Building Custom Machine Learning Algorithms with Apache SystemML

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SPARK SUMMIT 2016

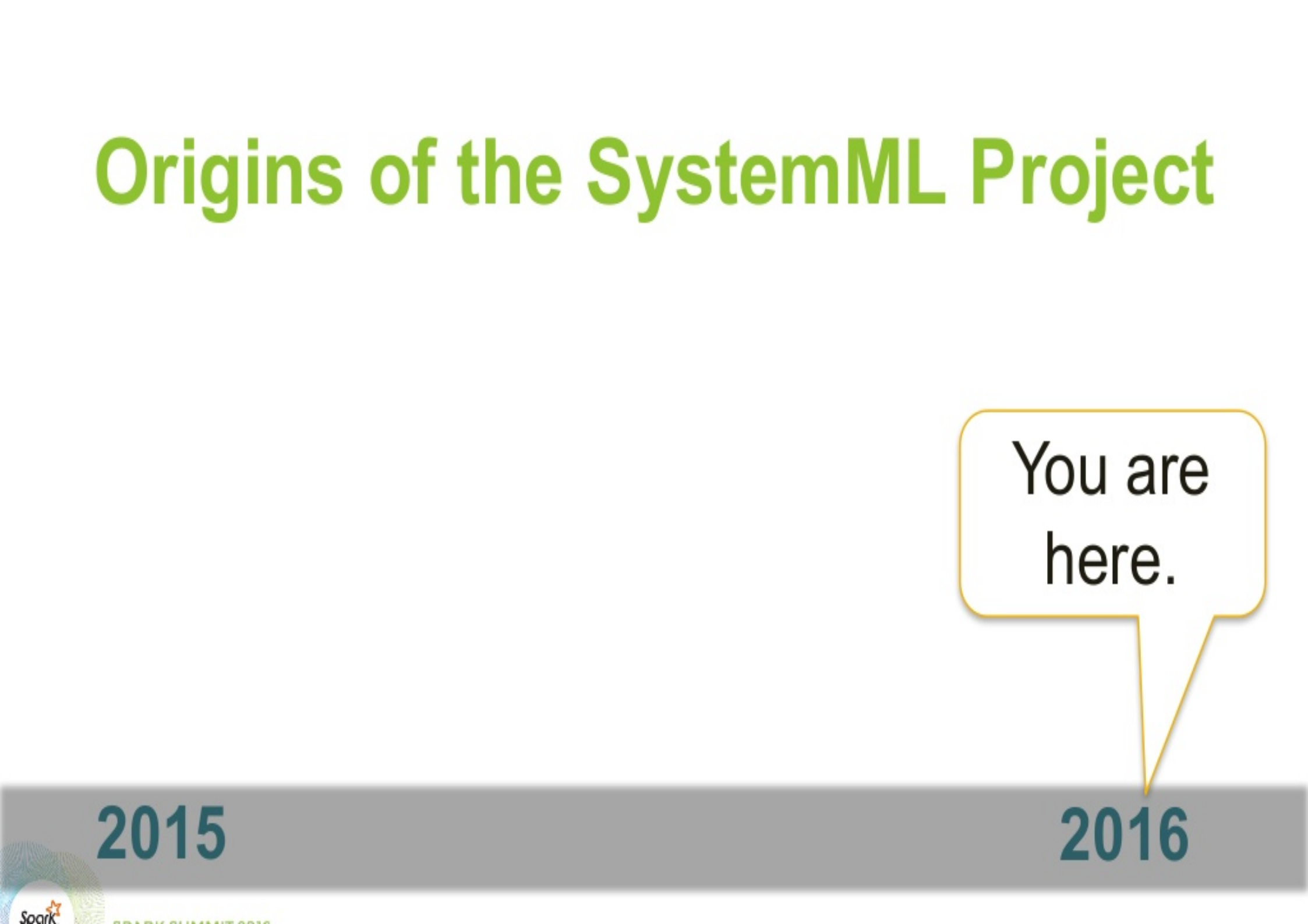
DATA SCIENCE AND ENGINEERING AT SCALE

Roadmap

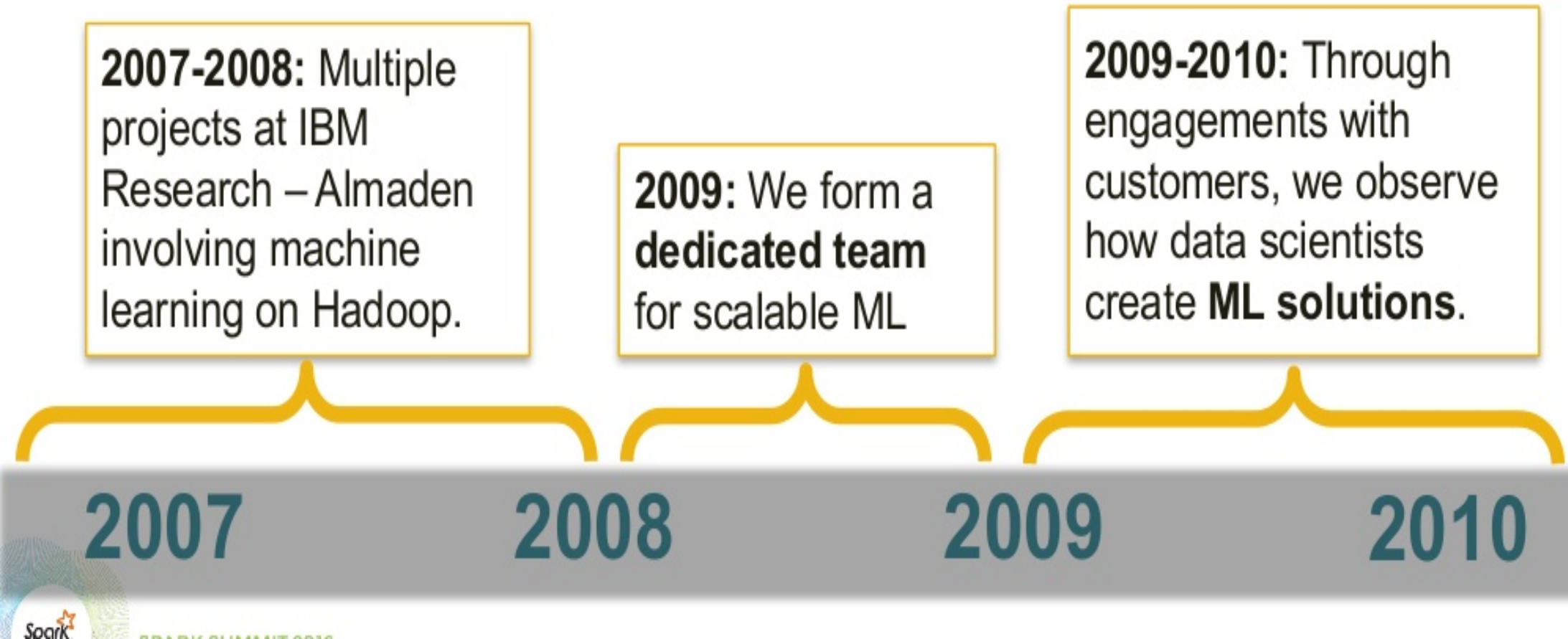
- What is Apache SystemML?
- Demo!
- How to get SystemML

What is Apache SystemML?

Origins of the SystemML Project



2011 2012 2013 2014


2007-2008: Multiple projects at IBM Research – Almaden involving machine learning on Hadoop.
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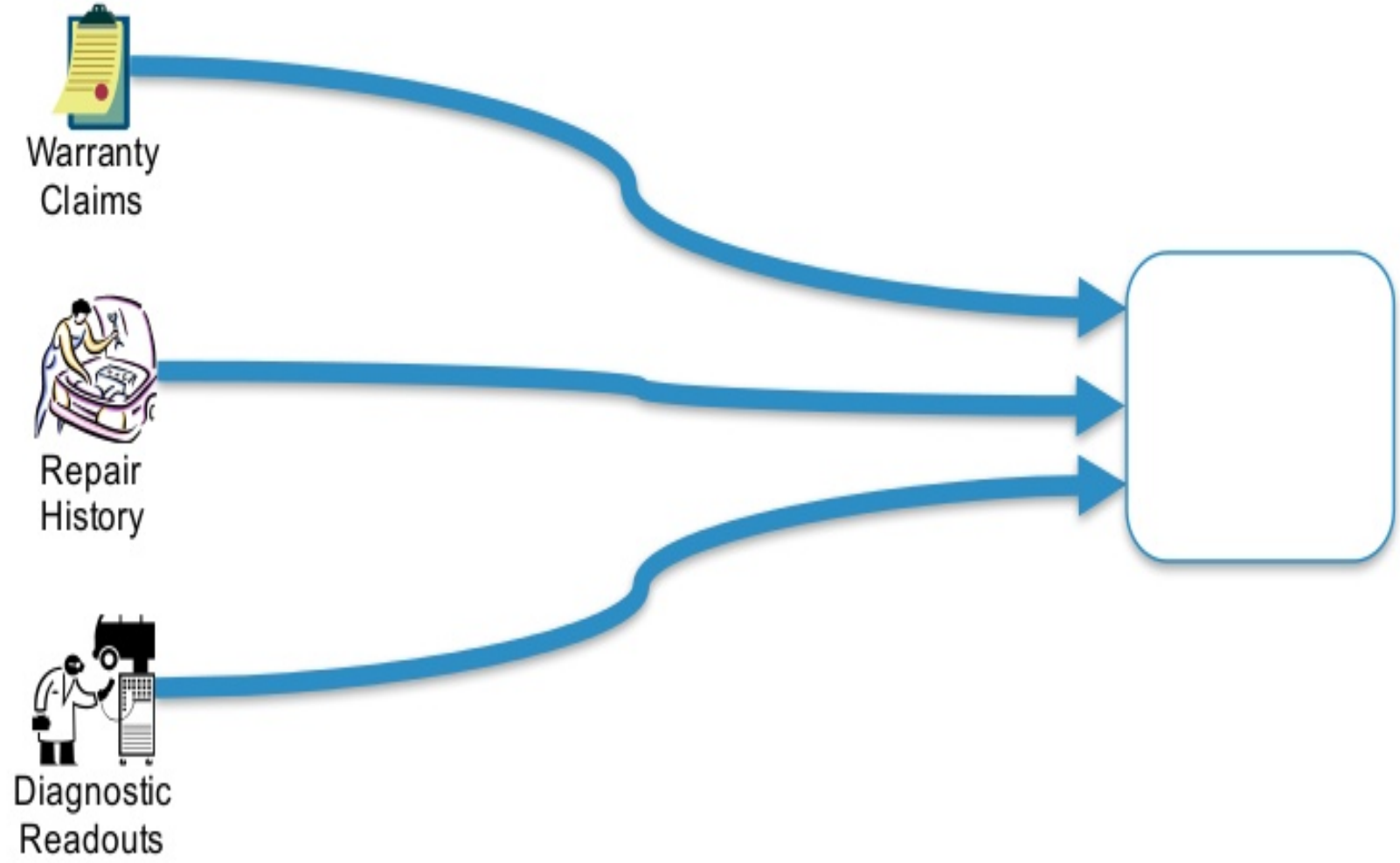
2007
2008
2009
2010

Case Study: An Auto Manufacturer



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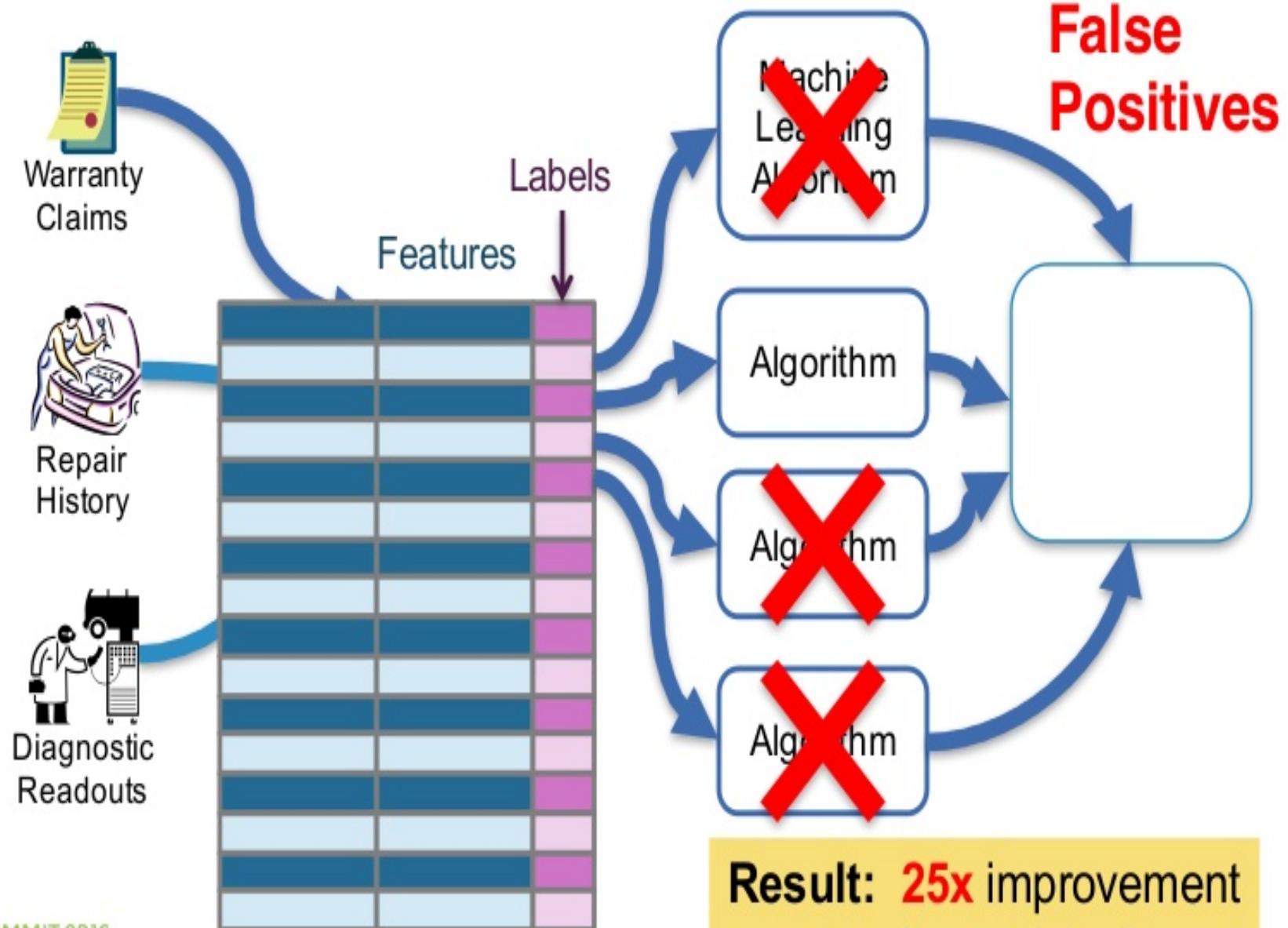
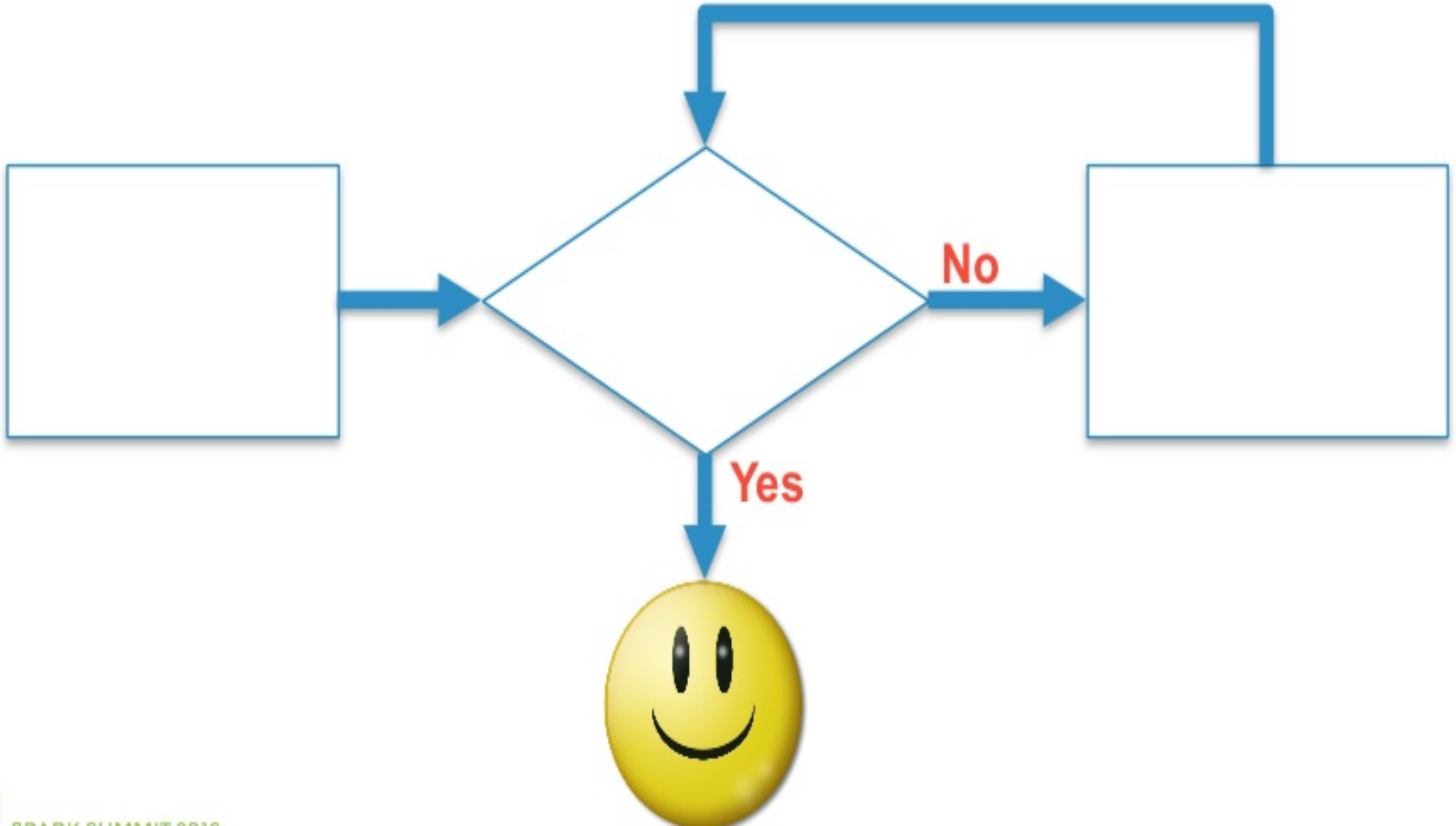
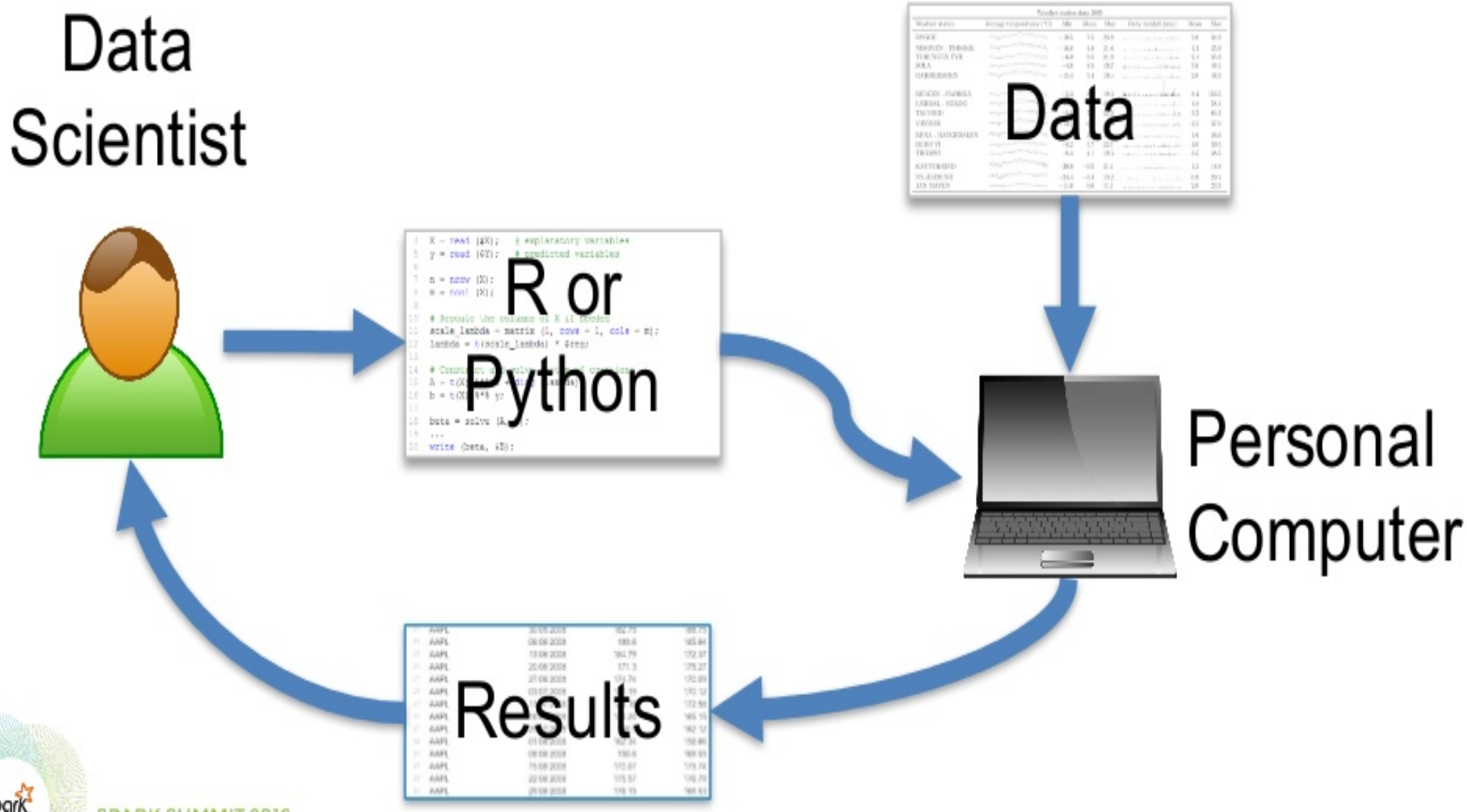


The Iterative Development Process



State-of-the-Art: Small Data



State-of-the-Art: Big Data

Data Scientist

Systems Programmer

R or Python

Scala

Spark

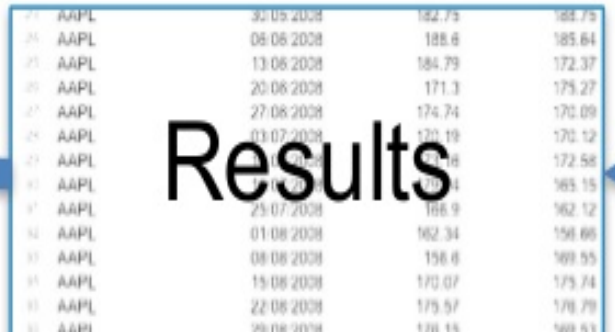
Results

State-of-the-Art: Big Data

Data Scientist

- Days or weeks per iteration
- Errors while translating algorithms

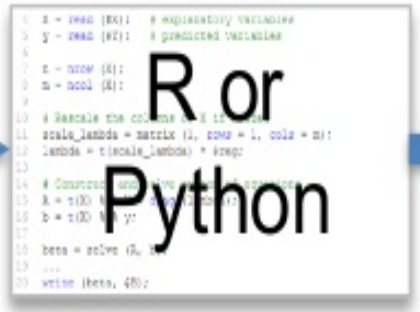
Spark



Results

The SystemML Vision

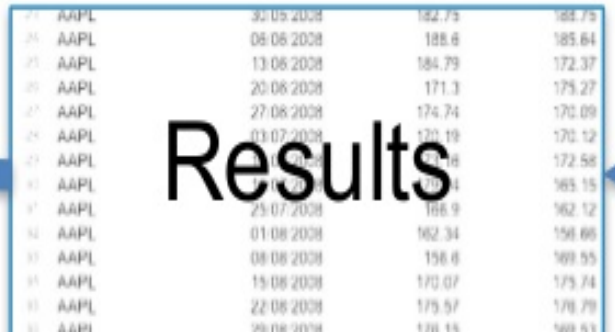
Data Scientist



SystemML

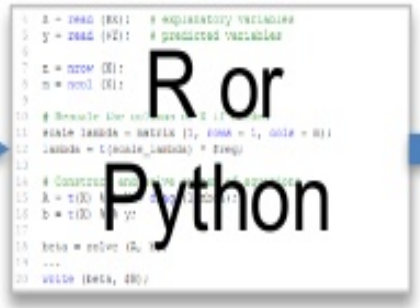
Spark

Results



The SystemML Vision

Data Scientist

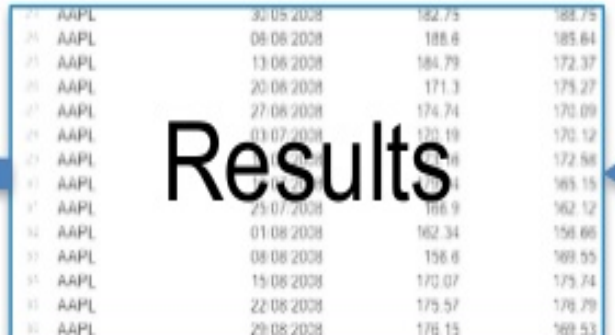


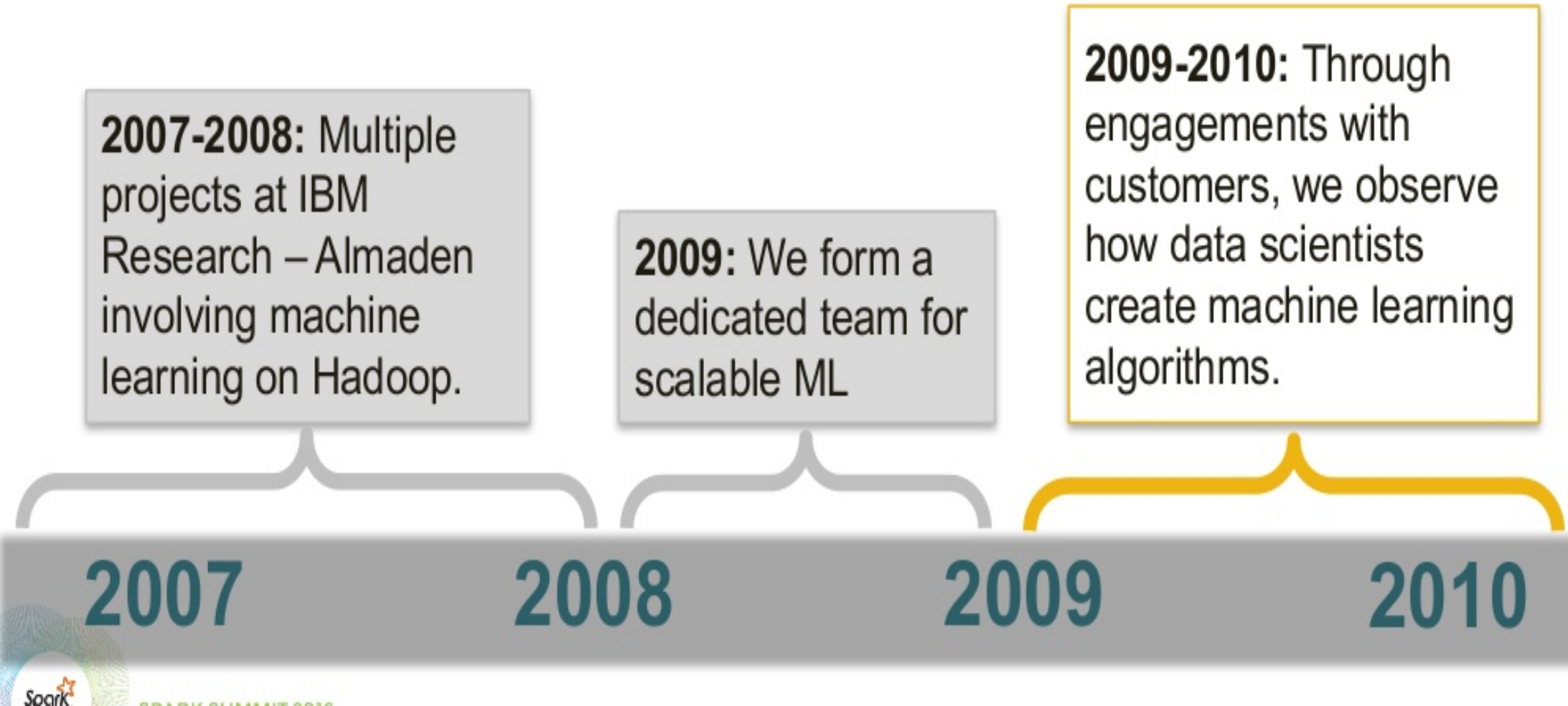
Fast iteration

Same answer

SystemML

Spark

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Research
2011
2012
2013
2014

Apache SystemML

June 2015: IBM Announces open-source SystemML

September 2015: Code available on Github

November 2015: SystemML enters Apache incubation

February 2016: First release (0.9) of Apache SystemML

June 2016: Second Apache release (0.10)

2015

2016

SystemML at  IBM Watson Health

- Built algorithms for predicting treatment outcomes
  - Substantial improvement in accuracy
- Moved from Hadoop MapReduce to Spark
  - SystemML supports both frameworks
  - **Exact same code**
  - **300X faster** on 1/40th as many nodes

SystemML at Cadent Technology

Cadent is a leading provider of TV advertising and data solutions, reaching over 140 million homes and trusted by the world's largest service providers.

"SystemML allows Cadent to implement advanced numerical programming methods in Apache Spark, empowering us to leverage specialized algorithms in our predictive analytics software."

Michael Zargham
Chief Scientist

Demo!

Demo Scenario

- **Application:** Targeted ads using demographic information tied to cookies
- **Problem:** The information is incomplete
- **Solution:** Estimate the missing values
  - Treat the problem as a **matrix completion** problem

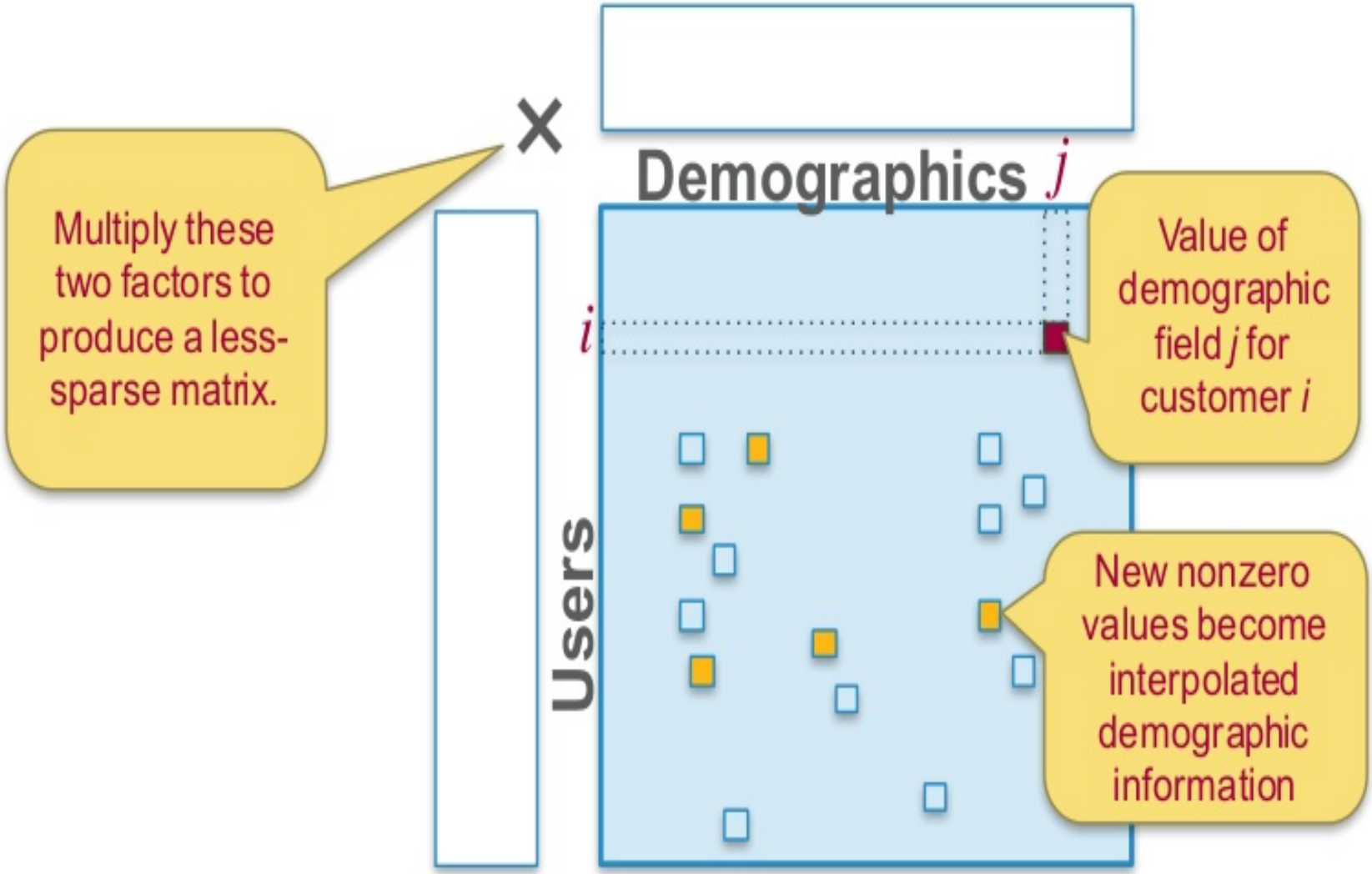
Data

- The U.S. Census Public Use Microdata Sample (PUMS) data set for 2010
- 10% sample of the U.S. population
  - We'll use just California today
- Use this full data set to generate synthetic incomplete data

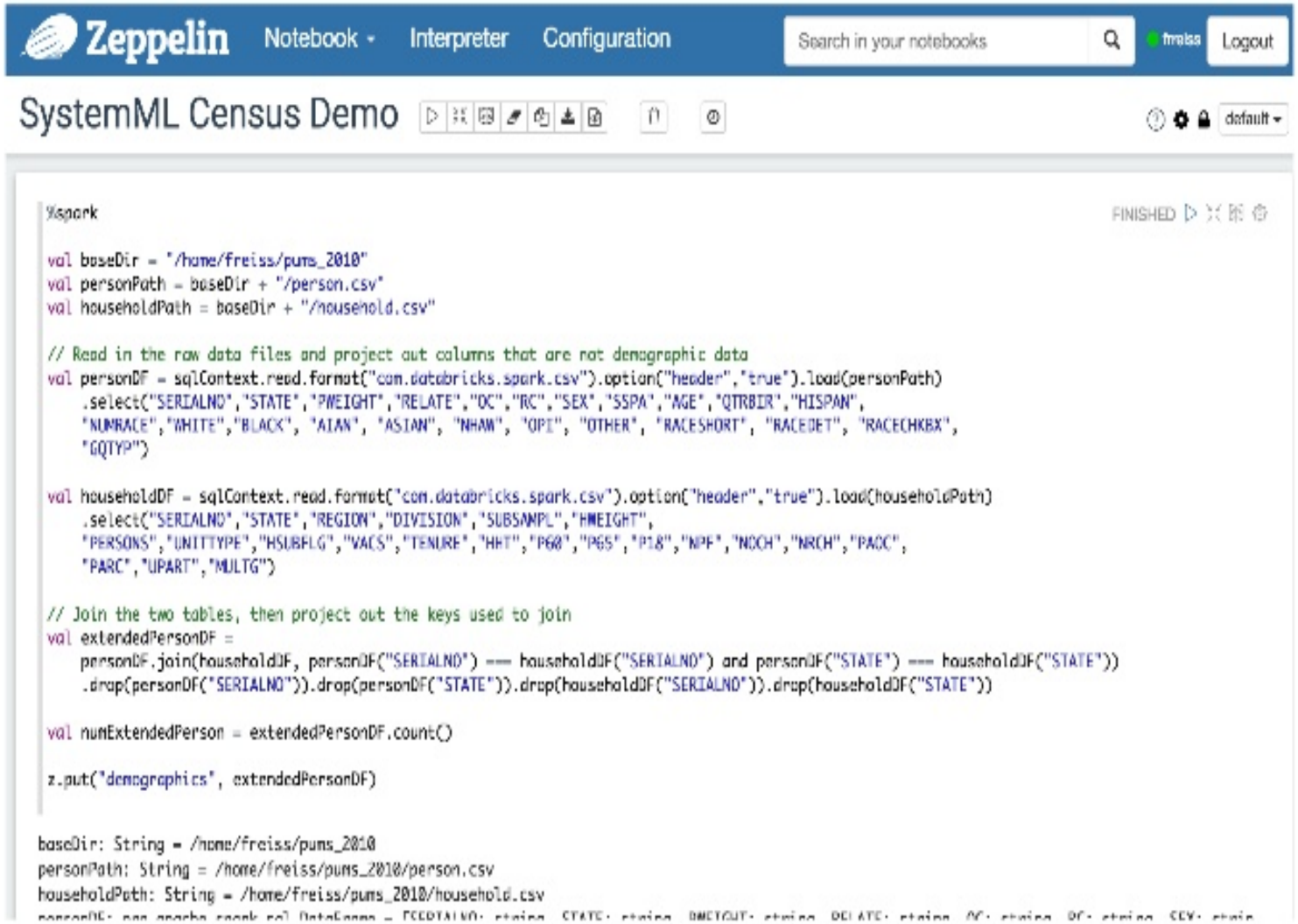
Demo Scenario

- **Application:** Identify products that are complementary (often purchased together)
- **Problem:** Customers are not currently buying the best complements at the same time
- **Solution:** Suggest new product pairings
  - Treat the problem as a **matrix completion** problem

Matrix Factorization



Demo Part 1: Data wrangling



Demo Part 2: Custom algorithm

Algorithm Customizability

ML algorithms are expressed in an R-like or Python-like syntax that includes linear algebra primitives, statistical functions, and ML-specific constructs. This high-level language significantly increases the productivity of data scientists as it provides (1) full flexibility in expressing custom analytics, and (2) data independence from the underlying input formats and physical data representations. Automatic optimization according to data and cluster characteristics ensures both efficiency and scalability.

Poisson Nonnegative Matrix Factorization in SystemML's R-like Syntax

```
while (iter < max_iterations) {
  iter = iter + 1;
  H = (H * (t(W) %*% (V/(W%*%H)))) / t(colSums(W));
  W = (W * ((V/(W%*%H)) %*% t(H))) / t(rowSums(H));
  obj = as.scalar(colSums(W) %*% rowSums(H)) - sum(V * log(W%*%H));
  print("iter=" + iter + " obj=" + obj);
}
```

Key Points

- SystemML, Spark, and Zeppelin work together
- Linear algebra is great for data science
- Customization is important

How to get Apache SystemML

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The Apache SystemML Web Site

http://systemml.apache.org

THANK YOU.

Please try out Apache SystemML!

http://systemml.apache.org

Special thanks to Nakul Jindal and Mike Dusenberry for helping with the demo!