FlashFill++: Scaling Programming by Example by Cutting to the Chase

Paper by: Jose Cambronero et al.

Presented by: Tae Eun Kim

Background

Background

Program synthesis

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- Automatically synthesizing programs

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- Mostly focused on Domain Specific Language (DSL)

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Programming-By-Example (PBE)

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- FlashFill[1]

Sumit Gulwani, Automating String Processing in Spreadsheets using Input-Output Examples, POPL, 2011

FlashFill

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- Program synthesizer embedded in Microsoft Excel

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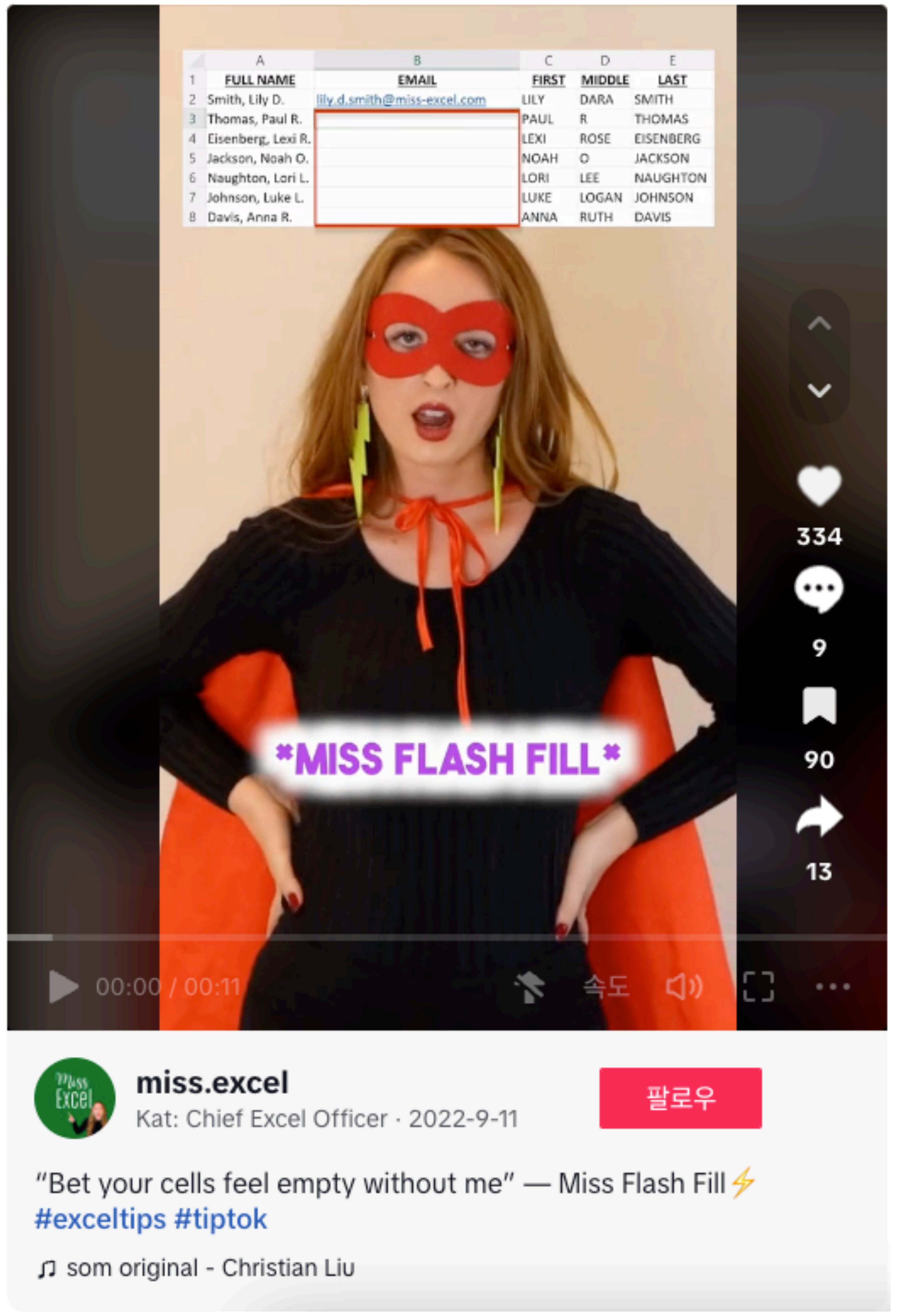

	A	B	C	D	E
1	FULL NAME	EMAIL	FIRST	MIDDLE	LAST
2	Smith, Lily D.	lily.d.smith@miss-excel.com	LILY	DARA	SMITH
3	Thomas, Paul R.		PAUL	R	THOMAS
4	Eisenberg, Lexi R.		LEXI	ROSE	EISENBERG
5	Jackson, Noah O.		NOAH	O	JACKSON
6	Naughton, Lori L.		LORI	LEE	NAUGHTON
7	Johnson, Luke L.		LUKE	LOGAN	JOHNSON
8	Davis, Anna R.		ANNA	RUTH	DAVIS

miss.excel
Kat: Chief Excel Officer · 2022-9-11

“Bet your cells feel empty without me” — Miss Flash Fill⚡
#exceltips #tiptok

♫ som original - Christian Liu

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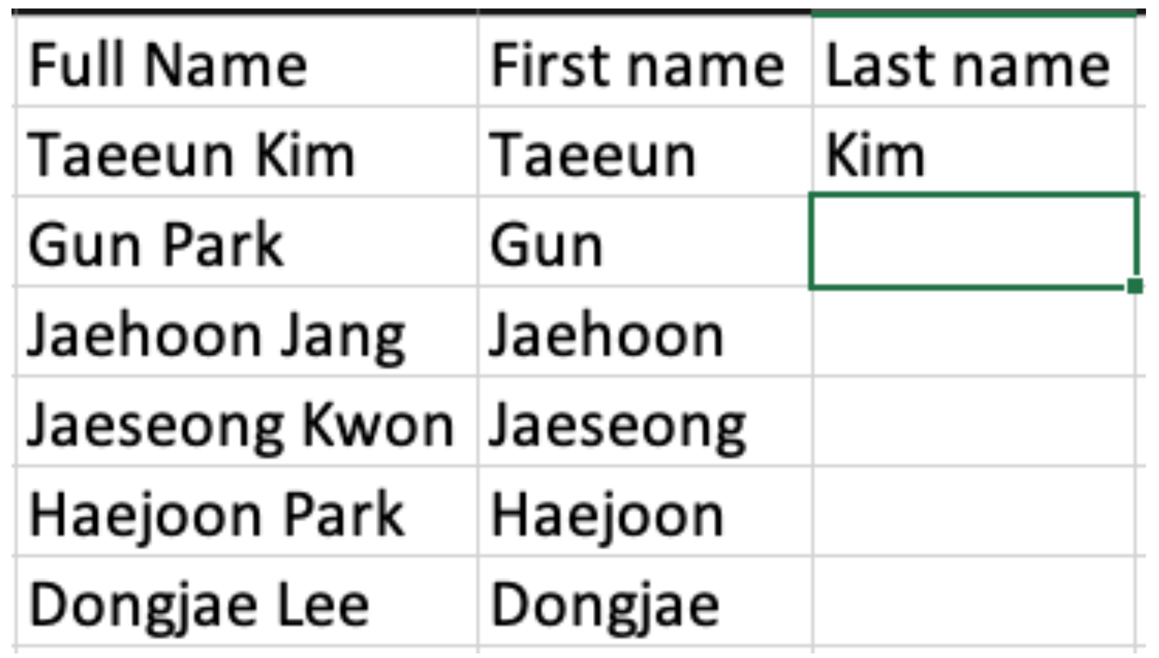

Full Name	First name	Last name
Taeeun Kim	Taeeun	Kim
Gun Park	Gun	
Jaehoon Jang	Jaehoon	
Jaeseong Kwon	Jaeseong	
Haejoon Park	Haejoon	
Dongjae Lee	Dongjae	

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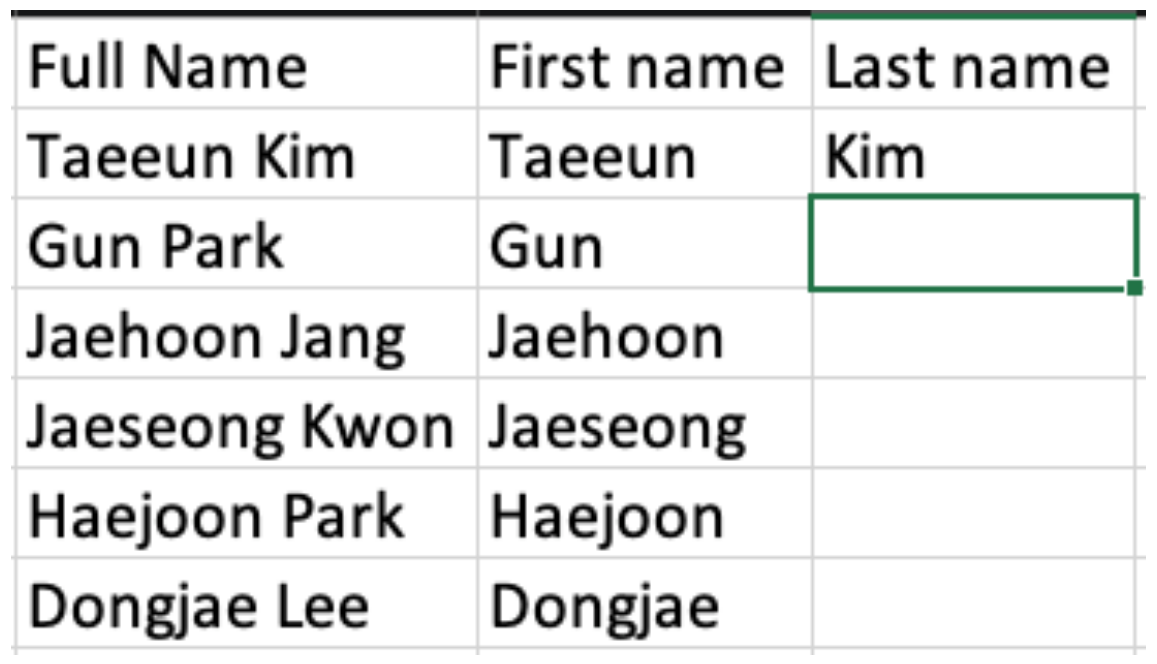

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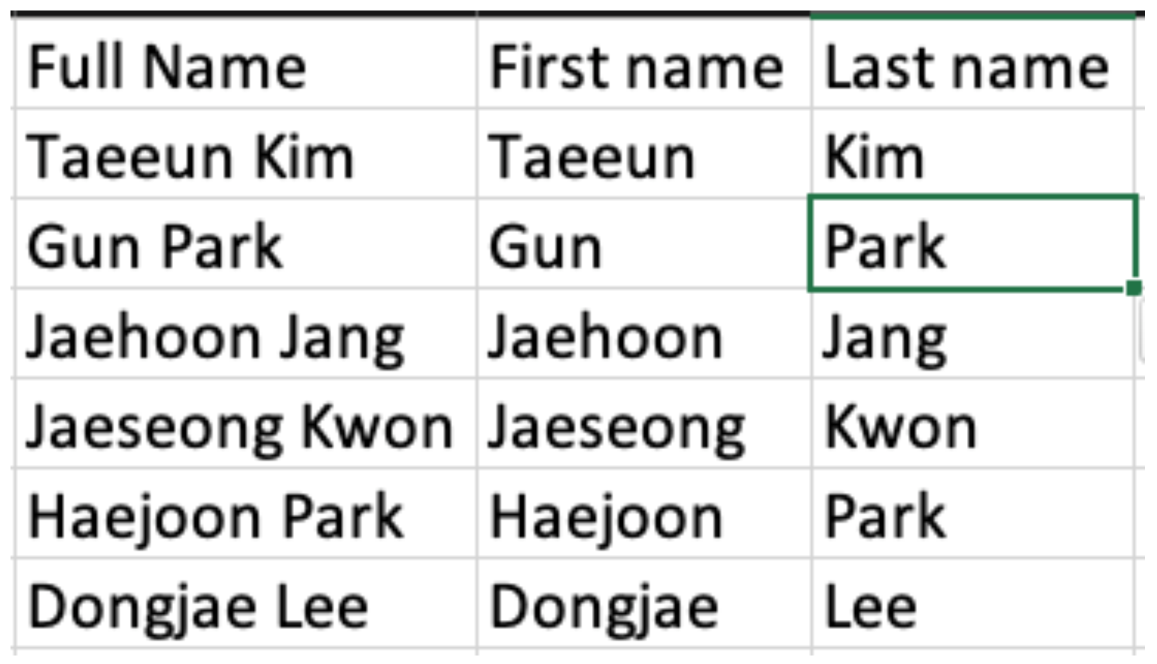

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```
Concatenate(
  Mid(Left(input1, Match(input1, "\p{Lu}+").StartMatch
                   + Len(Match(input1, "\p{Lu}+").FullMatch) - 1),
      Match(input1, "\p{Lu}+").StartMatch),
Concatenate("-",
Concatenate(Mid(Left(input2,Len(input2)-2), Match(input2,"[0-9]+").StartMatch),
Concatenate("#",
  Lower(Mid(
    Left(input1,
      First(LastN(MatchAll(input1, "[\p{Lu}\p{Ll}]+"), 1)).StartMatch
      + Len(First(LastN(MatchAll(input1, "[\p{Lu}\p{Ll}]+"), 1)).FullMatch)-1),
    Last(MatchAll(input1, "[\p{Lu}\p{Ll}]+")).StartMatch)))))
```

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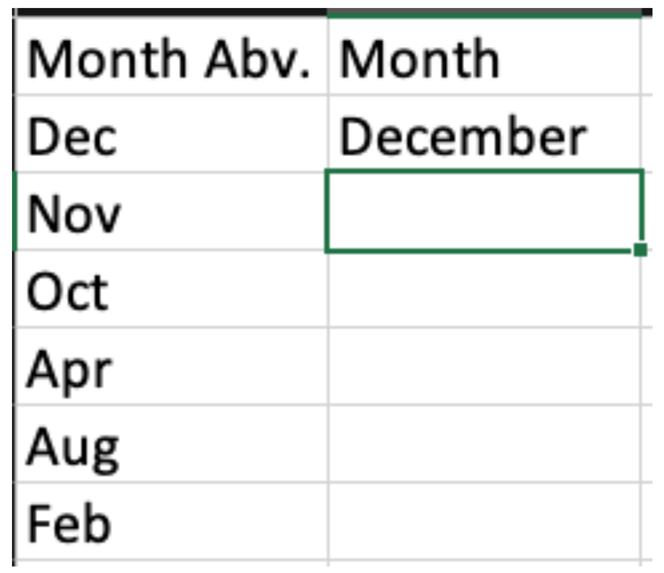

Month Abv.	Month
Dec	December
Nov	
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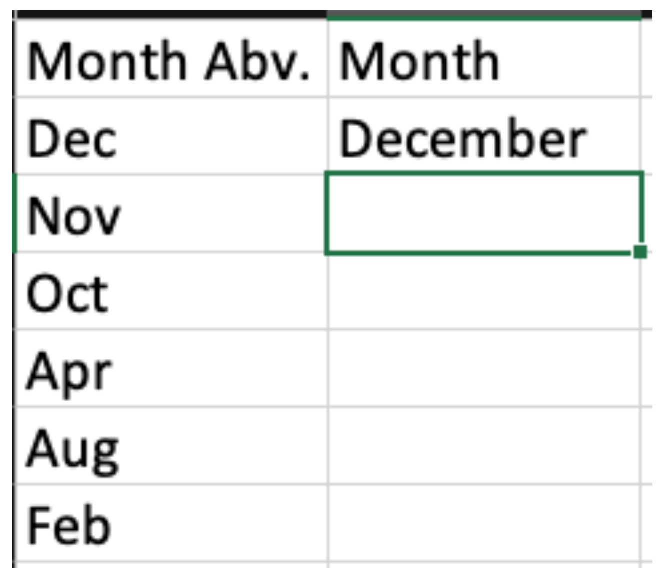

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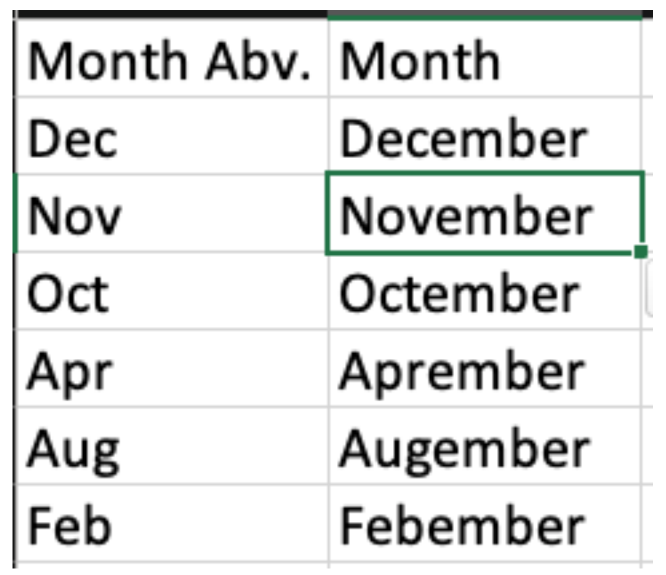

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Woosuk Lee, Combining the Top-Down Propagation and Bottom-Up Enumeration for Inductive Program Synthesis POPL, 2021

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Left(input1, 1) & "-" & Left(input2, 4) & "#"
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VSA-driven synthesis

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Version Space

- Set of programs that satisfy the given I/O examples

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- Top-Down vs Bottom Up

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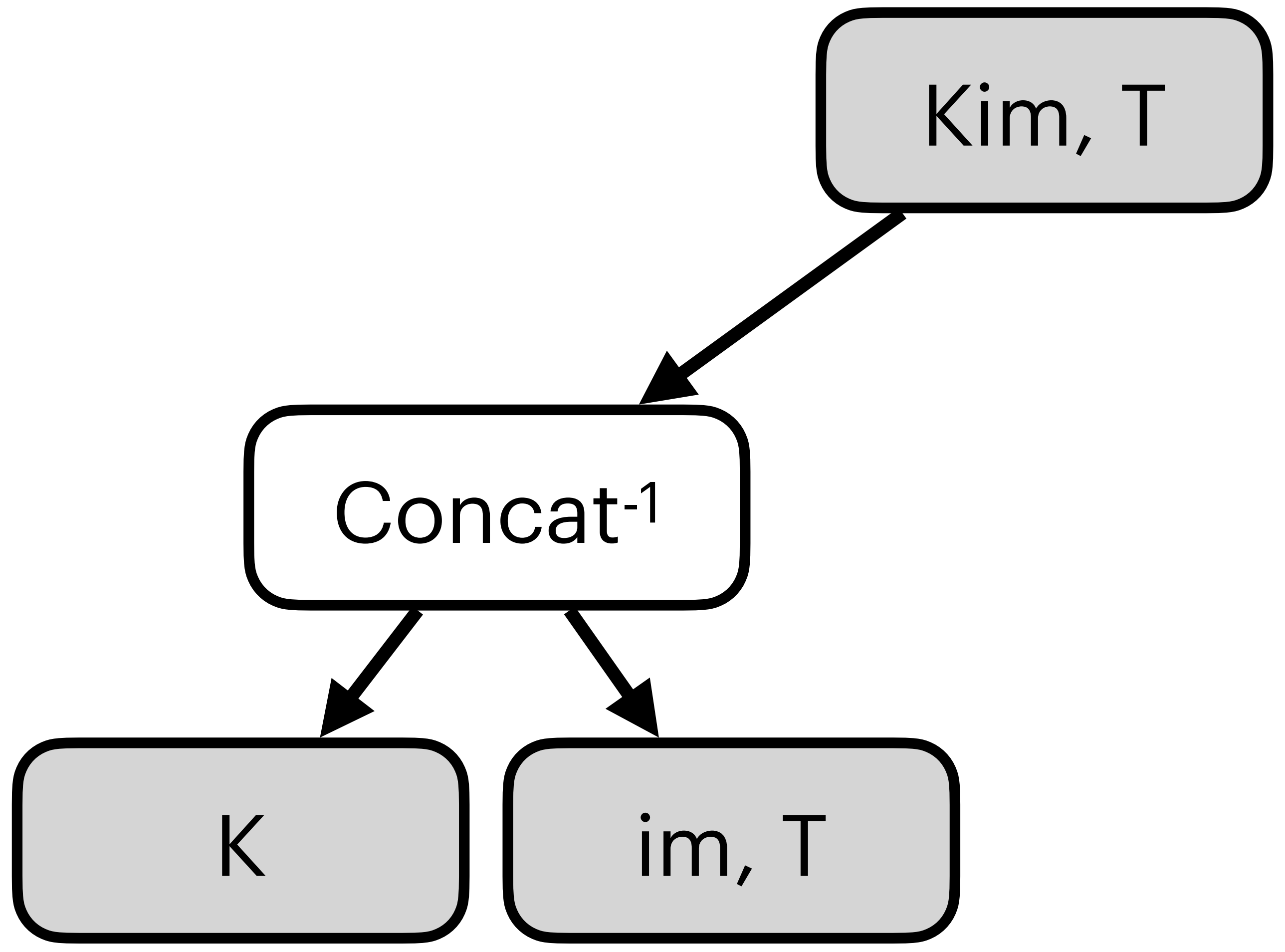

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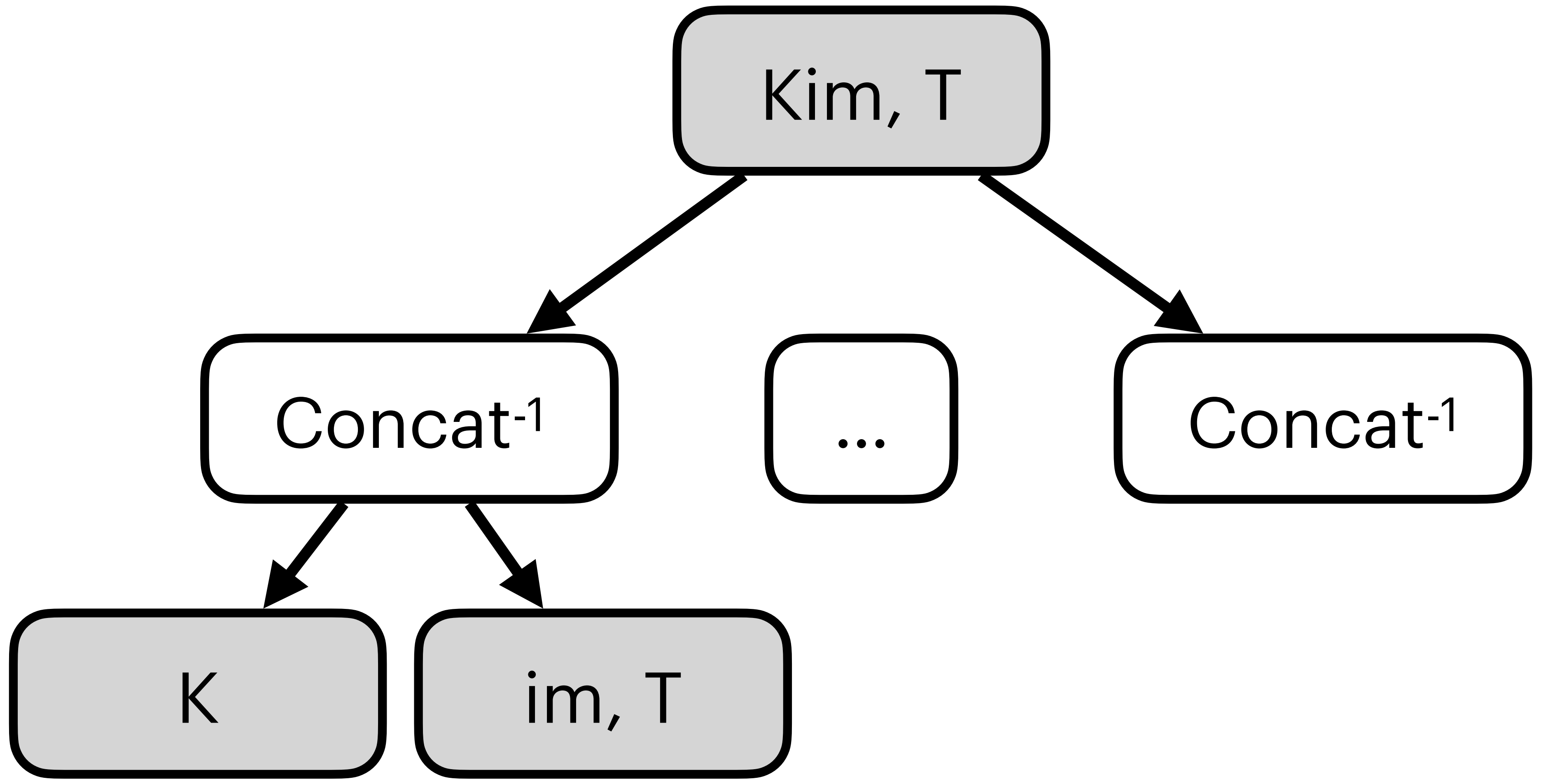

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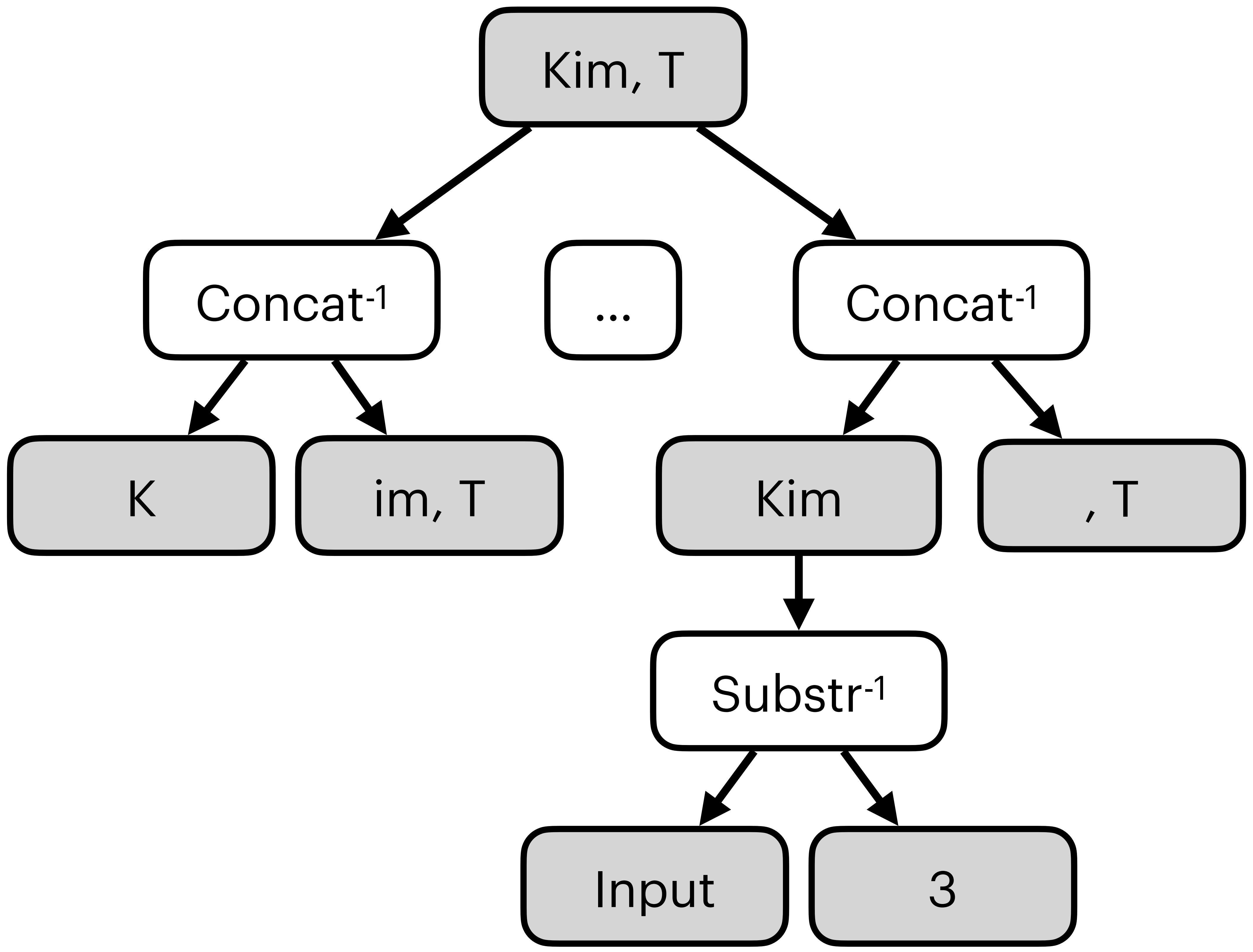

Bottom-Up Search

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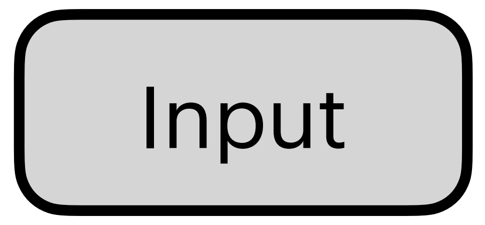

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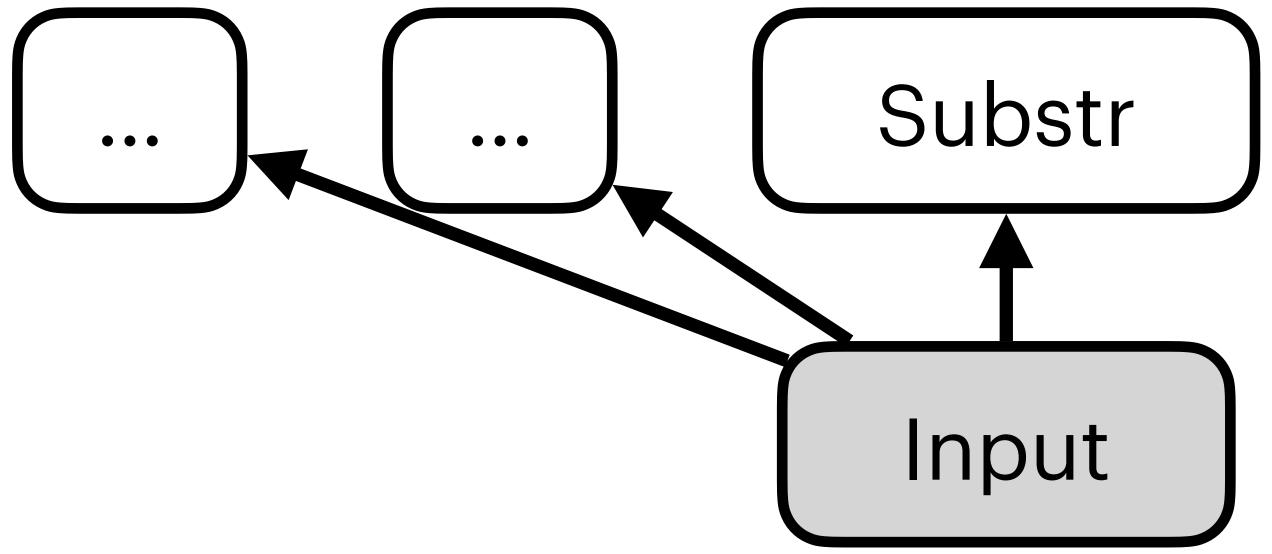

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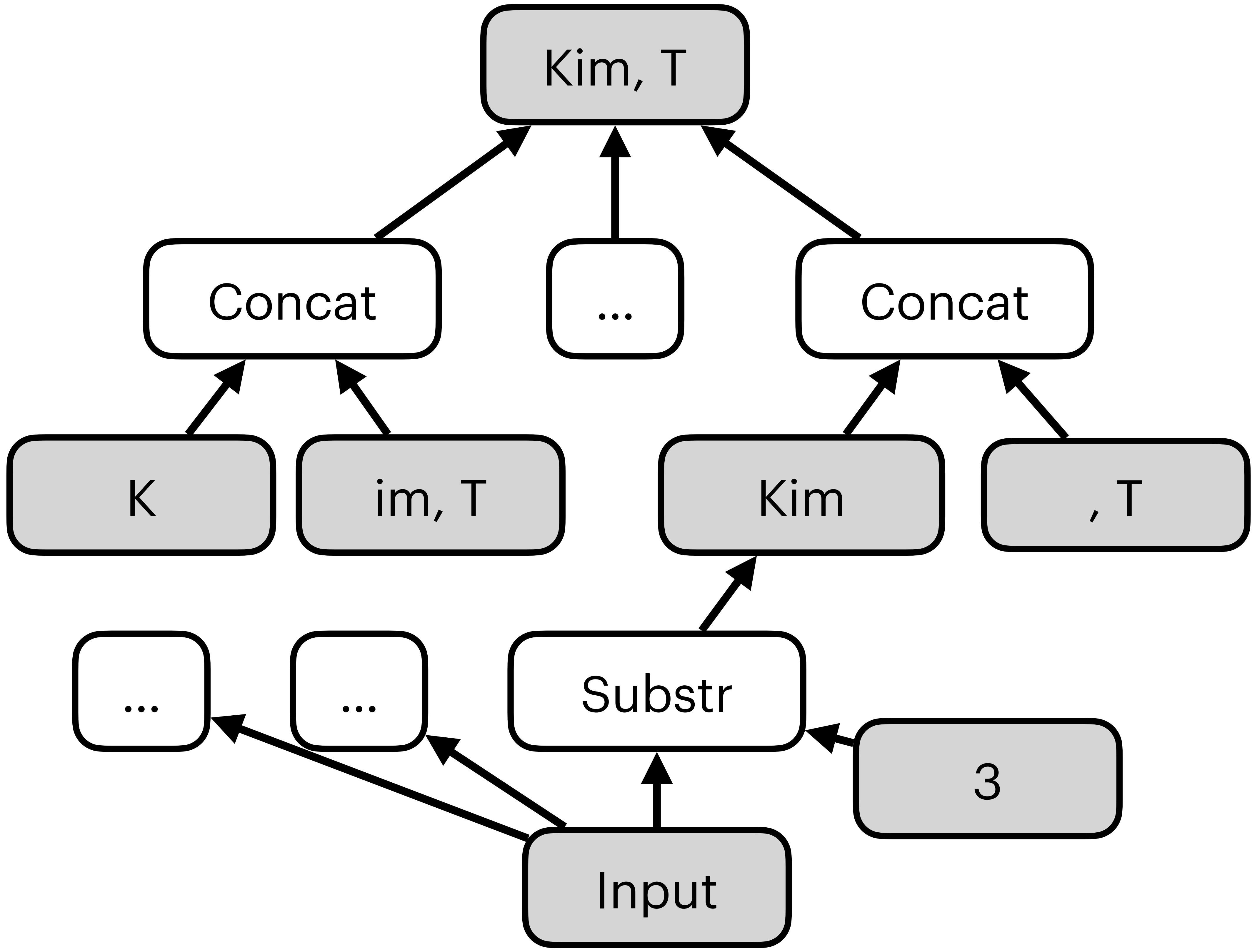

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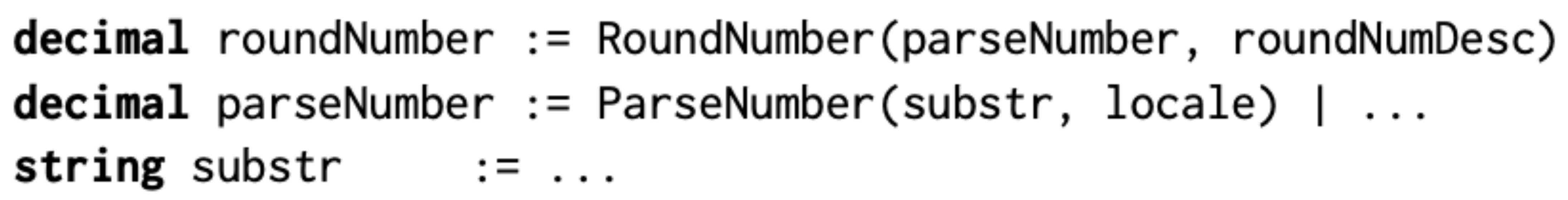

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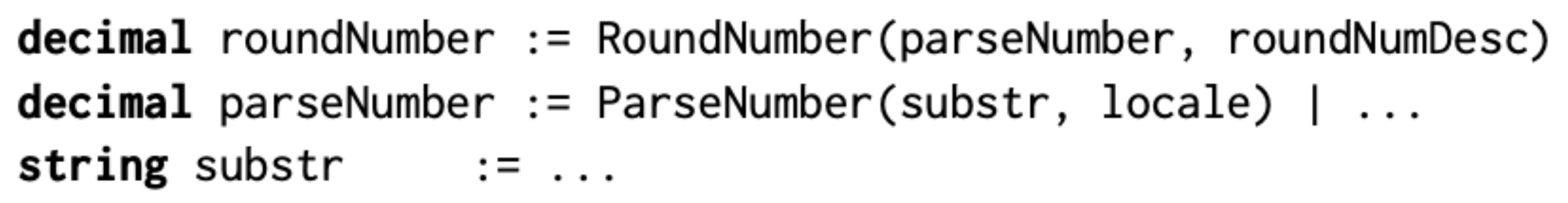

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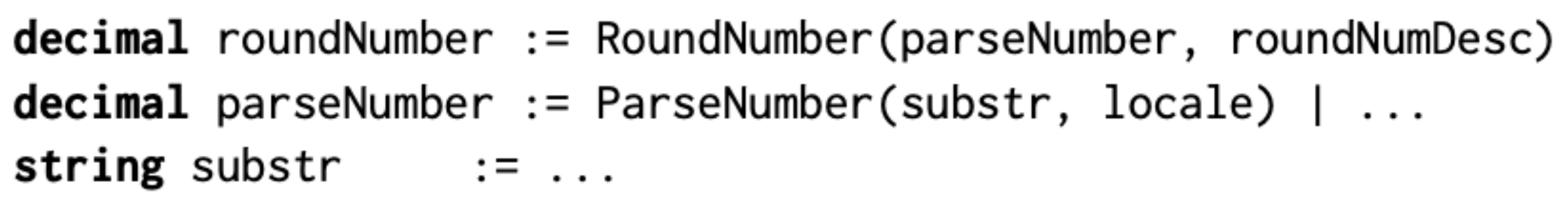

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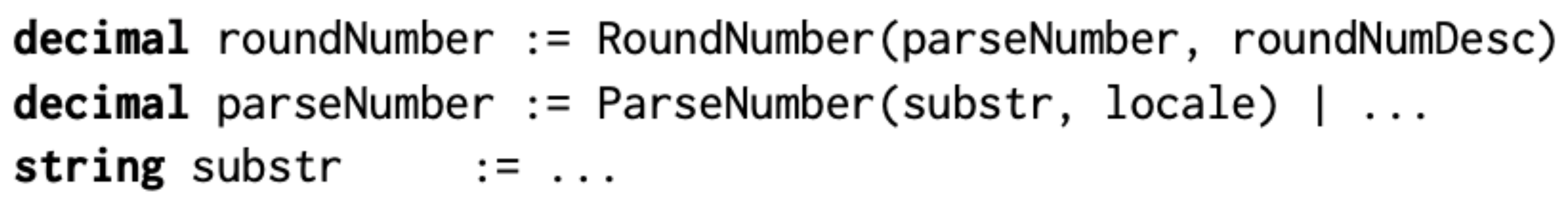

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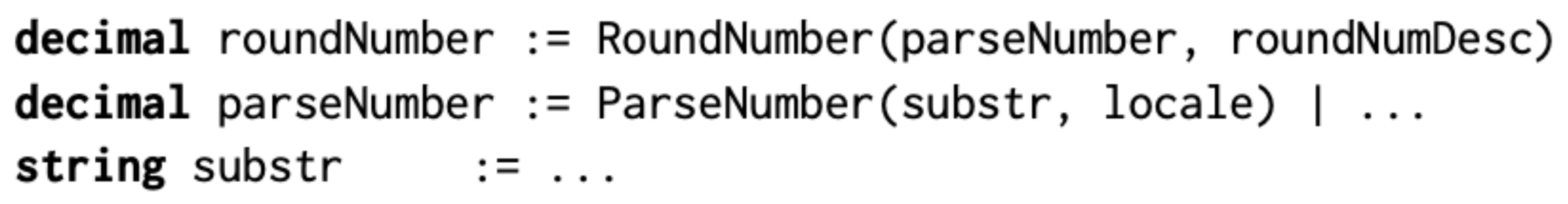

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Limitations

- Top-Down: Inverse of roundNumber() is infinite
- Bottom-Up: Too many possible substring from the input

Cut: Divide into two synthesis

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Intuition

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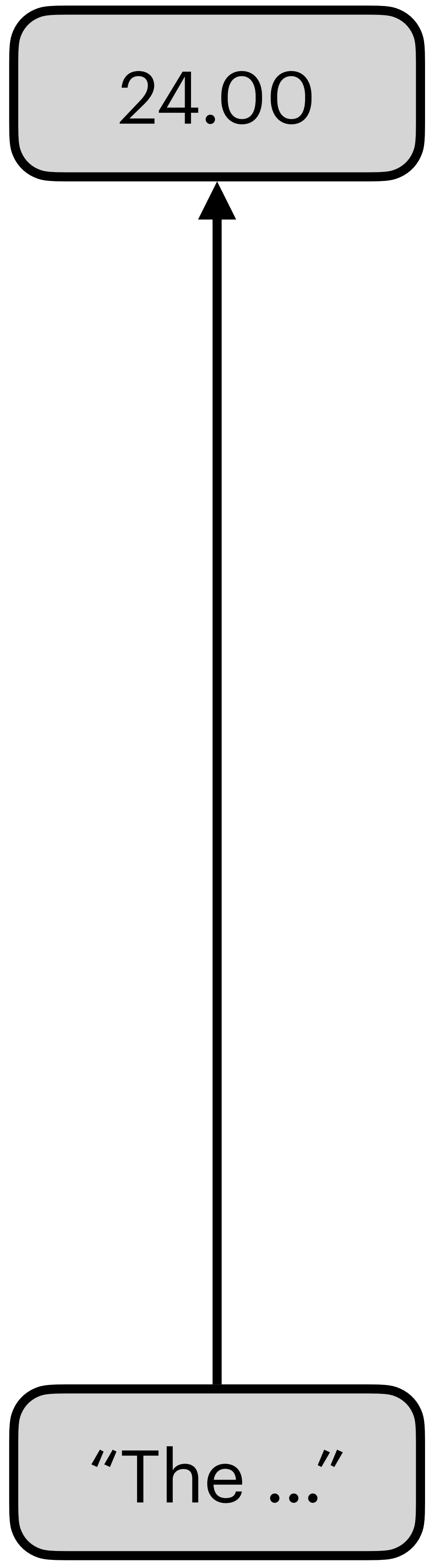

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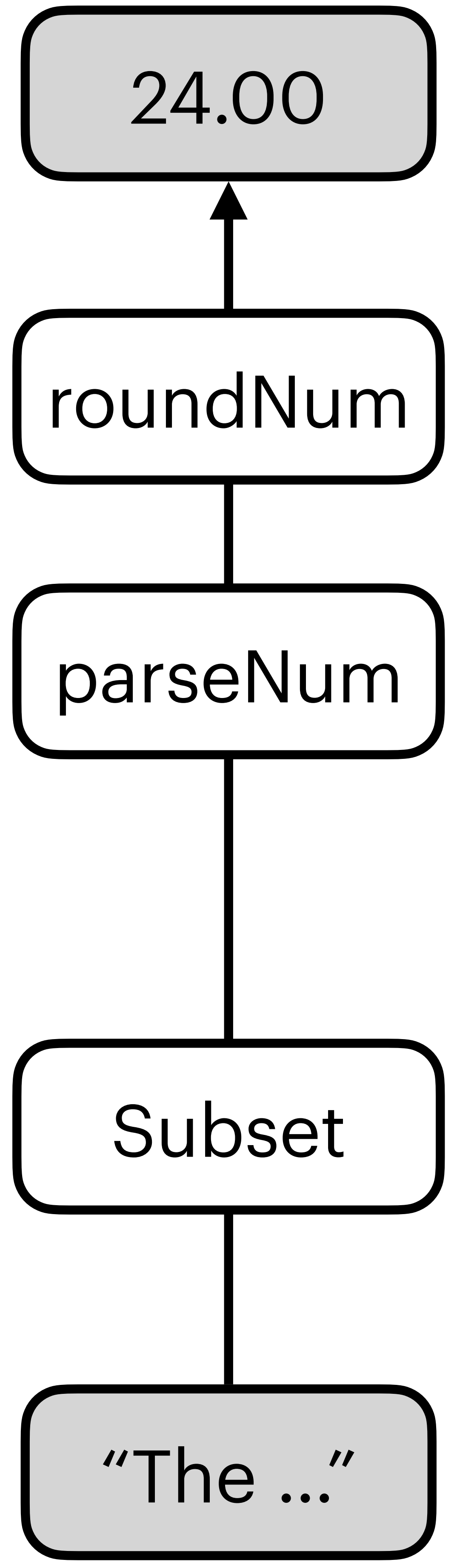

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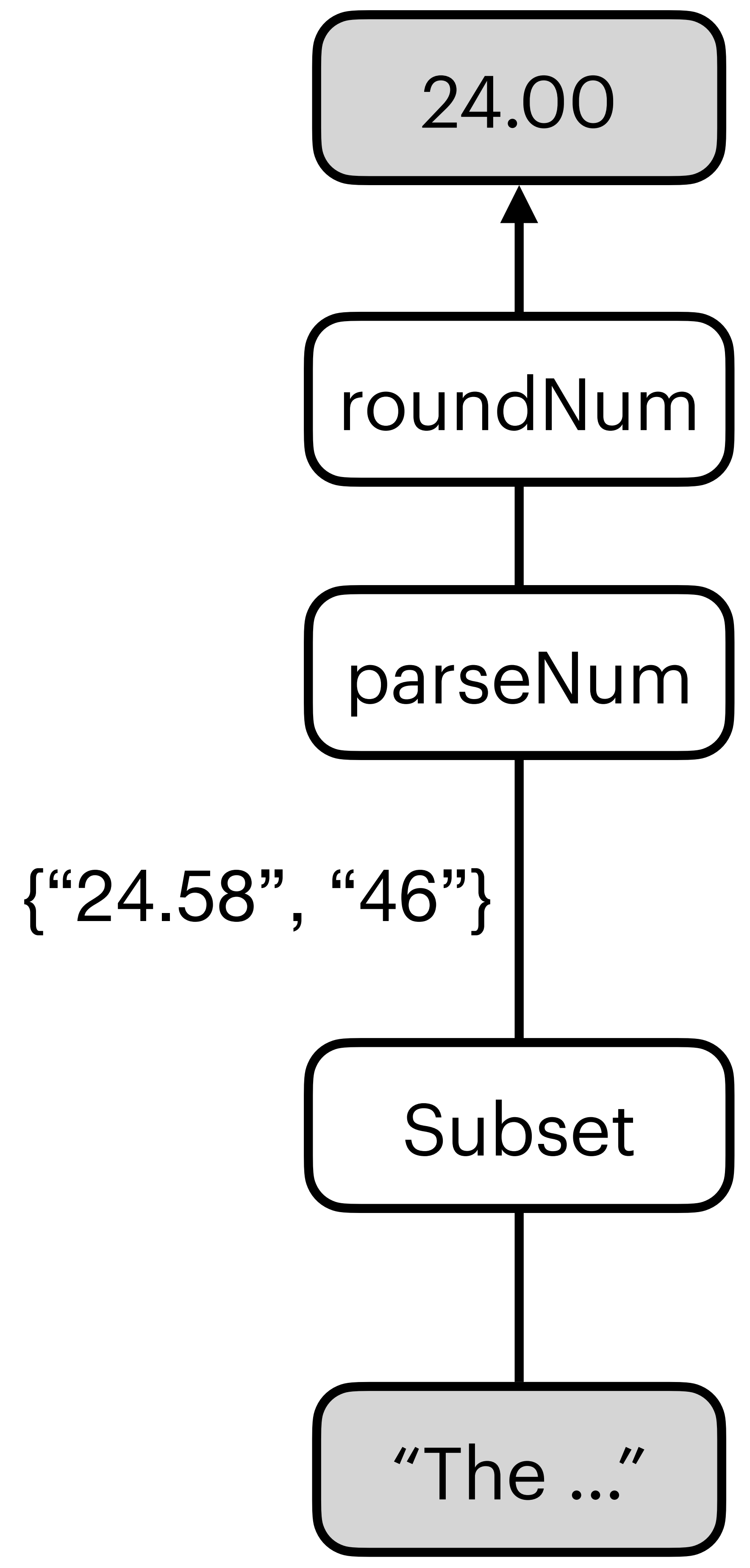

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- Q. In a solution program,
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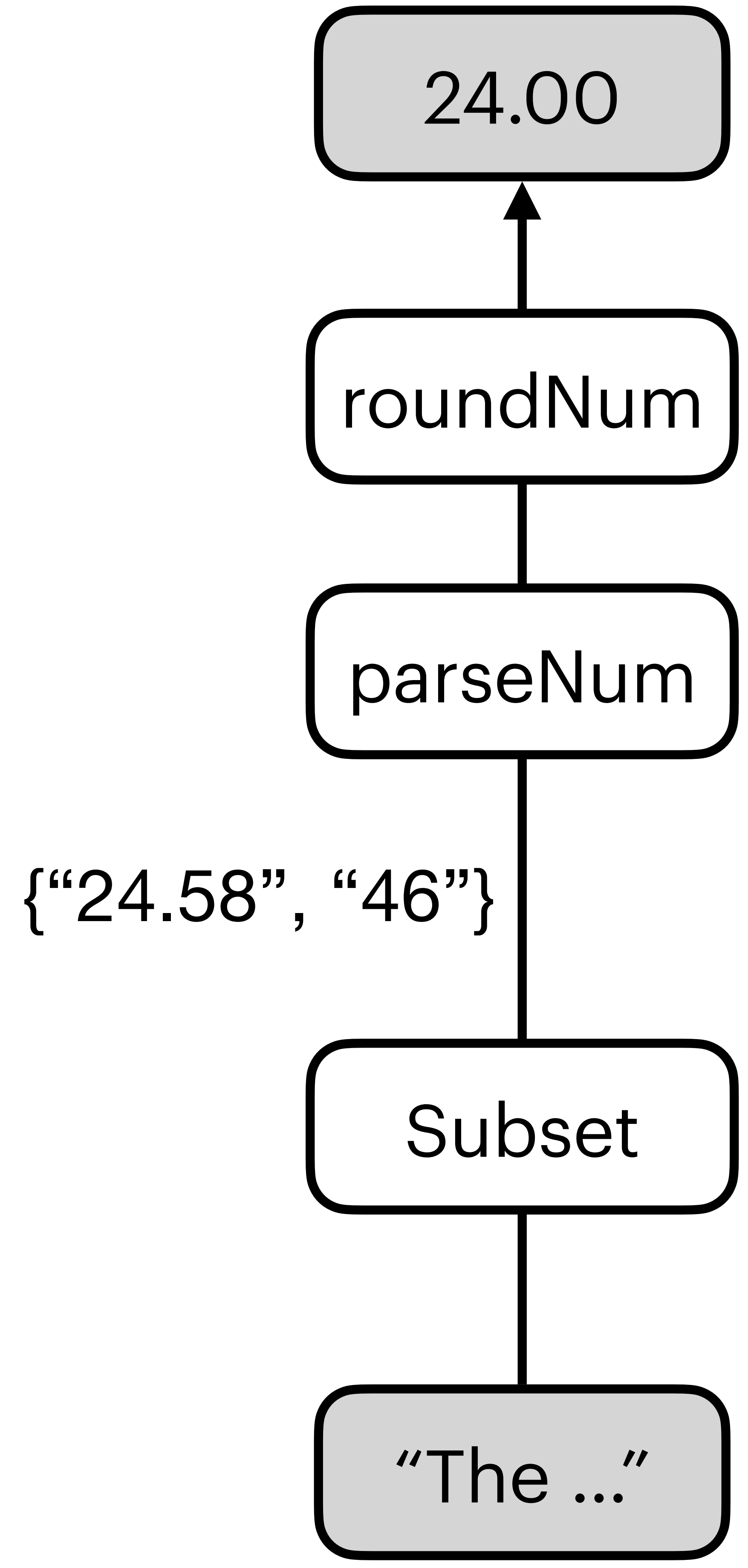
- A. String with only numbers
- Splits the problem before and after such invariants



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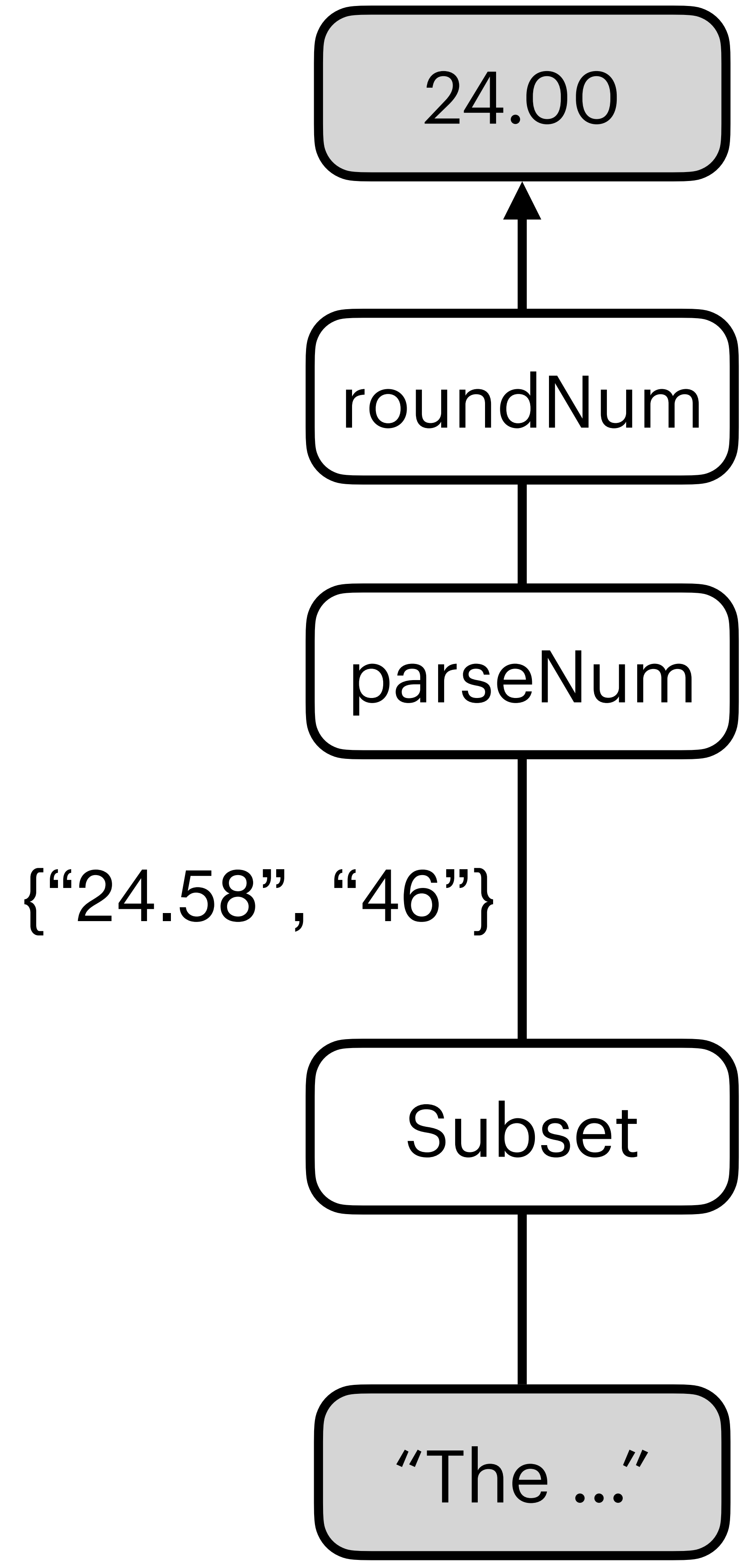

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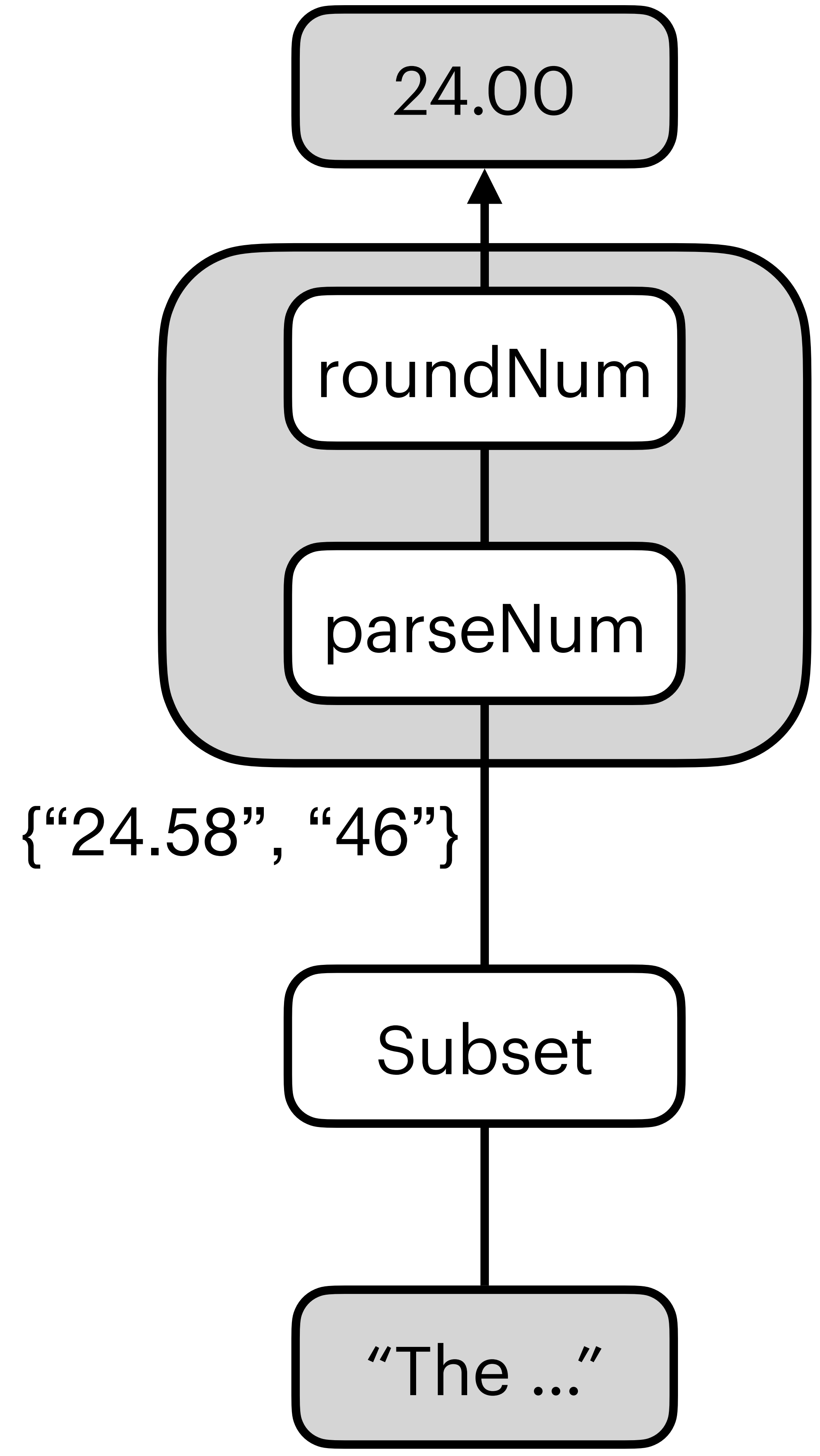

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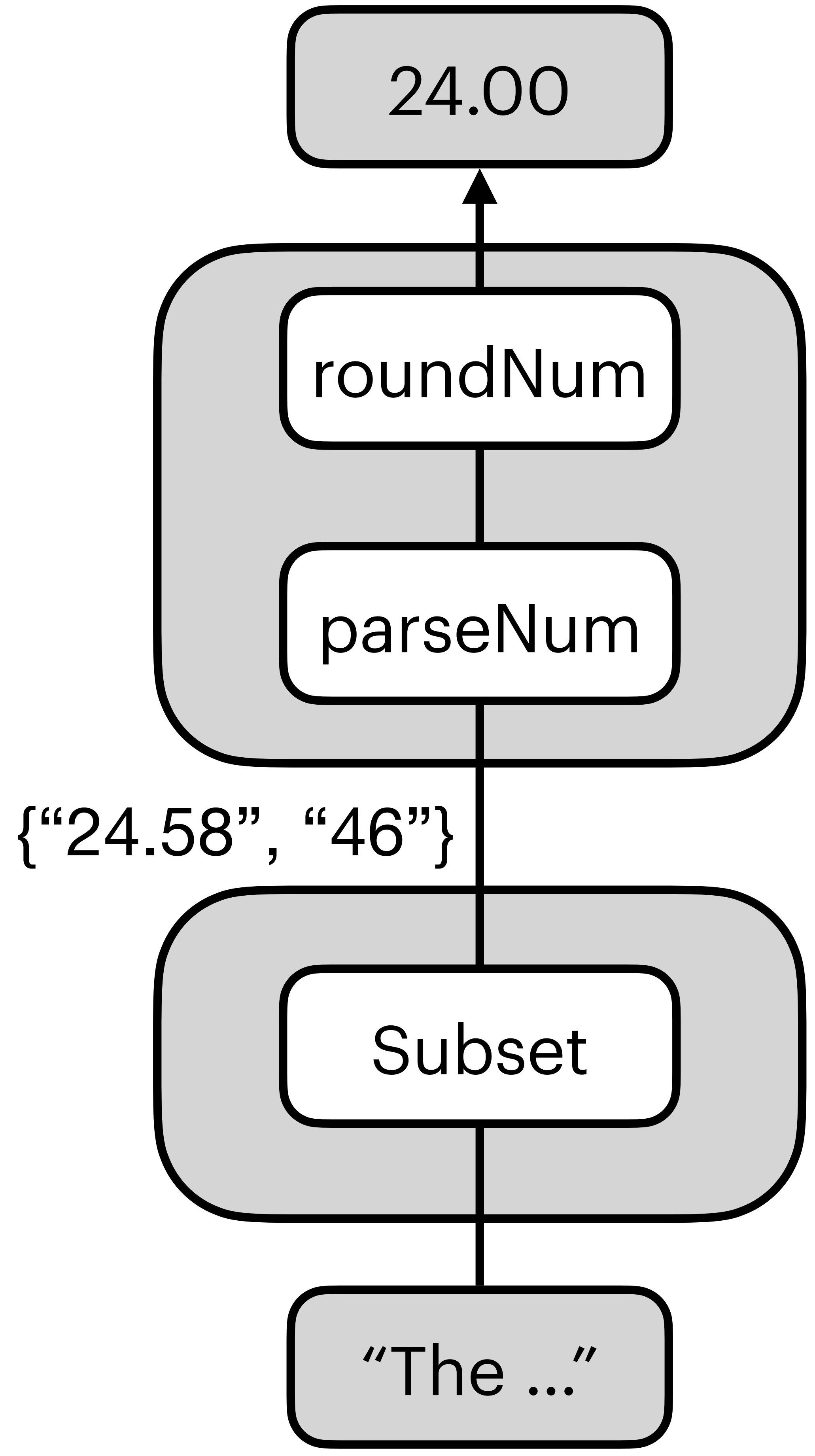
Smaller problems

- “24.58” -> 24.00
- “The …” -> “24.58”



Precedence: Guided synthesis

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Intuition

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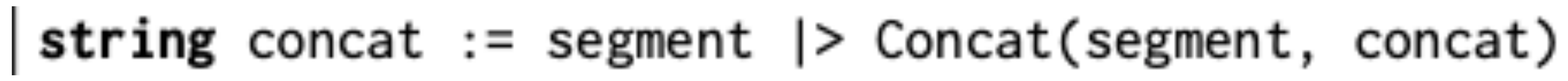

```
| string concat := segment |> Concat(segment, concat)
```

Evalutation

Evalutation

Baseline

Evalutation

Baseline

- FlashFill, Duet, SmartFill

Evalutation

Baseline

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Evalutation

Baseline

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Benchmark

- 886 string transformations

Evalutation

Baseline

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Criteria

Evalutation

Baseline

- FlashFill, Duet, SmartFill

Benchmark

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Criteria

- Correctness, Efficiency, Readability

Correctness

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RQ1. Can FlashFill++ solve more benchmarks?

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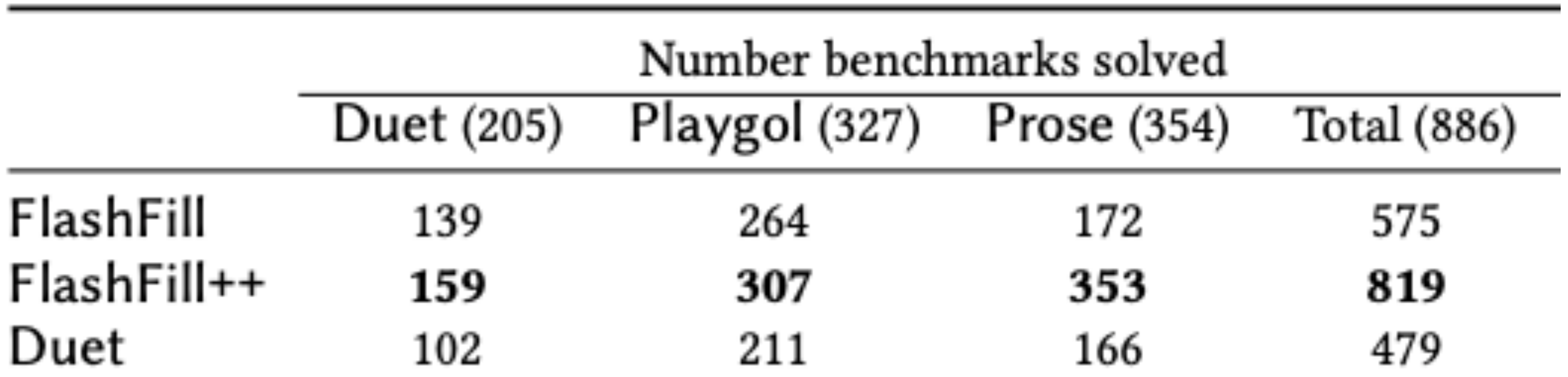

	Number benchmarks solved			
	Duet (205)	Playgol (327)	Prose (354)	Total (886)
FlashFill	139	264	172	575
FlashFill++	**159**	**307**	**353**	**819**
Duet	102	211	166	479

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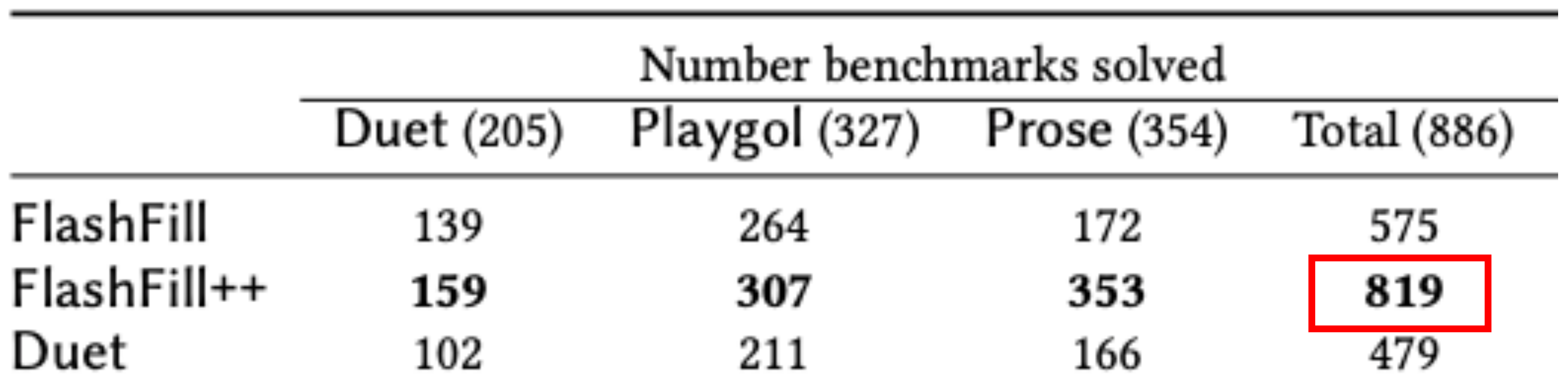

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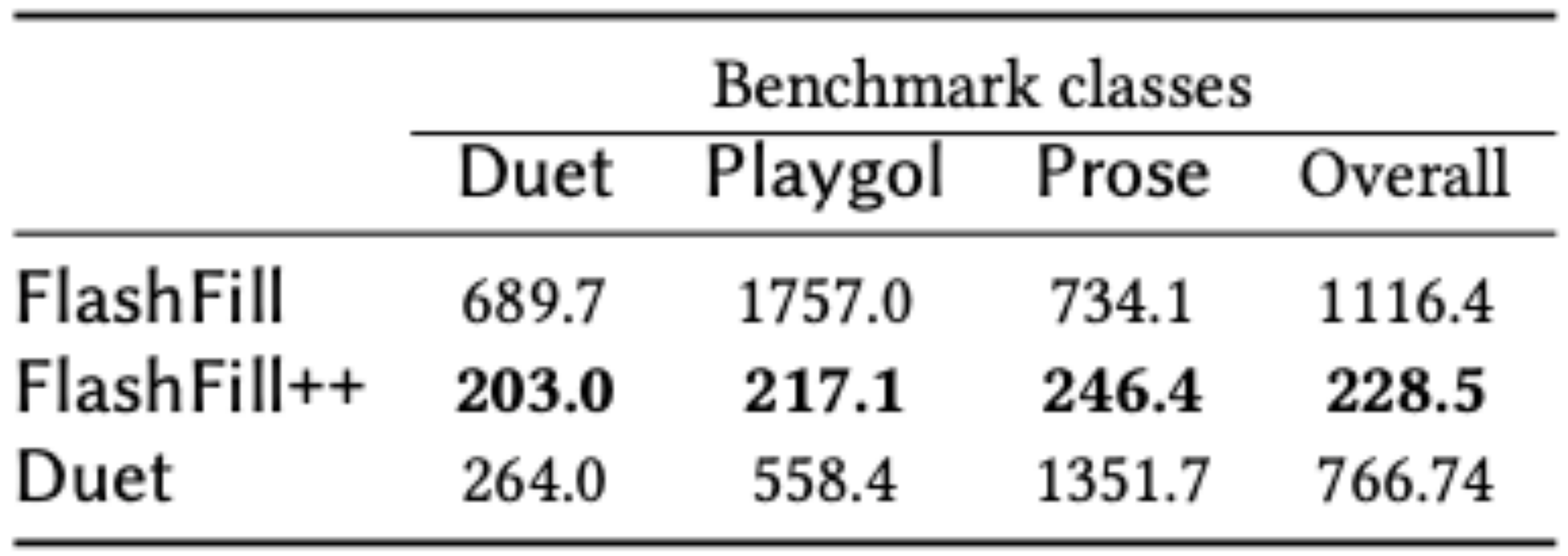

	Benchmark classes			
	Duet	Playgol	Prose	Overall
FlashFill	689.7	1757.0	734.1	1116.4
FlashFill++	**203.0**	**217.1**	**246.4**	**228.5**
Duet	264.0	558.4	1351.7	766.74

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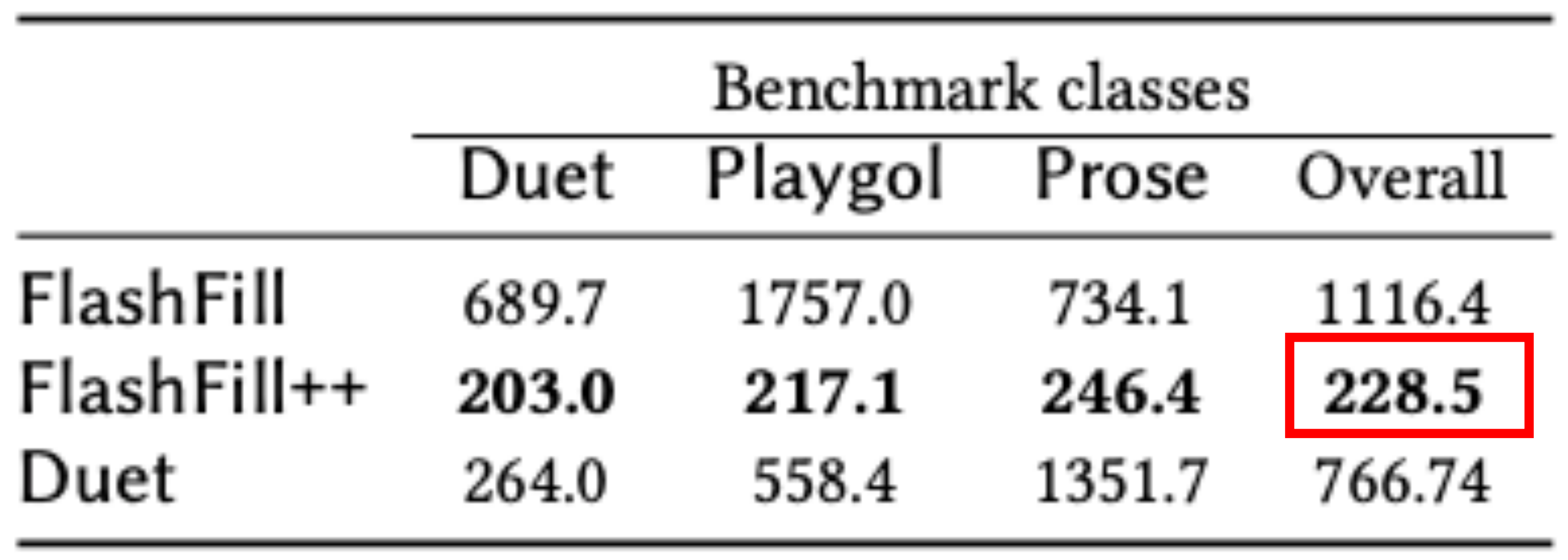

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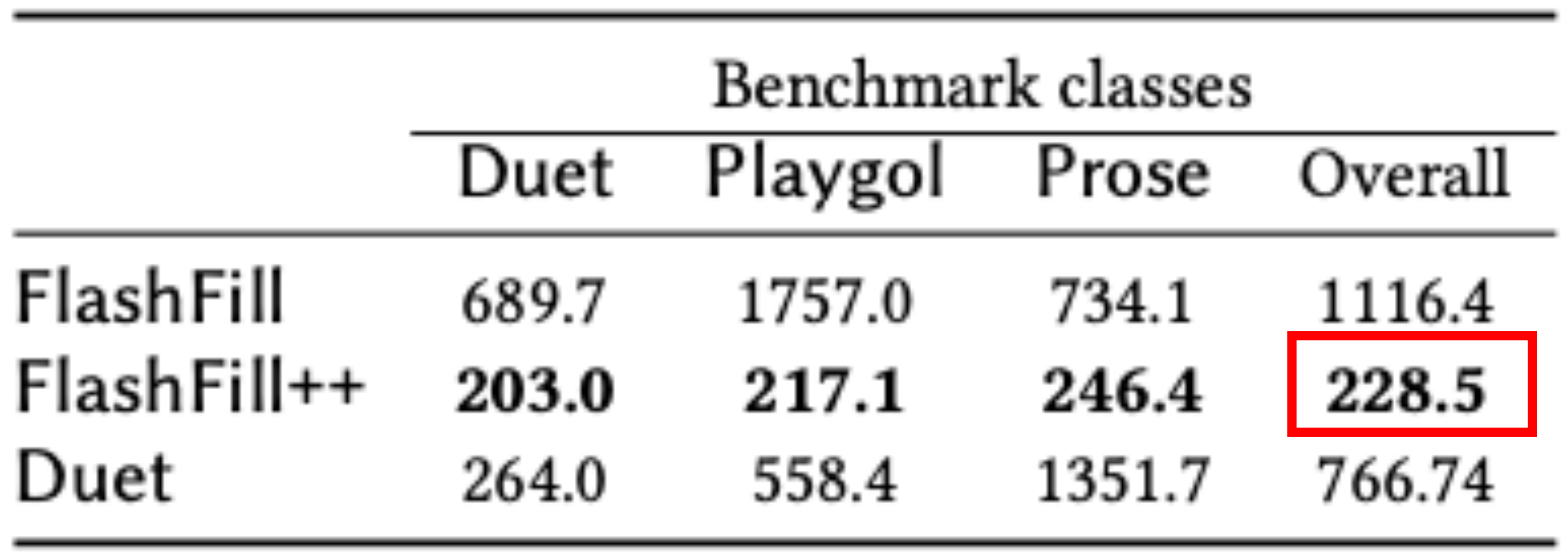

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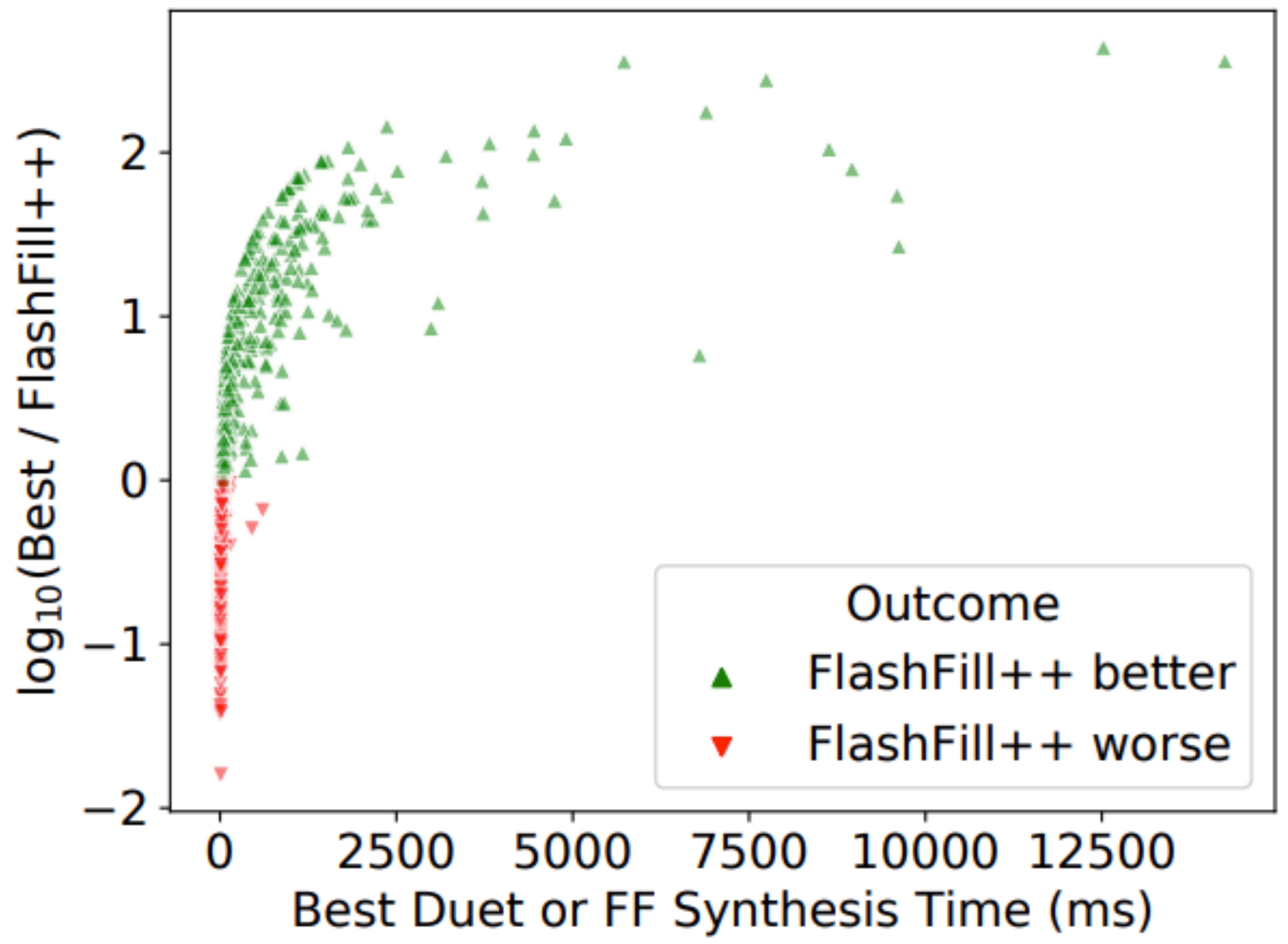

Readability

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Readability

RQ3. Does FlashFill++ generate more readable programs?

- Yes, FlashFill++ is more readable.

- 100 participants on 10 examples
  - 92% : FlashFill++ is more readable than FlashFill
  - 81% : FlashFill++ generates code more similar to mine

Comment

Comment

Consistency

Comment

Consistency

- Future work after 13 years

Comment

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Response of Academia to the Industry

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Summary

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