edit Distance

- Let x to y be two strings.

- Convert x to y by insertion, deletion, and replacement.

- Edit distance is the minimum number of operations.

Edit Distance

- Example inputs:

  - x = "algorithm".

  - y = "algorithm**s**".

- Example output:

  - Distance = 1. (Inserted **'s'** to x.)

Edit Distance

- Example inputs:

  - x = "al**g**orithm".

  - y = "alorithm".

- Example output:

  - Distance = 1. (Deleted **'g'**.)

Edit Distance

- Example inputs:

    - **x** = "al**g**orithm".

    - **y** = "bl**f**orithm".

- Example output:

    - Distance = 1. (Replaced **'a'** by **'b'**.)

Edit Distance

- Example inputs:

  - **x** = "giv**e**".

  - **y** = "giv**ing**".

- Example input:

  - Distance = 3. (Replaced **'e'** by **'i'**; inserted **'n'** and **'g'**.)

Applications

- **Application 1:** Spelling corrections.

  - Find a word in the dictionary that minimizes the edit distance.

  - E.g., "algorithn" ==> "algorithm".

Applications

- **Application 1:** Spelling corrections.
  - Find a word in the dictionary that minimizes the edit distance.
 - E.g., "algorithn" ==> "algorithm".

- **Application 2:** Quantify the difference between two DNA sequences.
  - **DNA1** = "ATTAGCCCAAGGTAAACCCAGT…".
  - **DNA2** = "ATCAGCTCAAGGTAGACTCAAT…".

Optimal Substructure

D[i][j]: edit distance between **x[1:i]** and **y[1:j]**.

`D[i][j]`: edit distance between `x[1:i]` and `y[1:j]`.

- `x` = "PQZABCDEFG".
- `y` = "PQBCDEFG".

- **What is `D[4][2]`?**

- `x[1:4]` = "PQZA".
- `y[1:2]` = "PQ".

- **Thus `D[4][2] = 2`.**

Case 1: x[i] = y[j]

x[1 : i-1]

y[1 : j-1]
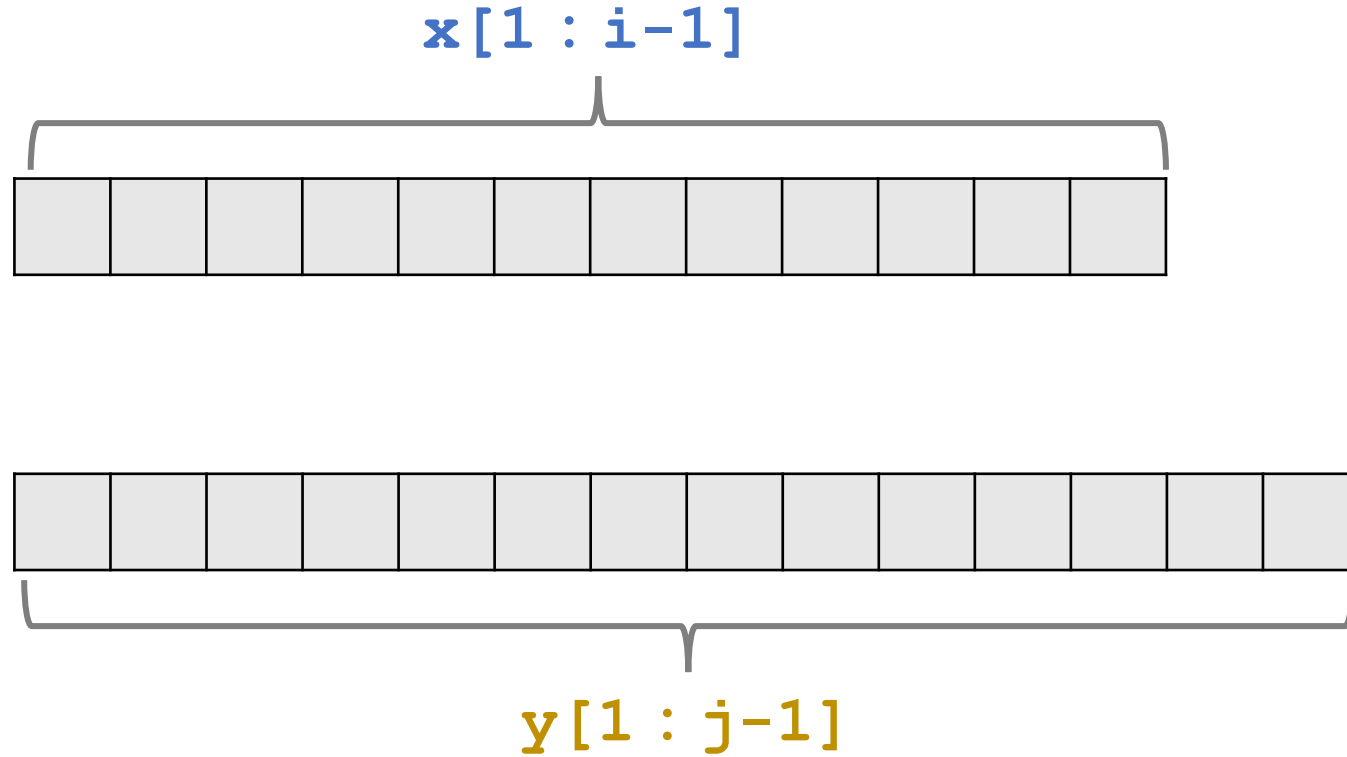
Suppose we already know D[i-1][j-1].

Case 1: `x[i]` = `y[j]`
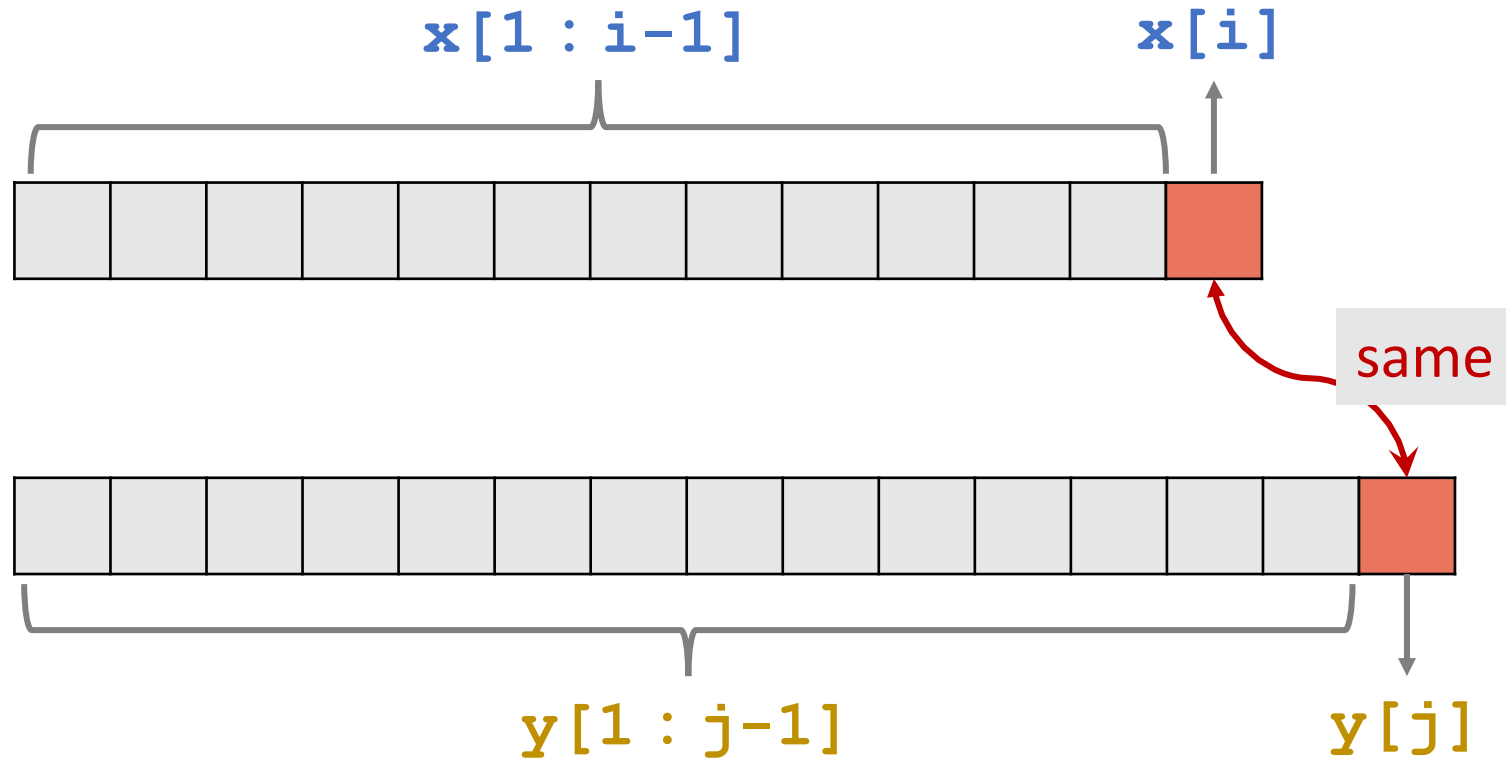
If `x[i]` = `y[j]`, then `D[i][j]` = `D[i-1][j-1]`.

Case 2: $x[i] \neq y[j]$
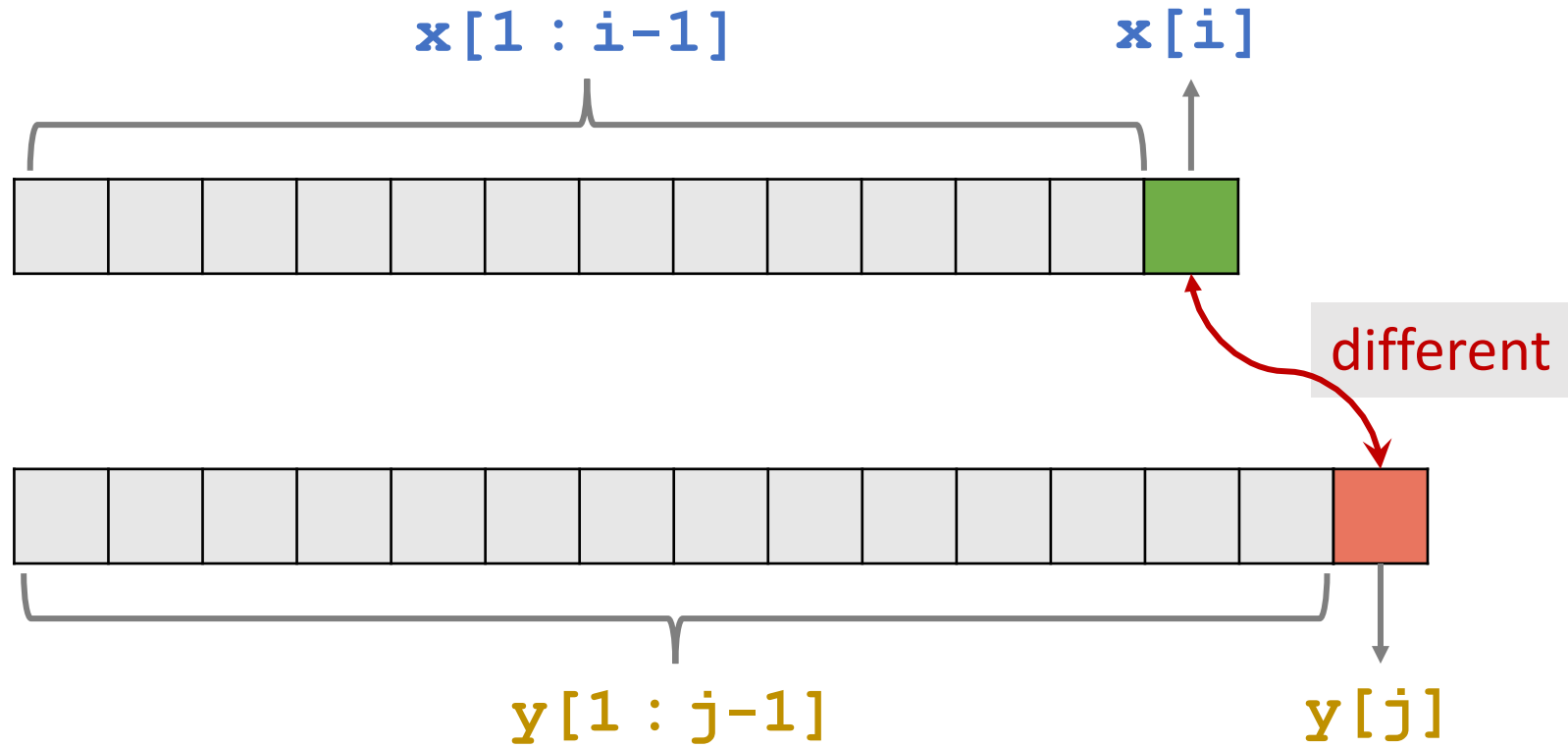
Case 2(A): Replacement
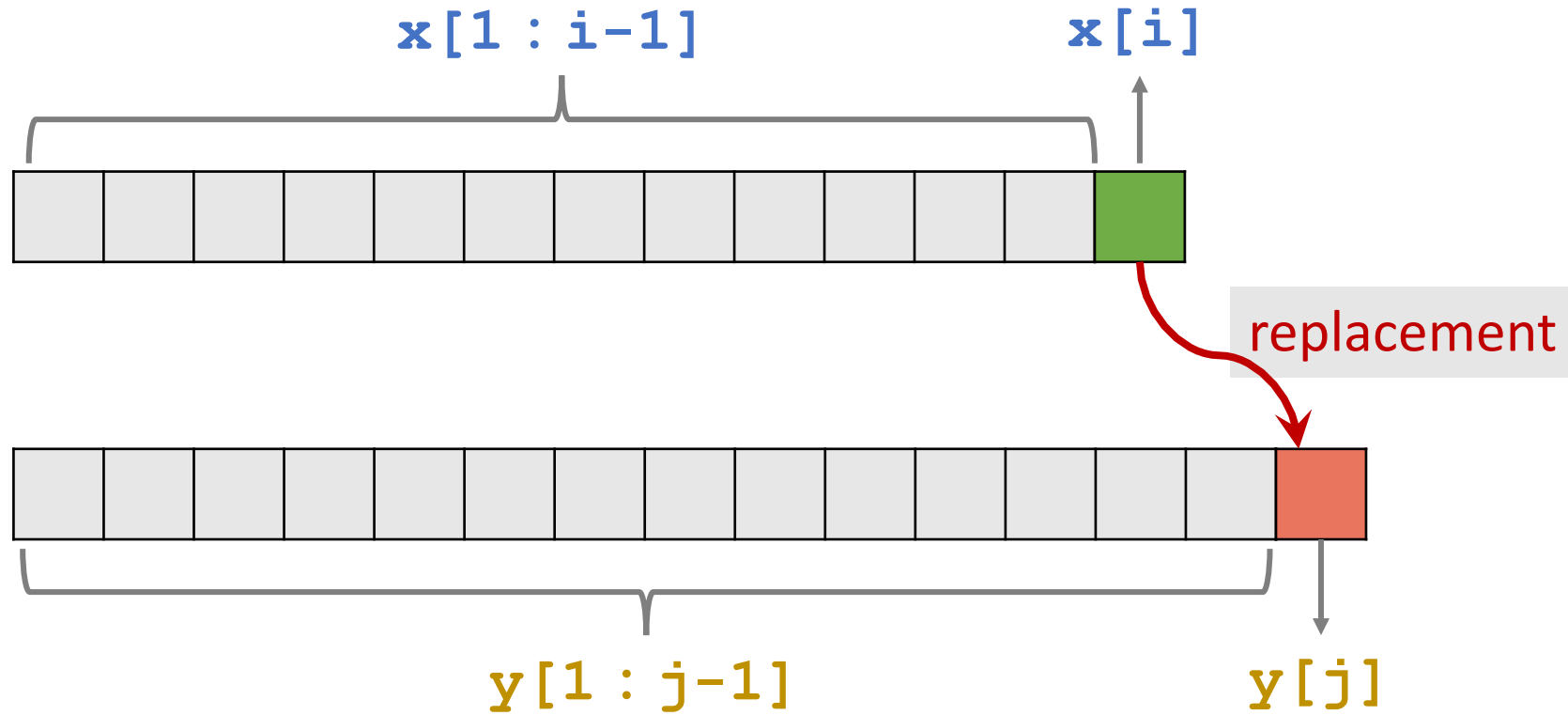
Case 2(A): `y[j]` is obtained by replacing `x[i]`.

Case 2(A): Replacement
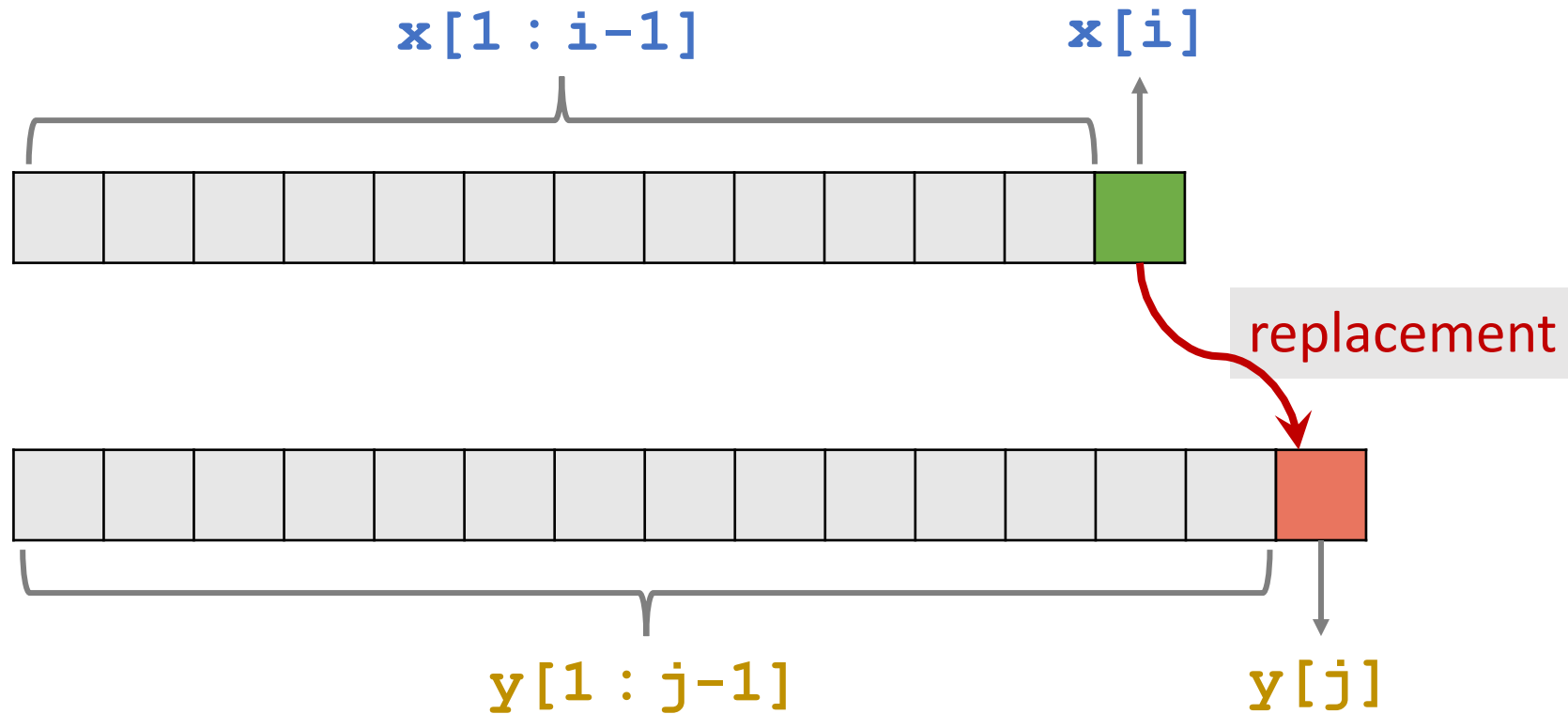
In the case of replacement, `D[i][j]` `=` `D[i-1][j-1]` `+` `1`.

Case 2(B): Insertion
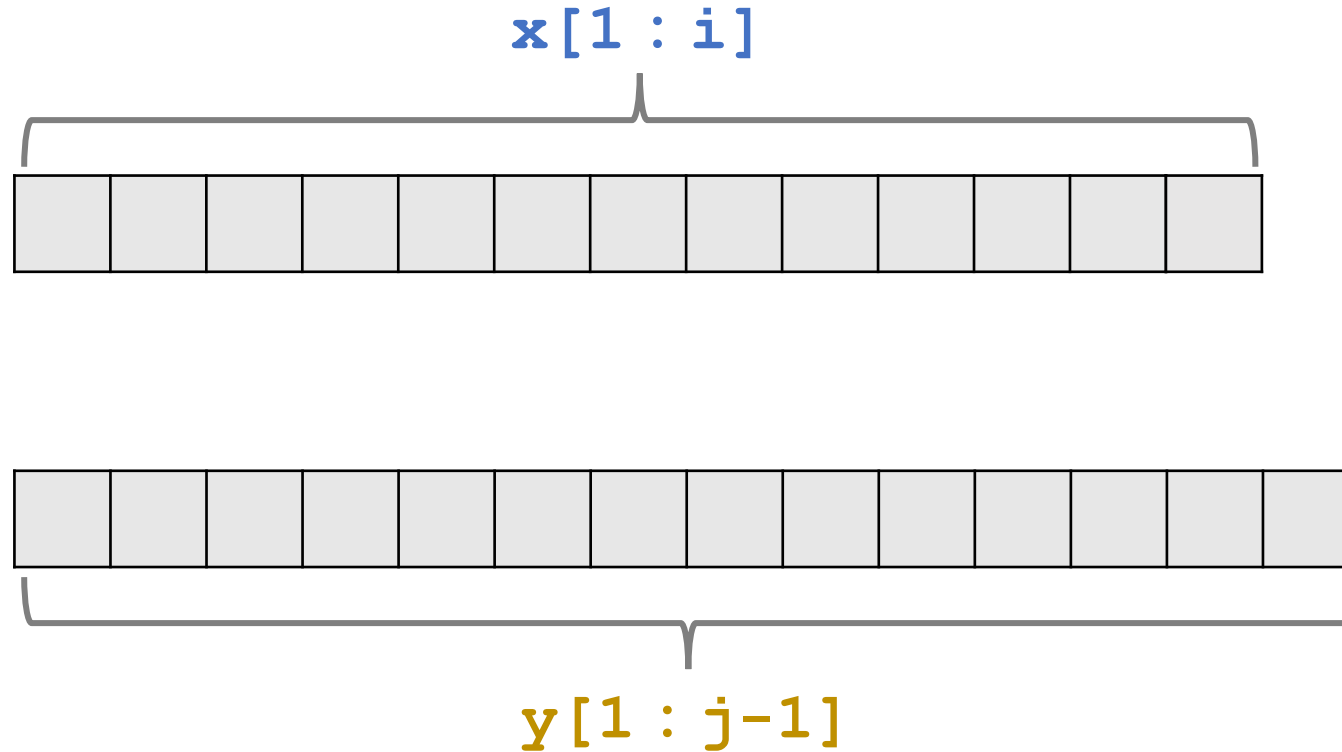
$x[1:i]$

$y[1:j\text{-}1]$

Case 2(B): $y[j]$ is obtained by insertion.

Case 2(B): Insertion

$x[1:i]$

insert:

$y[1:j-1]$ $y[j]$

Case 2(B): `y[j]` is obtained by insertion.

Case 2(B): Insertion

$x[1:i]$

$y[1:j-1]$

insert:

$y[j]$
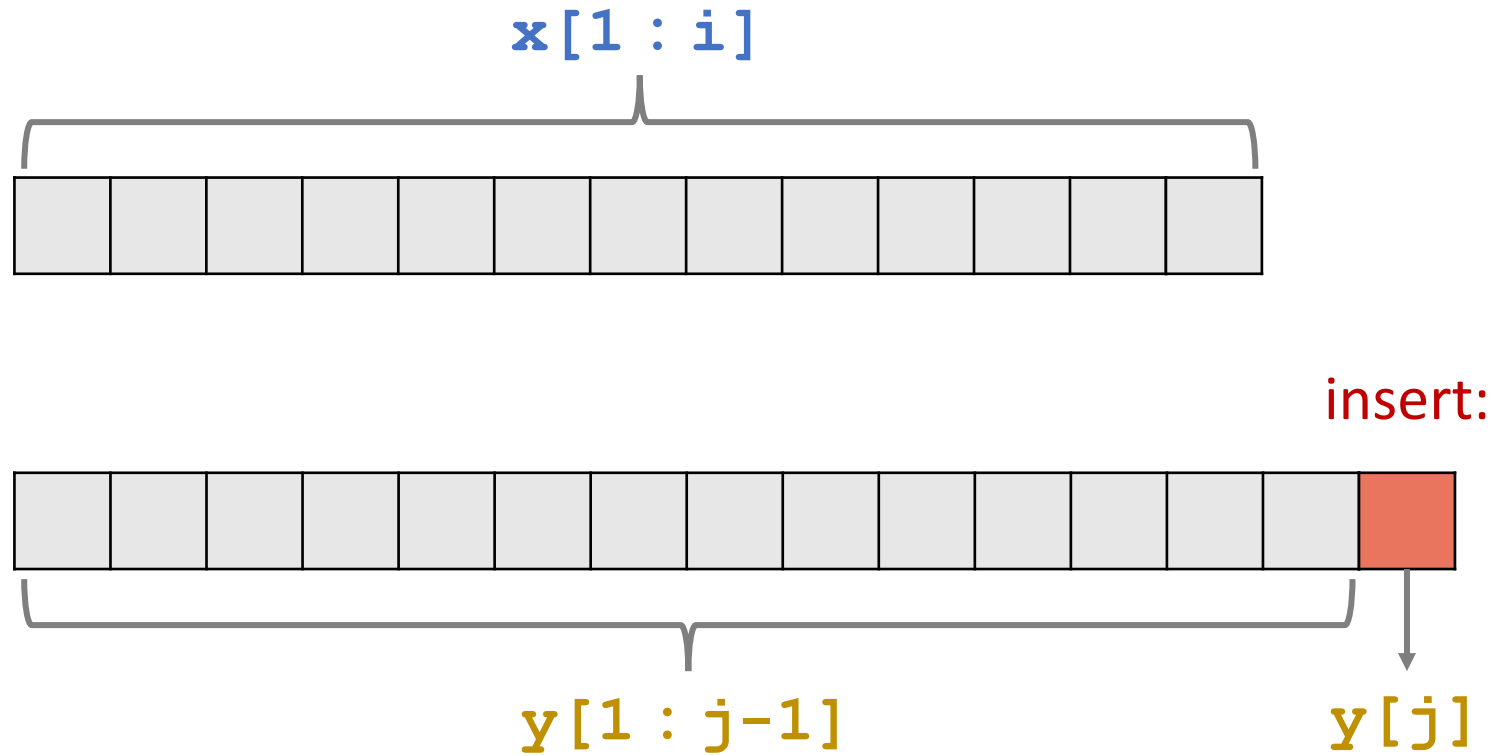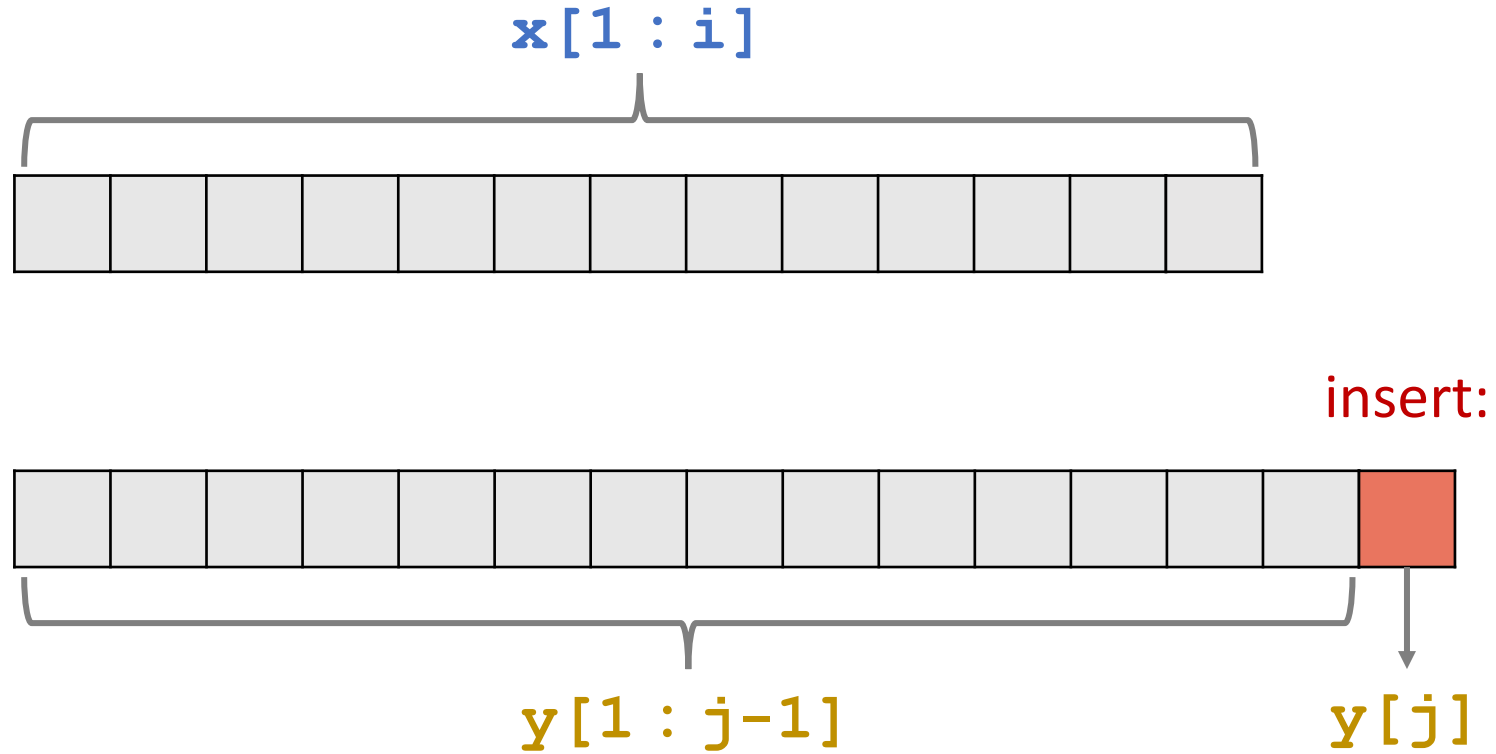
In the case of insertion, `D[i][j] = D[i][j-1] + 1`.

Case 2(C): Deletion
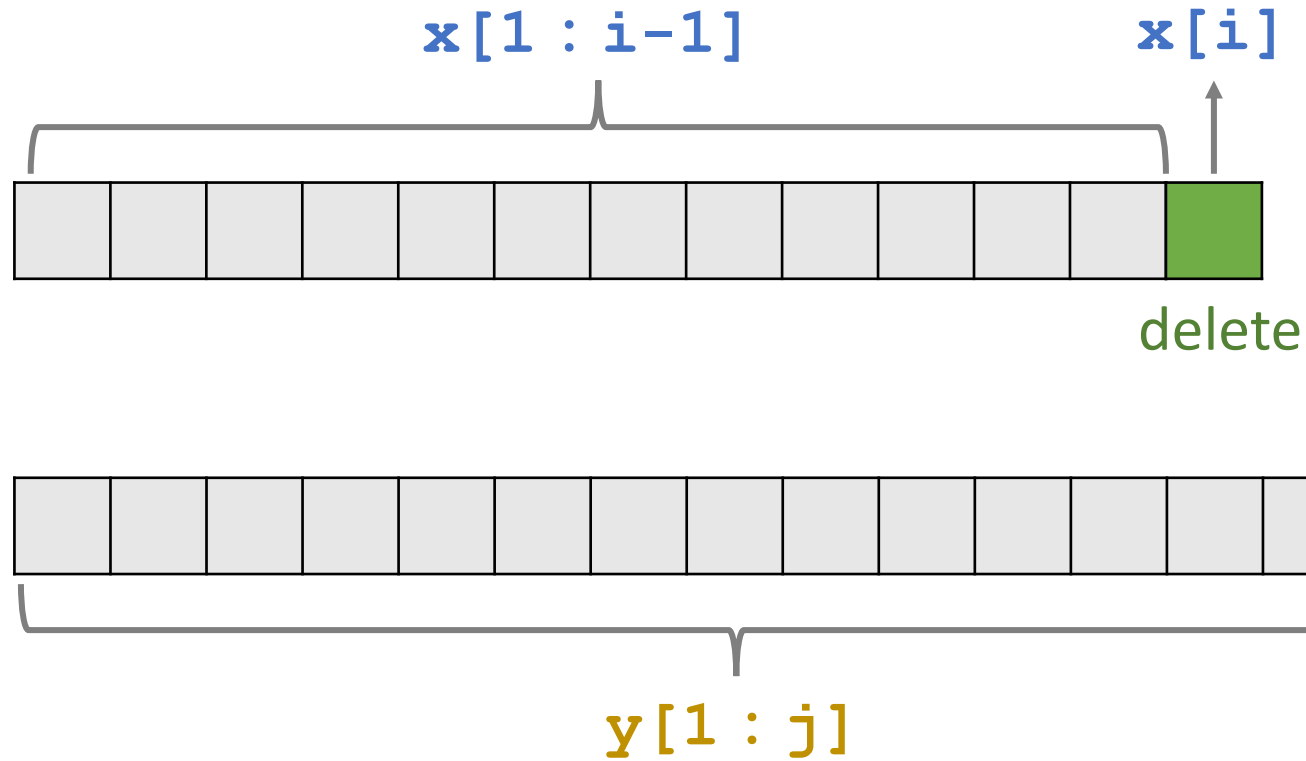
Case 2(C): `y[1:j]` is obtained by deleting `x[i]`.

Case 2(C): Deletion
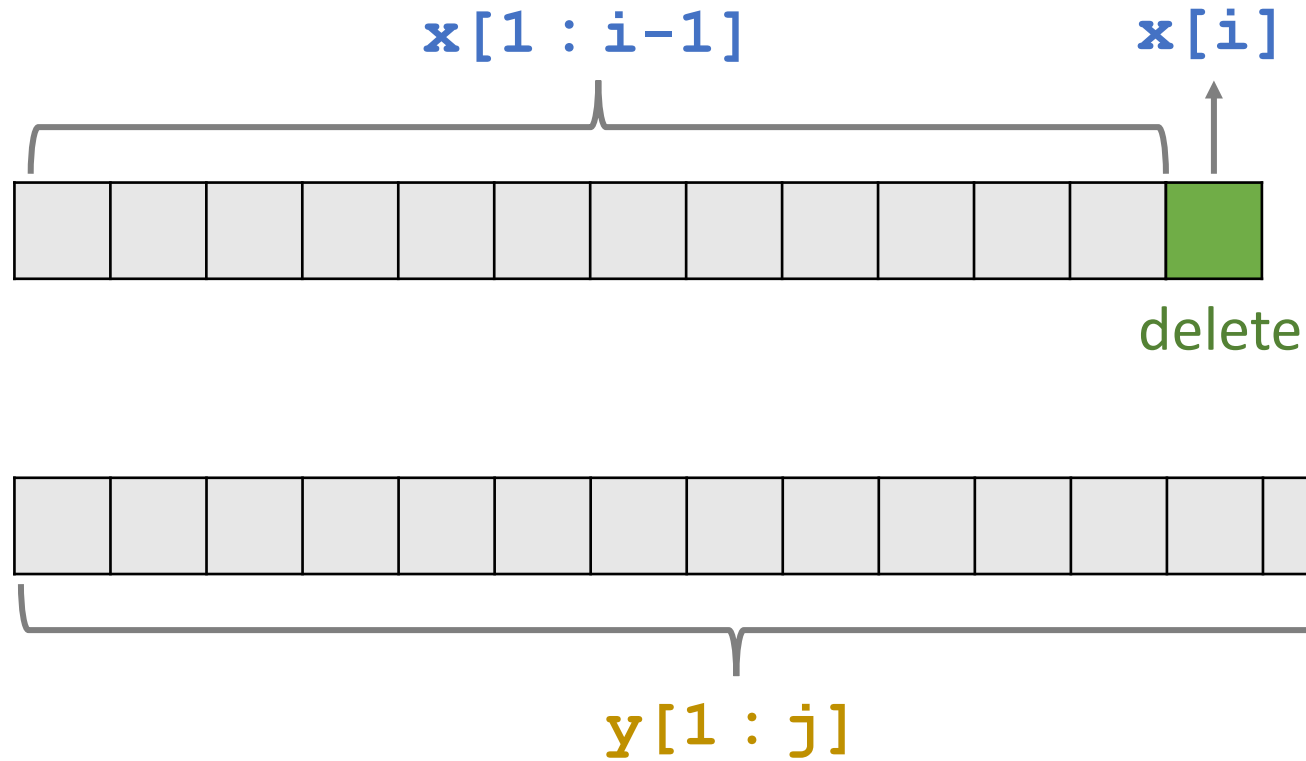
x[1 : i-1]   **x[i]**

delete

y[1 : j]

In the case of deletion, `D[i][j] = D[i-1][j] + 1`.

Case 2: `x[i]` ≠ `y[j]`

In the case of replacement, `D[i][j] = D[i-1][j-1] + 1`.

In the case of insertion, `D[i][j] = D[i][j-1] + 1`.

In the case of deletion, `D[i][j] = D[i-1][j] + 1`.

Case 2: `x[i]` ≠ `y[j]`

In the case of replacement, `D[i][j]` = `D[i-1][j-1] + 1`.

In the case of insertion, `D[i][j]` = `D[i][j-1] + 1`.

In the case of deletion, `D[i][j]` = `D[i-1][j] + 1`.

Case 2: `x[i]` ≠ `y[j]`

In the case of replacement, `D[i][j] = D[i-1][j-1] + 1`.

In the case of insertion, `D[i][j] = D[i][j-1] + 1`.

In the case of deletion, `D[i][j] = D[i-1][j] + 1`.

- In sum, if `x[i] ≠ y[j]`, then

$$D[i][j] = 1 + \min \left\{ \begin{array}{c} D[i-1][j-1] \\ D[i][j-1] \\ D[i-1][j] \end{array} \right\}.$$

Optimal Substructure

- **Case 1:** If `x[i]` = `y[j]`, then

$$D[i][j] = D[i-1][j-1].$$

- **Case 2:** If `x[i]` ≠ `y[j]`, then

$$D[i][j] = 1 + \min \begin{cases} D[i-1][j-1] \\ D[i][j-1] \\ D[i-1][j] \end{cases}.$$

Example

Example

Case 1: $x[i] = y[j]$

Case 1: x[i] = y[j]

Case 2: $x[i] \neq y[j]$

Case 2: $x[i] \neq y[j]$

Dynamic Programming

Inputs: two strings

Base Case

	NULL	R	E	L	A	T	I	V	E
NULL									
A									
C									
T									
I									
V									
E									

Base Case

	NULL	R	E	L	A	T	I	V	E
NULL	0								
A									
C									
T									
I									
V									
E									

Base Case

	NULL	**R**	**E**	**L**	**A**	**T**	**I**	**V**	**E**
NULL	0	1	2	3	4	5	6	7	8
A									
C									
T									
I									
V									
E									

Base Case

	NULL	R	E	L	A	T	I	V	E
NULL	0	1	2	3	4	5	6	7	8
A									
C									
T									
I									
V									
E									

Base Case

	NULL	R	E	L	A	T	I	V	E
NULL	0	1	2	3	4	5	6	7	8
A	1								
C	2								
T	3								
I	4								
V	5								
E	6								

$$x[1] \neq y[1]$$

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	?							
C	2								
T	3								
I	4								
V	5								
E	6								

$x[1] \neq y[1]$

	R	E	L	A	T	I	V	E	E
	0	1	2	3	4	5	6	7	8
A	1	?							
C	2	$\min\{1,0,1\} + 1$							
T	3								
I	4								
V	5								
E	6								

$x[1] \neq y[2]$

	R	**E**	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	**?**						
C	2								
T	3								
I	4								
V	5								
E	6								

$x[1] \neq y[2]$

	0	1	2	3	4	5	6	7	8
		R	E	L	A	T	I	V	E
A	1	1	?						
C	2		$\text{min}\{1,1,2\} + 1$						
T	3								
I	4								
V	5								
E	6								

x[1] ≠ y[3]

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2 → 3					
C	2								
T	3								
I	4								
V	5								
E	6								

x[1] = y[4]

	R	E	L	A	T	I	V	E
0	1	2	**3**	4	5	6	7	8
A 1	1	2	3	**?**				
C 2								
T 3								
I 4								
V 5								
E 6								

$$x[1] = y[4]$$

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	?				
C	2								
T	3								
I	4								
V	5								
E	6								

`L[1][4] = L[0][3]`

$x[1] \neq y[5]$

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3 → 4			
C	2							
T	3							
I	4							
V	5							
E	6							

x[1] ≠ y[6]

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4 → 5		
C	2								
T	3								
I	4								
V	5								
E	6								

x[1] ≠ y[7]

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5 → 6	
C	2								
T	3								
I	4								
V	5								
E	6								

x[1] ≠ y[8]

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6 → 7
C	2								
T	3								
I	4								
V	5								
E	6								

$x[2] \neq y[1]$

	R	**E**	**L**	**A**	**T**	**I**	**V**	**E**
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2							
T	3								
I	4								
V	5								
E	6								

$$x[2] \neq y[2]$$

	R	**E**	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2						
T	3								
I	4								
V	5								
E	6								

$$x[2] \neq y[3]$$

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2 → 3					
T	3							
I	4							
V	5							
E	6							

$x[2] \neq y[4]$

	R	**E**	**L**	**A**	**T**	**I**	**V**	**E**
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3 → 4				
T	3							
I	4							
V	5							
E	6							

$x[2] \neq y[5]$

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4			
T	3								
I	4								
V	5								
E	6								

$$x[2] \neq y[6]$$

	R	E	L	A	T	**I**	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4 → 5		
T	3							
I	4							
V	5							
E	6							

$$x[2] \neq y[7]$$

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	
T	3								
I	4								
V	5								
E	6								

x[2] ≠ y[8]

		R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	→ 7
T	3								
I	4								
V	5								
E	6								

$x[3] \neq y[1]$

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3							
I	4								
V	5								
E	6								

$x[3] \neq y[2]$

	R	E	L	A	T	I	V	E
0	1	2	3	4	5	6	7	8
A 1	1	2	3	3	4	5	6	7
C 2	2	2	3	4	4	5	6	7
T 3	3	3						
I 4								
V 5								
E 6								

x[3] ≠ y[3]

		R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3					
I	4								
V	5								
E	6								

x[3] ≠ y[4]

	R	E	L	**A**	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3 → 4					
I	4								
V	5								
E	6								

$\mathtt{x[3]} = \mathtt{y[5]}$

		R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	?			
I	4								
V	5								
E	6								

x[3] ≠ y[7]

		R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	→6	
I	4								
V	5								
E	6								

x[3] ≠ y[8]

		R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4								
V	5								
E	6								

$$x[4] \neq y[1]$$

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4							
V	5								
E	6								

x[4] ≠ y[2]

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4						
V	5								
E	6								

x[4] ≠ y[3]

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4					
V	5								
E	6								

$x[4] \neq y[4]$

	R	E	L	**A**	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4				
V	5								
E	6								

$\mathbf{x[4]} \neq \mathbf{y[5]}$

		R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4 → 5				
V	5								
E	6								

x[4] = y[6]

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	?		
V	5								
E	6								

x[4] = y[6]

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	?		
V	5								
E	6								

L[4][6] = L[3][5]

$x[4] \neq y[7]$

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4 → 5	
V	5								
E	6								

$x[4] \neq y[8]$

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5 → 6
V	5								
E	6								

x[5] ≠ y[1]

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5							
E	6								

$\mathbf{x[5]} \neq \mathbf{y[2]}$

	R	E	L	A	T	I	V	E
0	1	2	3	4	5	6	7	8
A 1	1	2	3	3	4	5	6	7
C 2	2	2	3	4	4	5	6	7
T 3	3	3	3	4	4	5	6	7
I 4	4	4	4	4	5	4	5	6
V 5	5	5						
E 6								

$\mathbf{x[5]} \neq \mathbf{y[3]}$

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5					
E	6								

$\mathbf{x[5]} \neq \mathbf{y[4]}$

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5				
E	6								

$x[5] \neq y[5]$

		R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5			
E	6								

$$x[5] \neq y[6]$$

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5	5		
E	6								

x[5] = y[7]

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5	5	?	
E	6								

x[5] = y[7]

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5	5	?	
E	6								

L[5][7] = L[4][6]

x[5] ≠ y[8]

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5	5	4 → 5
E	6								

$\mathtt{x[6]} \neq \mathtt{y[1]}$

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5	5	4	5
E	6	6							

$x[6] = y[2]$

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5	5	4	5
E	6	6	?						

x[6] = y[2]

L[6][2] = L[5][1]

x[6] ≠ y[3]

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5	5	4	5
E	6	6	5 → 6						

x[6] ≠ y[4]

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5	5	4	5
E	6	6	5	6	6				

$\mathbf{x[6]} \neq \mathbf{y[5]}$

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5	5	4	5
E	6	6	5	6	6	6			

x[6] ≠ y[6]

		R	E	L	A	T	**I**	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5	5	4	5
E	6	6	5	6	6	6	6		

x[6] ≠ y[7]

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5	5	4	5
E	6	6	5	6	6	6	6	5	

x[6] = y[8]

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5	5	4	5
E	6	6	5	6	6	6	6	5	?

End of Procedure

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5	5	4	5
E	6	6	5	6	6	6	6	5	**4**

Edit Distance = 4
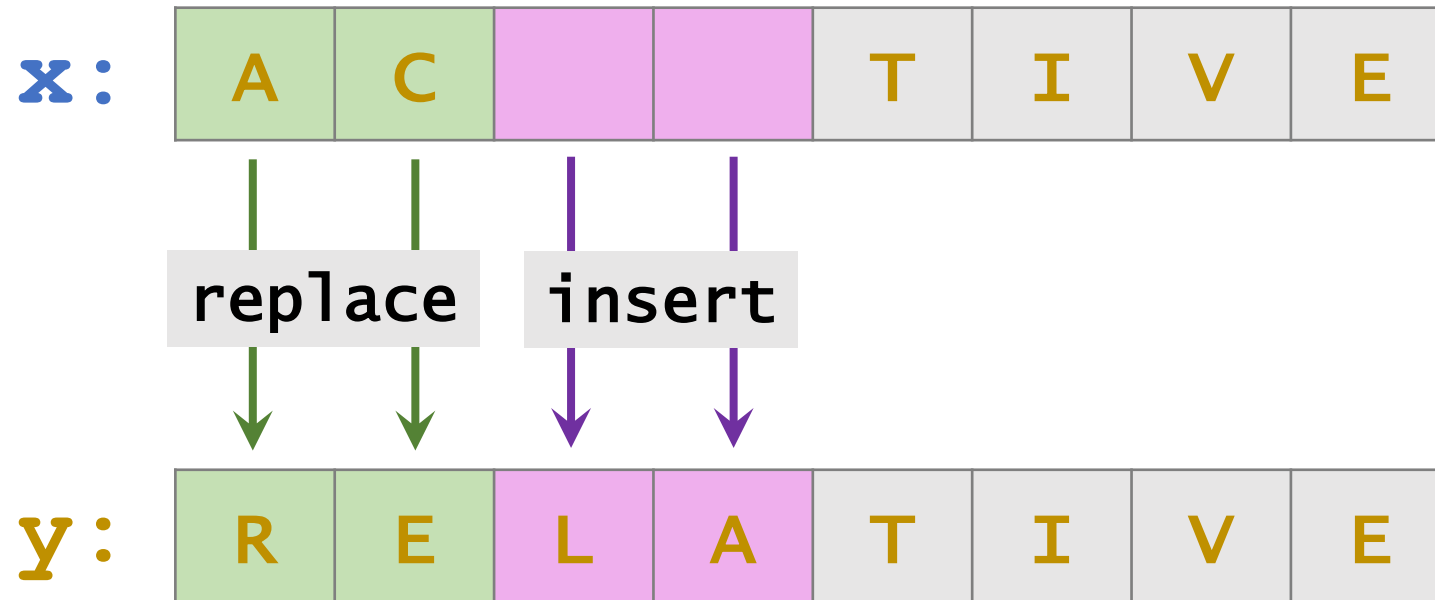
Summary

Optimal Substructure
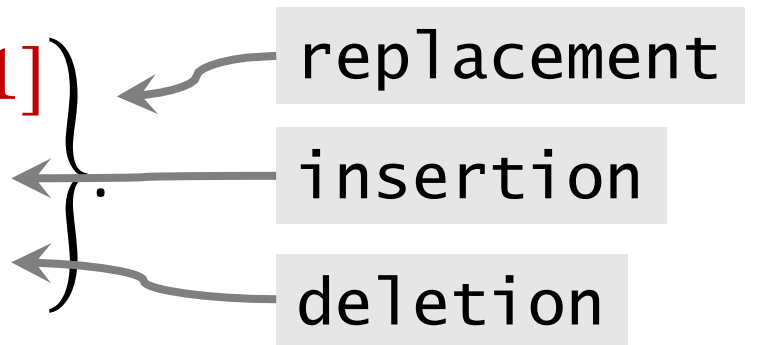
Case 1: $x[i] = y[j]$.

- Recursion: $D[i][j] = D[i-1][j-1]$.

Optimal Substructure

Case 1: x[i] = y[j].

- Recursion: $D[i][j] = D[i-1][j-1]$.

Case 2: x[i] ≠ y[j].

- Recursion: $D[i][j] = 1 + \min \begin{cases} D[i-1][j-1] & \text{replacement} \\ D[i][j-1] & \text{insertion} \\ D[i-1][j] & \text{deletion} \end{cases}$.

Time Complexity

- Inputs:
  - String **x**. (The length is m.)
  - String **y**. (The length is n.)
- Size of the table is $(m+1) \times (n+1)$.
- $O(1)$ time for filling each entry of the table.
- Thus, the overall time complexity is $O(mn)$.

Thank You!

Find the edits from the table

What are the edits?

	R	**E**	**L**	**A**	**T**	**I**	**V**	**E**
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5	5	4	5
E	6	6	5	6	6	6	6	5	4

What are the edits?

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5	5	4	5
E	6	6	5	6	6	6	6	5	4

What are the edits?

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5	5	4	5
E	6	6	5	6	6	6	6	5	4

What are the edits?

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	**4**	5	6	7
I	4	4	4	4	4	5	**4**	5	6
V	5	5	5	5	5	5	5	**4**	5
E	6	6	5	6	6	6	6	5	**4**

What are the edits?

What are the edits?

insert

	R	E	L	A	T	I	V	E
	0	1	2	3	4	5	6	7	8
A	1	1	2	3	3	4	5	6	7
C	2	2	2	3	4	4	5	6	7
T	3	3	3	3	4	4	5	6	7
I	4	4	4	4	4	5	4	5	6
V	5	5	5	5	5	5	5	4	5
E	6	6	5	6	6	6	6	5	4

What are the edits?

What are the edits?