SPARK+AI
SUMMIT EUROPE

FP&A with Spreadsheets and Spark

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#SAISEco2

About

- Researcher at Universidad del Valle de Guatemala.

- Research Interests:
  - Program Transformation,
  - Model-driven Data Product Design & Development

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    - Design and Development of
    - Large-scale Data Products
    - with Spreadsheets as Models

Prototyping …

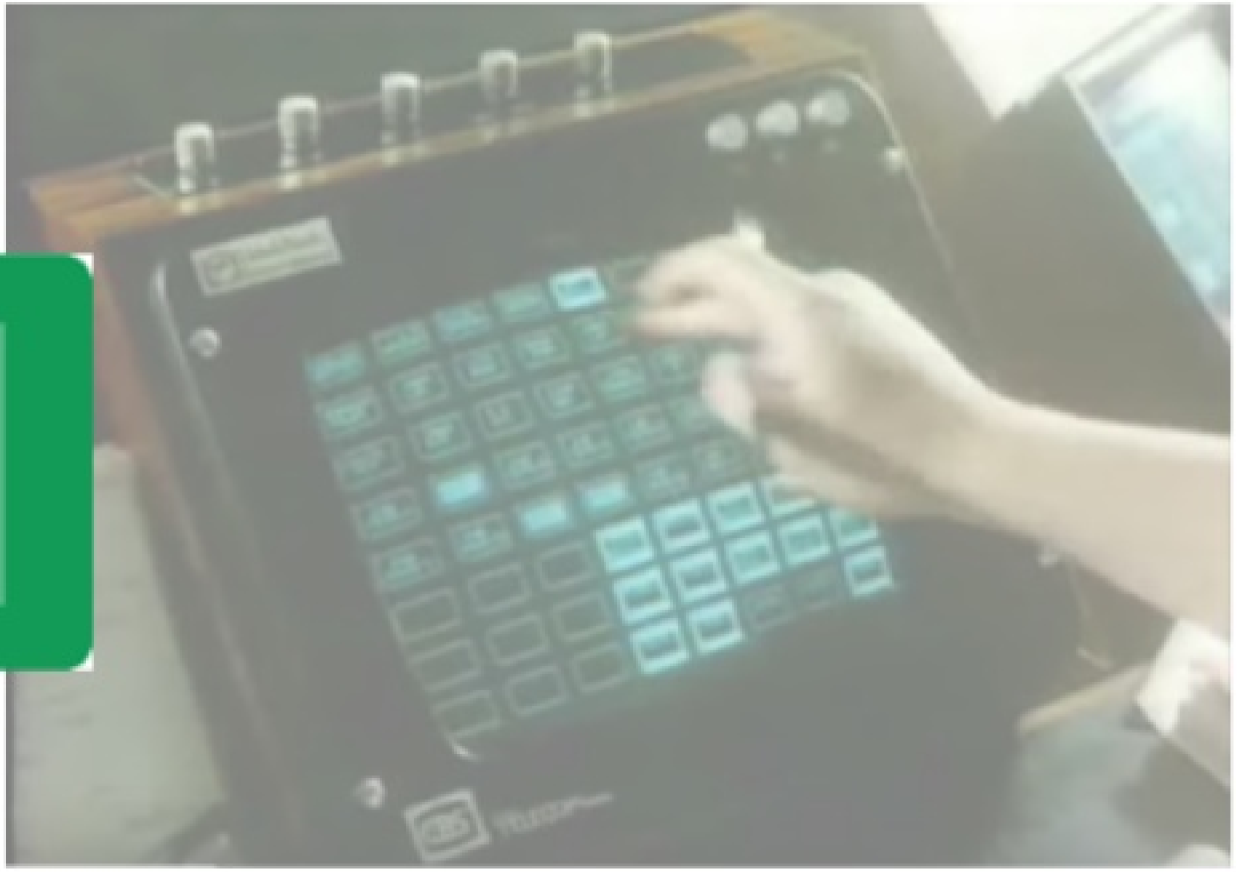
http://bit.ly/2e5GmyY

Prototyping Spark programs with …

http://bit.ly/2e5GmyY

http://bit.ly/2edYfMs

Spreadsheets!



http://bit.ly/2e5GmyY http://bit.ly/2e0TZA8 http://bit.ly/2edYfMs

EXCEL

Agenda

- Problem Statement and Motivation
    - Architecture
- Program Transformation
    - Pipeline
    - Code-to-Code Transformation
- Code Generation
    - Abstract Tree
    - Parse Tree
- Spreadsheets as a DSL
    - Generating Code
- Demo
- Q&A

Disclaimer(s)

- Ongoing research …
- FP&A is one use case, but Spreadsheets are much broader!

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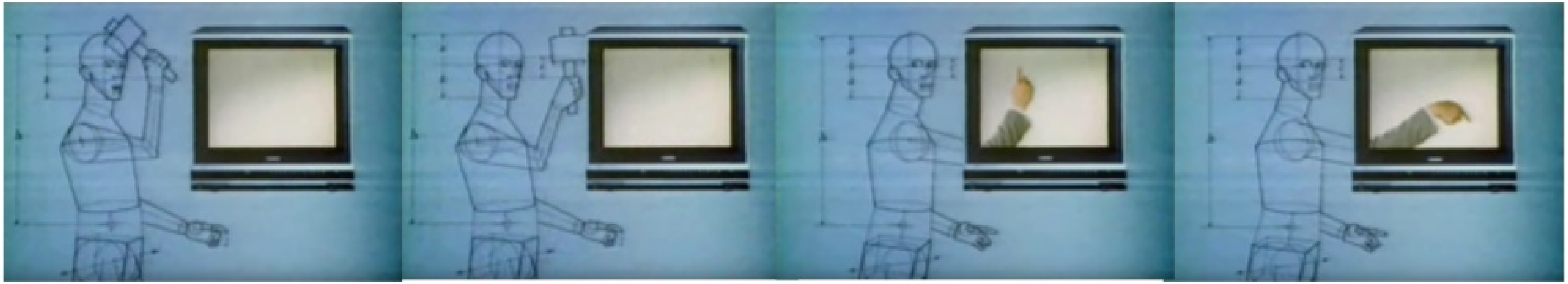
- FP&A is one use case, but Spreadsheets are much broader!
    - E.g. People have even modeled Turing machines with Spreadsheets! [1]

Problem Statement

Prototype FP&A programs using Spreadsheet formulas and automatically translate to Scala / Spark.



Problem Statement

Prototype ***Any*** program using Spreadsheet formulas and automatically translate to Scala / Spark.

Motivation

- At Spark Summit Europe 2016 I presented the **Sparksheet** code generator for Spreadsheet formulas.
- Initially **Sparksheet** supported only 5 Spreadsheet formulas, now it supports 150+ Spreadsheet formulas!
- Motivation is finding use cases.

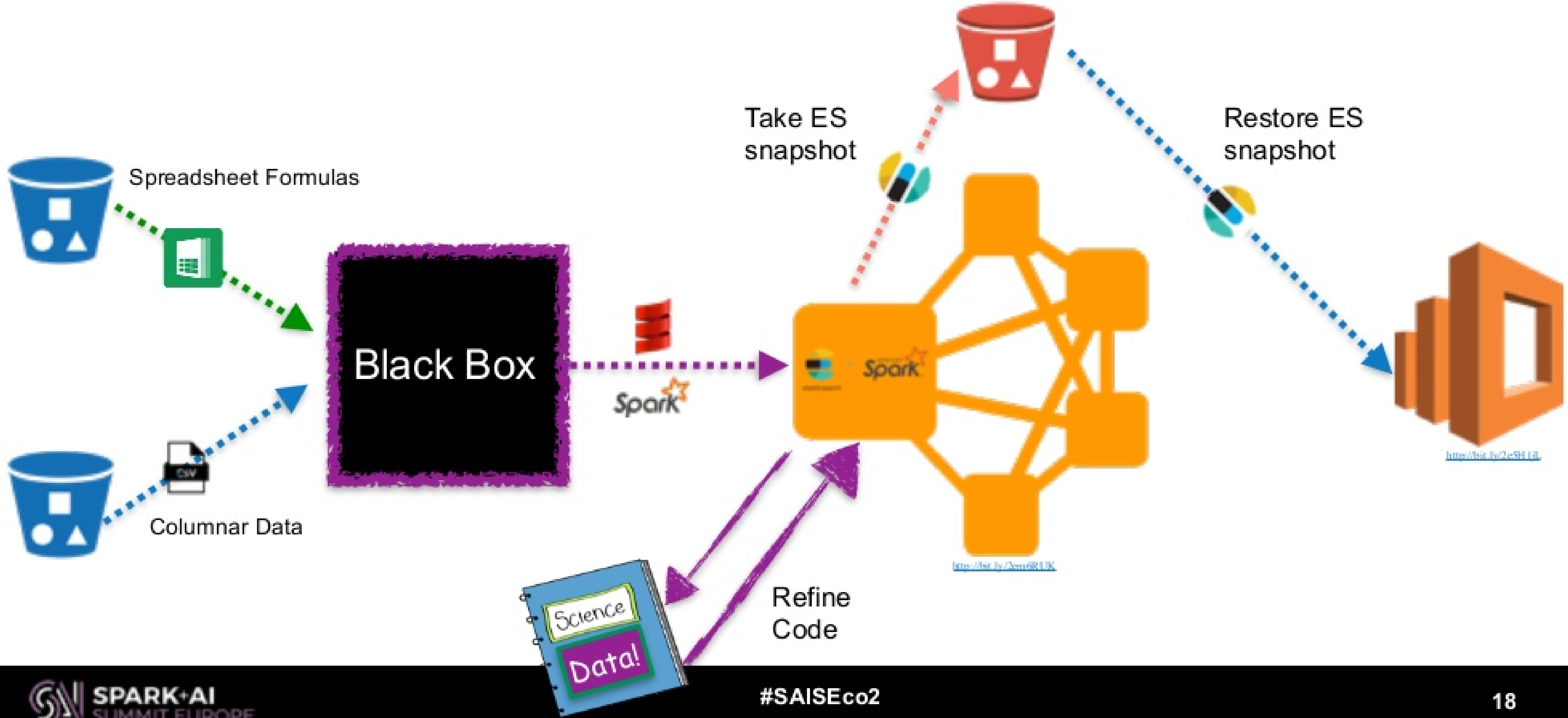
Motivation

Automatically translate Spreadsheet datasets* to Spark data pipelines on Scala/Spark

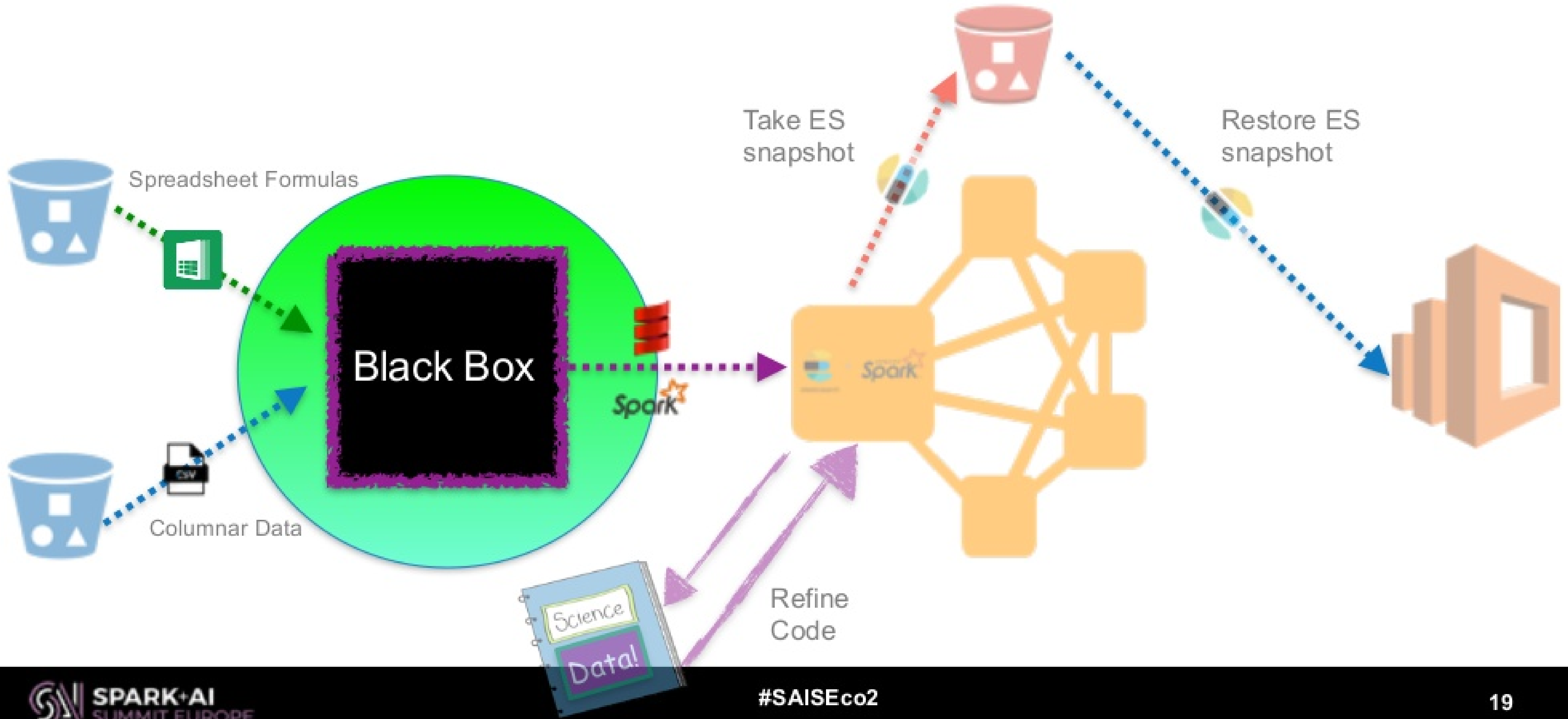
*Spreadsheet dataset = Structured data + Spreadsheet formulas

http://bit.ly/2expmoF

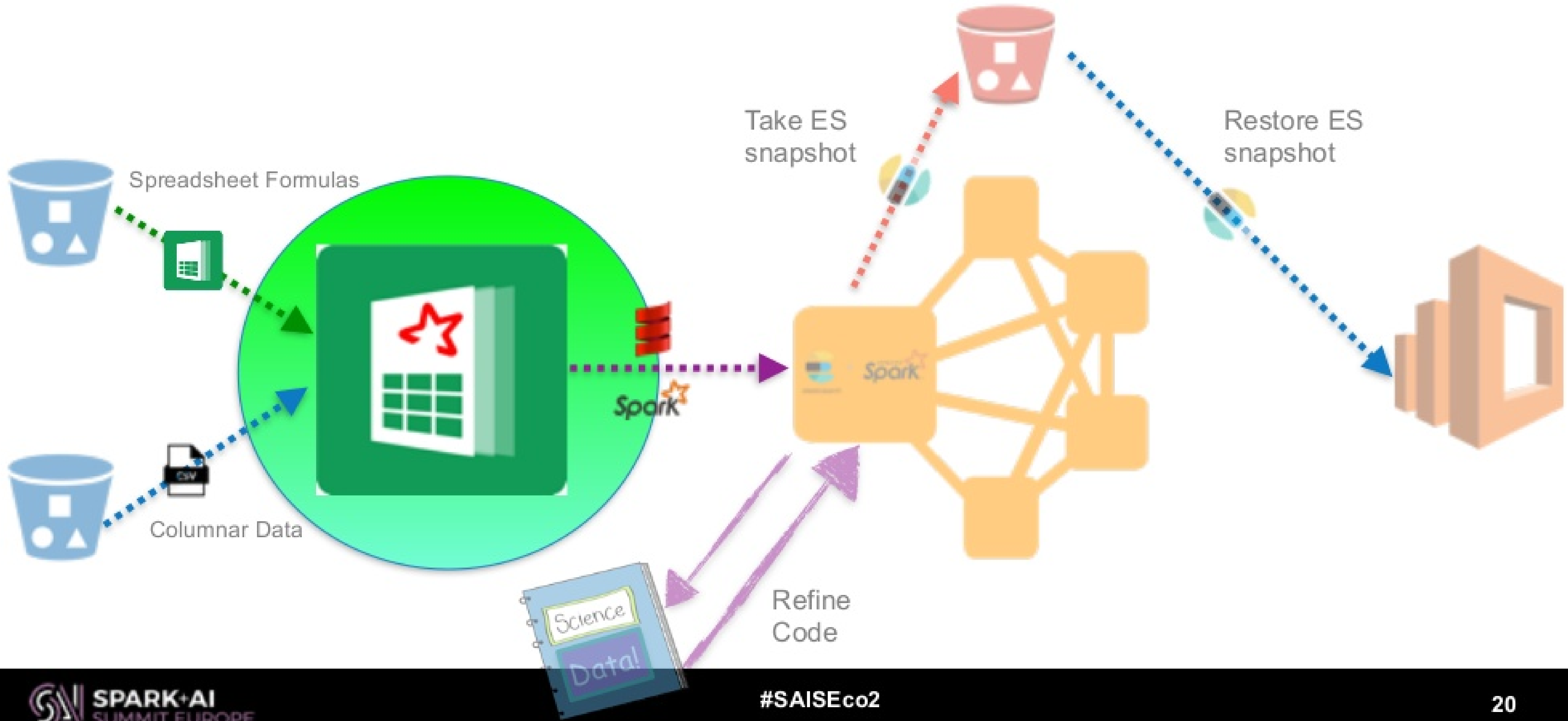
Architecture



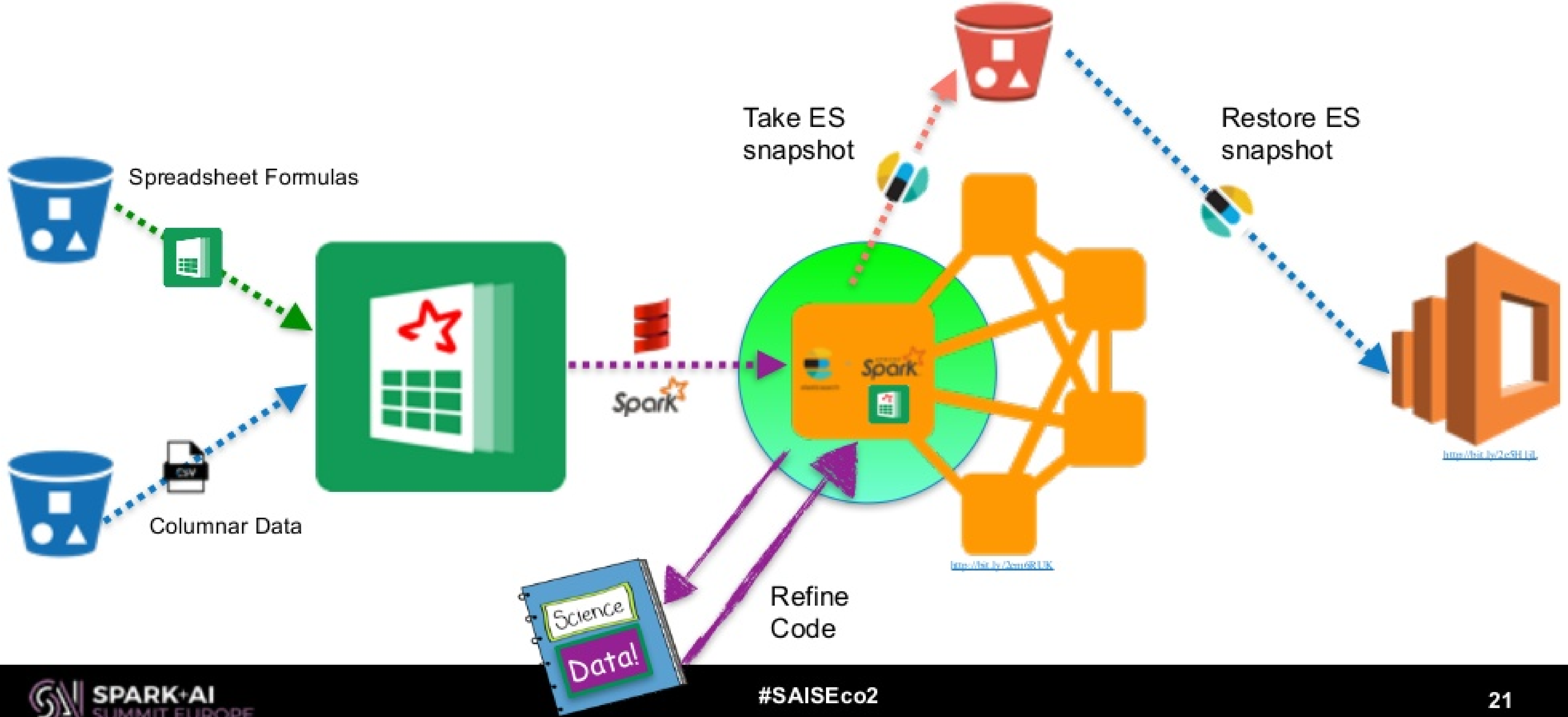
Architecture



Architecture



Architecture

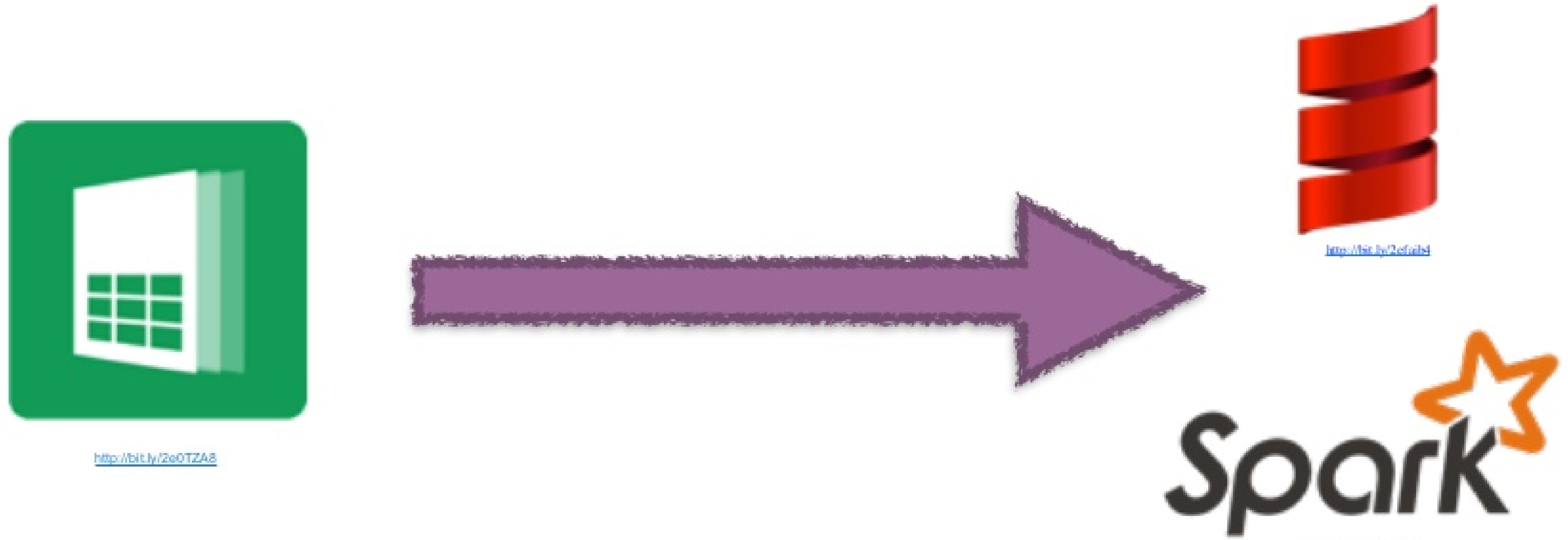


Program Transformation

"A **program transformation** is any operation that takes a computer program and generates another program."

https://en.wikipedia.org/wiki/Program_transformation

Program Transformation Pipeline



http://bit.ly/2e0TZA8

http://bit.ly/2efzibd

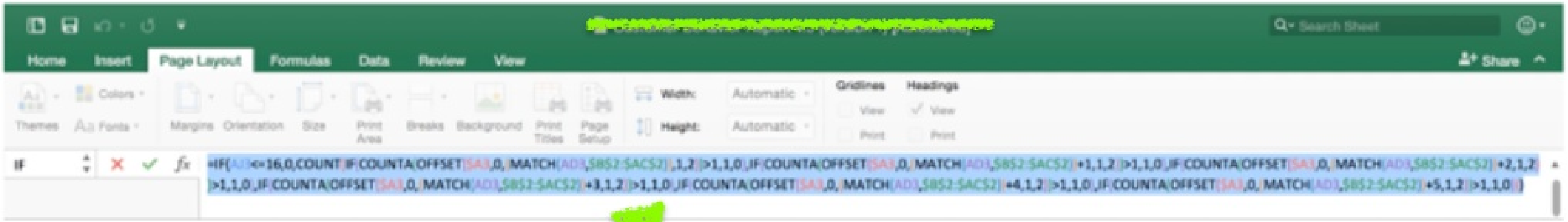
http://bit.ly/2dl0cFg

Demo #1

1. Show Spreadsheet model
2. Show Complex Spreadsheet Formula

http://bit.ly/2e0TZA8

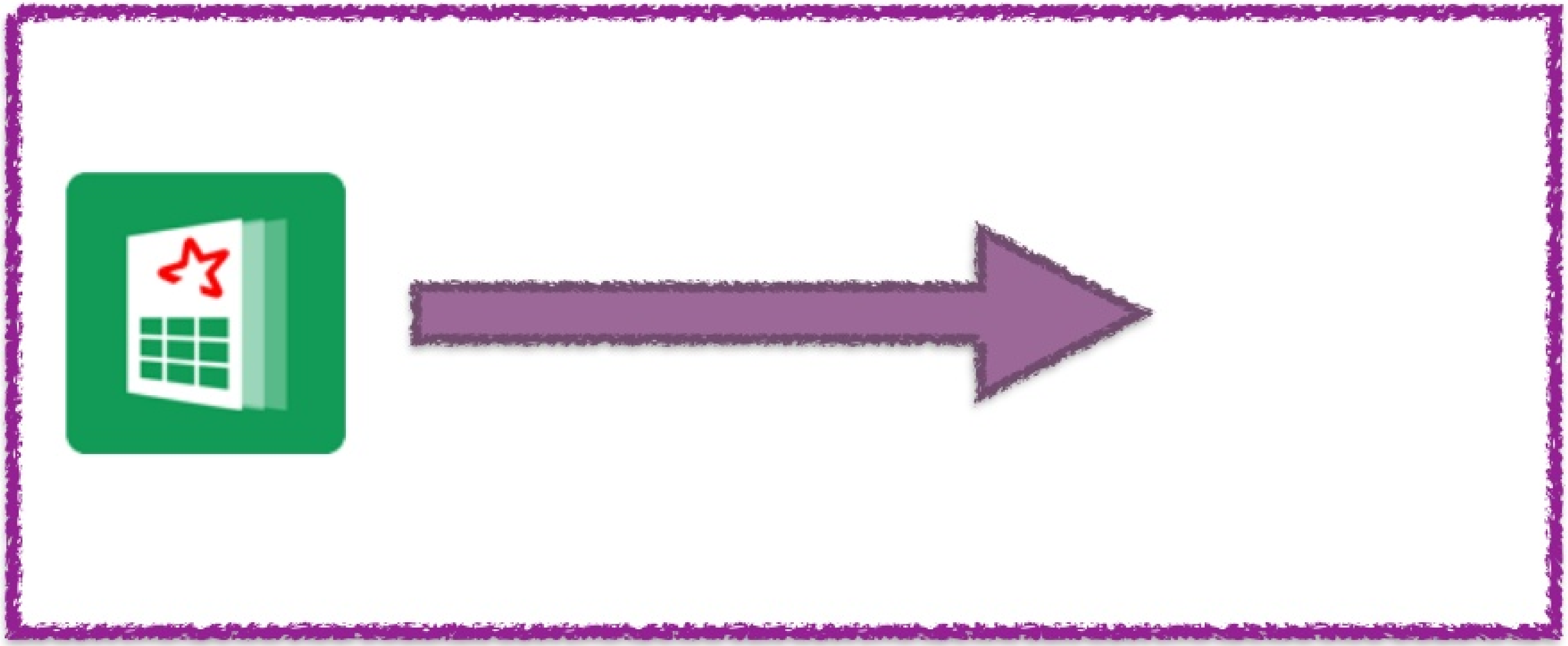
Program Transformation



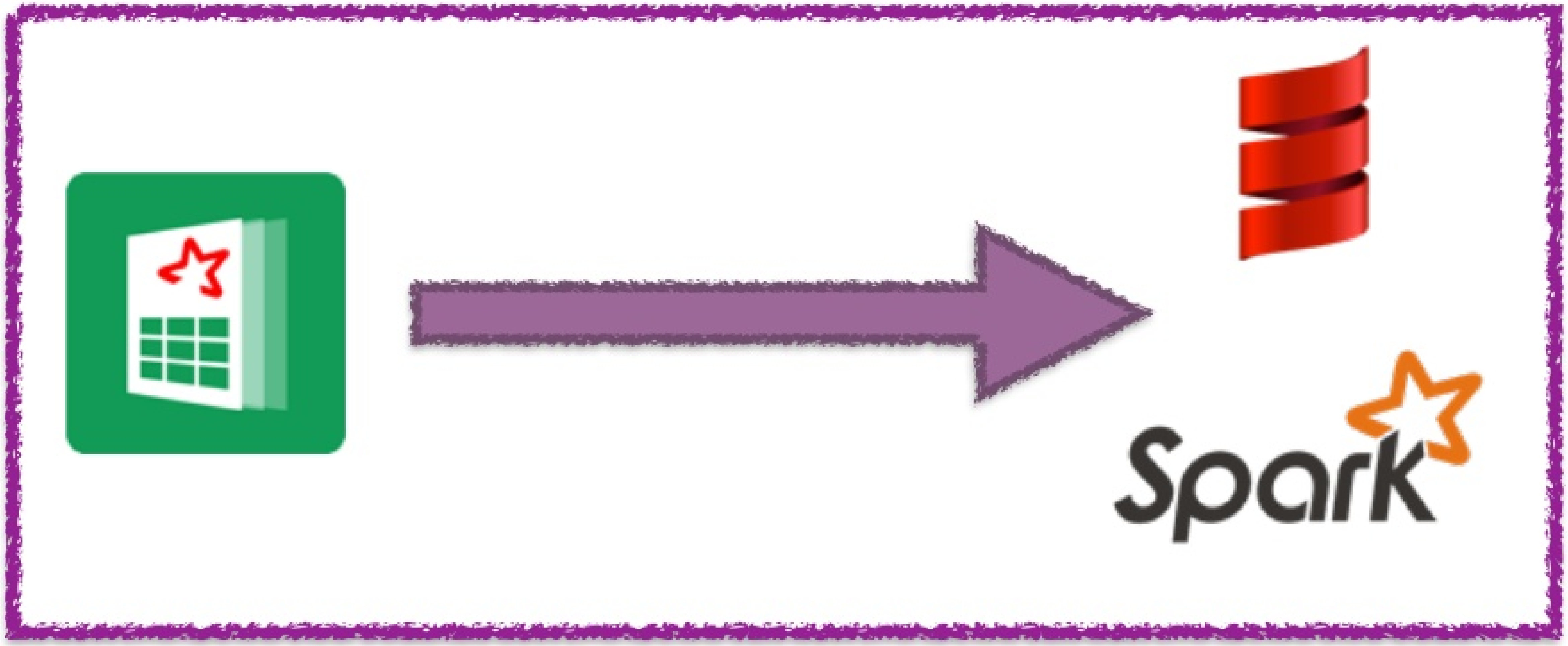
```
=IF(AD3<=16,0,COUNT(IF(COUNTA(OFFSET($A3,0,(MATCH(AD3,$B$2:$AC$2)),1,2))>1,1,0),IF(COUNTA(OFFSET($A3,0,(MATCH(AD3,$B$2:$AC$2))+1,1,2))>1,1,0),IF(COUNTA(OFFSET($A3,0,(MATCH(AD3,$B$2:$AC$2))+2,1,2)
)>1,1,0),IF(COUNTA(OFFSET($A3,0,(MATCH(AD3,$B$2:$AC$2))+3,1,2))>1,1,0),IF(COUNTA(OFFSET($A3,0,(MATCH(AD3,$B$2:$AC$2))+4,1,2))>1,1,0),IF(COUNTA(OFFSET($A3,0,(MATCH(AD3,$B$2:$AC$2))+5,1,2))>1,1,0)))
```

Source program in Excel formula language.

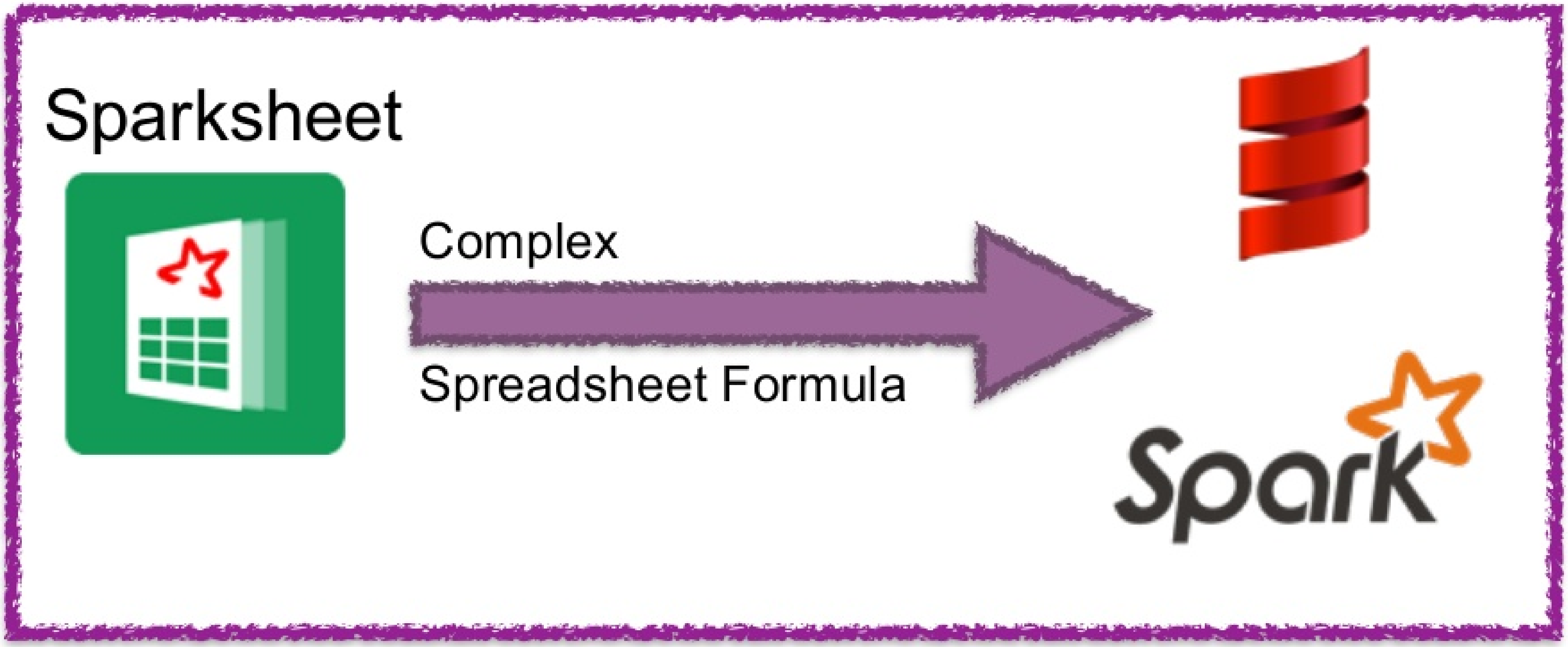
Demo #2

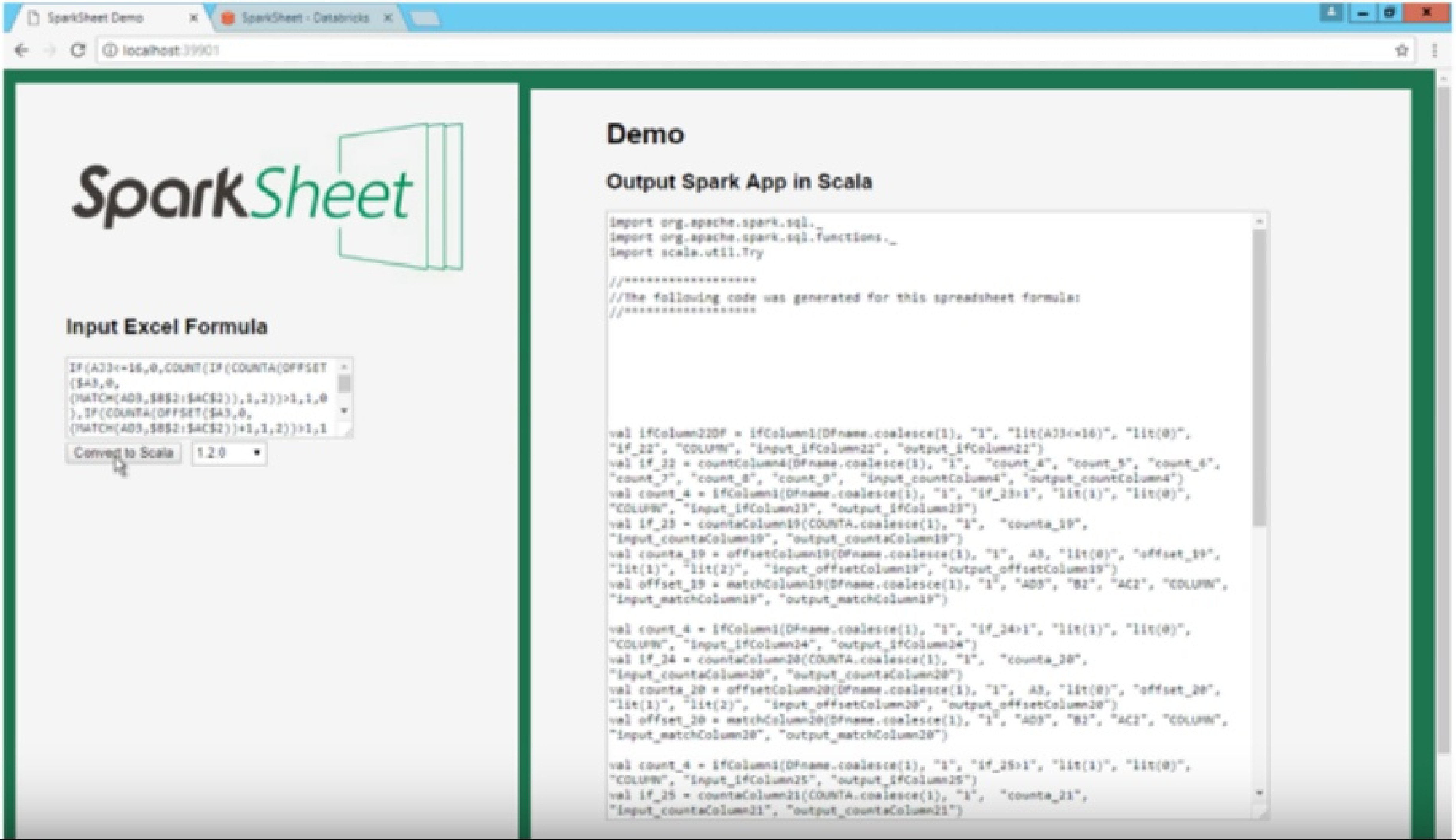


Demo #2



Demo #2





Demo

Output Spark App in Scala

```
import org.apache.spark.sql._
import org.apache.spark.sql.functions._
import scala.util.Try

//*******************
//The following code was generated for this spreadsheet formula:
//*******************






val ifColumn22DF = ifColumn1(DFname.coalesce(1), "1", "lit(AJ3<=16)", "lit(0)",
"if_22", "COLUMN", "input_ifColumn22", "output_ifColumn22")
val if_22 = countColumn4(DFname.coalesce(1), "1",  "count_4", "count_5", "count_6",
"count_7", "count_8", "count_9",  "input_countColumn4", "output_countColumn4")
val count_4 = ifColumn1(DFname.coalesce(1), "1", "if_23>1", "lit(1)", "lit(0)",
"COLUMN", "input_ifColumn23", "output_ifColumn23")
val if_23 = countaColumn19(COUNTA.coalesce(1), "1",  "counta_19",
"input_countaColumn19", "output_countaColumn19")
val counta_19 = offsetColumn19(DFname.coalesce(1), "1",  A3, "lit(0)", "offset_19",
"lit(1)", "lit(2)",  "input_offsetColumn19", "output_offsetColumn19")
val offset_19 = matchColumn19(DFname.coalesce(1), "1", "AD3", "B2", "AC2", "COLUMN",
"input_matchColumn19", "output_matchColumn19")

val count_4 = ifColumn1(DFname.coalesce(1), "1", "if_24>1", "lit(1)", "lit(0)",
"COLUMN", "input_ifColumn24", "output_ifColumn24")
val if_24 = countaColumn20(COUNTA.coalesce(1), "1",  "counta_20",
"input_countaColumn20", "output_countaColumn20")
val counta_20 = offsetColumn20(DFname.coalesce(1), "1",  A3, "lit(0)", "offset_20",
"lit(1)", "lit(2)",  "input_offsetColumn20", "output_offsetColumn20")
val offset_20 = matchColumn20(DFname.coalesce(1), "1", "AD3", "B2", "AC2", "COLUMN",
"input_matchColumn20", "output_matchColumn20")

val count_4 = ifColumn1(DFname.coalesce(1), "1", "if_25>1", "lit(1)", "lit(0)",
"COLUMN", "input_ifColumn25", "output_ifColumn25")
val if_25 = countaColumn21(COUNTA.coalesce(1), "1",  "counta_21",
"input_countaColumn21", "output_countaColumn21")
```

Input Excel Formula

```
IF(AJ3<=16,0,COUNT(IF(COUNTA(OFFSET
($A3,0,
(MATCH(AD3,$B$2:$AC$2)),1,2))>1,1,0
),IF(COUNTA(OFFSET($A3,0,
(MATCH(AD3,$B$2:$AC$2))+1,1,2))>1,1
```

Code-to-Code Transformation

Code-to-Code Transformation

"The input to the code generator typically consists of a **parse tree** or an **abstract syntax tree**."

http://bit.ly/2dH0ybF

https://en.wikipedia.org/wiki/Code_generation_(compiler)

Generating Code

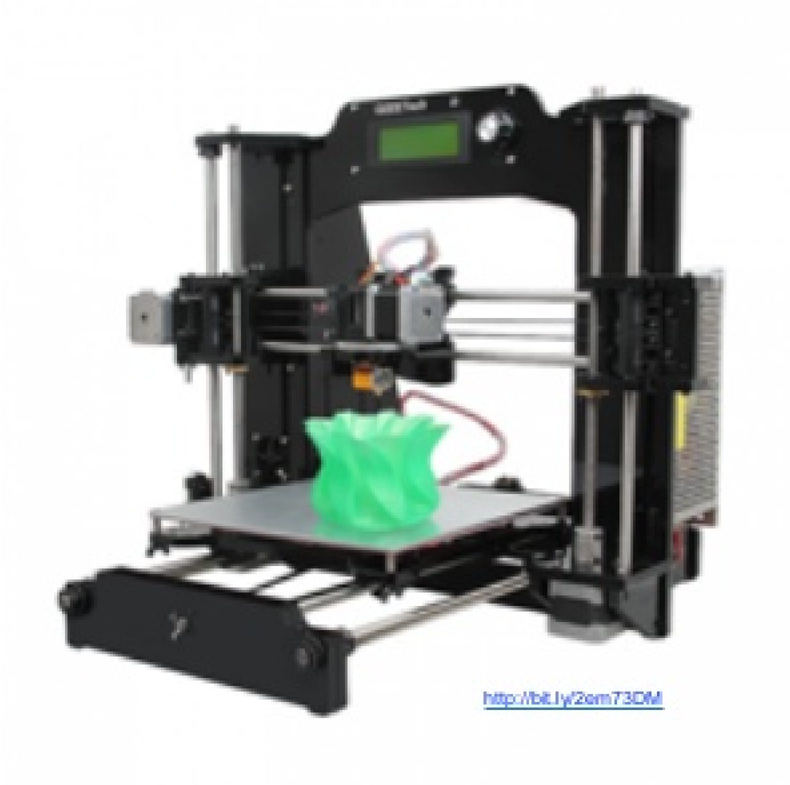
“An elegant way to generate code from an AST is to write a class for each non-terminal node in the tree, and then each node in the tree simply generates the piece of code that it is responsible for.”

http://bit.ly/2dH0ybE

http://www.codeproject.com/Articles/26975/Writing-Your-First-Domain-Specific-Language-Part

Generating Code

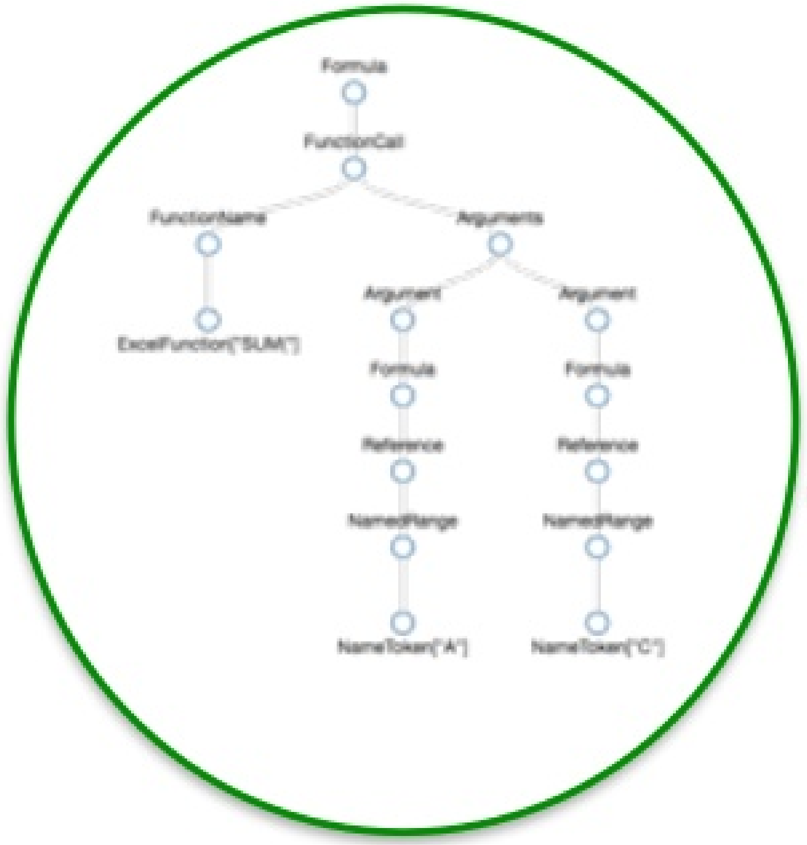
A **practical** way to generate code is to take a <u>Parse Tree</u> and write a pretty printer for the target language.



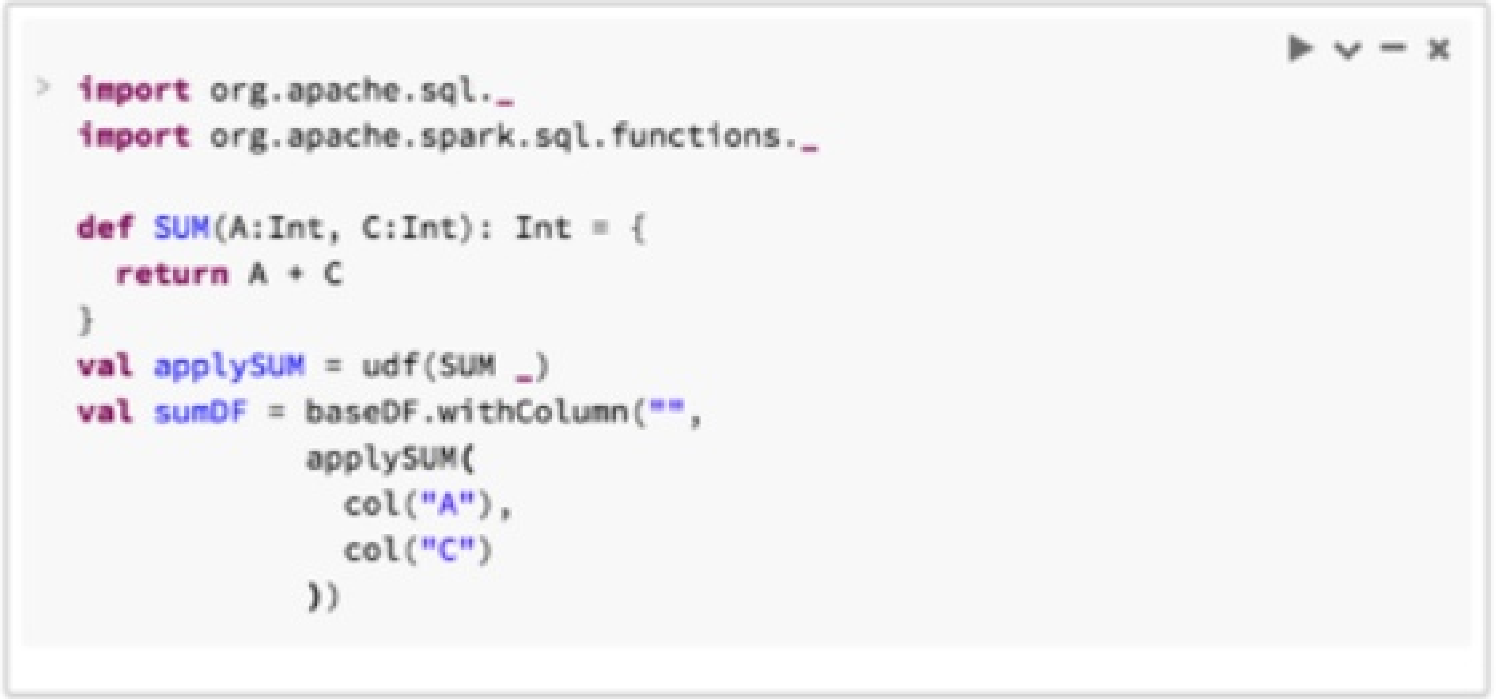
Generating Code (Example)

SUM(A,C)

Generating Code (Example)



SUM(A,C)

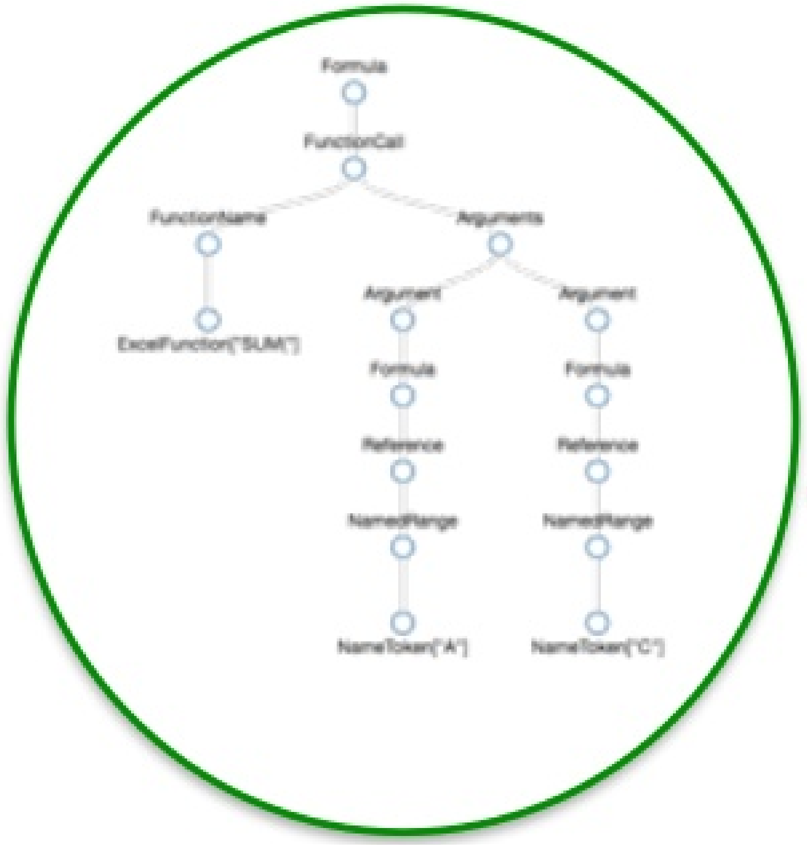


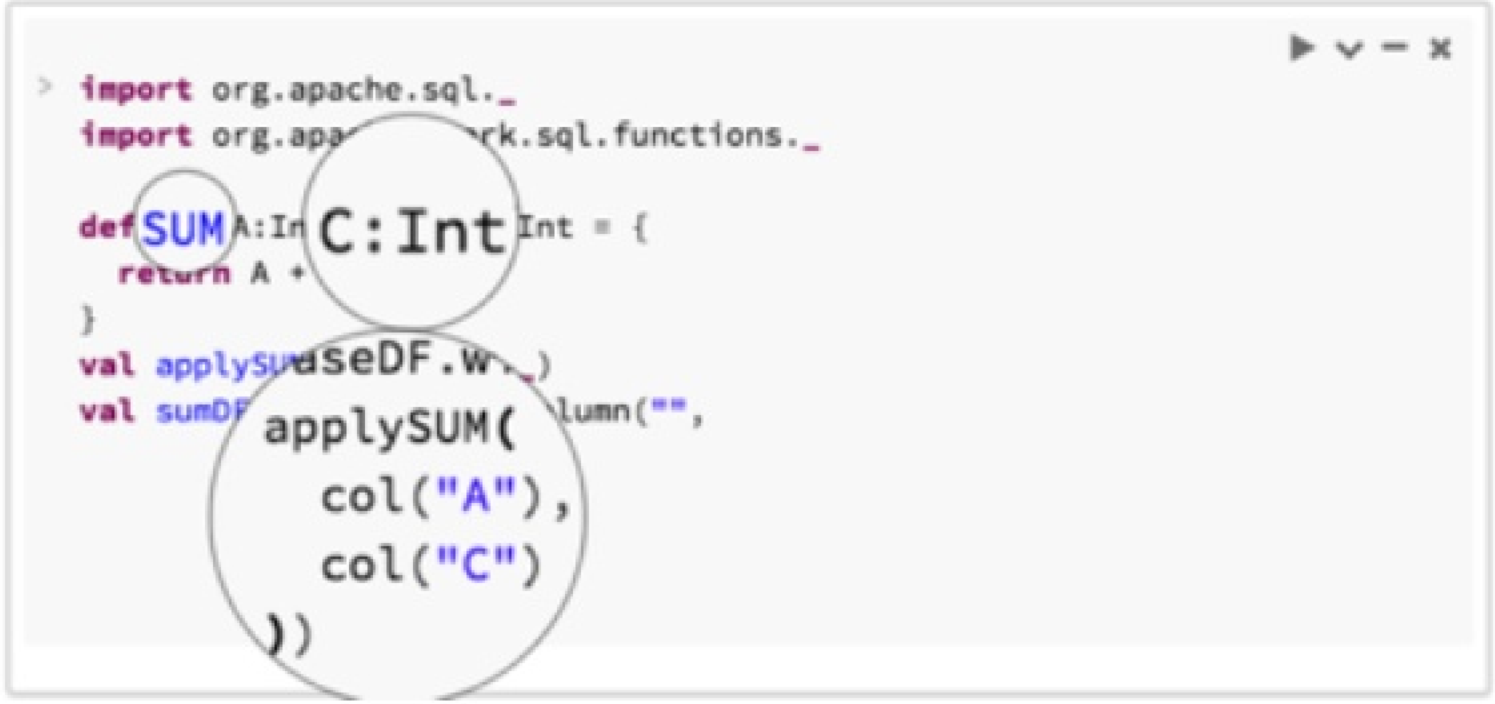
```
import org.apache.sql._
import org.apache.spark.sql.functions._

def SUM(A:Int, C:Int): Int = {
  return A + C
}
val applySUM = udf(SUM _)
val sumDF = baseDF.withColumn("",
              applySUM(
                col("A"),
                col("C")
              ))
```

Generating Code (Example)

SUM(A,C)

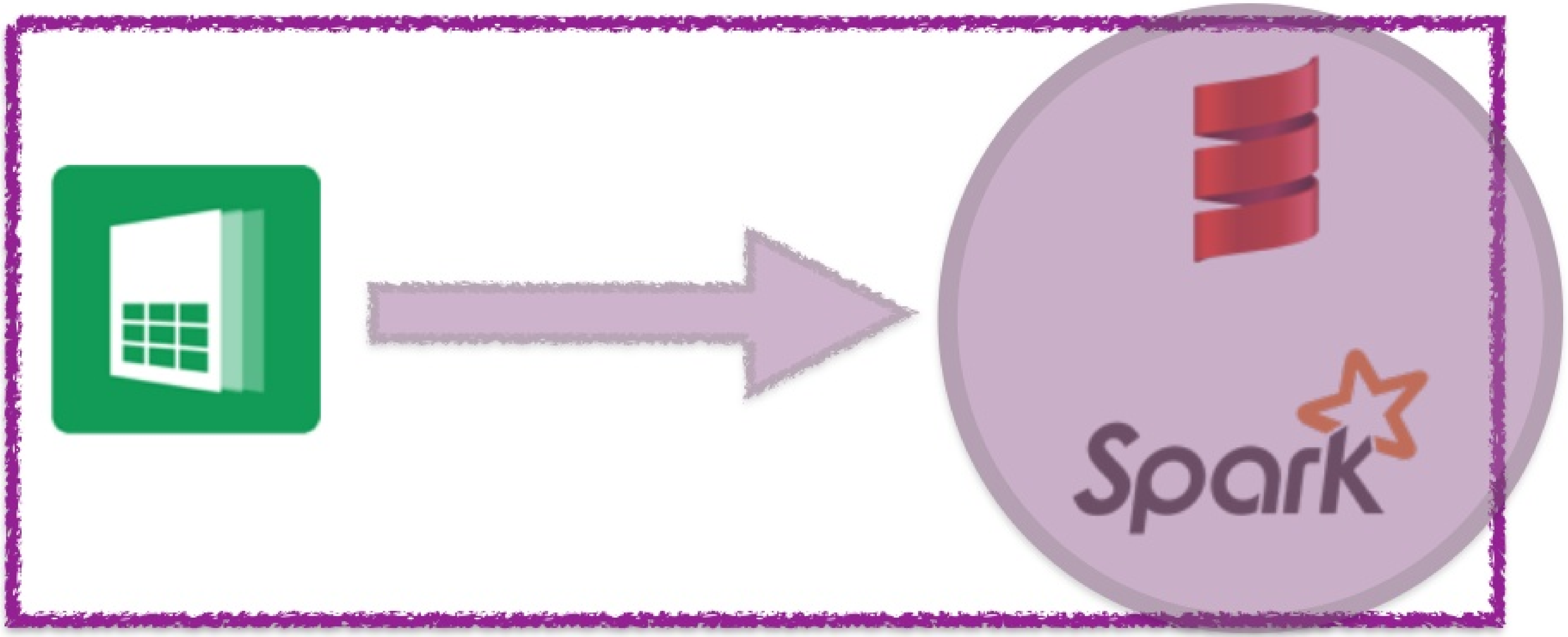




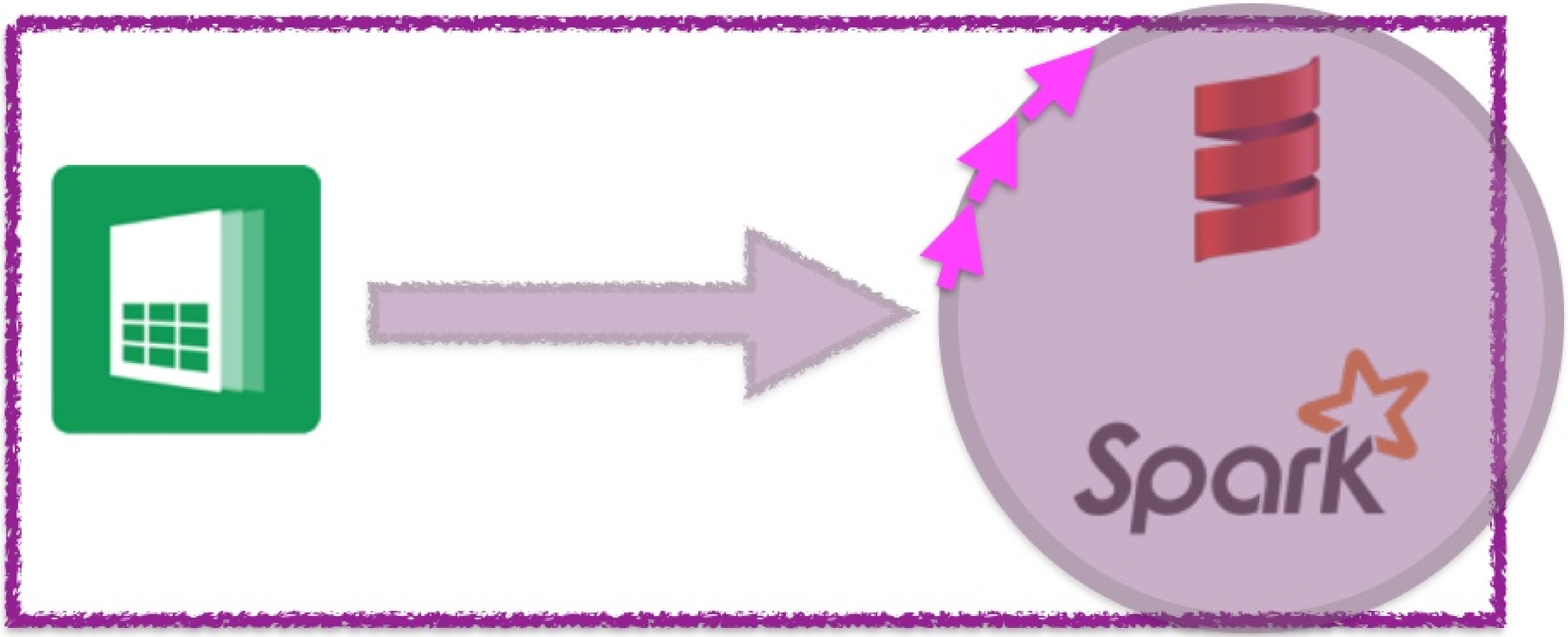
```
> import org.apache.sql._
  import org.apa      rk.sql.functions._

  def SUM A:In C:Int Int = {
    return A +
  }
  val applySU useDF.w _)
  val sumDF  applySUM(  lumn("",
               col("A"),
               col("C")
             ))
```

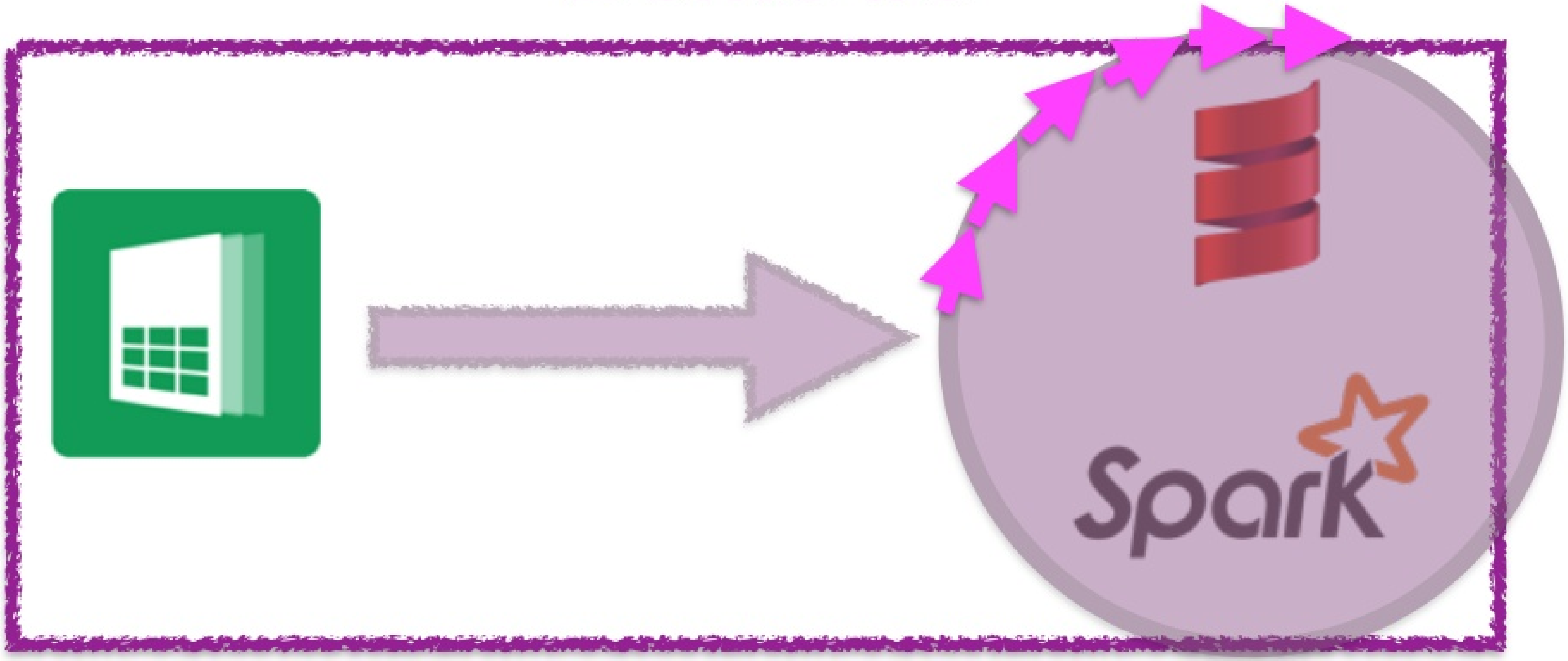
Demo #3



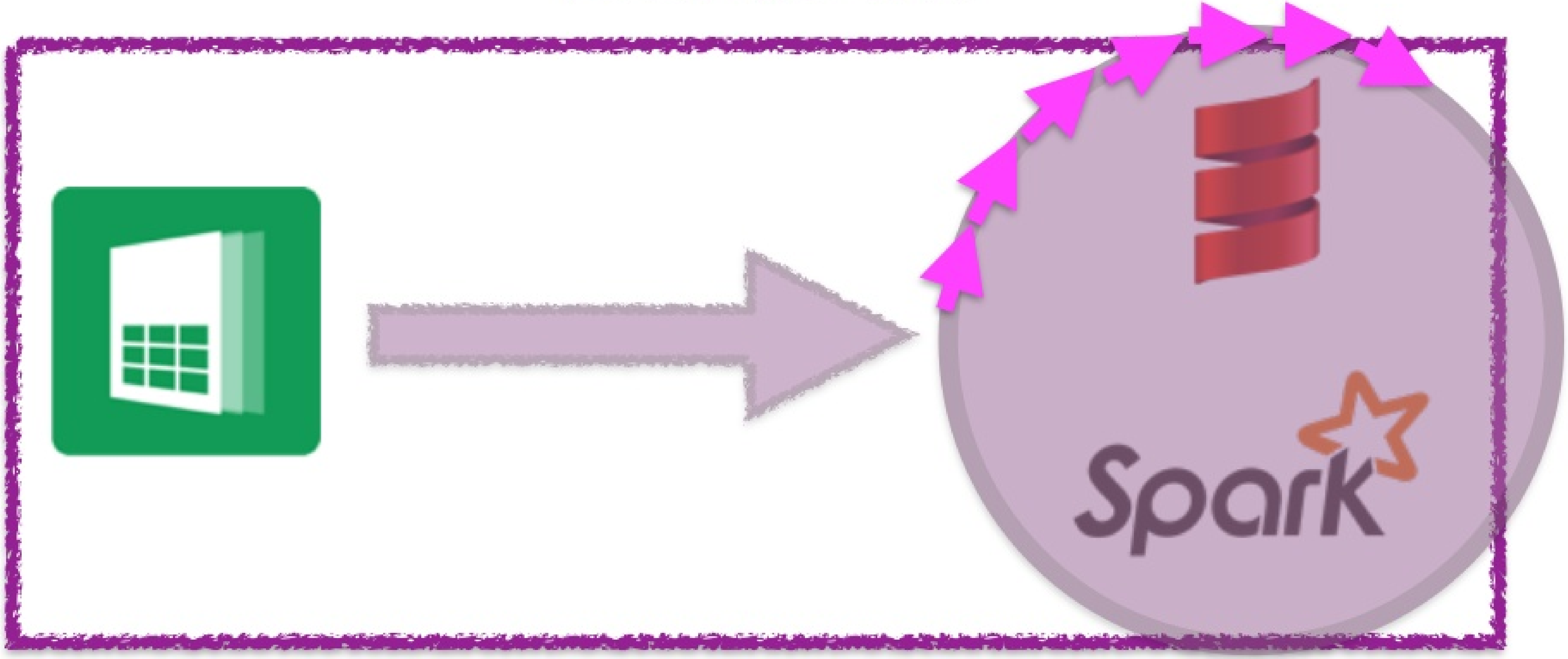
Demo #3



Demo #3



Demo #3



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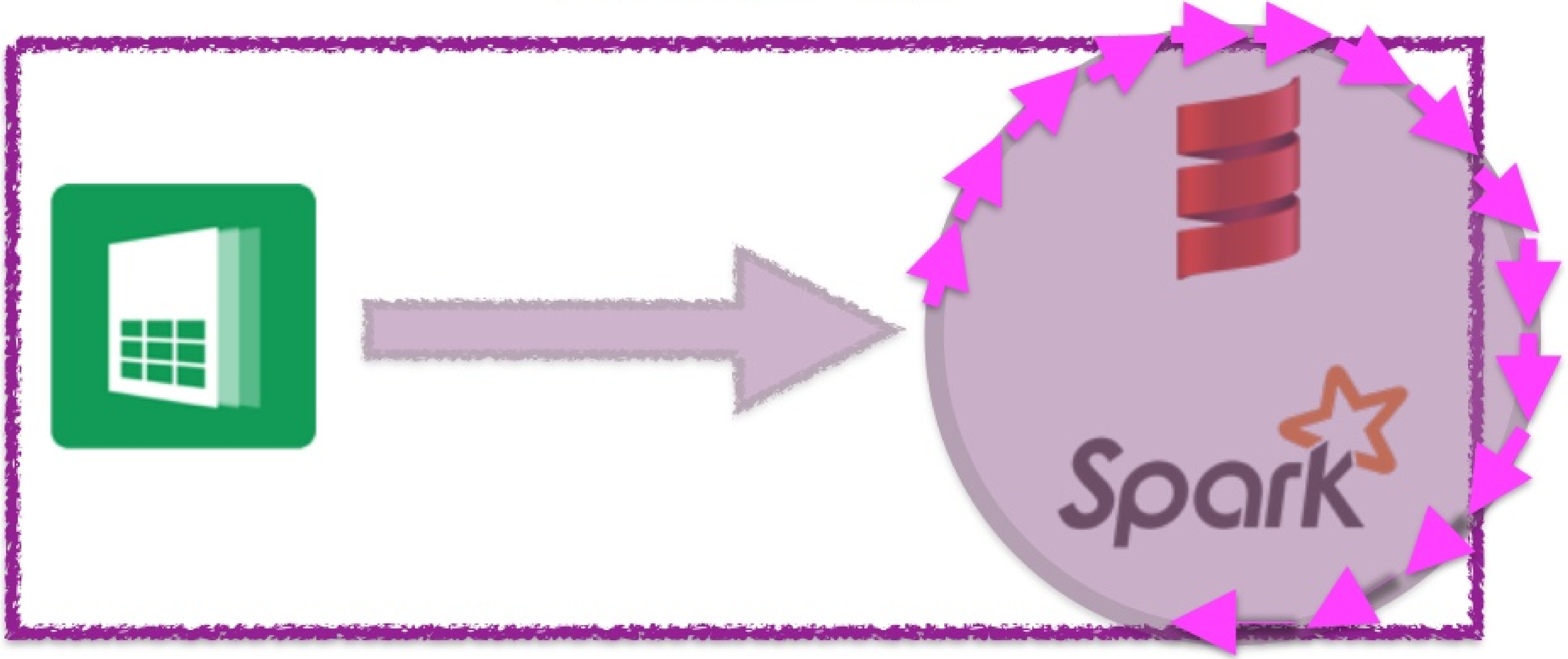
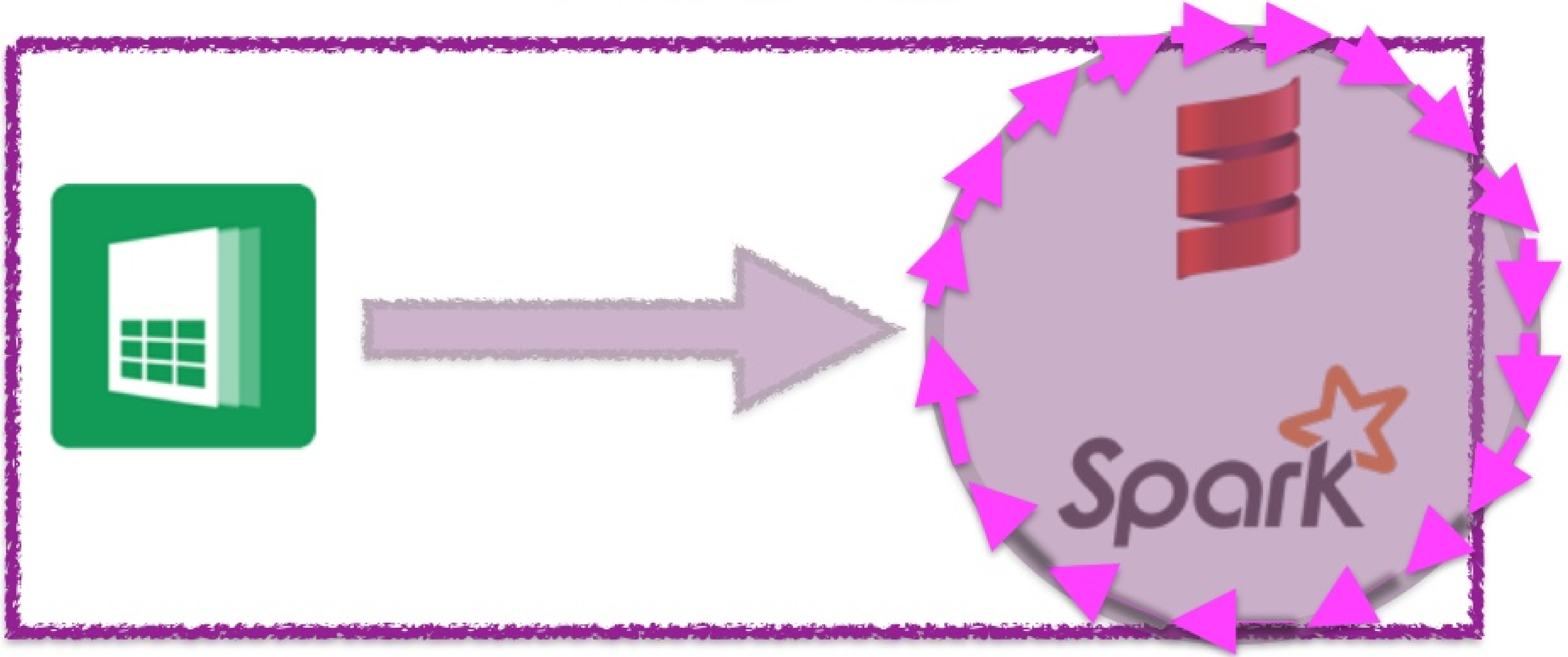
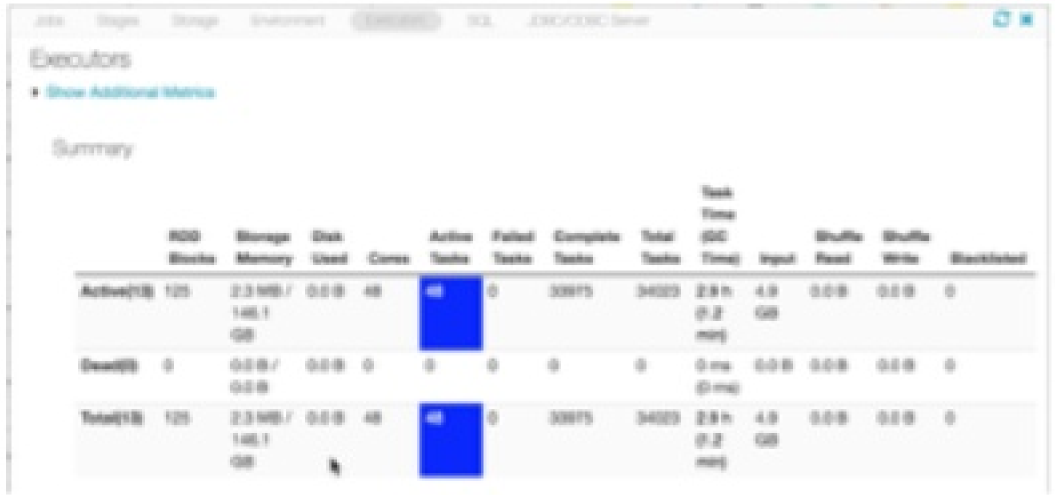


Demo #3



Demo #3

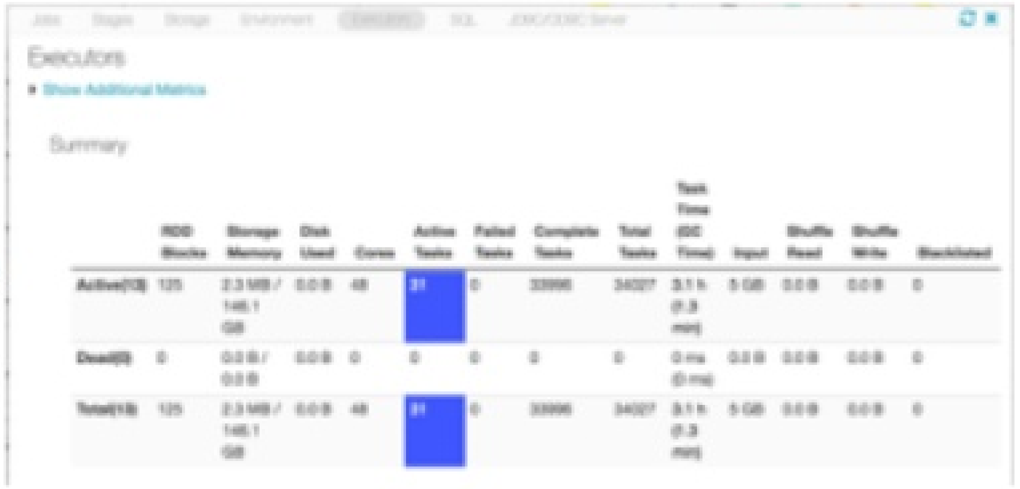


Executors

▸ Show Additional Metrics

Summary

	RDD Blocks	Storage Memory	Disk Used	Cores	Active Tasks	Failed Tasks	Complete Tasks	Total Tasks	Task Time (GC Time)	Input	Shuffle Read	Shuffle Write	Blacklisted
Active(13)	125	2.3 MB / 146.1 GB	0.0 B	48	48	0	33975	34023	2.8 h (1.2 min)	4.9 GB	0.0 B	0.0 B	0
Dead(0)	0	0.0 B / 0.0 B	0.0 B	0	0	0	0	0	0 ms (0 ms)	0.0 B	0.0 B	0.0 B	0
Total(13)	125	2.3 MB / 146.1 GB	0.0 B	48	48	0	33975	34023	2.8 h (1.2 min)	4.9 GB	0.0 B	0.0 B	0



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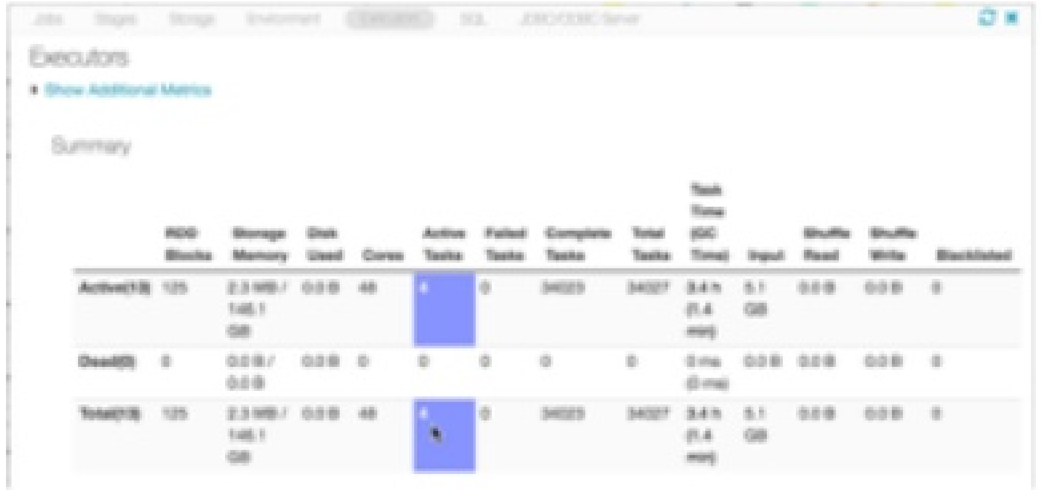
Active(13)	125	2.3 MB / 146.1 GB	0.0 B	48	31	0	33996	34027	3.1 h (1.3 min)	5 GB	0.0 B	0.0 B	0
Dead(0)	0	0.0 B / 0.0 B	0.0 B	0	0	0	0	0	0 ms (0 ms)	0.0 B	0.0 B	0.0 B	0
Total(13)	125	2.3 MB / 146.1 GB	0.0 B	48	31	0	33996	34027	3.1 h (1.3 min)	5 GB	0.0 B	0.0 B	0



Executors

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Summary

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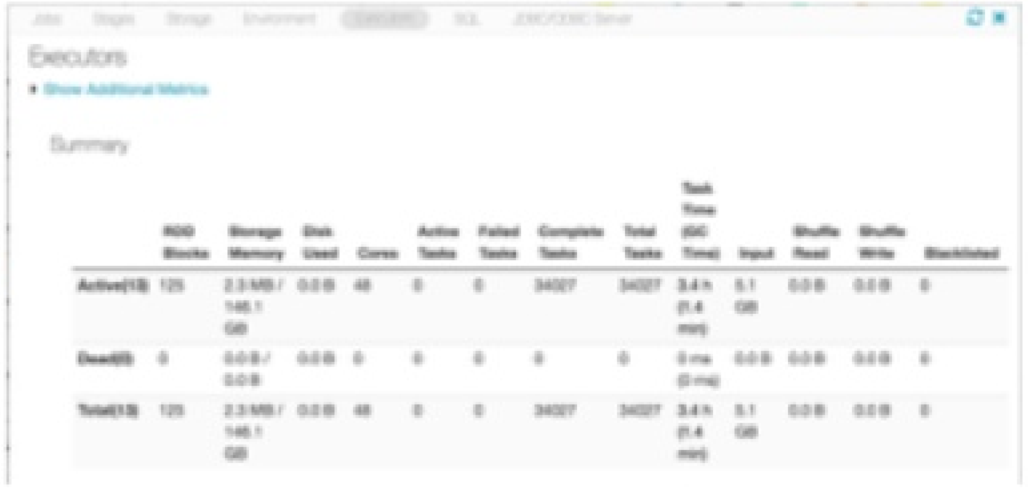
Active(13)	125	2.3 MB / 146.1 GB	0.0 B	48	4	0	34023	34027	3.4 h (1.4 min)	5.1 GB	0.0 B	0.0 B	0
Dead(0)	0	0.0 B / 0.0 B	0.0 B	0	0	0	0	0	0 ms (0 ms)	0.0 B	0.0 B	0.0 B	0
Total(13)	125	2.3 MB / 146.1 GB	0.0 B	48	4	0	34023	34027	3.4 h (1.4 min)	5.1 GB	0.0 B	0.0 B	0



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	RDD Blocks	Storage Memory	Disk Used	Cores	Active Tasks	Failed Tasks	Complete Tasks	Total Tasks	Task Time (GC Time)	Input	Shuffle Read	Shuffle Write	Blacklisted
Active(13)	125	2.3 MB / 146.1 GB	0.0 B	48	0	0	34027	34027	3.4 h (1.4 min)	5.1 GB	0.0 B	0.0 B	0
Dead(0)	0	0.0 B / 0.0 B	0.0 B	0	0	0	0	0	0 ms (0 ms)	0.0 B	0.0 B	0.0 B	0
Total(13)	125	2.3 MB / 146.1 GB	0.0 B	48	0	0	34027	34027	3.4 h (1.4 min)	5.1 GB	0.0 B	0.0 B	0

Spreadsheets as a DSL

- Spreadsheet is a powerful data modeling tool.

- Start simple and evolve into a complex ML pipeline.

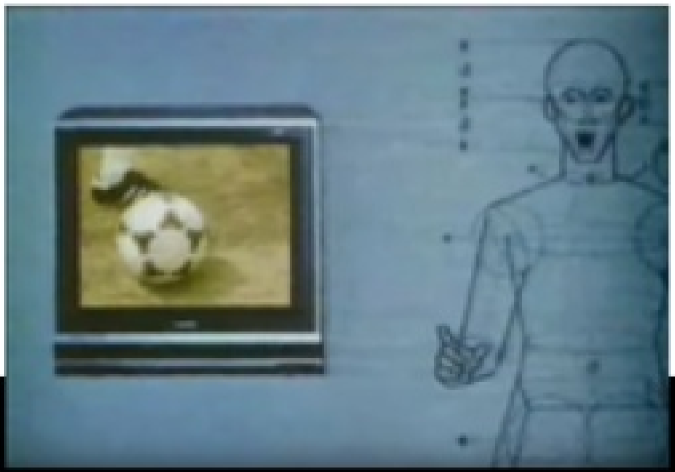
- Spreadsheets are suitable to many domains (FP&A is one such domain).

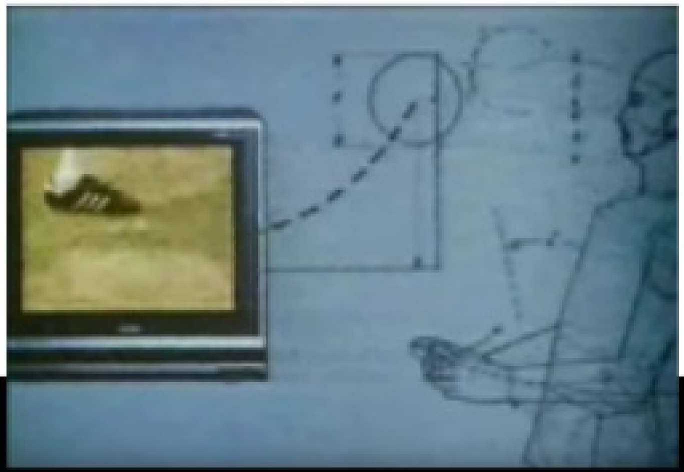
What have we seen?

- Spreadsheet applications as Prototypes for Spark programs
- Program Transformation
  - How to model as Pipeline
  - Why considered Code-to-Code Transformation
- How to Generate Code
  - AST (elegant)
  - Parse Tree (practical)
- Spreadsheets as a DSL
  - Generating Code
- Next Steps

Next Steps

- Use cases!
- Modeling Machine Learning in a Spreadsheet
- Prototype D|'s and ML|'s in a Spreadsheet





References

- A Grammar for Spreadsheet Formulas Evaluated on Two Large Datasets – Efthimia Aivaloglou, David Hoepelman & Felienne Hermans, Proceedings of SCAM ’15

- http://www.felienne.com/archives/2974

- Pictures in presentation from Boards of Canada video “roygbiv”

  https://youtu.be/yT0gRc2c2wQ

Q&A

SPARK+AI
SUMMIT EUROPE

THANK YOU.

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