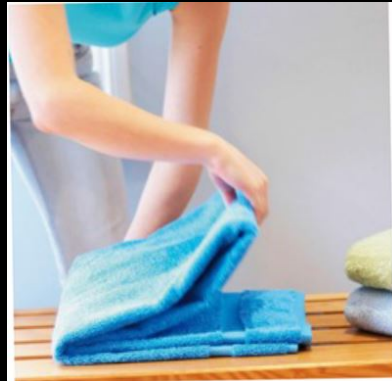


Programming by Examples

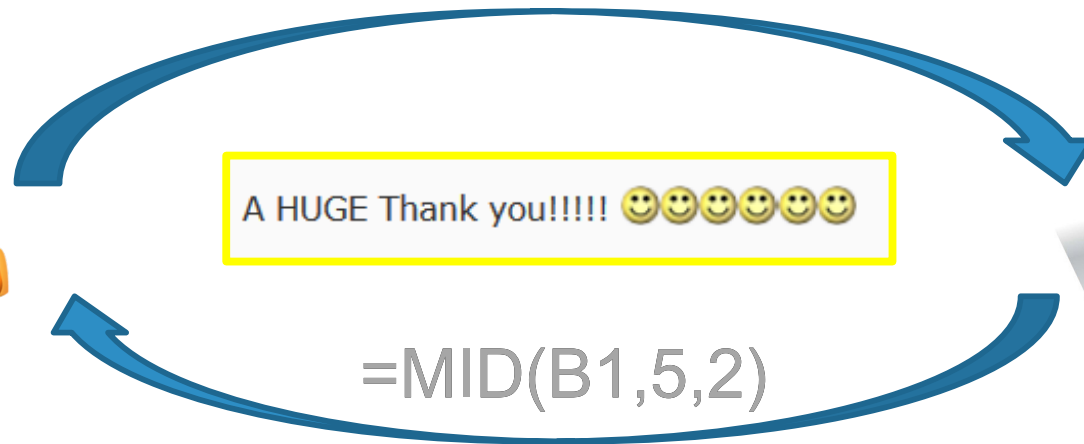


Sumit Gulwani, Microsoft

#Res8SAIS

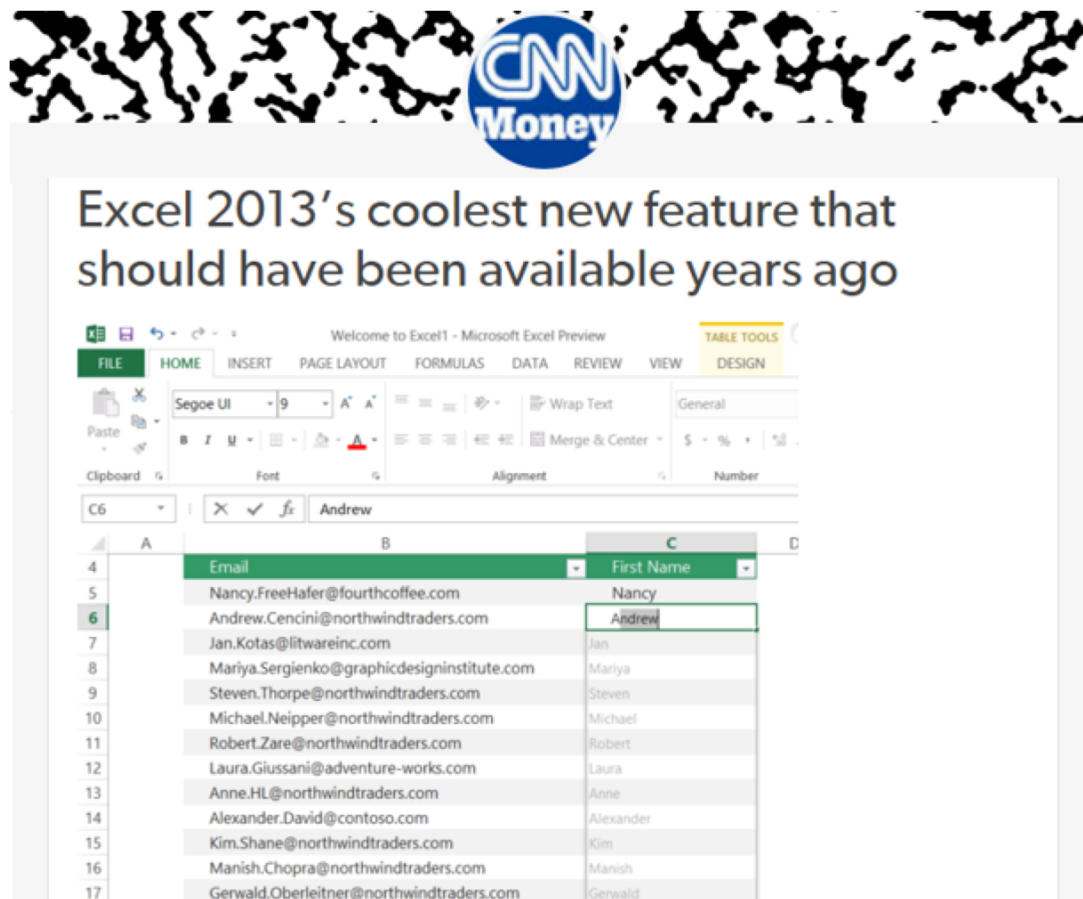
Example-based help-forum interaction

300_w30_aniSh_c1_b → w30
300_w5_aniSh_c1_b → w5



=MID(B1,FIND("_",\$B:\$B)+1,
FIND("_",REPLACE(\$B:\$B,1,FIND("_",\$B:\$B),"))-1)

Flash Fill (Excel feature)



Number, DateTime Transformations

Input	Output (round to 2 decimal places)
123.4567	123.46
123.4	123.40
78.234	78.23

Excel/C#: `#.00`

Python/C: `.2f`

Java: `###`

Input	Output (3-hour weekday bucket)
CEDAR AVE & COTTAGE AVE; HORSHAM; <code>2015-12-11 @ 13:34:52</code> ;	<code>Fri, 12PM - 3PM</code>
RT202 PKWY; MONTGOMERY; <code>2016-01-13 @ 09:05:41</code> -Station:STA18;	<code>Wed, 9AM - 12PM</code>
; UPPER GWYNEDD; <code>2015-12-11 @ 21:11:18</code> ;	<code>Fri, 9PM - 12AM</code>

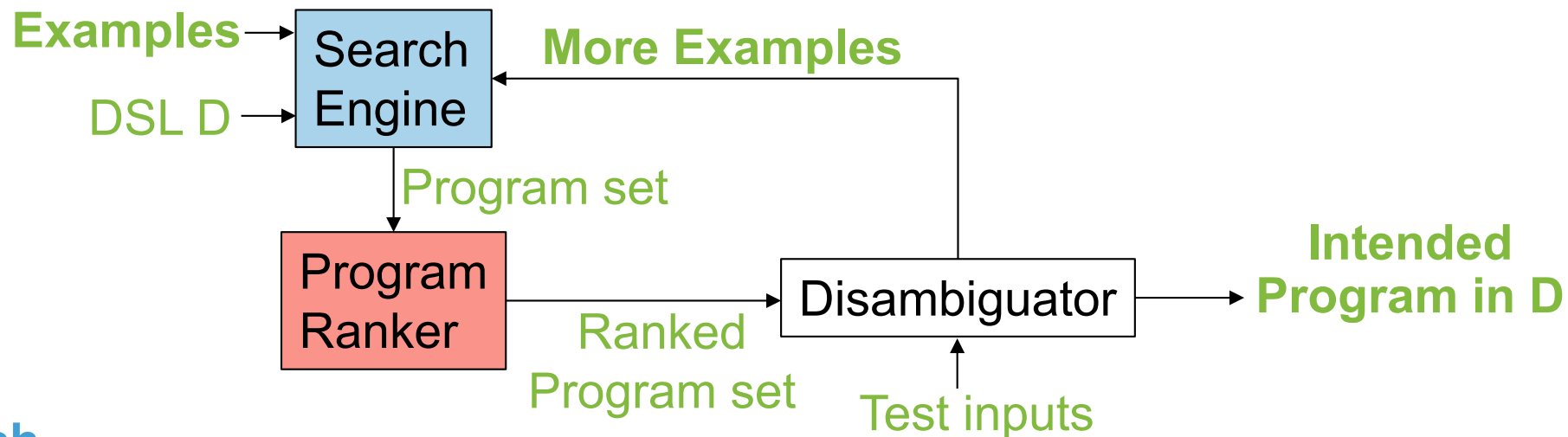
```

| style="text-align: center;" | {{Sort|01|[[Super Bowl I]]}}
| {{Dts|1967|January|15}}
| style="background:#d0e7ff;" | {{Sort|Green Bay Packers 01|[[1966 Green Bay Packers season|Green Bay Packers]]<sup>†</sup>}}
| style="text-align: center;" | {{Sort|3510|35-10}}
| style="background:#fcc;" | {{Sort|Kansas City Chiefs 01|[[1966 Kansas City Chiefs season|Kansas City Chiefs]]<sup>^</sup>}}
| {{Sort|Los Angeles Memorial Coliseum 01|[[Los Angeles Memorial Coliseum]]}}
| {{Sort|Pasadena, California 01|[[Los Angeles]]. [[California]]<#tag:ref|Both [[Los Angeles, California|Los Angeles]] and [[Pasadena, Ca
| style="text-align: center;" | {{Sort|061946|61.946}}
| style="text-align: center;" |<ref>{{Cite journal |last=Maule |first=Tex |url=http://sportsillustrated.cnn.com/vault/article/magazine/MAG10
| style="text-align: center;" | {{Sort|02|[[Super Bowl II]]}}
| {{Dts|1968|January|14}}
| style="background:#d0e7ff;" | {{Sort|Green Bay Packers 02|[[1967 Green Bay Packers season|Green Bay Packers]]<sup>†</sup> (2)}}
| style="text-align: center;" | {{Sort|3314|33-14}}
| style="background:#fcc;" | {{Sort|Oakland Raiders 01|[[1967 Oakland Raiders season|Oakland Raiders]]<sup>^</sup>}}
| {{Sort|Orange Bowl 01|[[Miami Orange Bowl|Orange Bowl]]}}
| {{Sort|Miami, Florida 01|[[Miami]]. [[Florida]]<#tag:ref|[[Miami Gardens, Florida|Miami Gardens]] was incorporated as a [[sub
| style="text-align: center;" | {{Sort|075546|75.546}}
| style="text-align: center;" |<ref>{{Cite journal |url=http://aol.sportingnews.com/nfl/story/2008-01-15/super-bowl-2-lombardis-starr-rises
| style="text-align: center;" | {{Sort|03|[[Super Bowl III]]}}<!--During the AFL-NFL merger, As the Colts moved over to the AFC, which
| {{Dts|1969|January|12}}
| style="background:#fcc;" | {{Sort|New York Jets 01|[[1968 New York Jets season|New York Jets]]<sup>^</sup>}}
| style="text-align: center;" | {{Sort|04|[[Super Bowl IV]]}}
| {{Dts|1970|January|11}}
| style="background:#fcc;" | {{Sort|Kansas City Chiefs 02|[[1969 Kansas City Chiefs season|Kansas City Chiefs]]<sup>^</sup> (2)}}
| style="text-align: center;" | {{Sort|2307|23-7&nbsp;}}
| style="background:#d0e7ff;" | {{Sort|Minnesota Vikings 01|[[1969 Minnesota Vikings season|Minnesota Vikings]]<sup>†</sup>}}
| {{Sort|Tulane Stadium 01|[[Tulane Stadium]]}}
| {{Sort|New Orleans, Louisiana|[[New Orleans]]. [[Louisiana]]}}
| style="text-align: center;" | {{Sort|080562|80.562}}
| style="text-align: center;" |<ref>{{Cite web |url=http://www.cbsnews.com/htdocs/sports/football/history/superbowl_04.html |title=Super Bowl History: Super E

```

```
cat superbowl.txt | awk '$1=$1' ORS=' ' | sed 's/|- |/\n/g' | grep "^| style=\"text-align: center;\"" | grep -v "Championship"
```

PBE Architecture



Search

- **Logical Deduction:** [OOPSLA '15] *FlashMeta: A framework for inductive program synthesis*
- **Machine Learning:** [ICLR '18] *Neural-guided deductive search for real-time program synthesis from examples*

Ranking

- **Program Features:** [CAV '15] *Predicting a correct program in programming by example*
- **Output Features:** [IJCAI '17] *Learning to learn programs from examples: going beyond program structure*

New Frontiers

Predictive Synthesis

Synthesis of intended programs from just the input.

- Tabular data extraction, Sort, Join

Synthesis of readable/modifiable code

Synthesis in target language of choice.

- Scala, R, PySpark

Code-first experience in existing workflows.

- IDE, Notebook

Code Transformations by Examples

- **Code refactoring** consumes 40% time in migration.
 - Old version to new version
 - On-prem to cloud
 - One framework to another
- Custom formatting
- Performance enhancements
- Repetitive bug fixes
 - Feedback generation for programming education

Conclusion

Programming by examples is a new frontier in AI.

- 10-100x productivity increase in some domains.
 - Data Wrangling: Data scientists spend 80% time.
 - Code Refactoring: Developers spend 40% time in migration.
- 99% of end users are non-programmers.

Next-generation AI techniques under the hood

- Logical Reasoning + Machine Learning

The Future: Multi-modal programming with Examples and NL

Questions/Feedback: Contact me at sumitg@microsoft.com