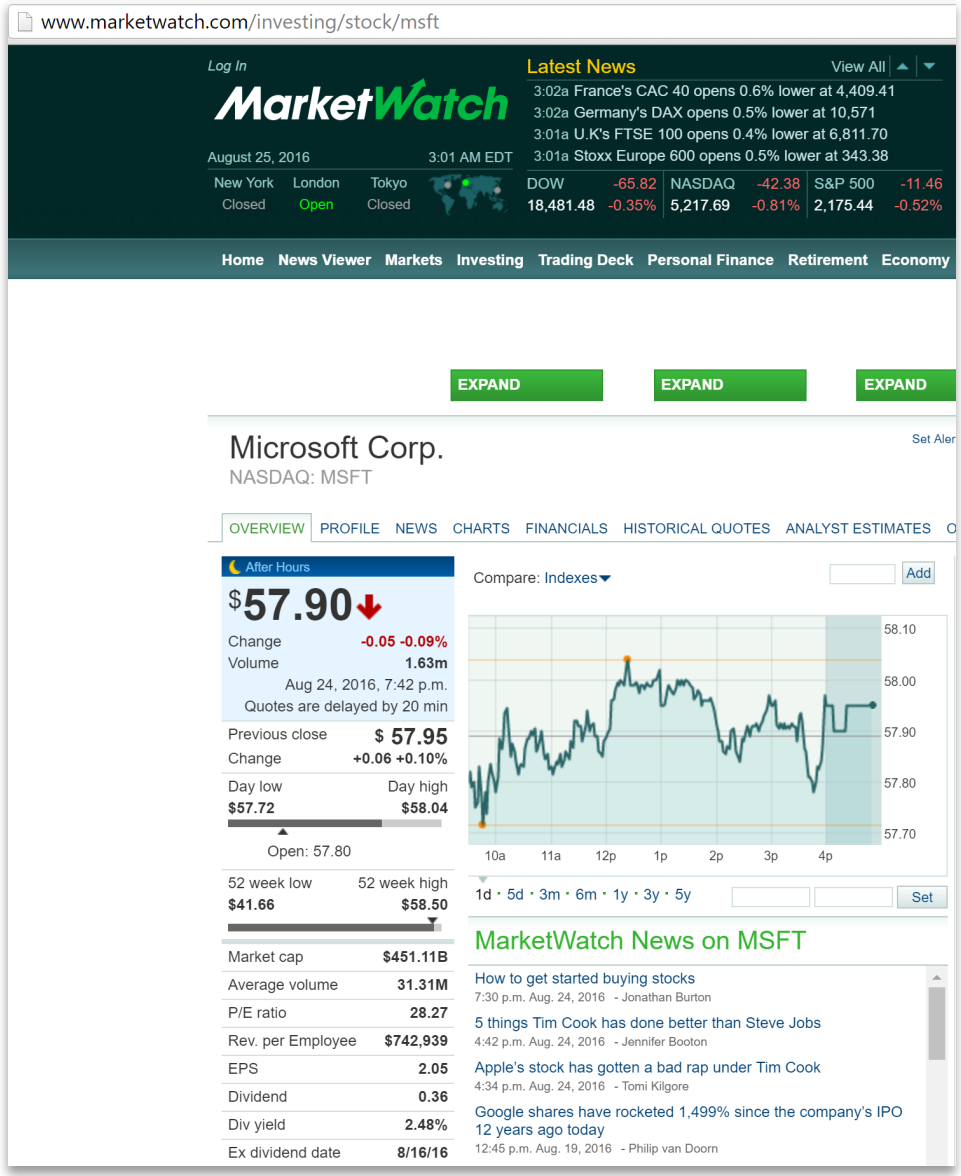
WebRelate: Integrating Web Data with Spreadsheets using Examples

Jeevana Inala
MIT

Rishabh Singh
Microsoft Research

Company	Stock value
MSFT	
AMZN	
AAPL	
T	
S	



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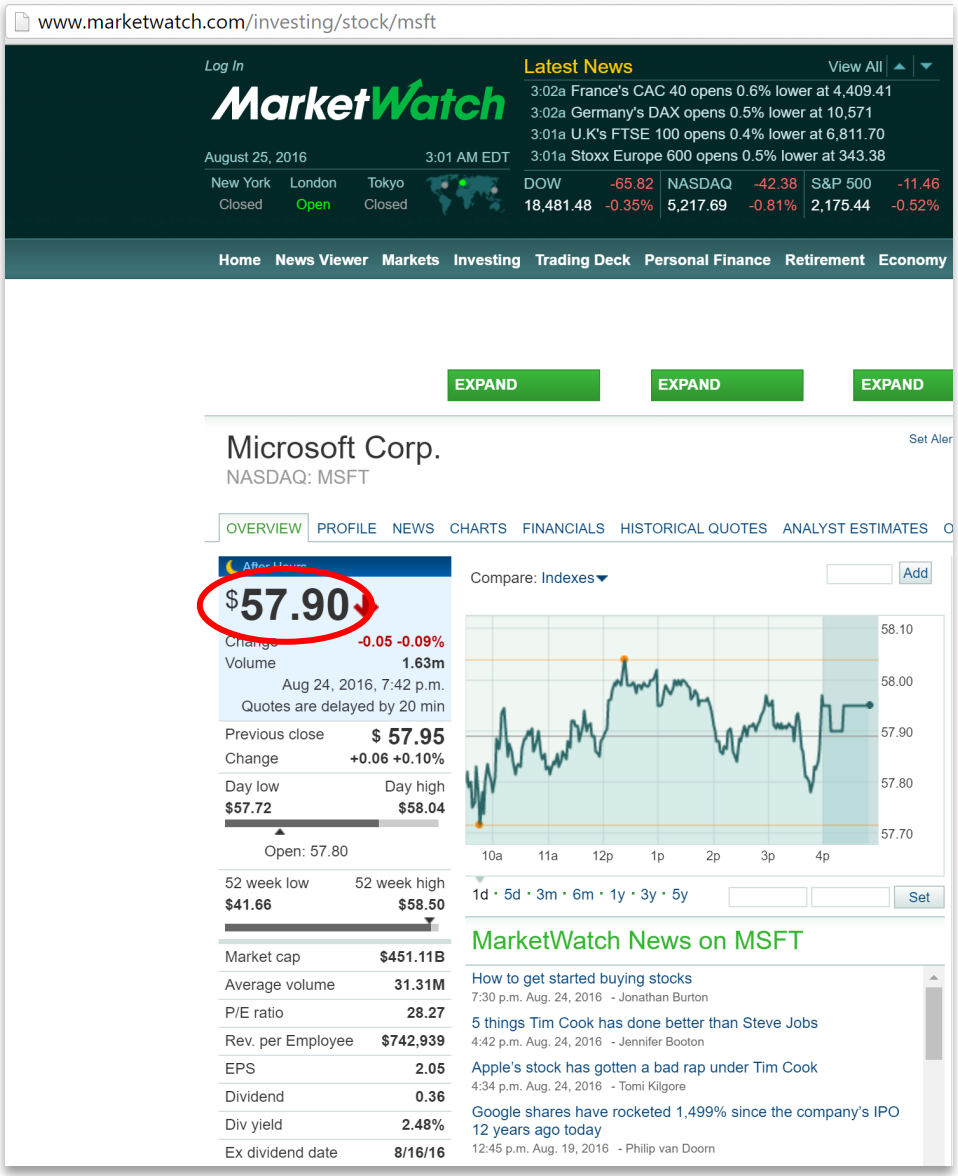
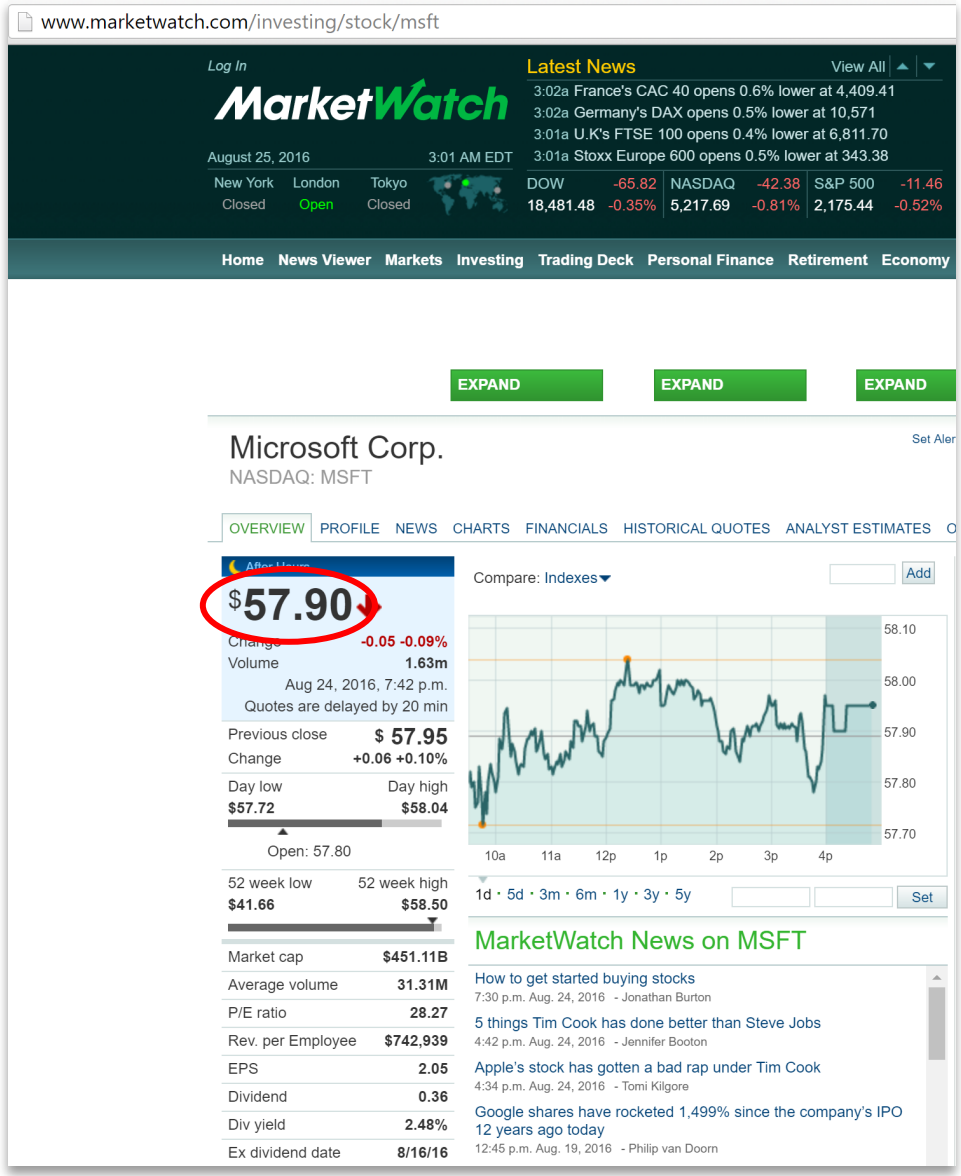


Company	Stock value
MSFT	57.90
AMZN	
AAPL	
T	
S	



Code:

```
Public Sub Import_Yahoo_Finance_Historical()

    Dim URL As String
    Dim dateParams As String

    'Date ranges from default earliest Yahoo start date (m/d/y) to current date (m/d/y)

    dateParams = "&a=0&b=3&c=1977&d=" & Month(Date) - 1 & "&e=" & Day(Date) & "&f=" & Year(Date)

    'Daily prices

    URL = "http://ichart.finance.yahoo.com/table.csv?s=" & Sheets("Analysis").Range("C2").Value & dateParams & "&g=d&ignore=.csv"

    With Worksheets("Input")
        With .QueryTables.Add(Connection:="TEXT;" & URL, Destination:=.Range("A1"))
            .TextFileStartRow = 1
            .TextFileParseType = xlDelimited
            .TextFileCommaDelimiter = True
            .Refresh BackgroundQuery:=False
        End With
        .QueryTables(1).Delete
    End With

    'Dividends only

    URL = "http://ichart.finance.yahoo.com/table.csv?s=" & Sheets("Analysis").Range("C2").Value & dateParams & "&g=v&ignore=.csv"

    With Worksheets("Input")
        With .QueryTables.Add(Connection:="TEXT;" & URL, Destination:=.Range("I1"))
            .TextFileStartRow = 1
```

WebRelate

Company	Stock value
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AMZN	
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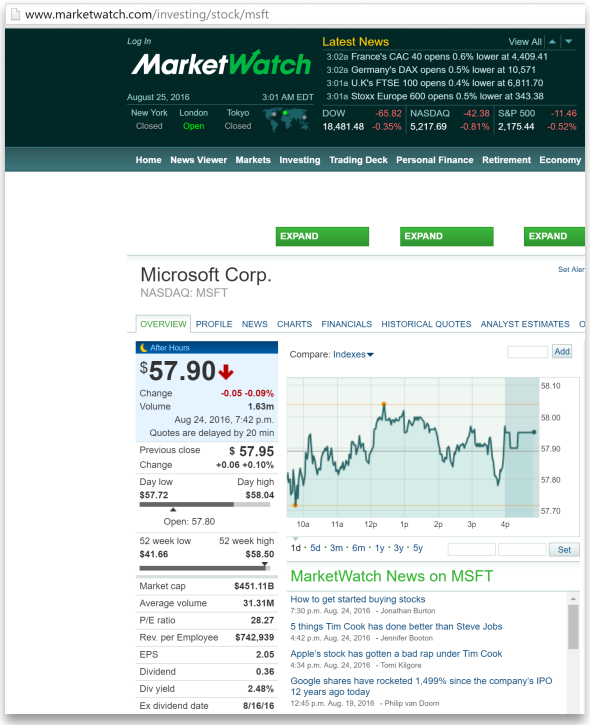


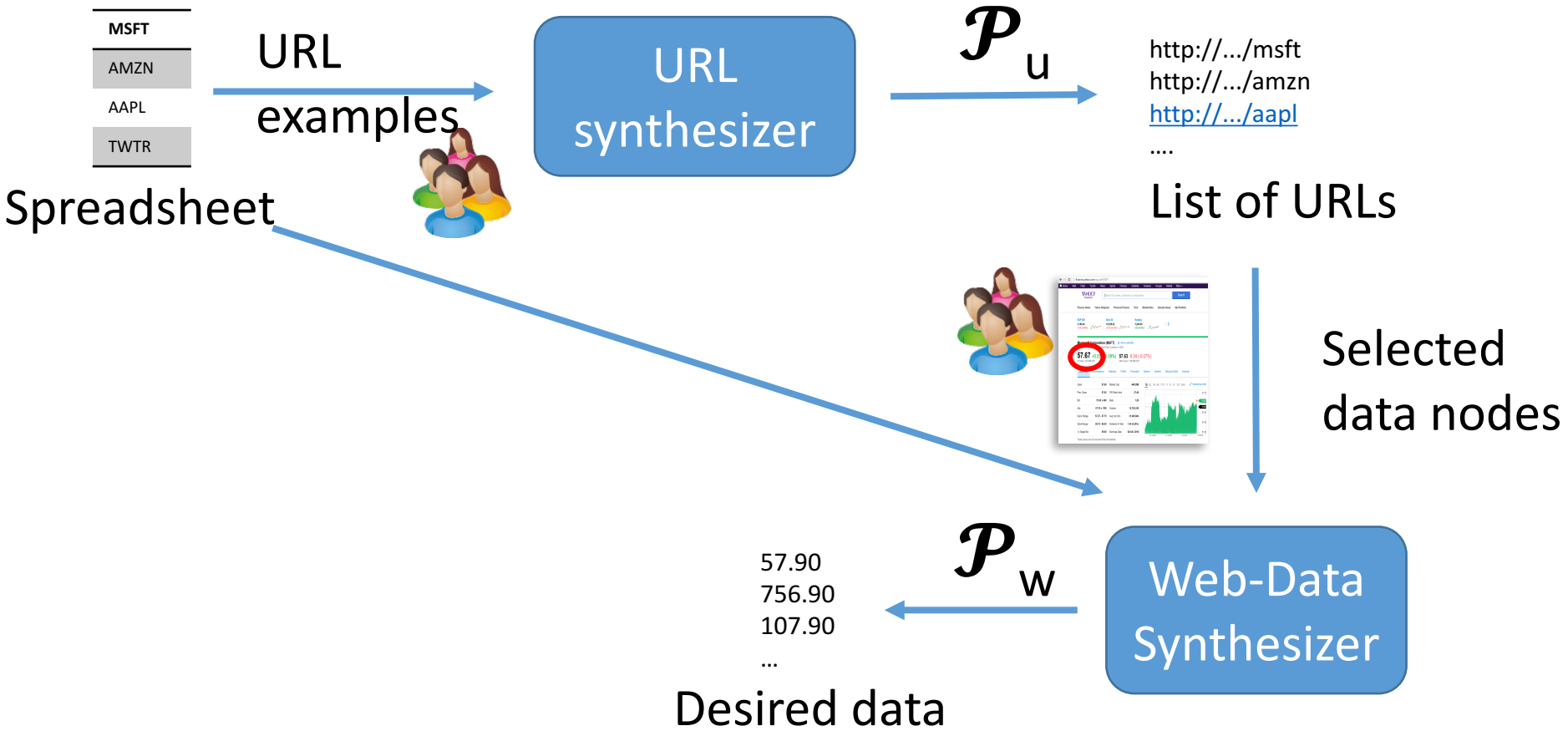
Examples

Program

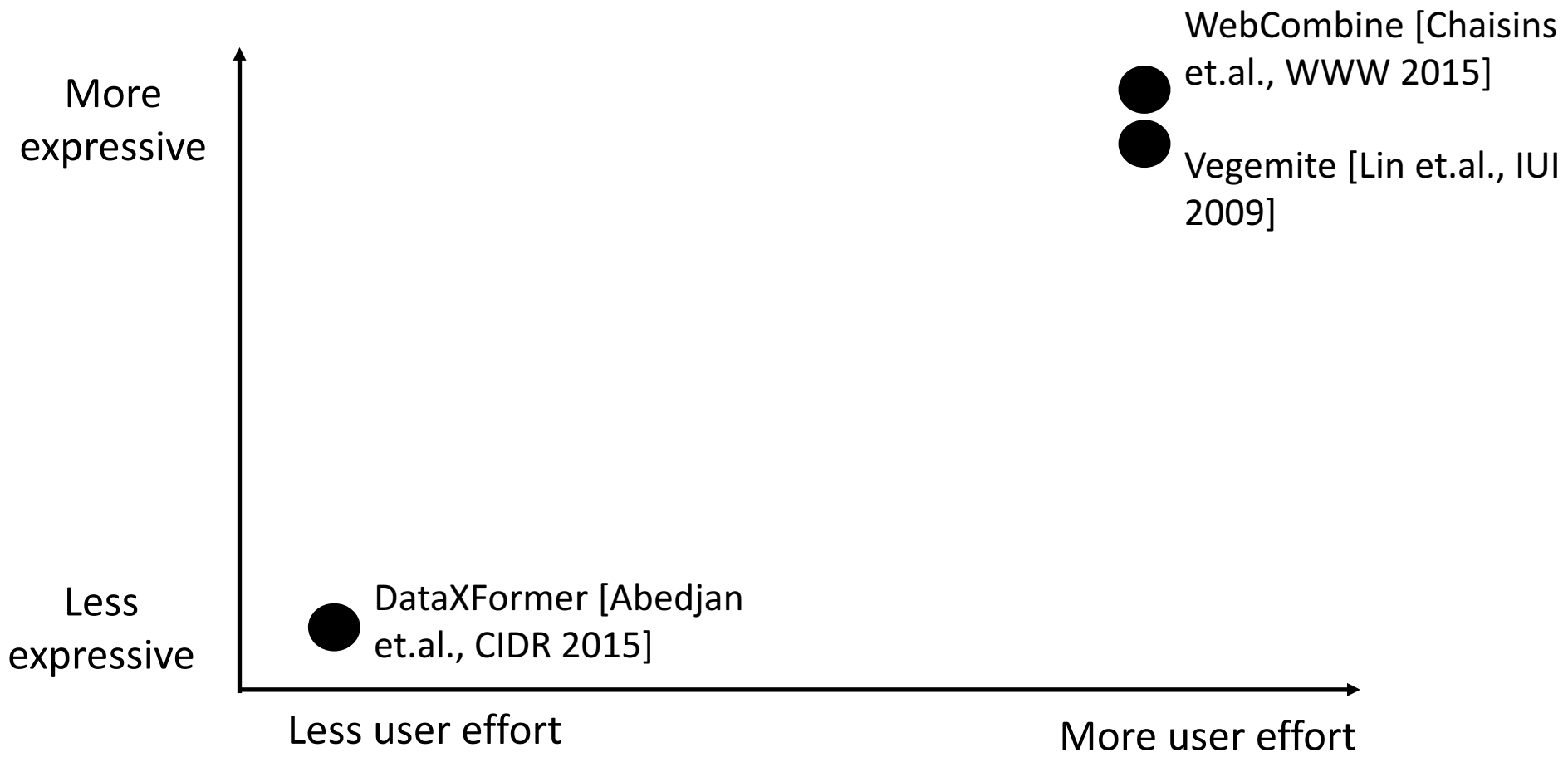
Company	Stock value
MSFT	57.90
AMZN	759.48
AAPL	108.51
T	40.91
S	6.04

Demo

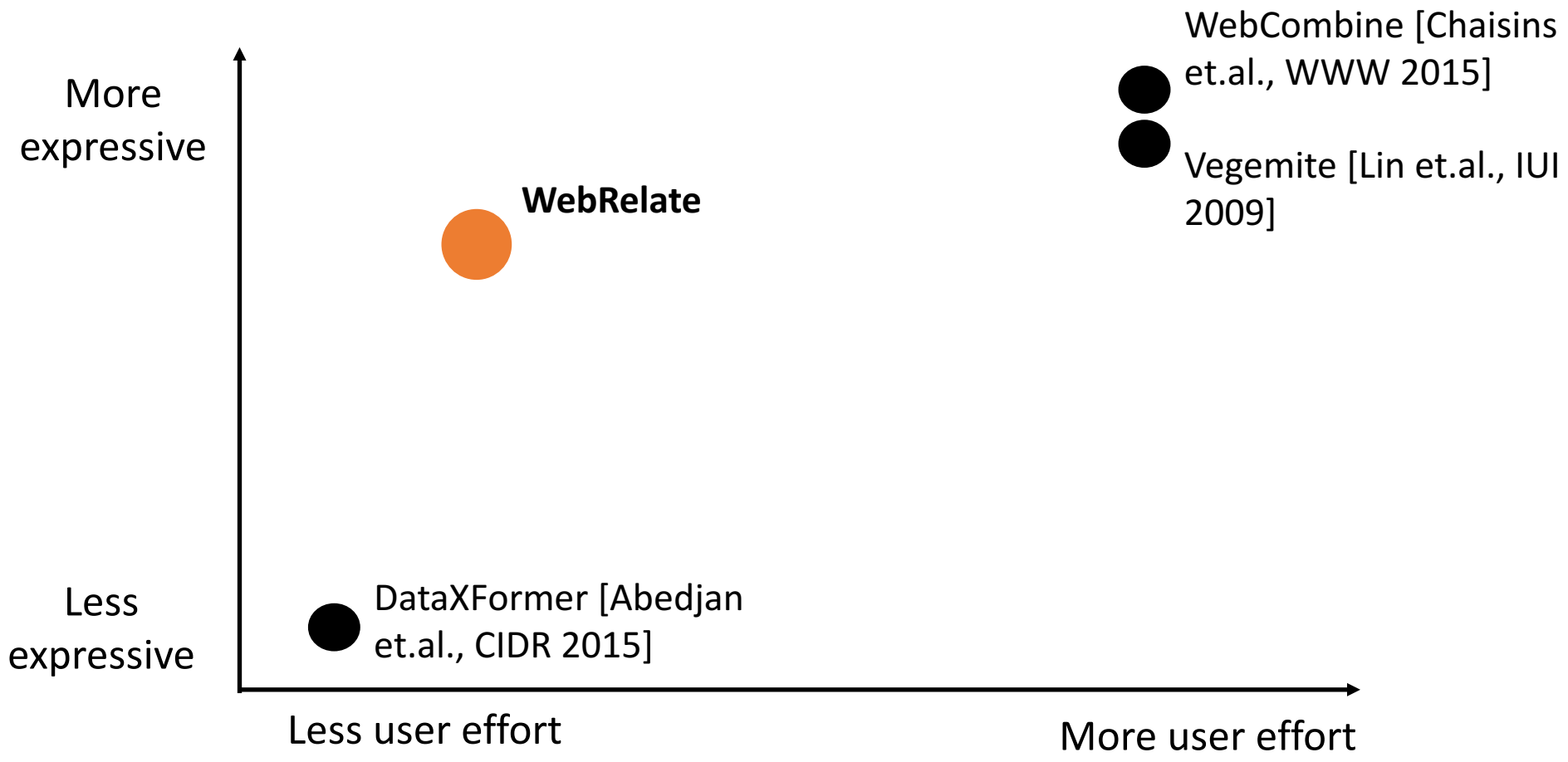
Overview


MSFT
AMZN
AAPL
TWTR
URL examples
Spreadsheet
URL synthesizer
$\mathcal{P}_u$
http://.../msft
http://.../amzn
http://.../aapl
....
List of URLs
Selected data nodes
Web-Data Synthesizer
$\mathcal{P}_w$
57.90
756.90
107.90
...
Desired data

Related Work



Related Work



Related Work

- Learning string transformations
  - Flash Fill (Gulwani, POPL 11), Blink Fill (Singh, VLDB 16)

Rishabh Singh  R.S.

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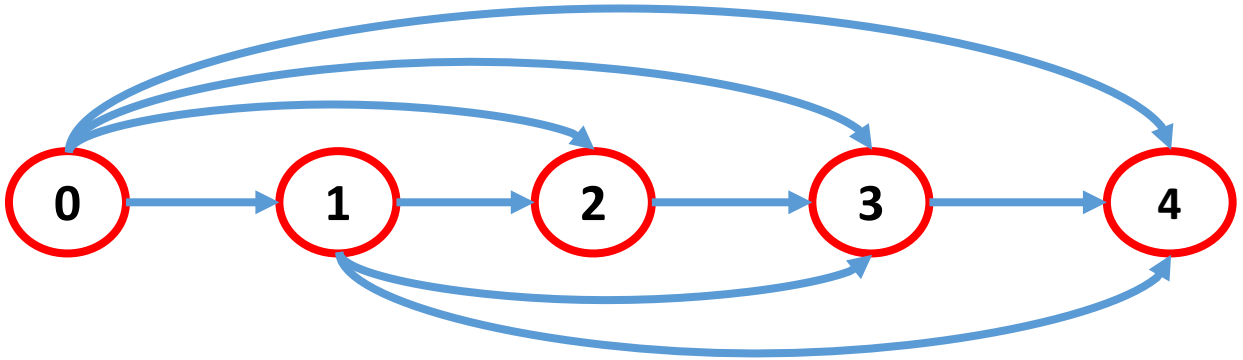

Version space algebra

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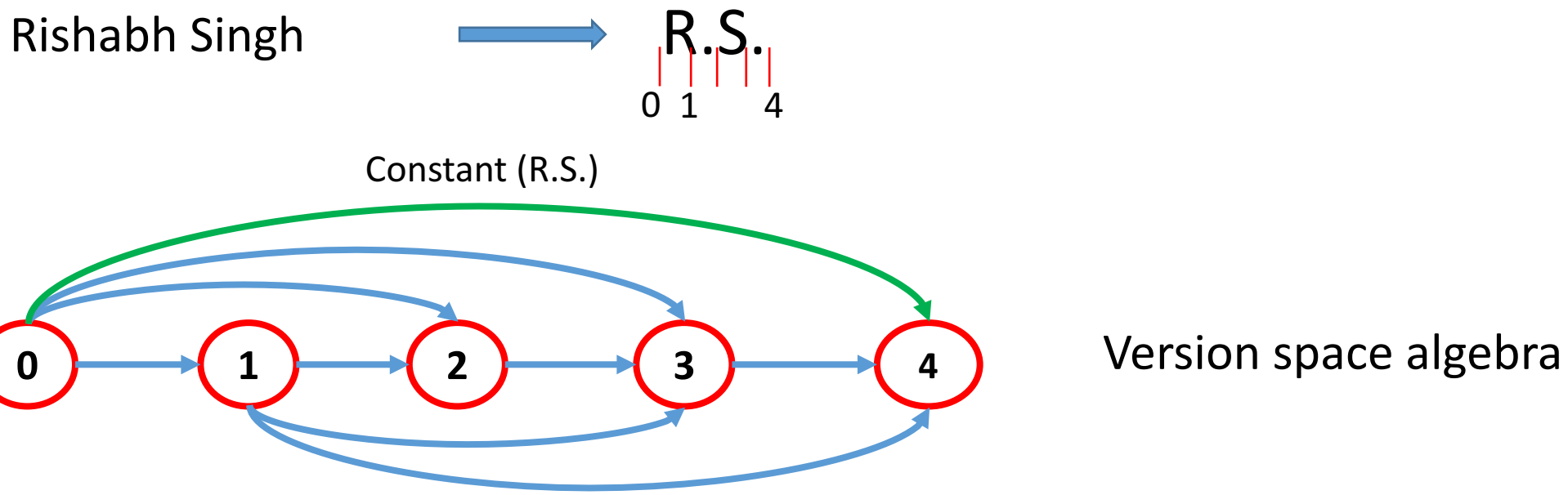

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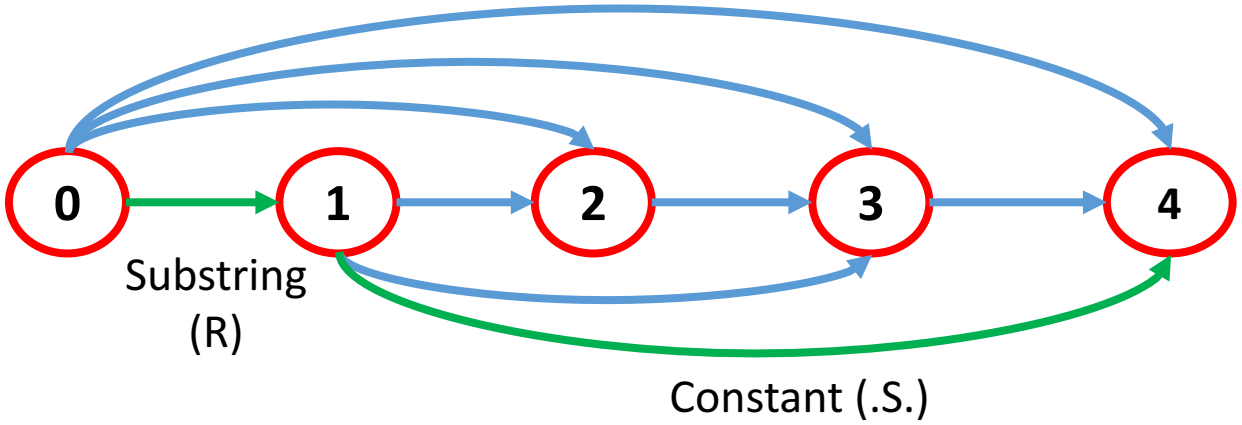
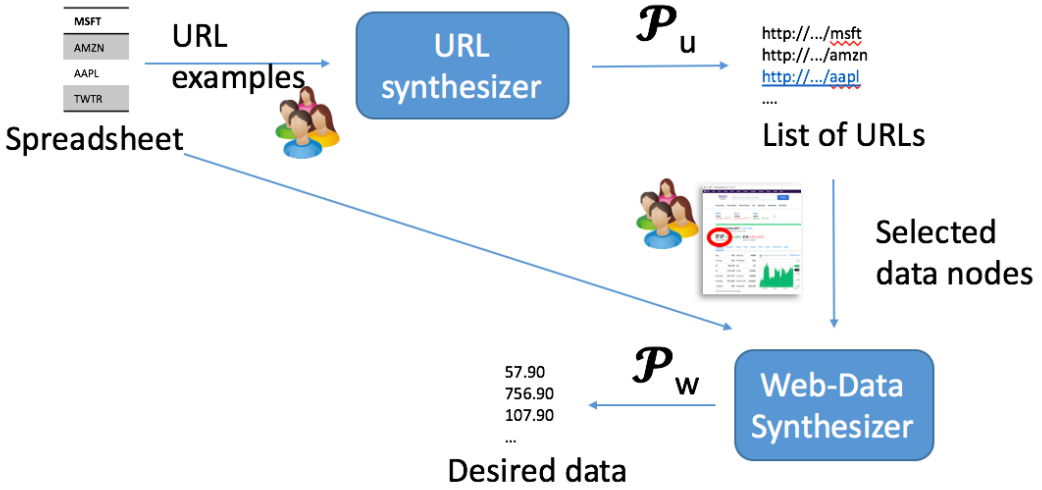


Version space algebra

Ranking: substring > constant

Overview

- Output-constrained PBE
- Layered Version Space Algebra
- Input-dependent Web Extraction



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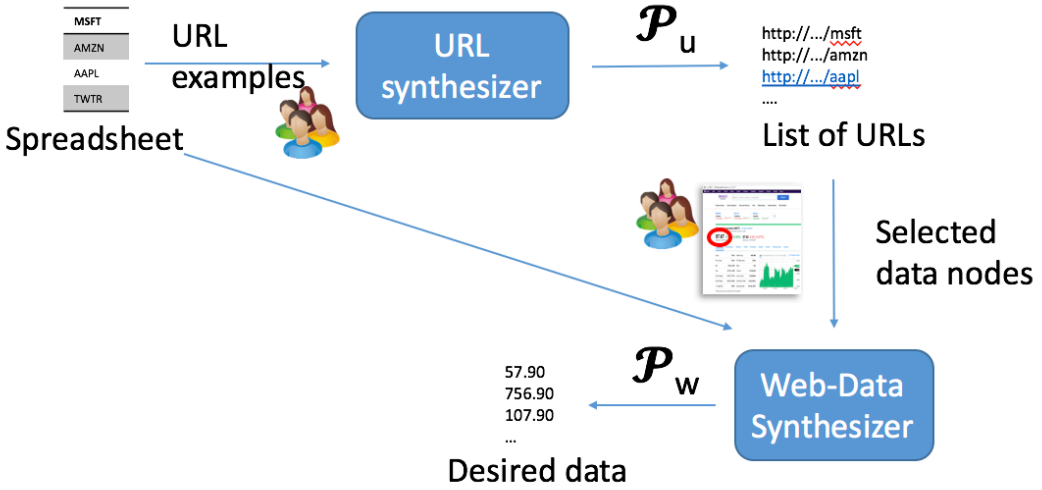
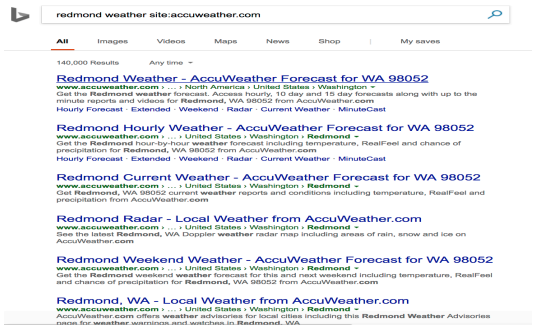


Traditional PBE

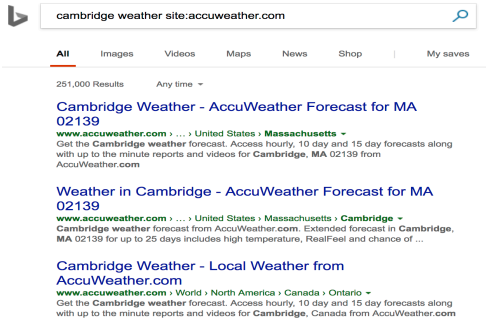
Ana Trujillo 357 21th Place SE,Redmond,WA → http://www.accuweather.com/en/us/redmond-wa/98052/weather-forecast/341347

Output-constrained PBE

Ana Trujillo 357 21th Place SE,Redmond,WA +



Charlie Gunaja 732 Memorial Drive, Cambridge,MA +



→ http://www.accuweather.com/en/us/redmond-wa/98052/weather-forecast/341347

Traditional PBE

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42°

Output-constrained PBE (O-PBE)

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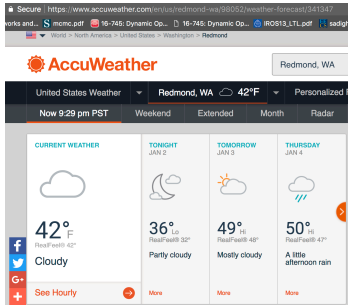

42°

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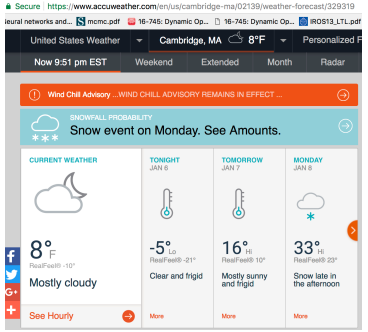

Output-constrained PBE (O-PBE)

- Generalization constraint
  - $\forall$ in $\in$ inputs. ***P(in)*** $\in$ ***list of possible of outputs for in***

- Uniqueness constraint
  - $\forall$ (in,out) $\in$ input-output examples. ***P(in) = out***

Richer class of problems

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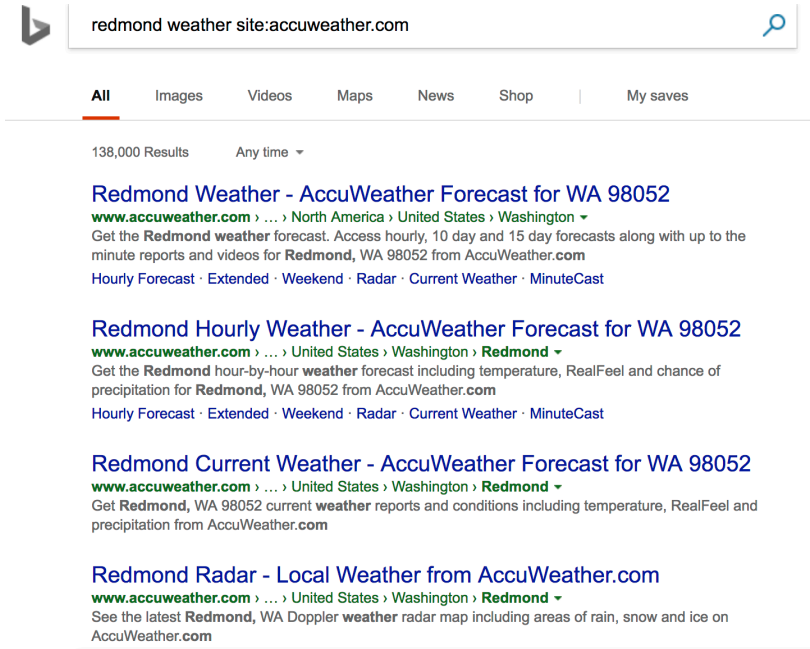

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https://www.accuweather.com/en/us/redmond-or/97756/weather-forecast/340247

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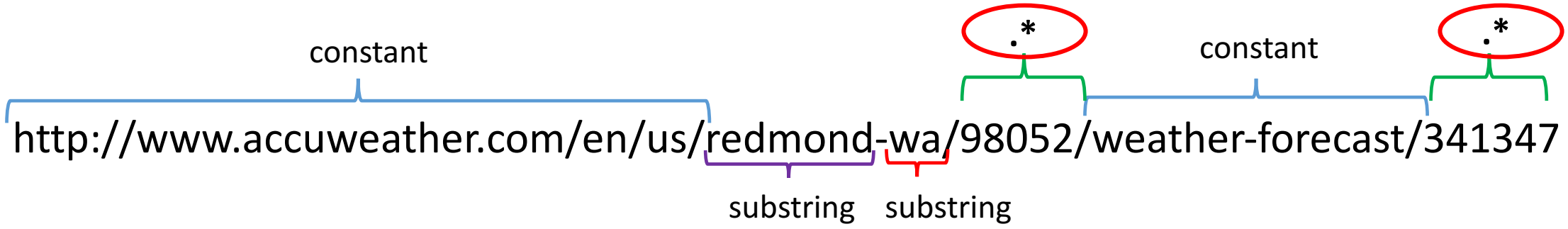

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http://www.accuweather.com/en/us/redmond-wa/.*/weather-forecast/.*

Richer class of problems

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http://www.accuweather.com/en/us/redmond-wa/.*/weather-forecast/.*

It is sufficient to learn a program that uniquely identifies the desired output.

Better ranking

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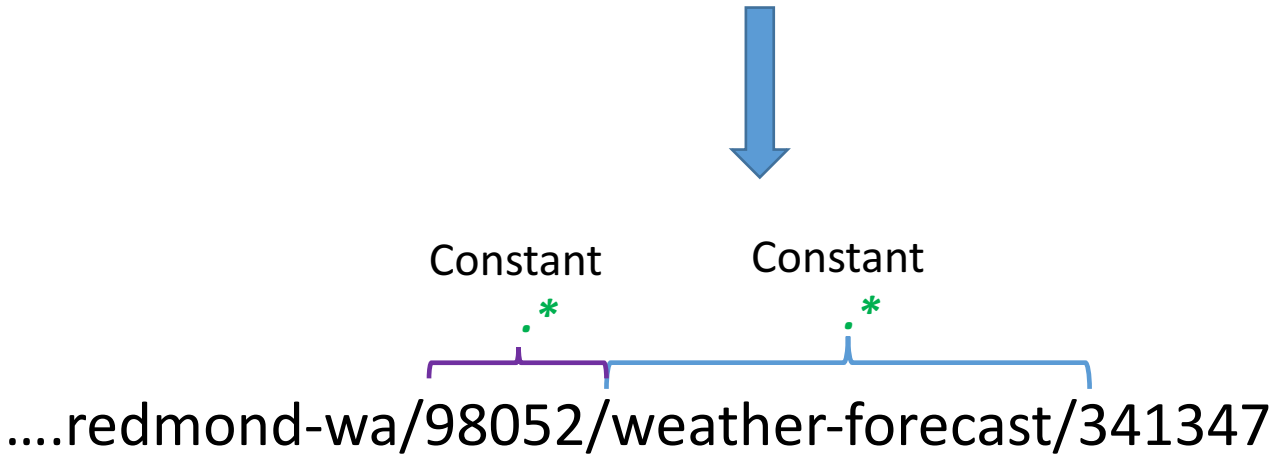

How do we know which part of the URL should be .*?

Better ranking

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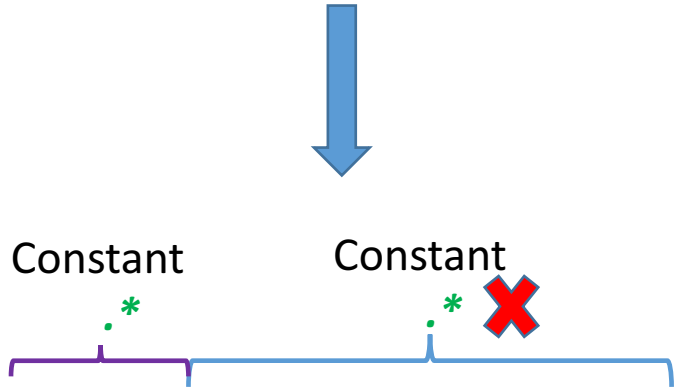

….redmond-wa/98052/weather-forecast/341347

https://www.accuweather.com/en/us/redmond-wa/98052/weather-forecast/341347

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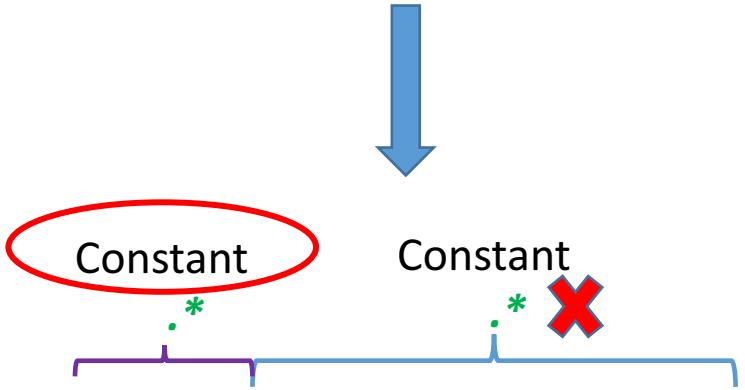

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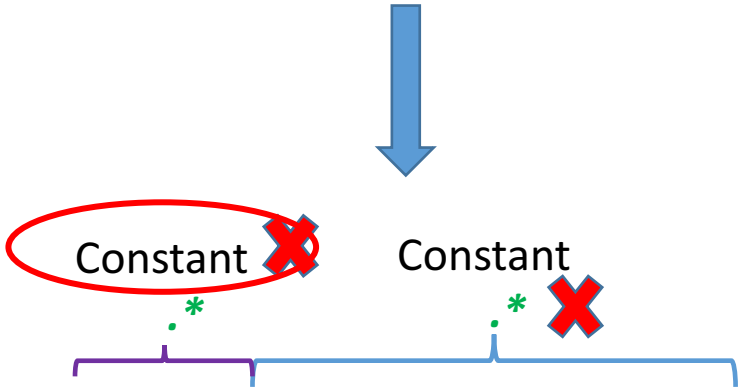

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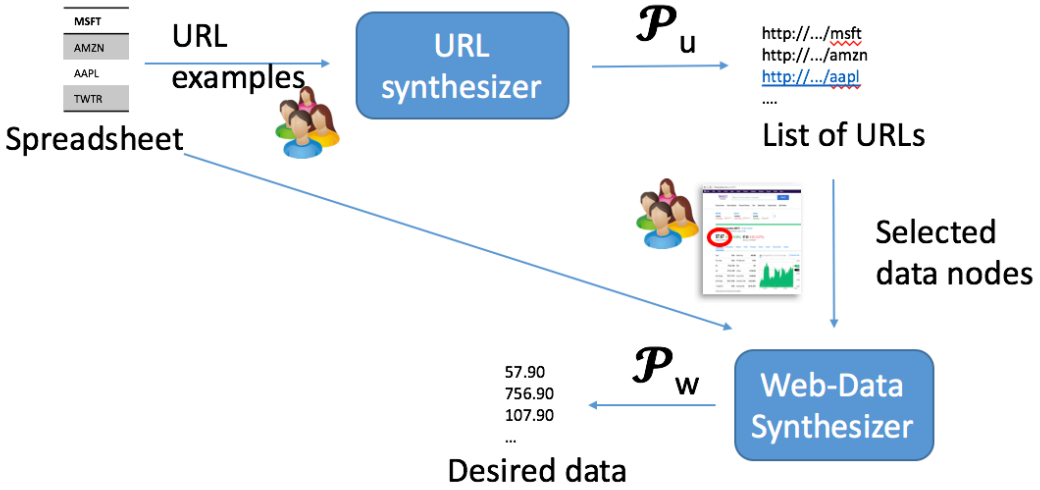
https://www.accuweather.com/en/us/cambridge-ma/02139/daily-weather-forecast/329319

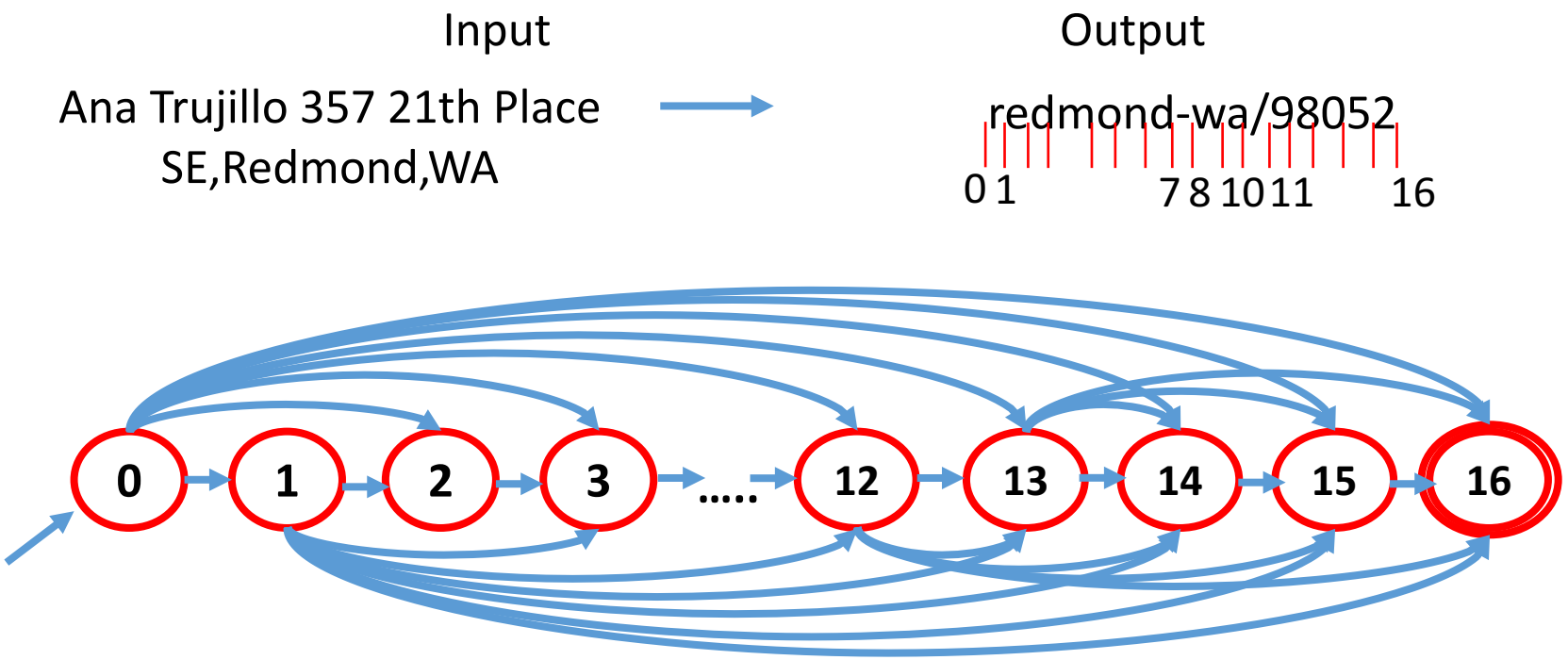
Overview

- Output-constrained PBE
- ***Layered Version Space Algebra***
- Input-dependent Web Extraction



URLs are long!

- Complexity of VSA used in Flash Fill
  - Quadratic in length of output
  - Exponential in number of examples



Layered Version Space Algebra

- Performs search over increasingly expressive sub-languages
  - $L_1 \subseteq L_2 \subseteq \ldots. \subseteq L_k$

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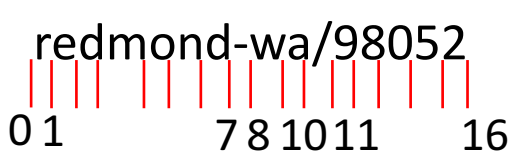
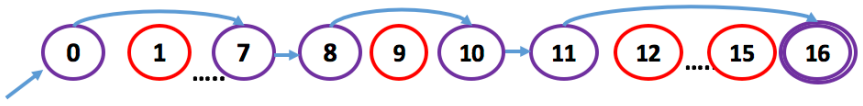
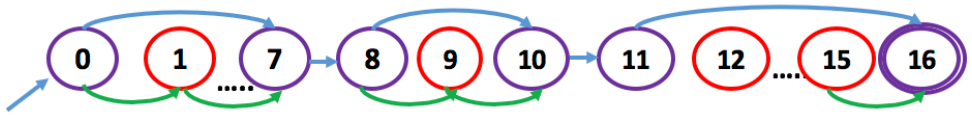
SE,Redmond,WA



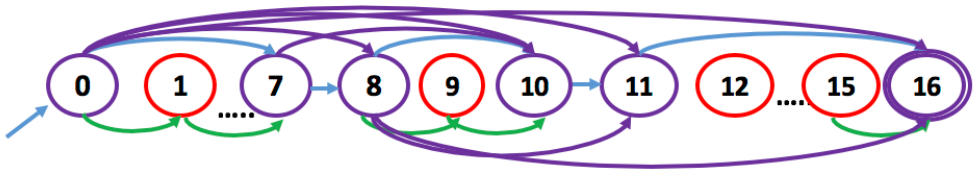
Layer 1



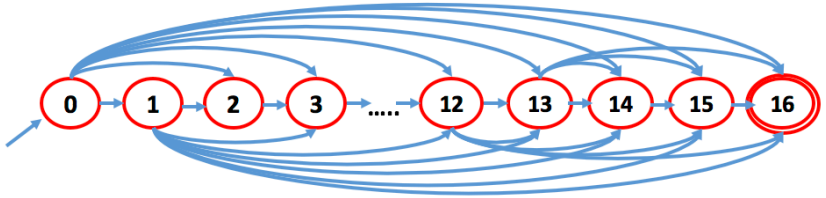
Layer 2



Layer 3



Layer 4 – Full dag



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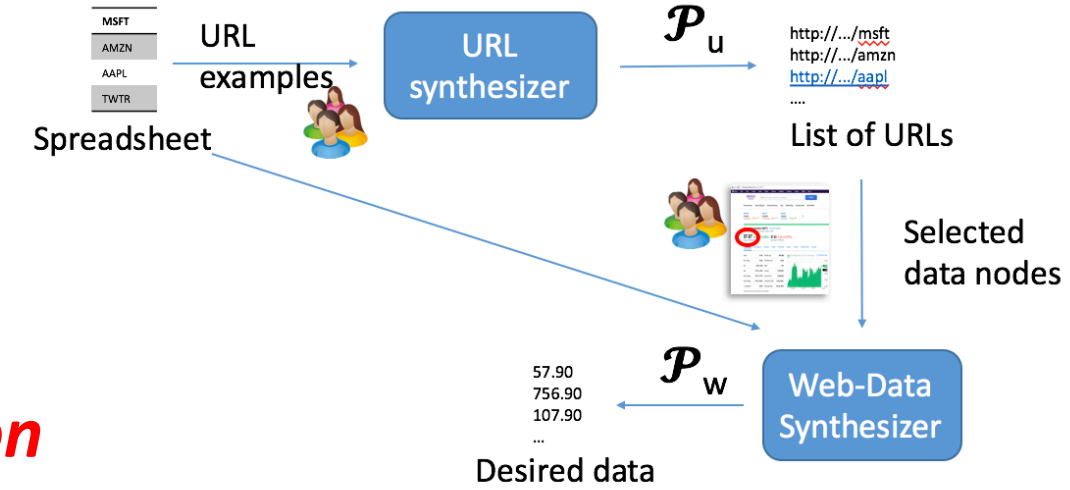
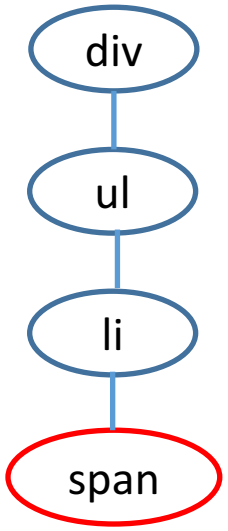
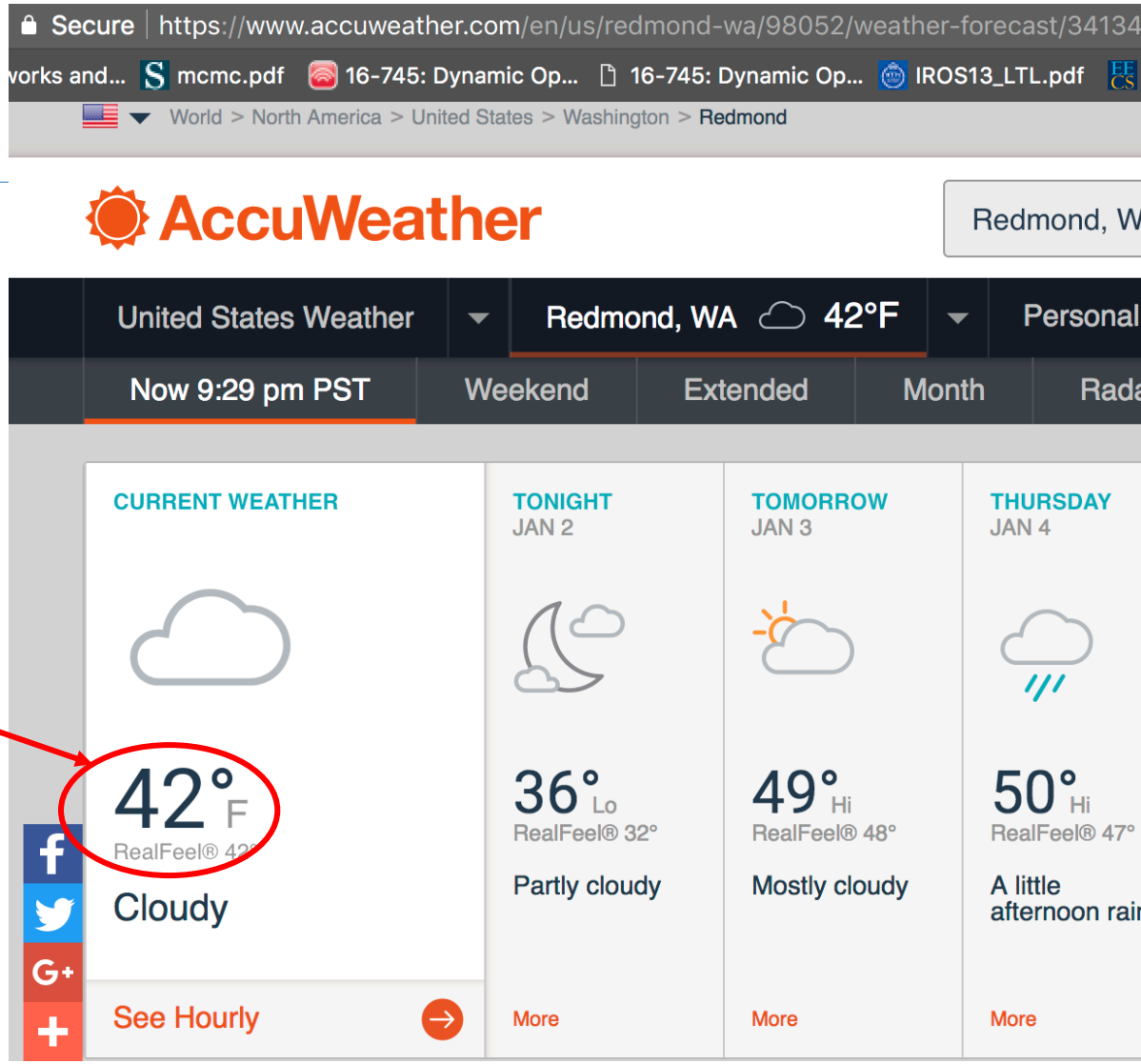
- ***Input-dependent Web Extraction***



Web-Extraction



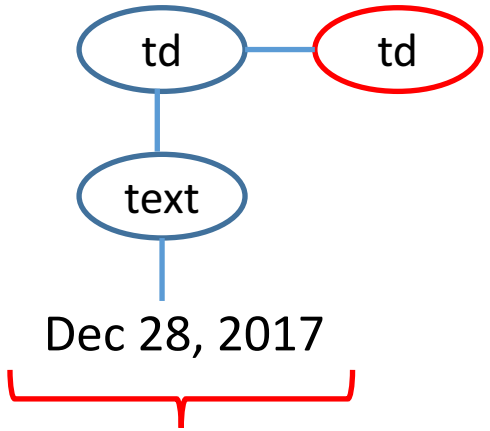
id = ”feed-tabs”



Can be expressed in Xpath query language

Web-Extraction

Cur1	Cur2	Date
USD	INR	28, December, 2017
EUR	GBP	03, January, 2018
USD	CHF	05, January, 2018



Transform(28, December, 2017)

Investing.com EUR/USD or AA

USD/INR 63.275 -0.095 (-0.15%)

USD/INR Historical Data

Time Frame: Daily

Date	Price
Jan 05, 2018	63.340
Jan 04, 2018	63.400
Jan 03, 2018	63.505
Jan 02, 2018	63.460
Jan 01, 2018	63.680
Dec 29, 2017	63.840
Dec 28, 2017	64.080
Dec 27, 2017	64.120

Input-dependent Web-Extraction

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USD	INR	28, December, 2017
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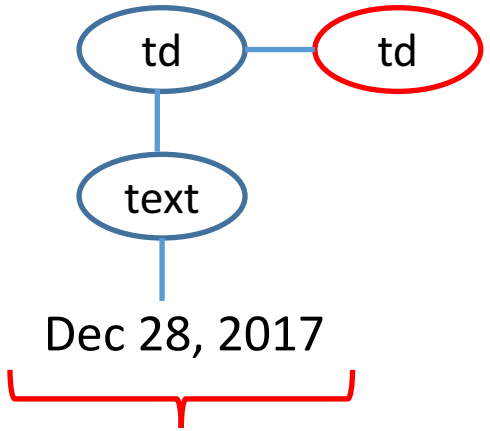

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Input-dependent Web-Extraction

USD; INR; 28, December, 2017

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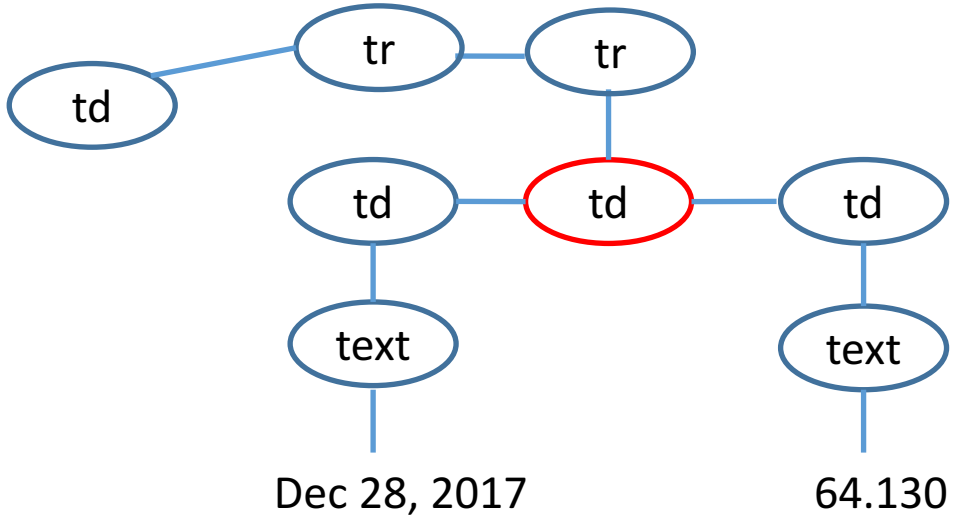

HTML tree

Find constraints in this tree that satisfy both *Uniqueness* and *Generalization* properties of the O-PBE problem

Input-dependent Web-Extraction

USD; INR; 28, December, 2017

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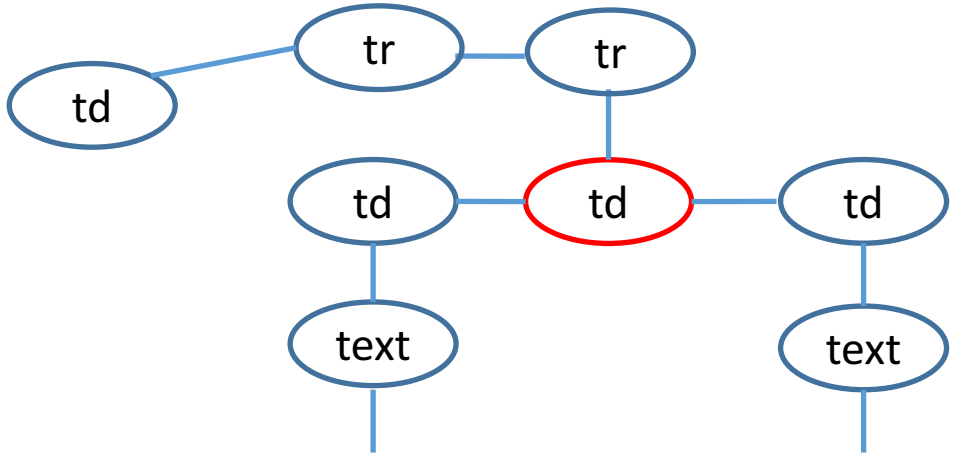

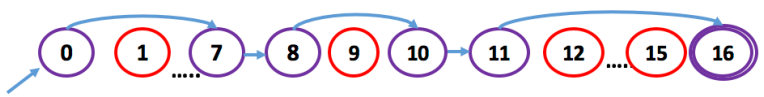

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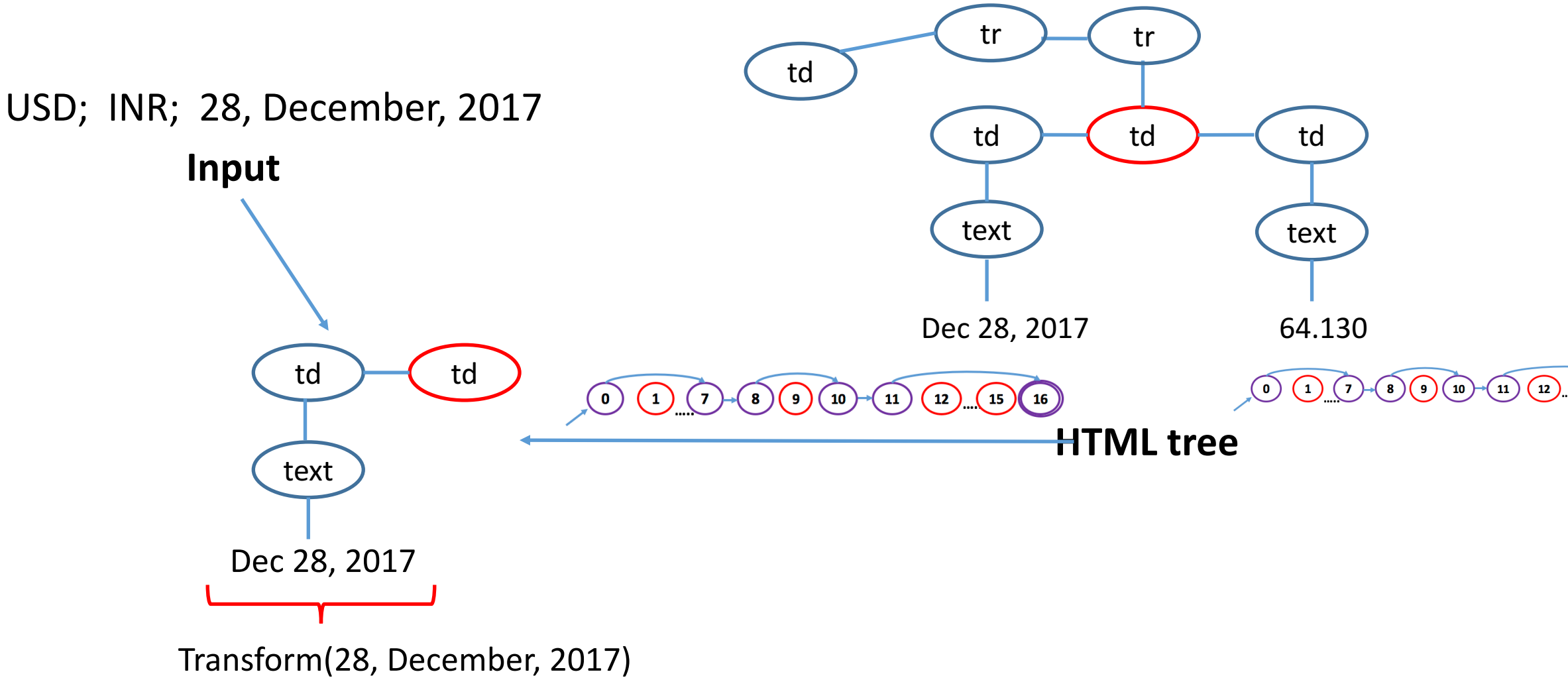
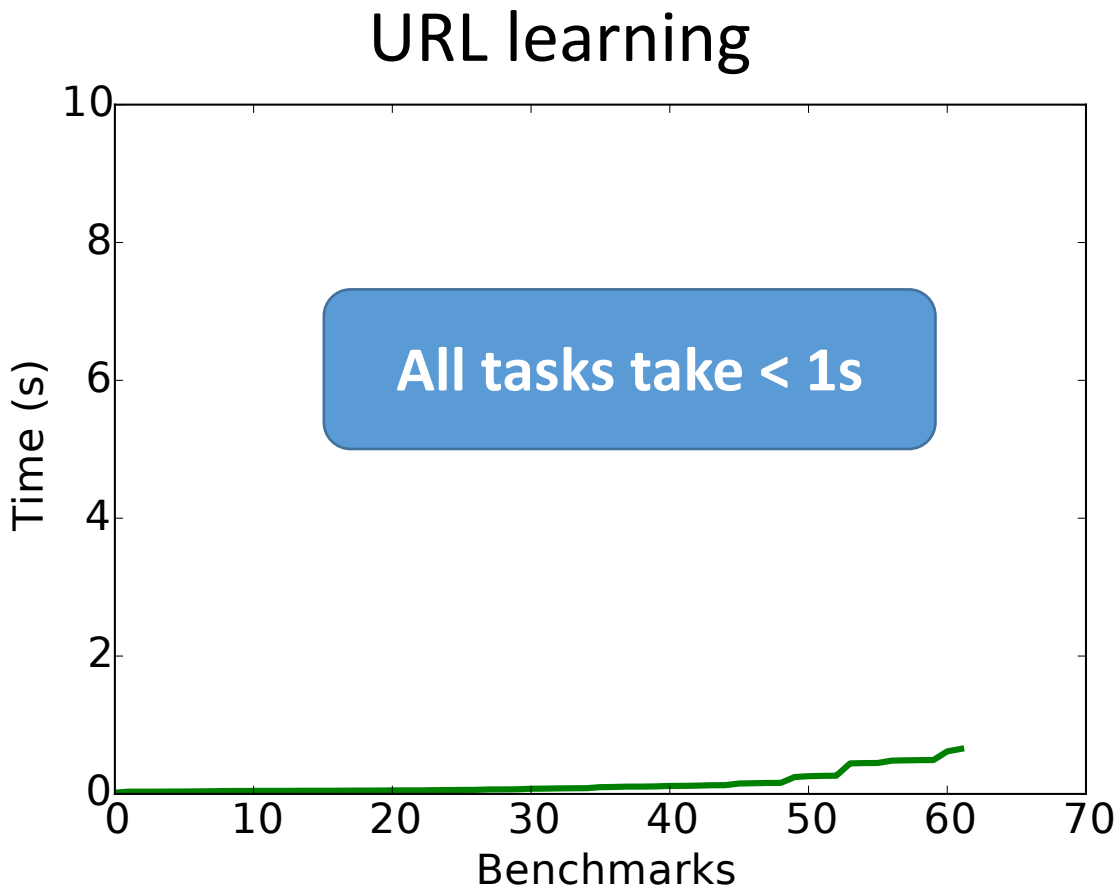


Results

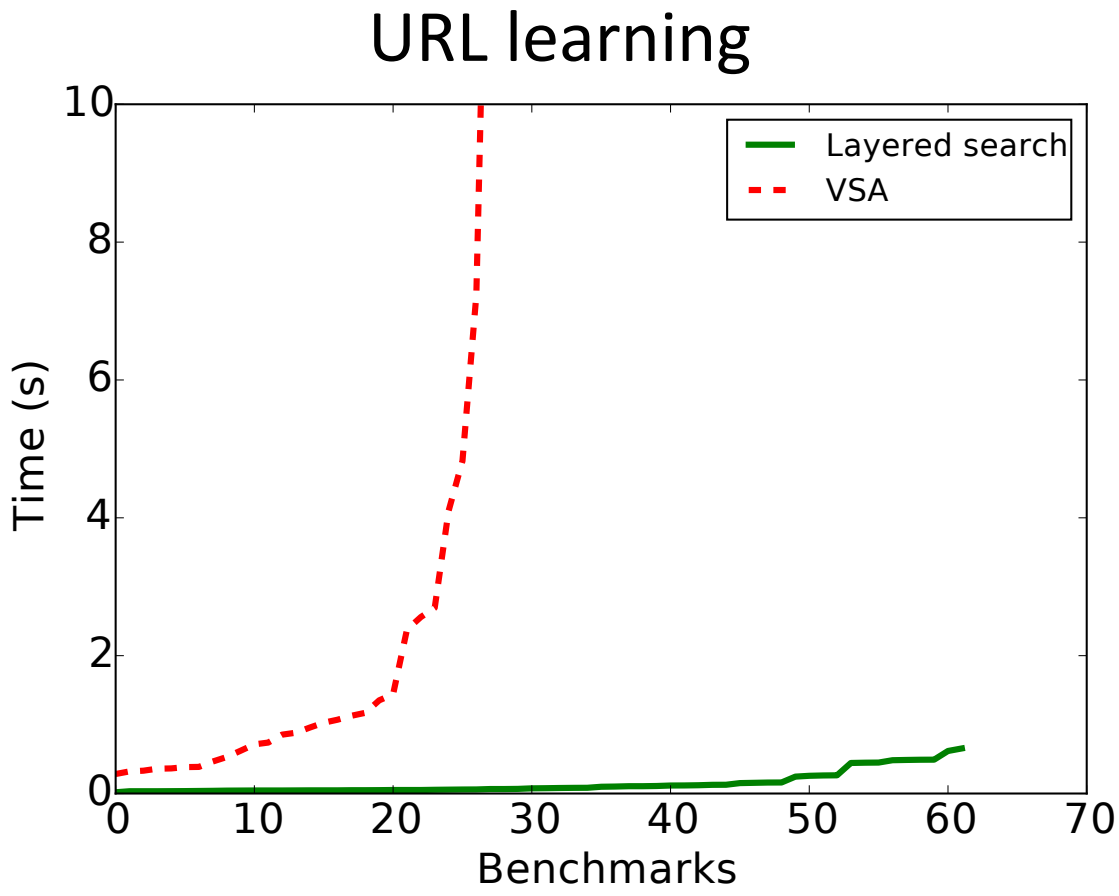
Expressive?

- 88 data integration scenarios
  - Stocks, weather, sports, currency, ….
  - 62 URL learning tasks
  - 88 Web-data extraction tasks
- 5 – 32 number of input rows in the spreadsheet
- Solves all of them correctly

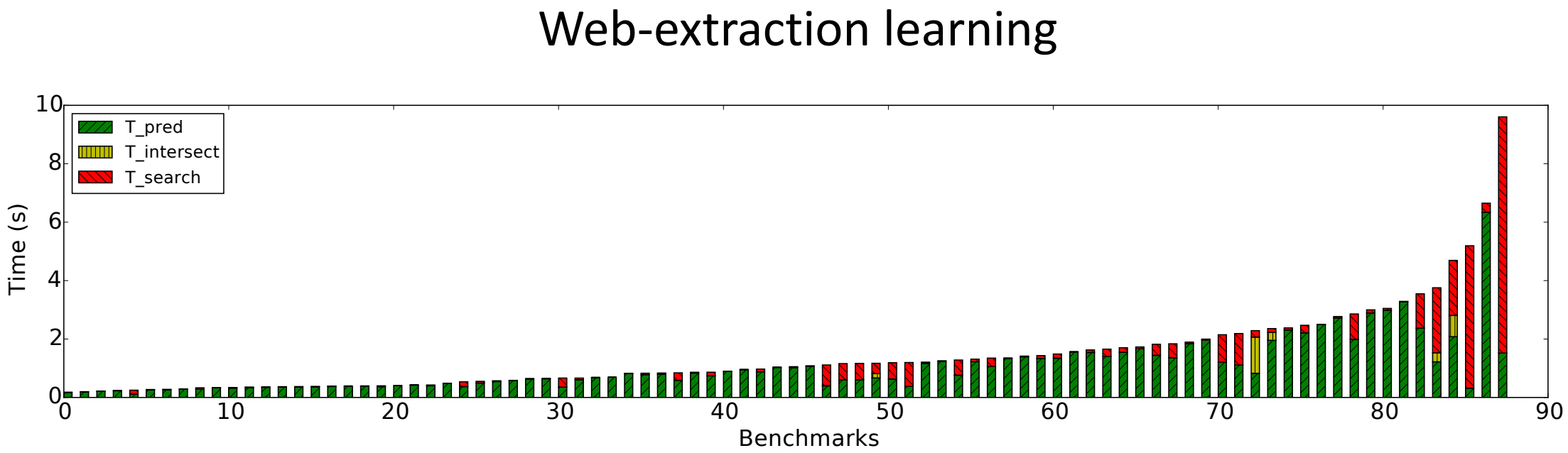
Fast?


URL learning
All tasks take < 1s
Time (s)
Benchmarks
0
2
4
6
8
10
0
10
20
30
40
50
60
70

Layered search beats VSA

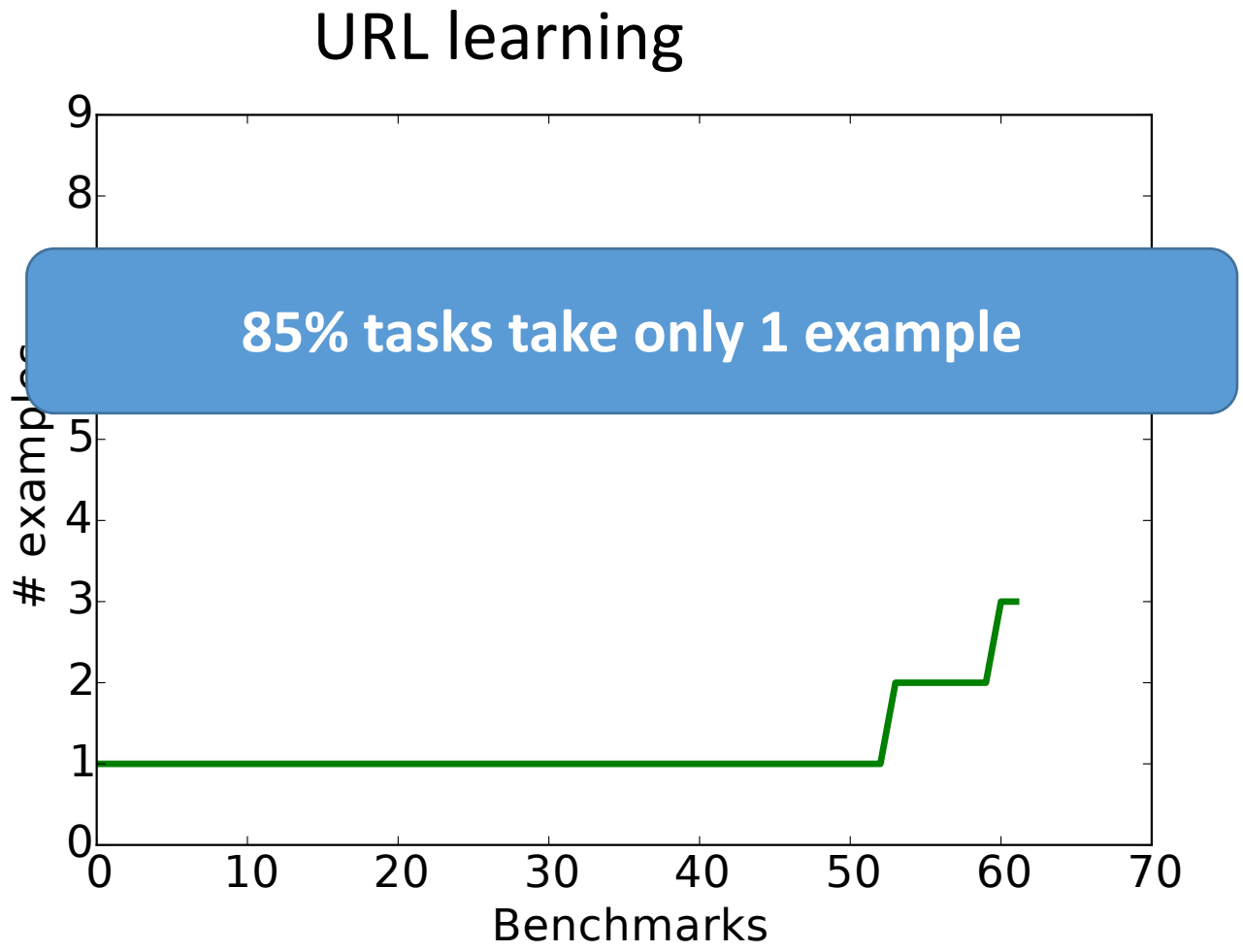


Fast?

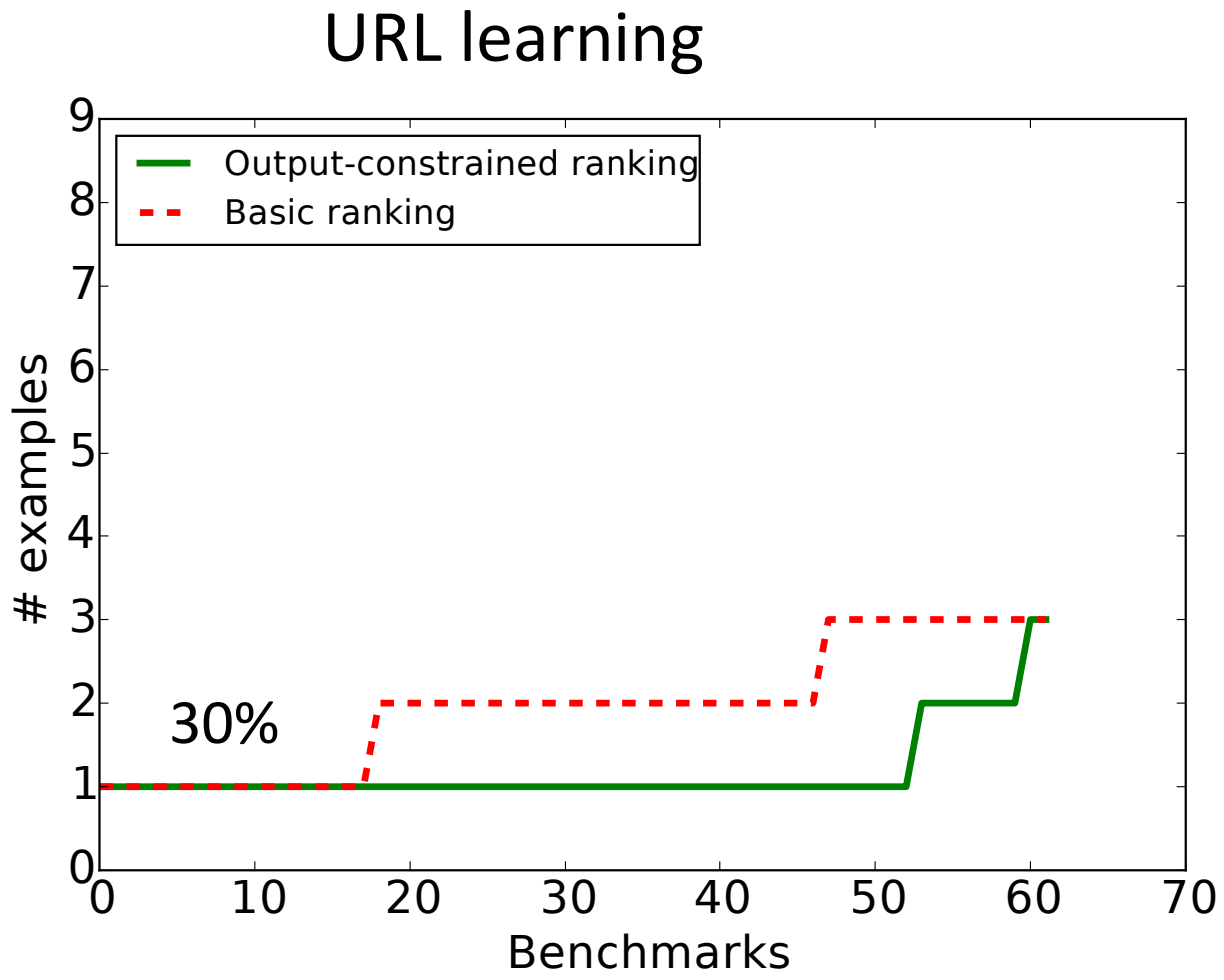


All tasks take < 10s

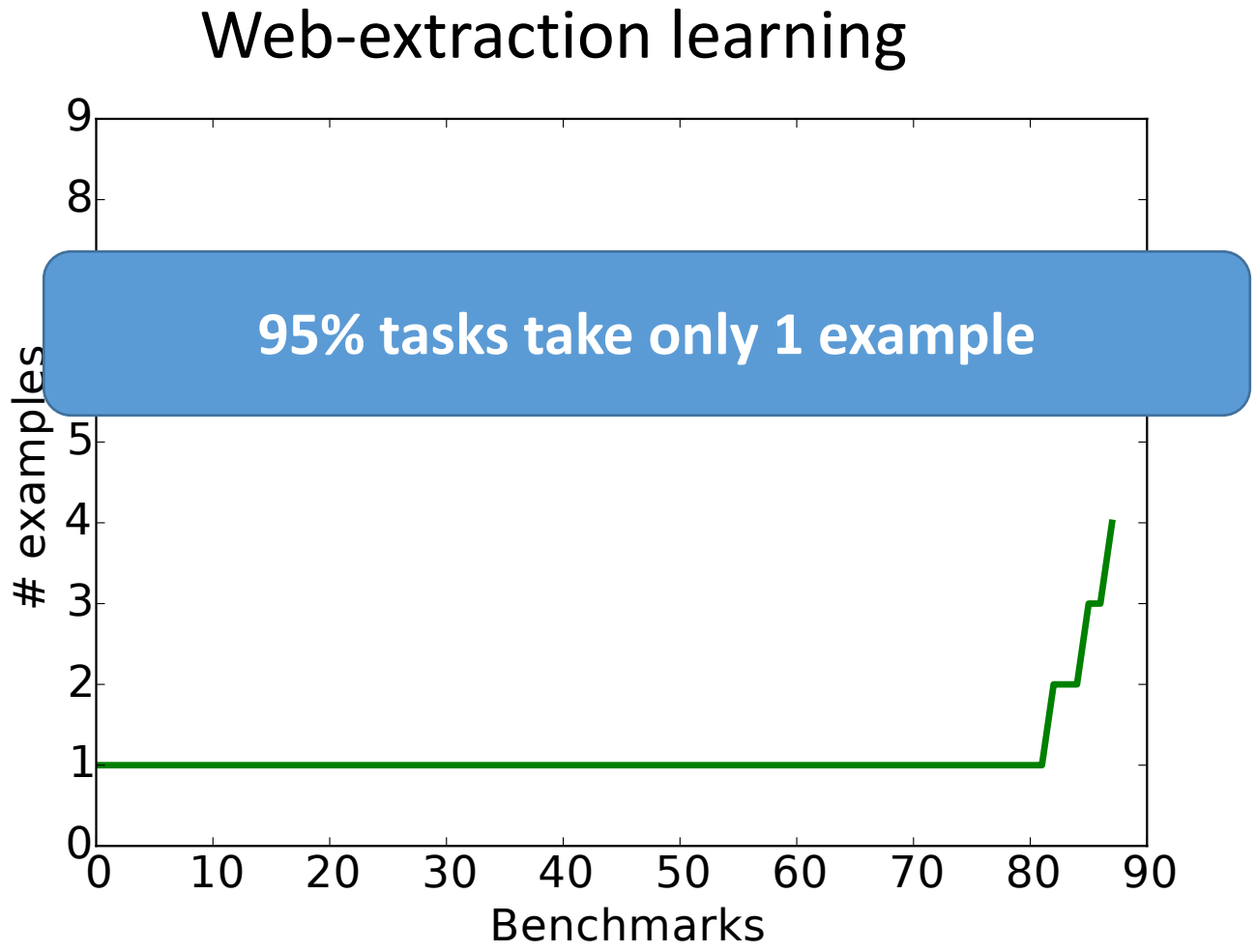
Easy to use?


URL learning
85% tasks take only 1 example
examples
0
1
2
3
4
5
8
9
0
10
20
30
40
50
60
70
Benchmarks

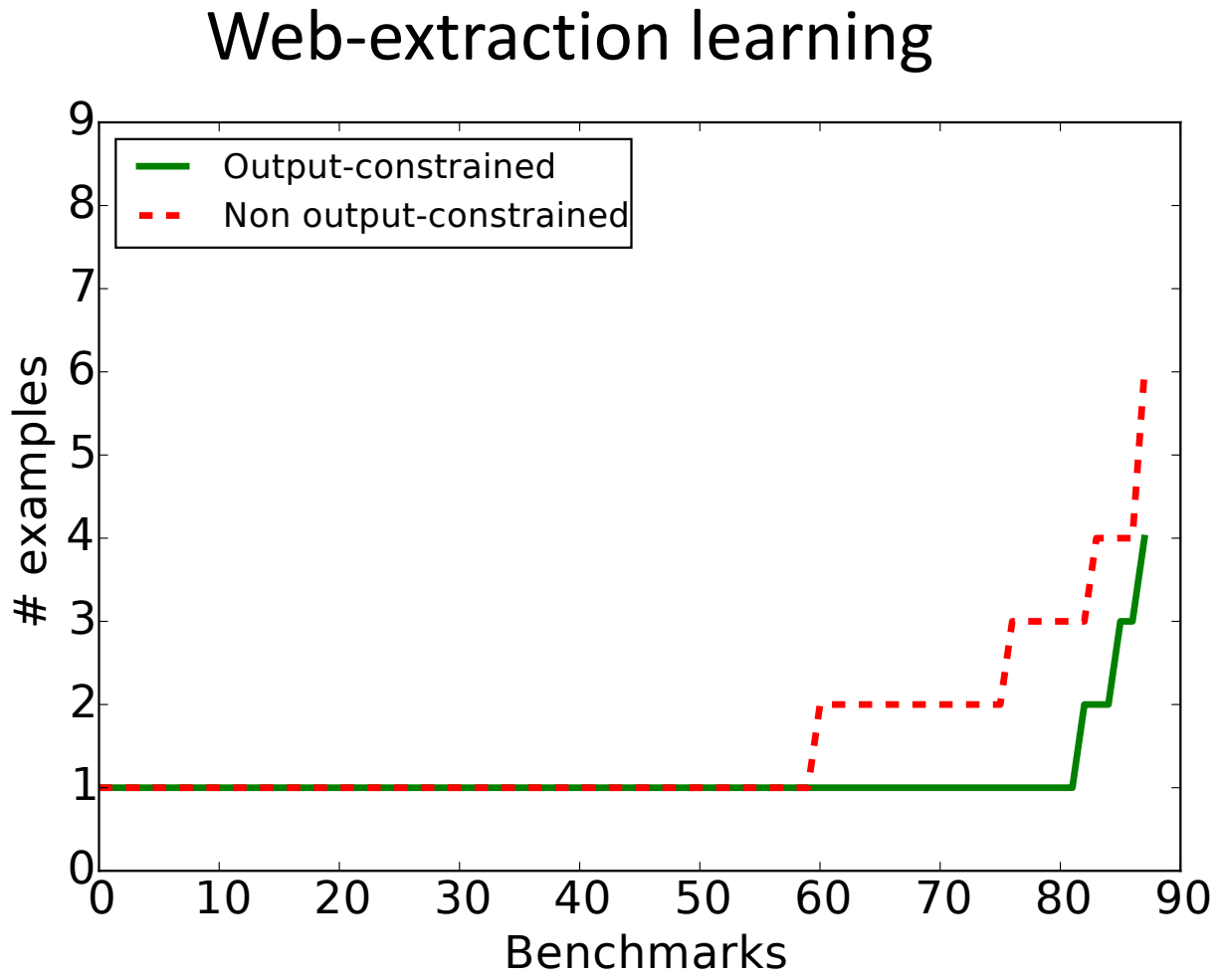
Impact of generalization constraint



Easy to use?

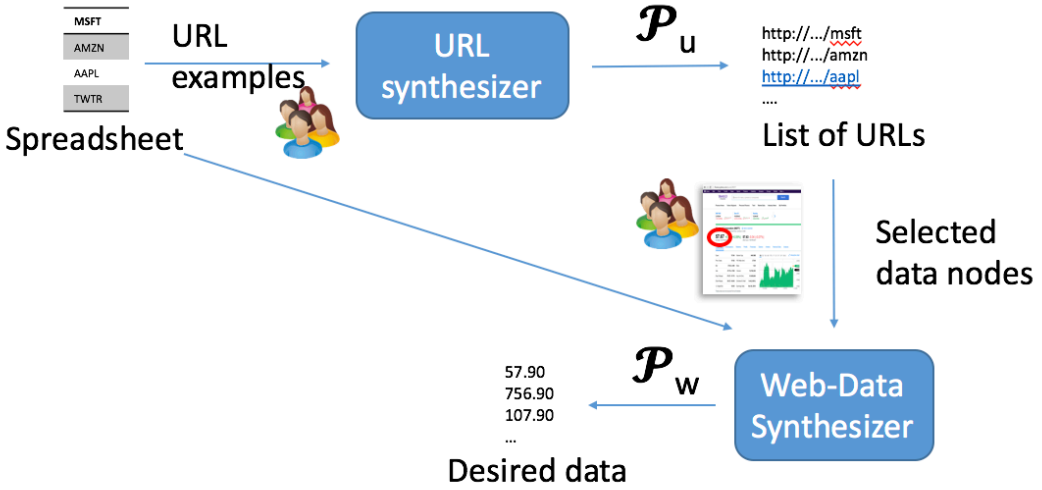

Web-extraction learning
95% tasks take only 1 example
examples
Benchmarks
0
1
2
3
4
5
8
9
0
10
20
30
40
50
60
70
80
90

Impact of generalization constraint



Summary

- Output-constrained PBE
- Layered Version Space Algebra
- Input-dependent Web Extraction



Thank You!

jinala@mit.edu