Automating string processing in spreadsheets using input-output examples

Junliang Yan

Spreadsheets

	A	B	C
1	**Name**	**City**	**Phone**
2	A	Nanjing	12345678910
3	B	Yangzhou	10987654321
4	C	Zhenjiang	11111111111
5	D	Suzhou	22222222222
6	E	Changzhou	33333333333
7	F	Wuxi	66666666666
8	G	Nantong	99999999999

Collect cities of residence

Name	Adress	City
A	Jiangsu, nanjing, nju	
B	Hubei, wuhan, hust	
C	Shandong, jinan, sdu	
D	Hunan, changsha, csu	

<u>Copy-Paste one by one?</u>

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✓ Flashfill using input-output example!

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- String Manipulation Language

```
SubStr2(
  Address,
  TokenSeq(AlphaToken),
  2
)
```

Program

Flashfill using input-output examples

- String Manipulation Language
- **Synthesize** a program with **input-output examples**

1	Address	Output
A	Jiangsu, nanjing, nju	nanjing

Input-output examples

Synthesize ➡

```
SubStr2(
  Address,
  TokenSeq(AlphaToken),
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Program

String Manipulation Language

Construct Output Strings

Trace

Trace Expr is a **concatenation** of atom expressions, **substrings of inputs** or a **constant string**.

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Trace(ConstStr(...), SubStr(...), ...)
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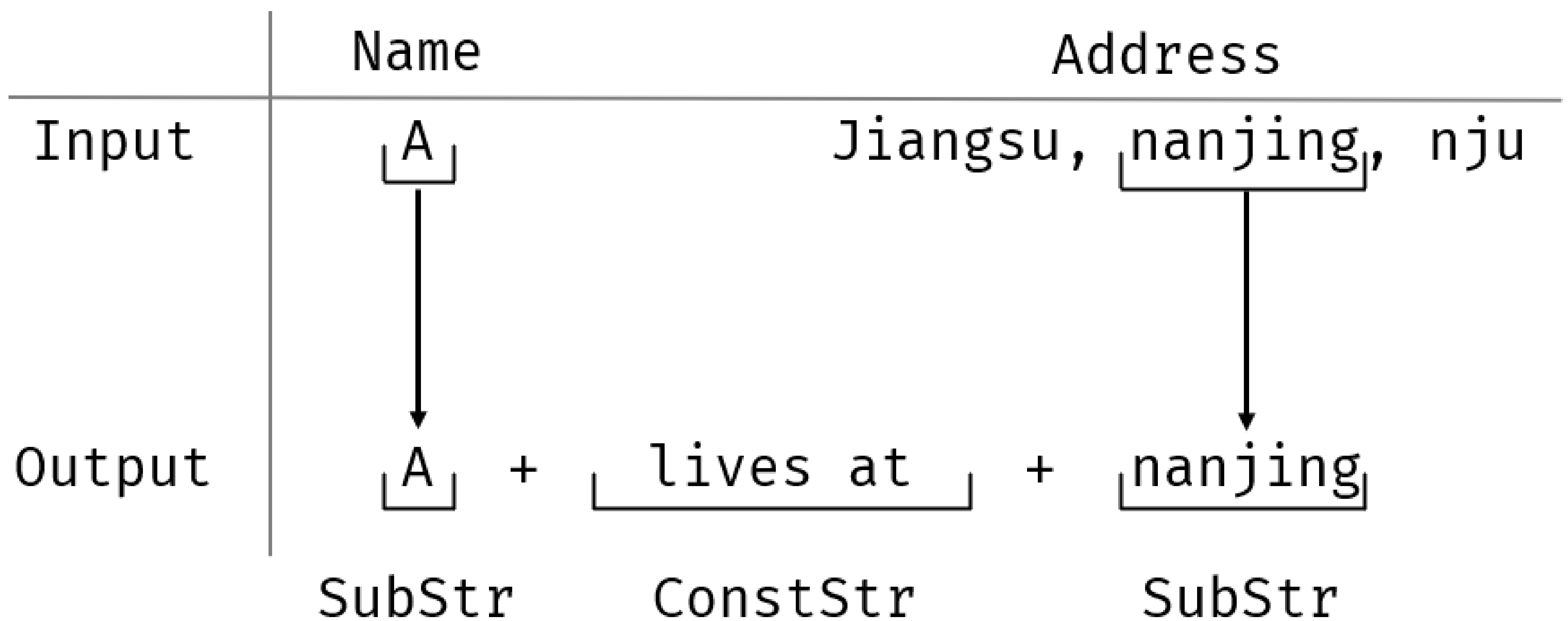


```
Output:  A lives at nanjing
```

SubString

```
SubStr(      ,      ,      )
```

SubString

```
SubStr(Input,        ,         )
```

`Input` : **Index**, which input string is used.

SubString

`SubStr(Input, Left, Right)`

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`Left, Right`: **Position Expressions**, the range of substring.

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✗ `SubStr(Address, CPos(9), CPos(-6))`

✓ `SubStr(Address, Pos(ε,RE,2), Pos(RE,ε,2))`
`where RE = LowercaseTokens`

Regular Expressions

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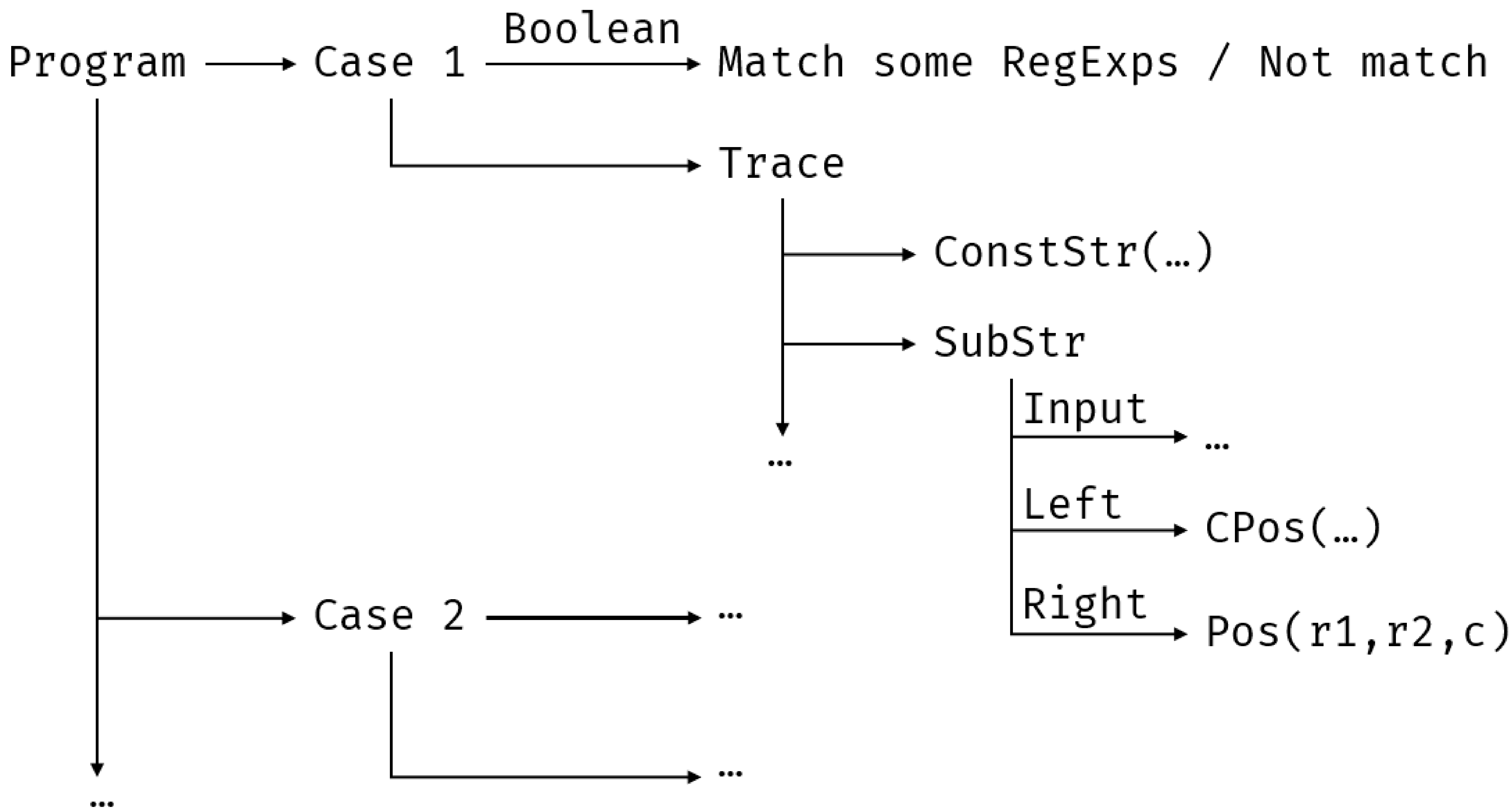
➡ **Efficient Algorithm**

Conditionals



Example

Num	Rev	Code
123	321	case 123: return 321;
456	654	case 456: return 654;
147	741	
258	852	

```
Trace("case ", SubStr(Num, CPos(0), CPos(-1)),
      ": return ", SubStr(Rev, CPos(0), CPos(-1)),
      ";")
```

Example

Item	Output
Check-in: 2000 mora	2000 mora
New character: 180 fate	180 fate
Intertwined fate: 160 primogem	
New weapon: 240 fate	

```
Trace(SubStr(Item,
Pos(TokenSeq(Colon, Space), TokenSeq(Numeric), -1),
CPos(-1)))
```

Alogrithom

Synthesize a program with input-output examples

Goal

> Given some input-output examples $(i_1, o_1), \ldots, (i_n, o_n)$,
> Synthesize a program P such that $P(i_1) = o_1, \ldots, P(i_n) = o_n$.

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2.

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2. **Intersect programs** into non-empty partitions **greedily**

$$(P_1 \cap P_2, \{(i_1, o_1), (i_2, o_2)\}), (P_3 \cap \ldots, \{(i_3, o_3), \ldots\}), \ldots$$

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3. **Construct boolean classification** for partitions

$$(\text{Boolean Expression}, P_1 \cap P_2), \ldots$$

Generate Trace

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```
Input    abcdef

Output ( abcdef )
```

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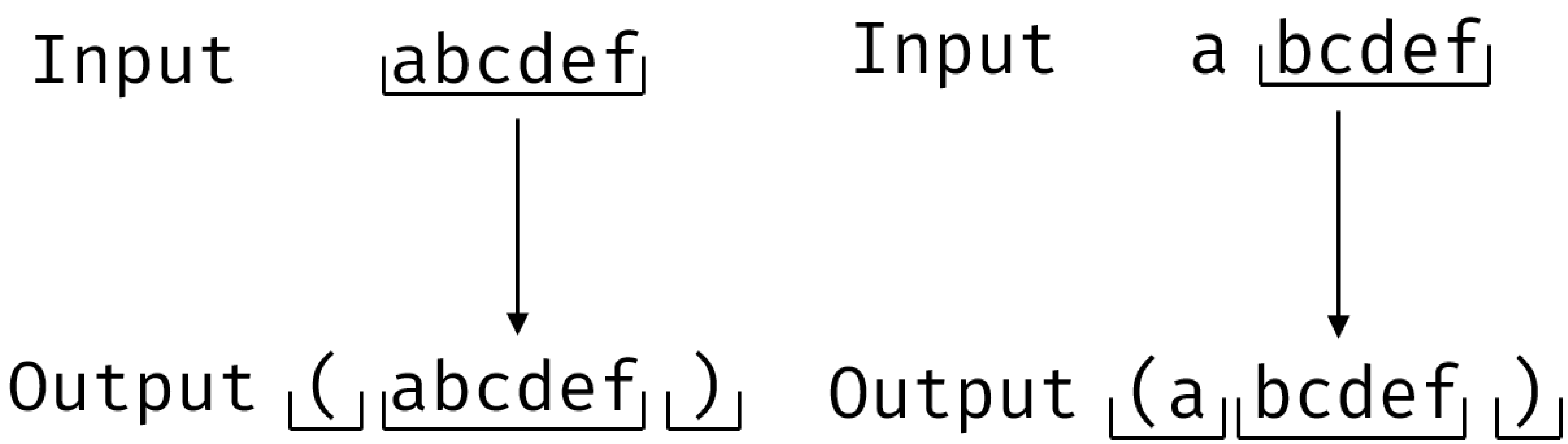

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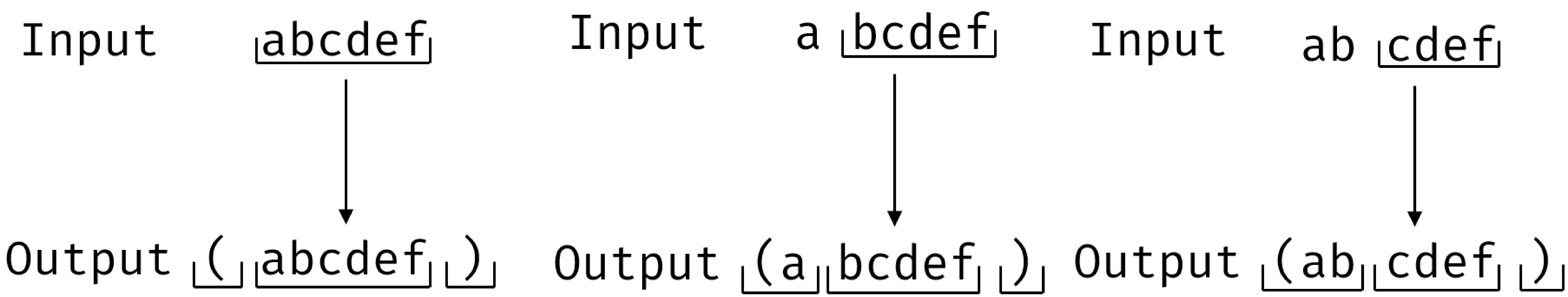

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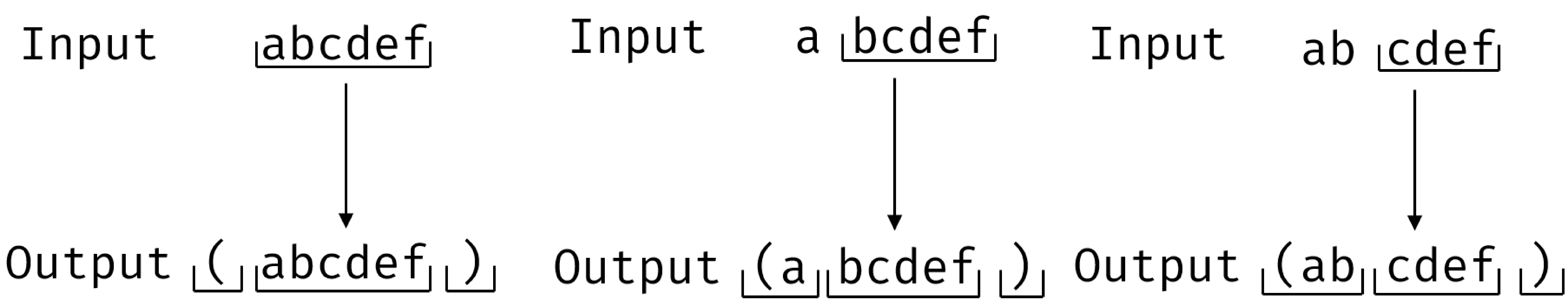

Iterative **all** possible trace expressions

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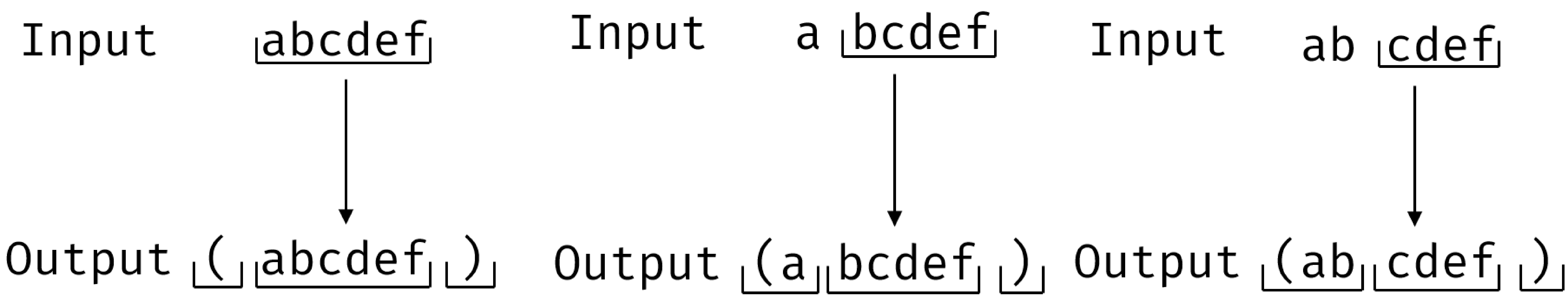


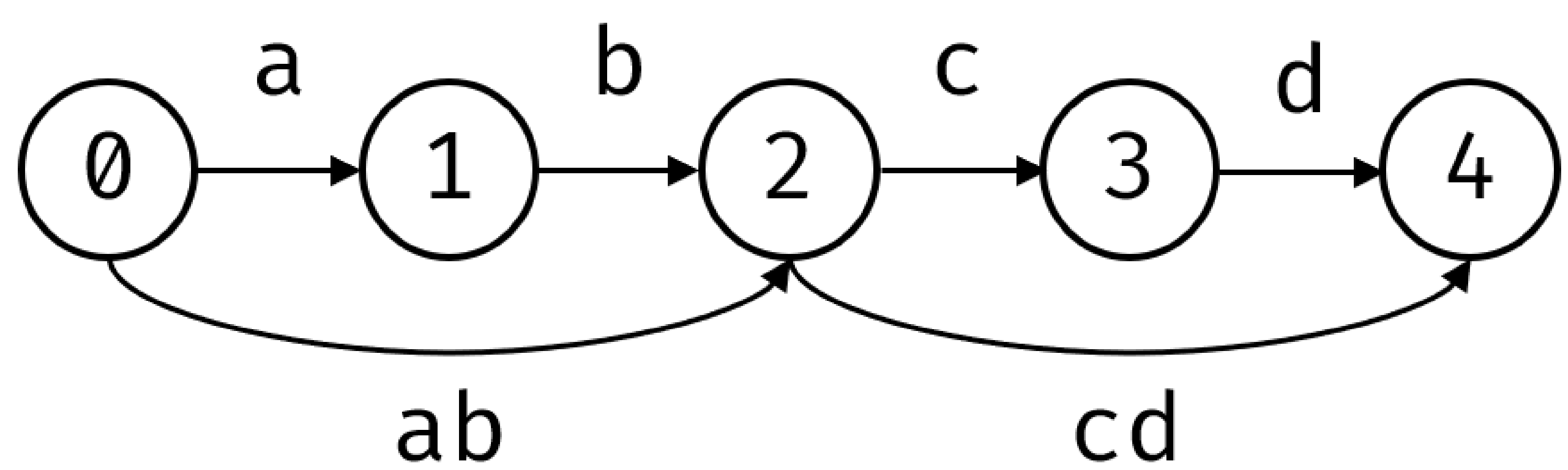
Iterative **all** possible trace expressions **?**

The number is **exponential** in the length of output (2^{n-1}).

DAG

`Nodes` = **Each position** in the output string.

`Edges` = **Each substring** (i, j) where $i < j$.



Example. $(0, 2) \rightarrow$ **`ab`**, $(2, 4) \rightarrow$ **`cd`**.

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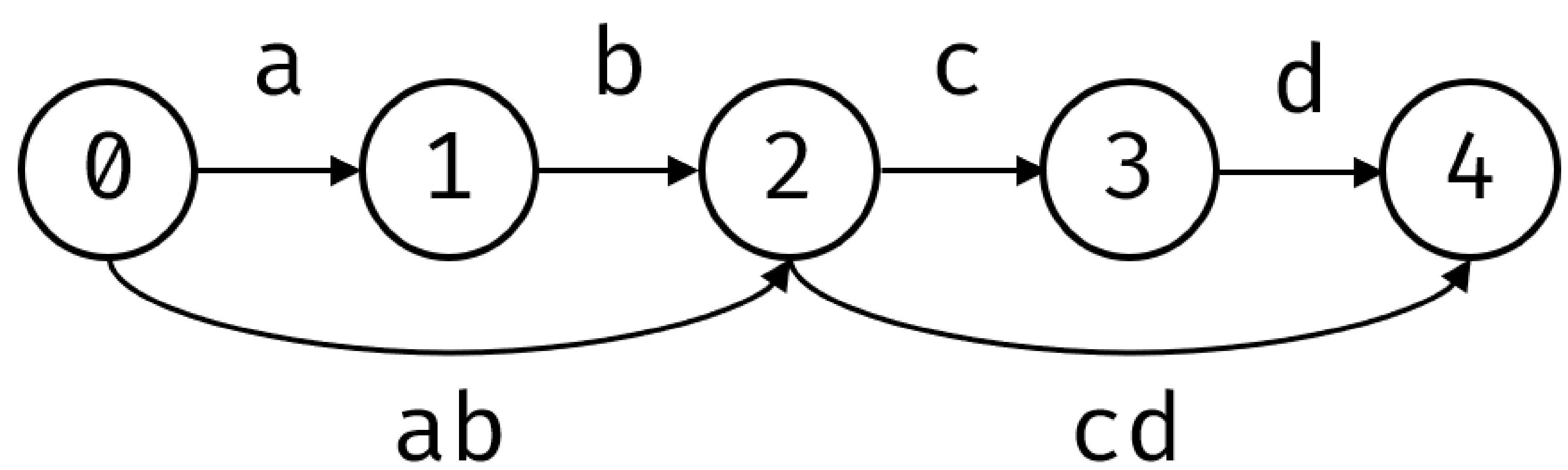

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Generate Substring

The origin **exponential** problem → **Quadratic** sub-problems

> **Goal.** For **each of n^2 substrings**, find all possible **atom expressions** to generate it.

```
Input  :
```
Jiangsu, nanjing, nju

```
Program: ConstStr("nanjing")

         SubStr(Address, CPos(9), CPos(-6))

         SubStr(Address, CPos(9), CPos(16))
```

…

Generate Substring

The origin **exponential** problem → **Quadratic** sub-problems

> **Goal.** For **each of n^2 substrings**, find all possible **atom expressions** to generate it.

`Input   :` Jiangsu, nanjing, nju

```
Program: ConstStr("nanjing")

         SubStr(Address, CPos(9), CPos(-6))

         SubStr(Address, CPos(9), CPos(16))

         ...
```

Use Brute-force!

Generate Partitions

Goal. Intersect programs into non-empty partitions

$$(P_1 \cap P_2, \{(i_1, o_1), (i_2, o_2)\}), (P_3 \cap \ldots, \{(i_3, o_3), \ldots\}), \ldots$$

Boolean Classification

Goal-2. Intersect programs into non-empty partitions

$$(P_1 \cap P_2, \{(i_1, o_1), (i_2, o_2)\}), (P_3 \cap \ldots, \{(i_3, o_3), \ldots\}), \ldots$$

↓

Goal-3. Construct boolean classification for partitions

$$((\text{Predicate} \wedge \ldots) \vee \ldots, P_1 \cap P_2), \ldots$$

where

$$\text{Predicate} := \text{Match}(\text{Input}, \text{RegExp}, \text{Times}) \mid \neg\text{Match}(\ldots)$$

↓

$$\text{Output Program}$$

END

Q & A

Demo

Input 1	Output

Push Pop