



**Pivotal**

# IoT in the Age of the Fourth Industrial Revolution

**Roman Shaposhnik**

Pivotal, Director of Open Source Strategy



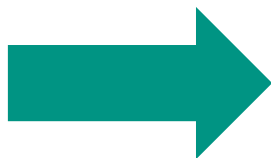
**BORDERS.**

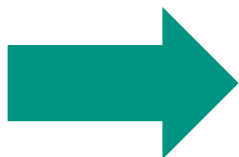
?



**BORDERS®**







Stephen O'Grady

# The New Kingmakers

How **Developers**  
Conquered the World



O'REILLY™

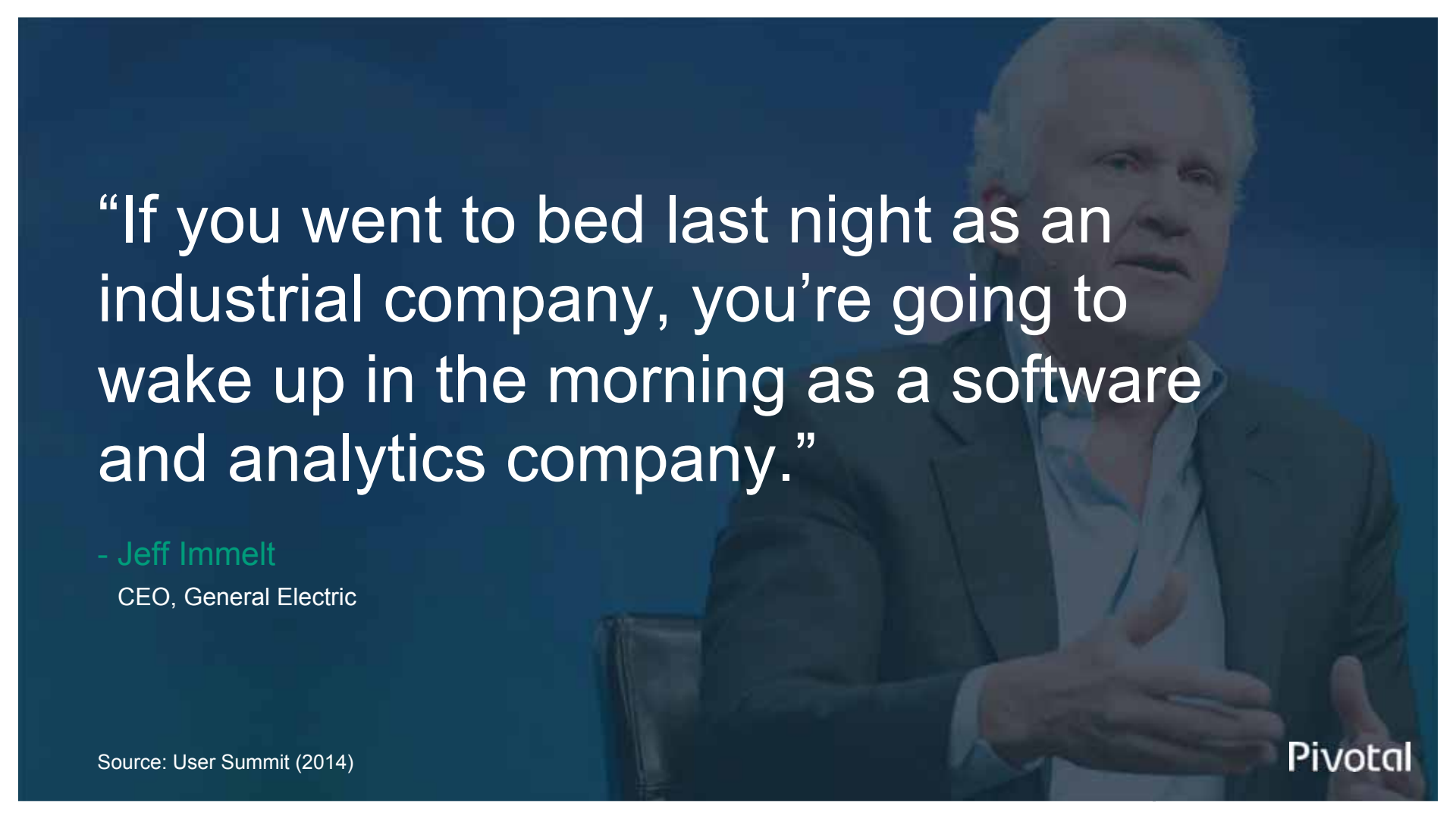
New Relic

# Disruption

# The drivers of transformation are **fear** and **hope**





A background image of Jeff Immelt, CEO of General Electric, speaking. He is an older man with white hair, wearing a dark suit jacket over a light blue shirt. He is gesturing with his hands while speaking. The image is overlaid with a semi-transparent dark blue filter.

“If you went to bed last night as an industrial company, you’re going to wake up in the morning as a software and analytics company.”

- Jeff Immelt

CEO, General Electric

Source: User Summit (2014)

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# Origins of Pivotal

EMC<sup>2</sup>

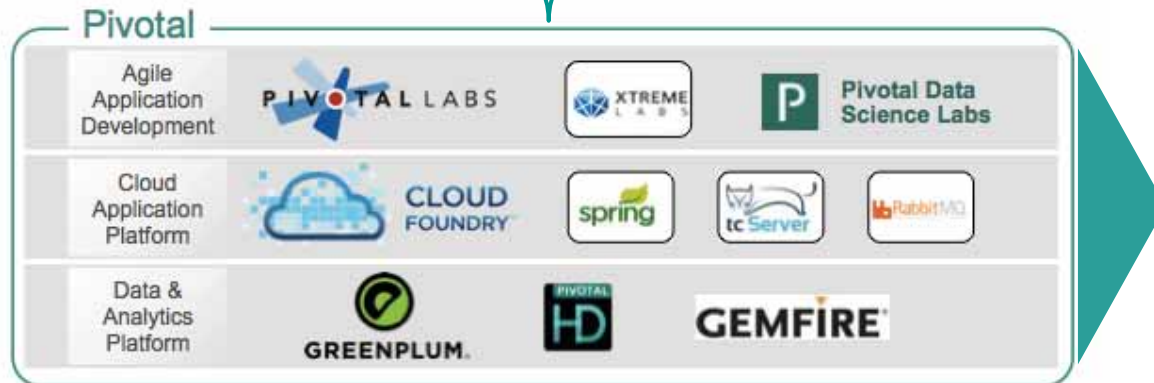


vmware



**\$105M**  
investment  
for 10%

*Spun out on April 2013*



...to provide the people, culture & technology required to transform businesses into modern software-driven organizations

“IoT is fundamentally nothing more than a simple *pattern*. It is not a business, a technology, a solution an architecture or a system.”

- Geoff Arnold  
CTO, Sensity



# How much of a “hype” is it?

Gartner



# Scale

# Is it really all that different scale-wise?

Devices	1,000,000	
×		
Input	2 status/min	$= 2,000,000 \text{ posts/min}$ $= 33,000 \text{ posts/sec}$ Google: 66,000 queries/sec
×		
Actions	100 ms/post	$= 3,300 \text{ cpu seconds / sec}$ $= 55 \text{ cpu hrs / sec}$
Data	250 bytes/post	$= 500 \text{ MB / min}$ $= 8.3 \text{ MB / sec}$

# Pratt & Whitney's Geared Turbo Fan Engine



- **5,000** sensors
- **10 GB** data per second
- **12 hours** of flight = **844 TB** data

# Smart Cities: Communities Using Technology To Serve Their Citizens Better

Traffic, parking, safety

Urban decay, poverty, crime  
Citizen engagement

Access to education  
and healthcare

Clean water, clean air,  
clean streets, energy efficiency

“If you can’t  
**measure** it,  
you can’t  
**manage** it.”



# City Top Ten Applications Today

- 1 Public Safety/Security
- 2 Public Wi-Fi - Emergency services Wi-Fi
- 3 Parking (compliance and enforcement)
- 4 Traffic monitoring and management
- 5 Better lighting, lower energy costs/maintenance
- 6 Nuisance identification: graffiti, abandoned vehicles, ill
- 7 Retail analytics for brick and mortar stores
- 8 Real-time infrastructure status: asphalt and potholes, r
- 9 Snow level reporting/plowing guidance
- 10 Environmental monitoring





# And those lights are all being converted to LED



Reuse existing assets; ideal location for smart city sensors

Each light needs a networked control unit, connected to line power 24/7

Labor to visit poles can be paid for by LED upgrade

## Ideal Infrastructure for Distributed Sensing

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# Enables Many Kinds of Sensory Systems

## Sensing Our World...

### Core Platform

- Temperature
- Pressure
- Humidity
- Accelerometer
- Ambient light
- Power monitoring
- Motion
- GPS

### Video Nodes

- Smart Parking
- Bus Scheduling
- Train Status
- Pedestrian Safety
- Security
- Roadway Maintenance
- Traffic Control

### Extensions

- RTLS
- O<sub>2</sub> and CO<sub>2</sub>
- UVA/UVB
- Ultrasound
- Radiation
- Rainfall
- Wind
- Particulate matter



# NetSense WorldWide

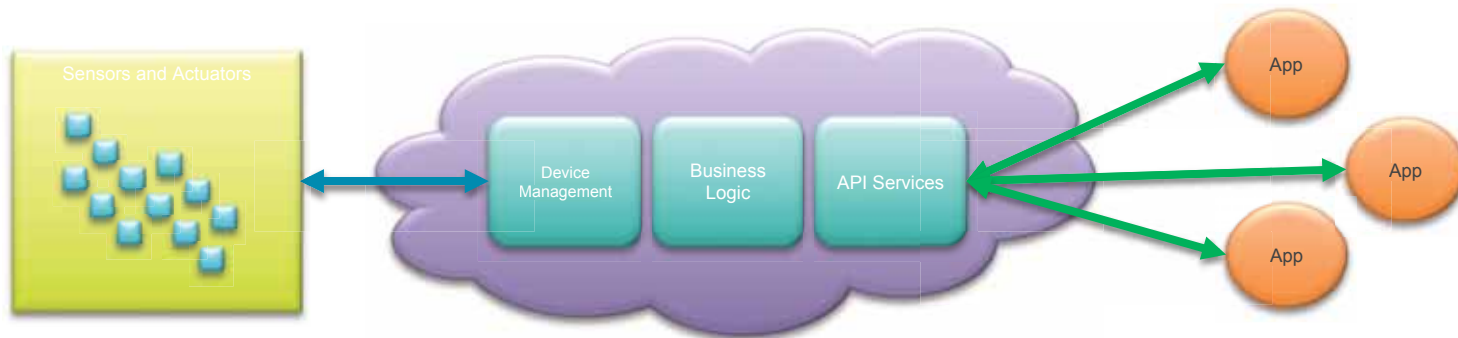


Certified in 34 Countries | Deployed in 10 Countries | 39 Deployment Sites

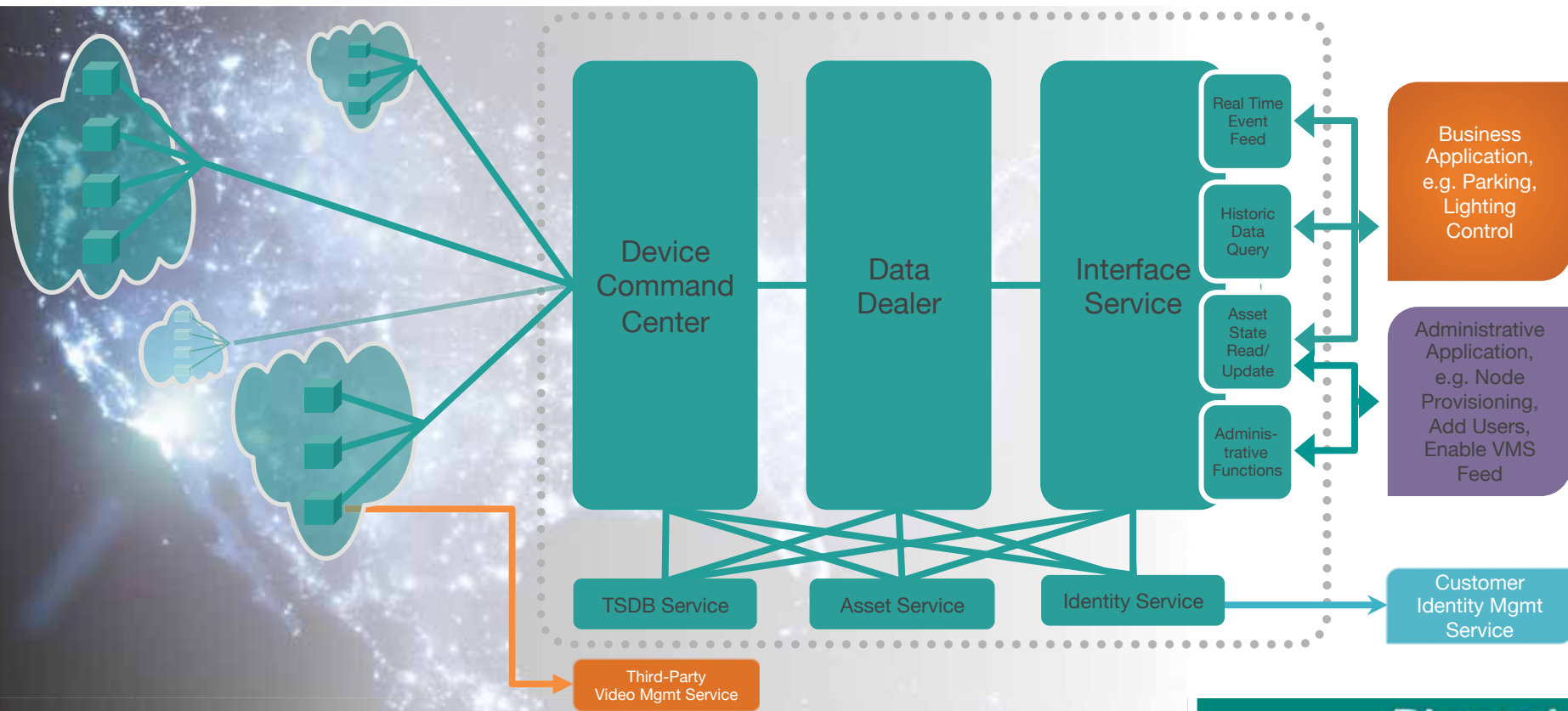


# Generic IOT Pattern

- 1 A Networked Collection of Sensors and Actuators
- 2 A Cloud-based System to Manage Them
- 3 Business Logic to Organize the Data
- 4 APIs to Provide Access to the Data
- 5 Applications Based on Those APIs



# NetSense Cloud Architecture



# Predix

**Your cloud platform for the  
Industrial Internet**

[Register for Free Trial](#)



Feedback





## About Predix

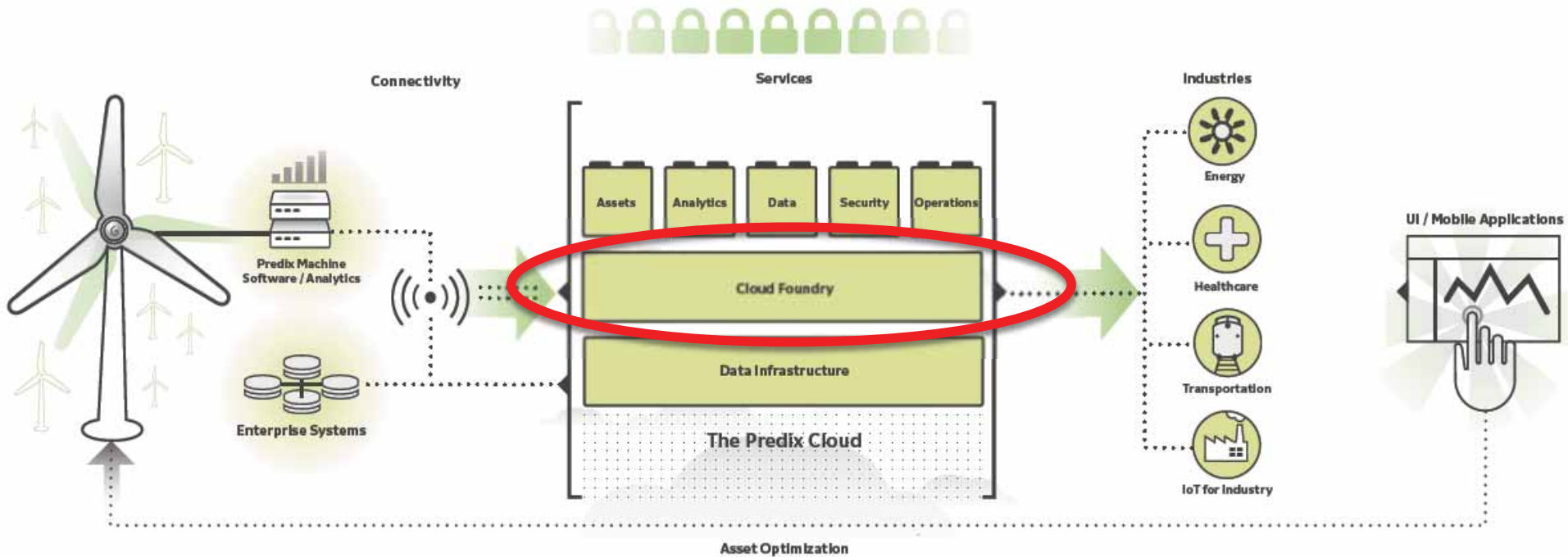
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Predix is the software platform that powers the Industrial Internet. Based on GE's unparalleled expertise in brilliant machines, Predix handles big data at an industrial scale and with industrial-strength security. Deployed on machines, onsite, or in the cloud, Predix drives the insights that transform and improve asset performance management (APM), operations, and business.



GE Digital

# Predix Architecture



Predix Architecture and Services Technical Whitepaper

[Industries](#)[Digital](#)[Investor](#)[News](#)[Careers](#)

# Industrial Dojo

Hack like a Blackbelt. Hone your skills in our dojo.

In collaboration with the Cloud Foundry Foundation, GE has launched the Industrial Dojo program to accelerate the ability for developers to contribute code that enables the Industrial Internet. Participants will be paired with experienced colleagues to immerse themselves in open source projects and quickly learn the core technology in an Agile development environment. [Learn more and apply.](#)

[JOIN THE PROJECTS](#)

# A “Pivotal Way”

## Modern Software Methodology

Extreme scale &  
performance advantages,  
built for the cloud

## (Data) Microservices

Loosely coupled  
services architecture,  
bounded by context

## Cloud-Native Platforms

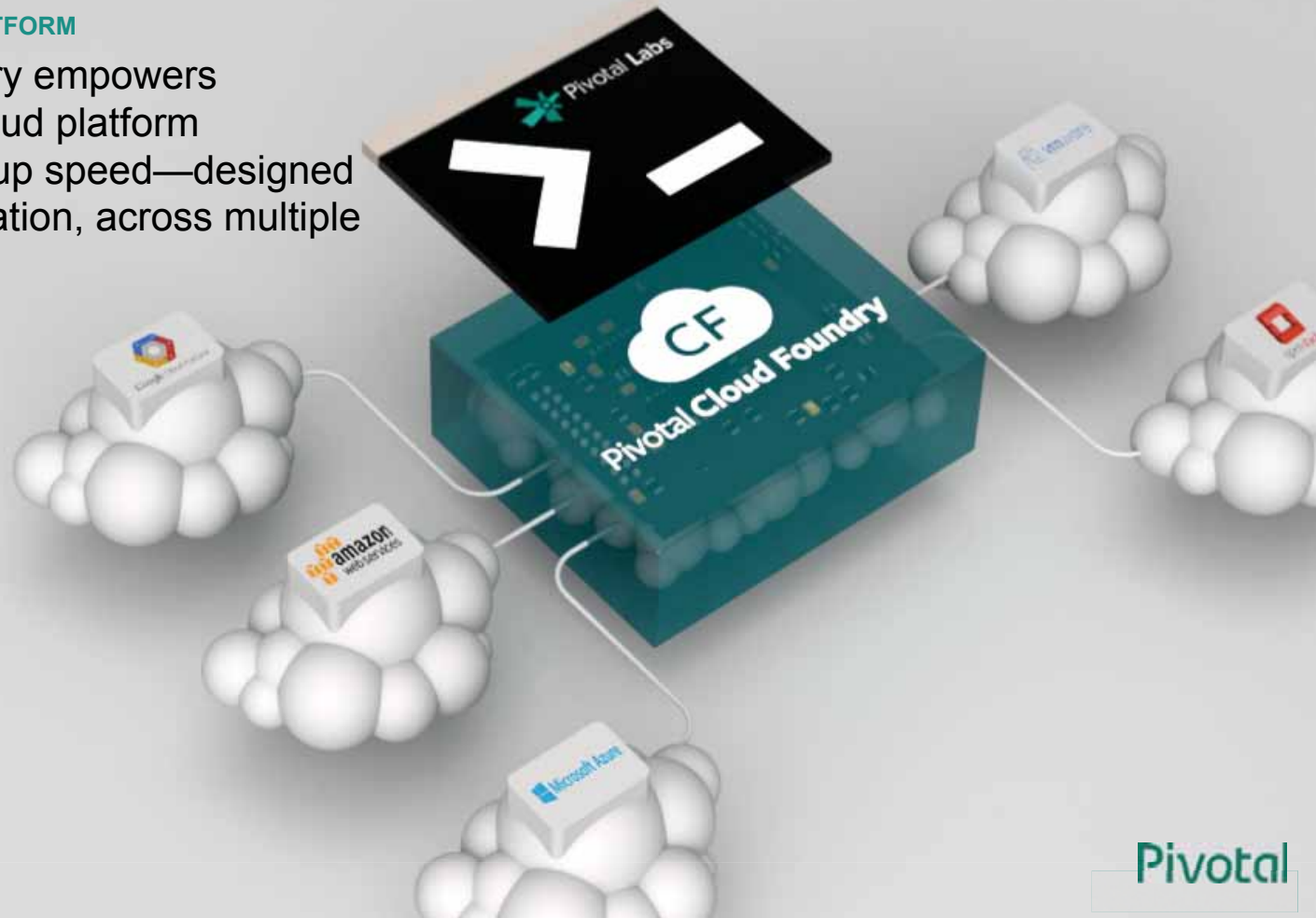
Enabling continuous  
delivery & automated  
operations

## Machine Learning

Use of predictive  
analytics to build  
smart apps

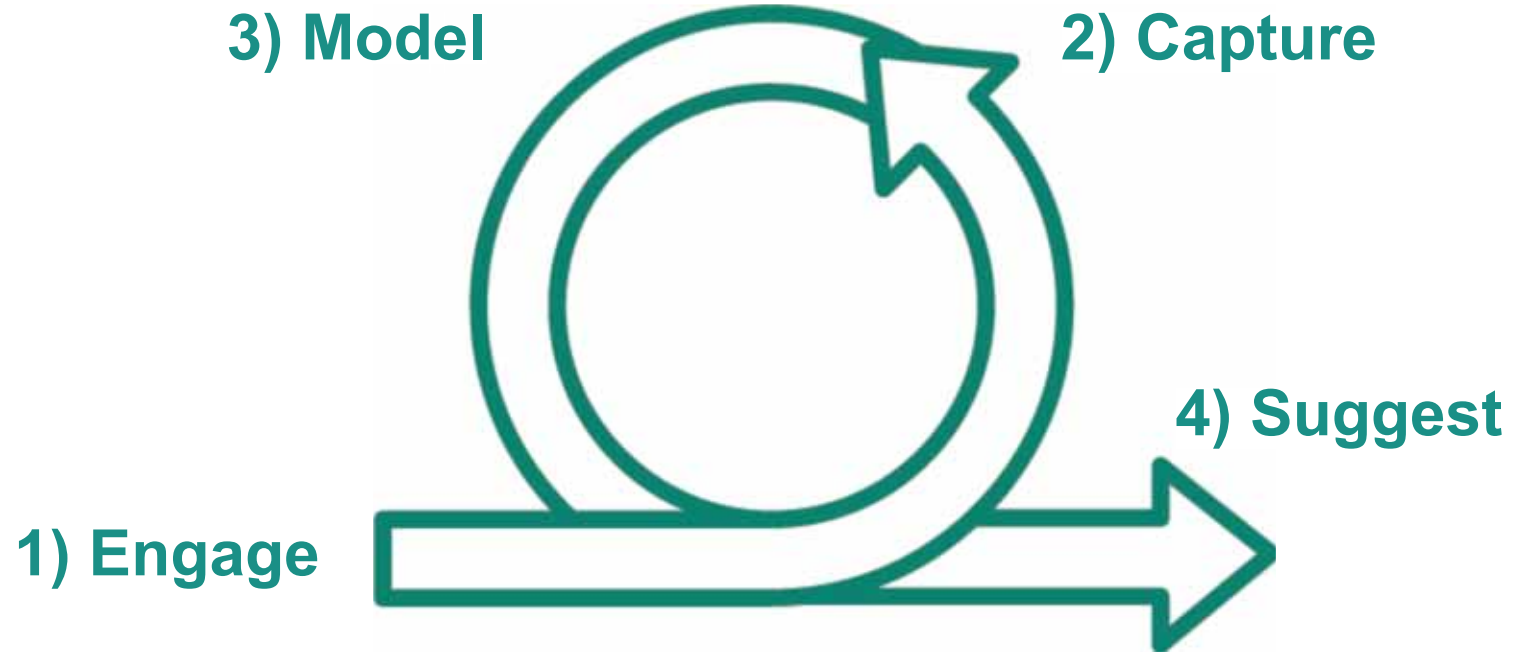
## MODERN CLOUD NATIVE PLATFORM

Pivotal Cloud Foundry empowers companies with a cloud platform engineered for start-up speed—designed for continuous innovation, across multiple clouds, at scale.

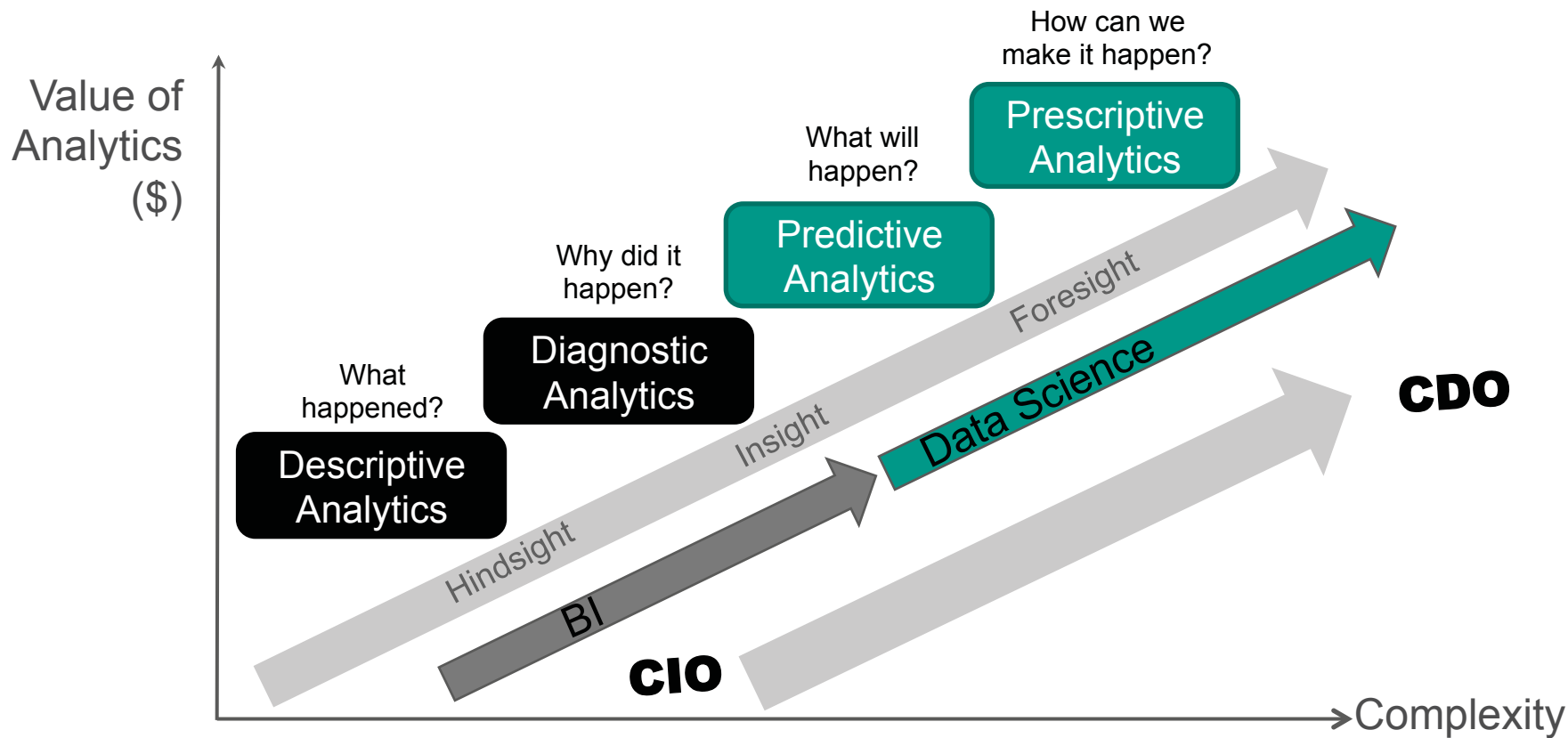


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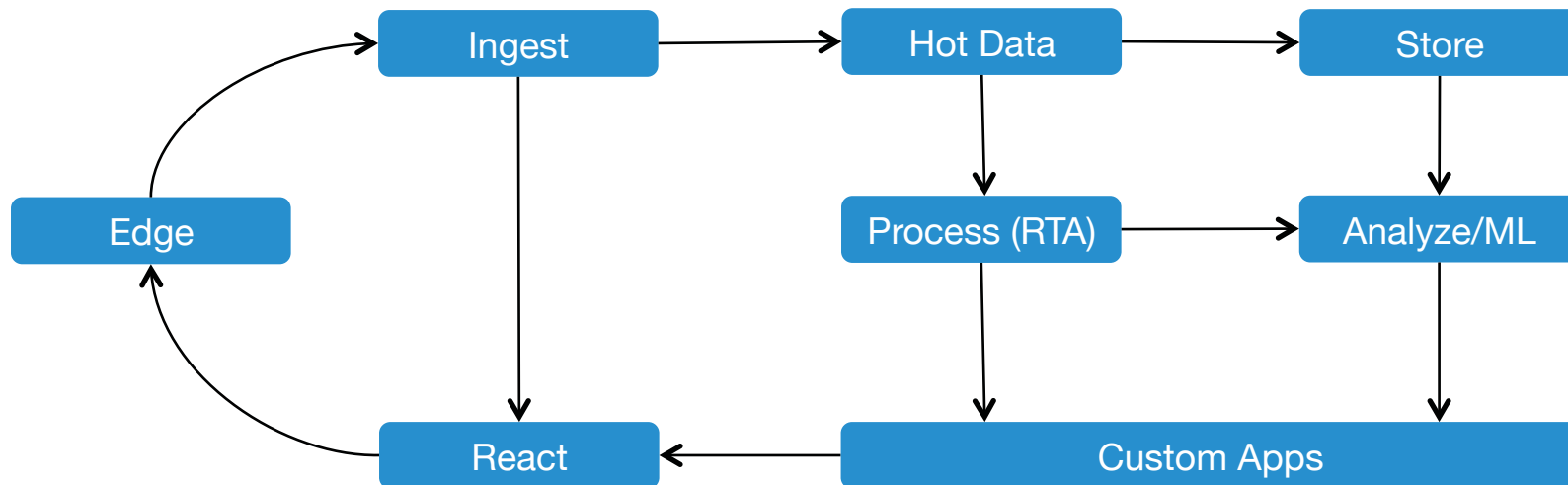
# Smart Apps running on converged OT+IT platform



# Data Science Complements & Enhances Traditional BI

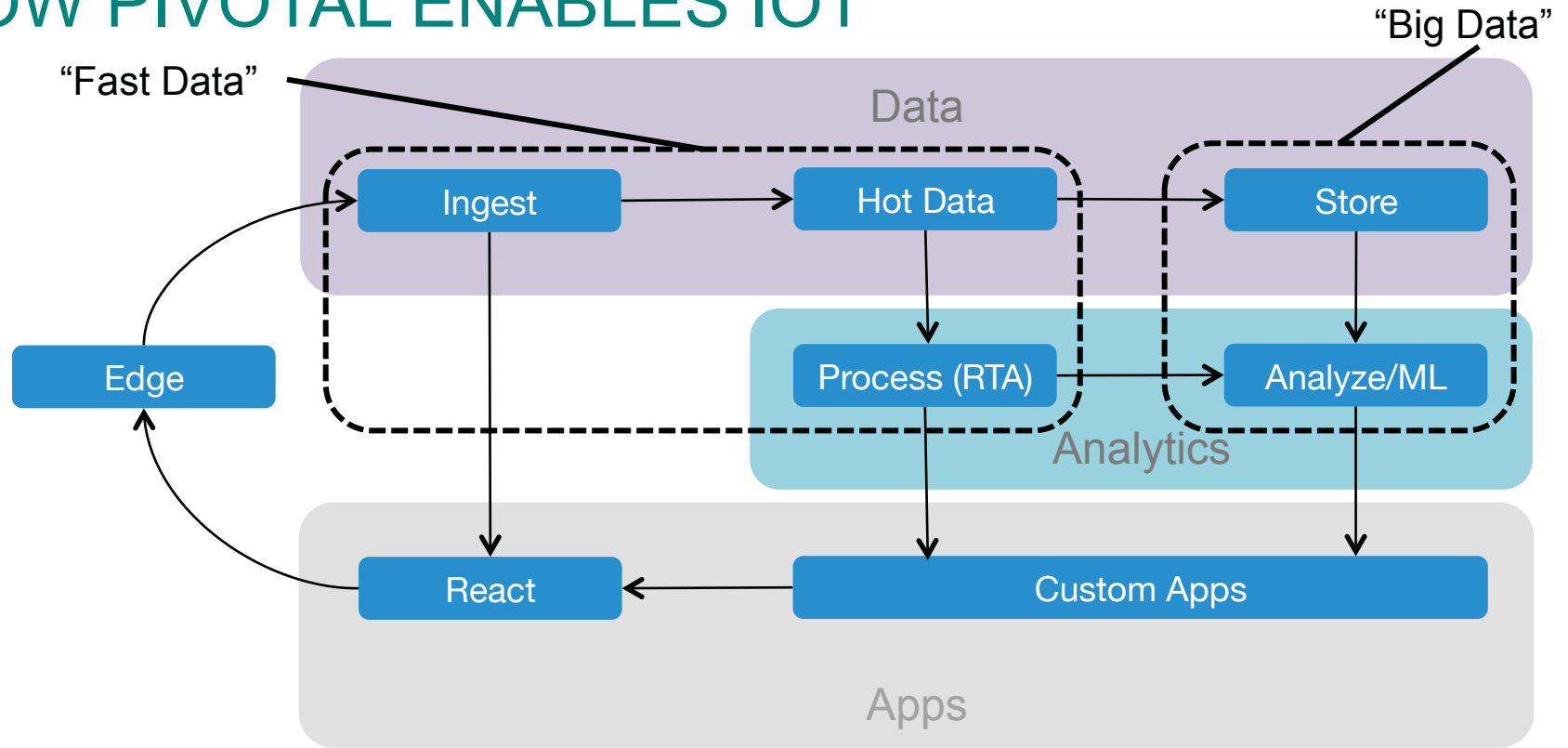


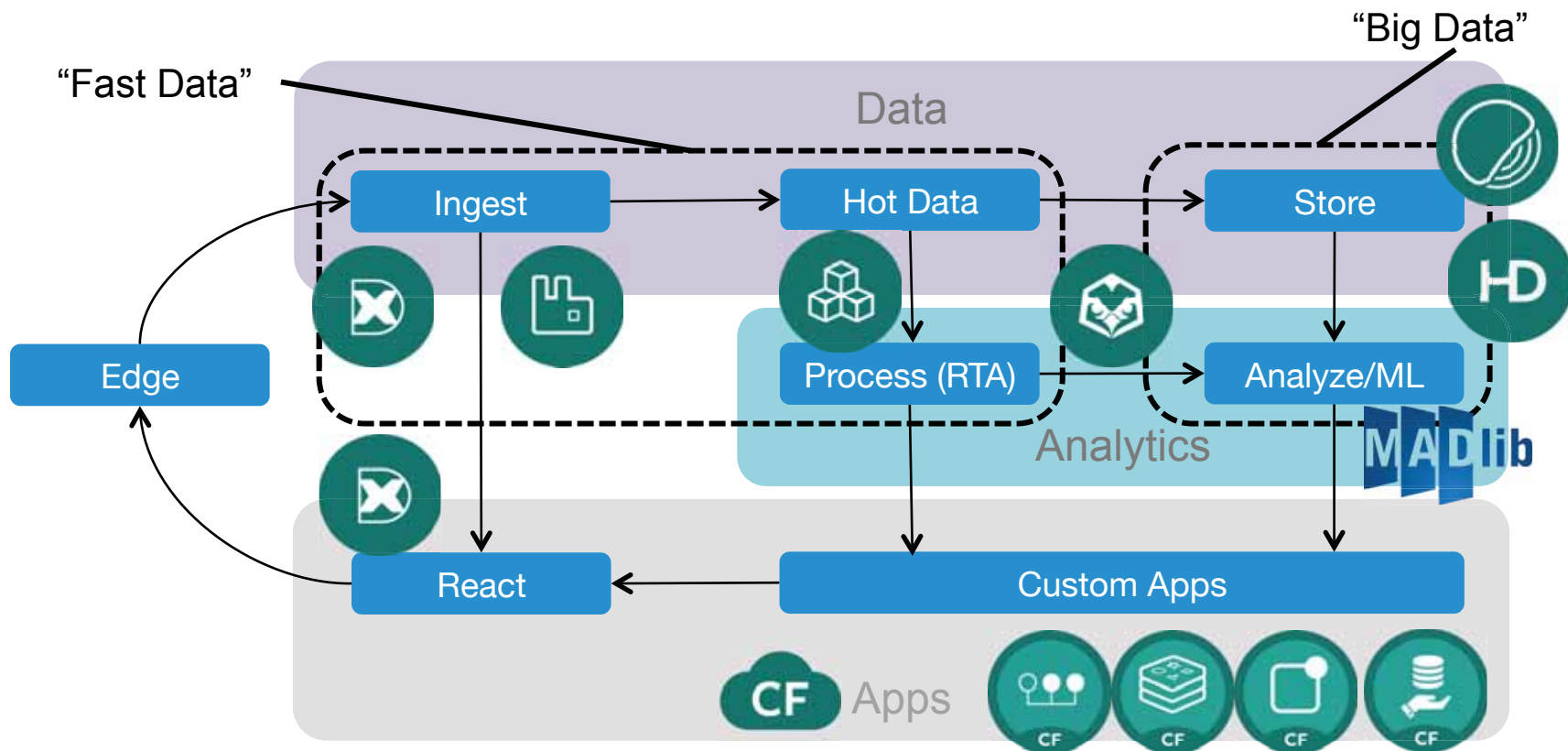
# PIVOTAL'S VIEW OF IOT





# HOW PIVOTAL ENABLES IOT





# End-to-end IIoT use case

- Oil & gas generates *large amounts of data from sensors* enabling *data-driven approaches* to improve operations

## Predictive maintenance

- Motivation:** Failure costs estimated at \$150,000/incident\*
- Goals**
  - Early warning system
  - Insights into prominent features impacting operation and failure
  - Reduction of non-productive drill time
  - Reduced incidents



\*<http://blog.pivotal.io/pivotal/case-studies-2/data-as-the-new-oil-producing-value-for-the-oil-gas-industry>

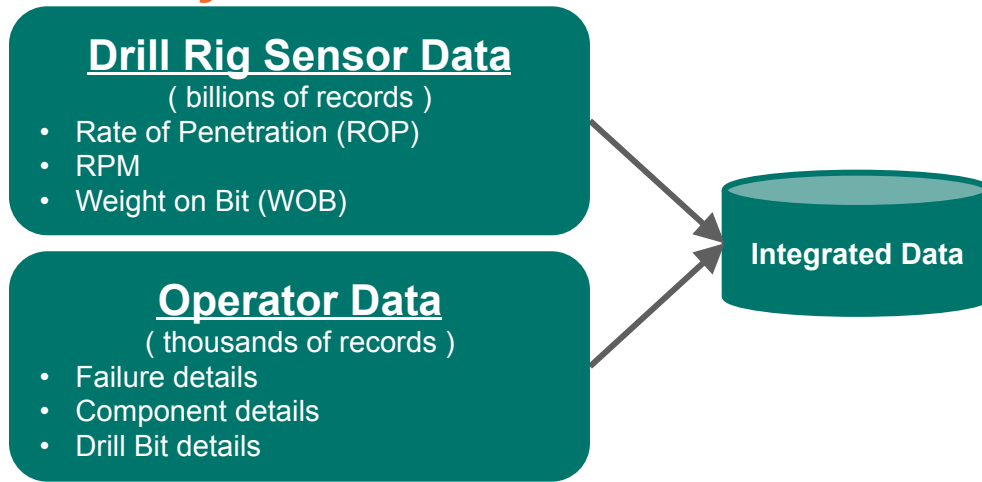
# How are models built using sensor data?



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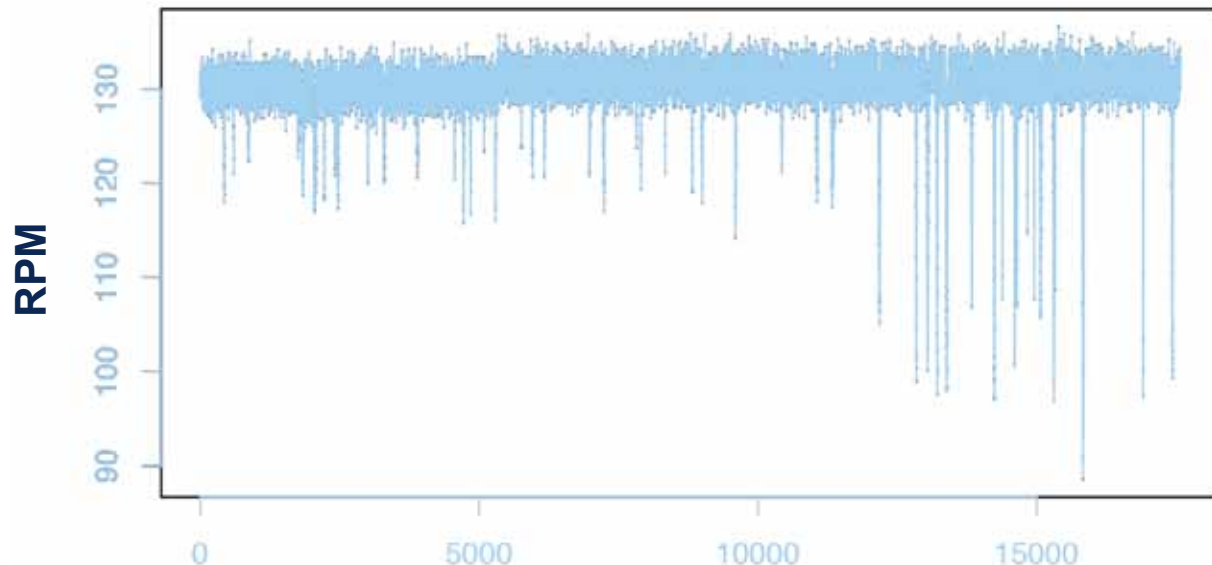
## Primary data sources



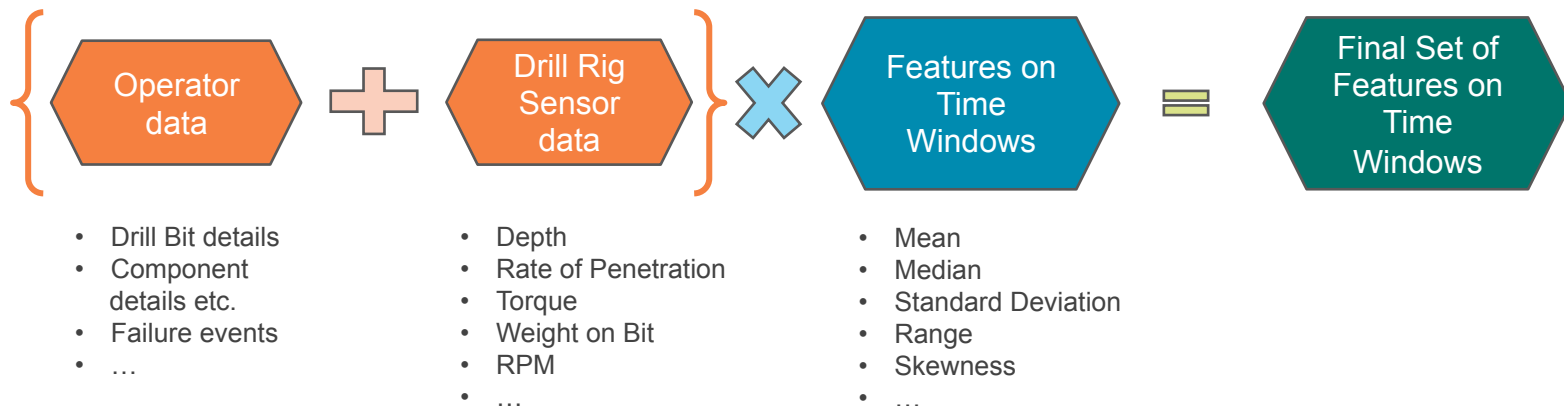
# How are models built using sensor data?



- A failure occurred at the end of this run
- Taking a window of time prior to failure, what features should we extract (e.g. variance of RPM, max bit position velocity)?



# Complex Feature Set Across Multiple Sources



Leverage GPDB / HAWQ (+ MADlib and PL/R if needed) for **fast computation of hundreds of features** over time windows within billions of rows of time-series data

# How are models built using sensor data?



**Predict occurrence of equipment failure in a chosen future time window**

- Logistic Regression
- Elastic Net Regularized Regression (Binomial)
- Support Vector Machines

**Predict remaining life of equipment**

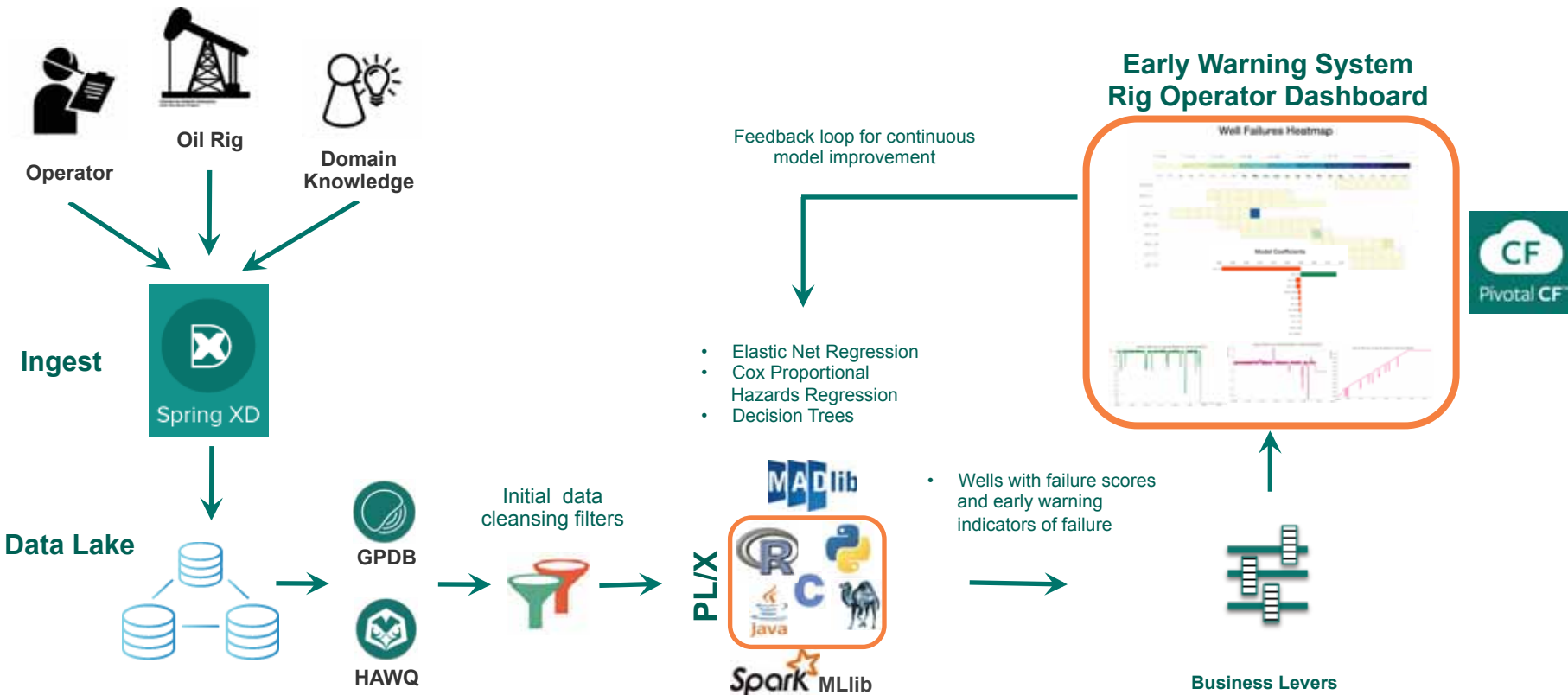
- Cox Proportional Hazards Regression

**Predict Rate-of-Penetration**

- Linear Regression
- Elastic Net Regularized Regression (Gaussian)
- Support Vector Machines



# IoT Predictive Maintenance App Pipeline

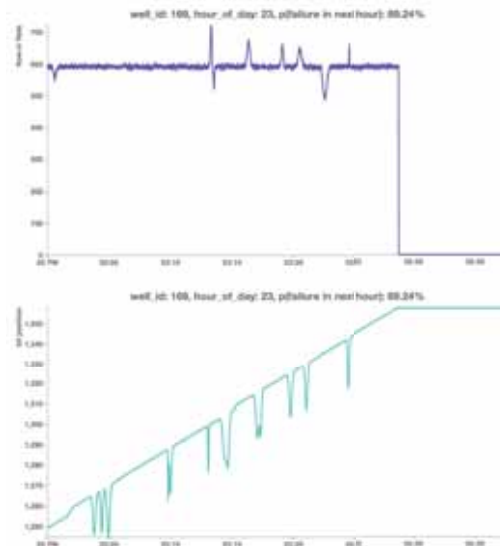
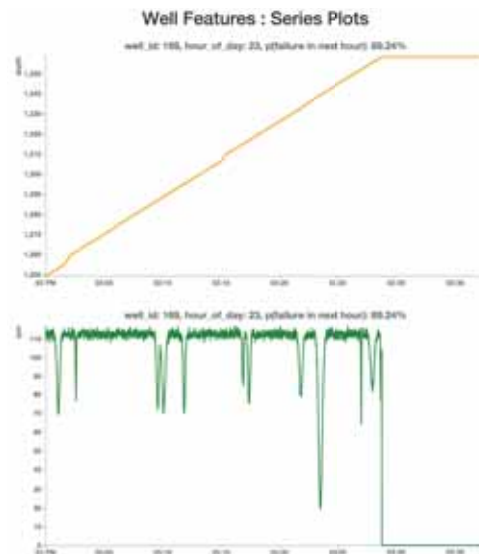
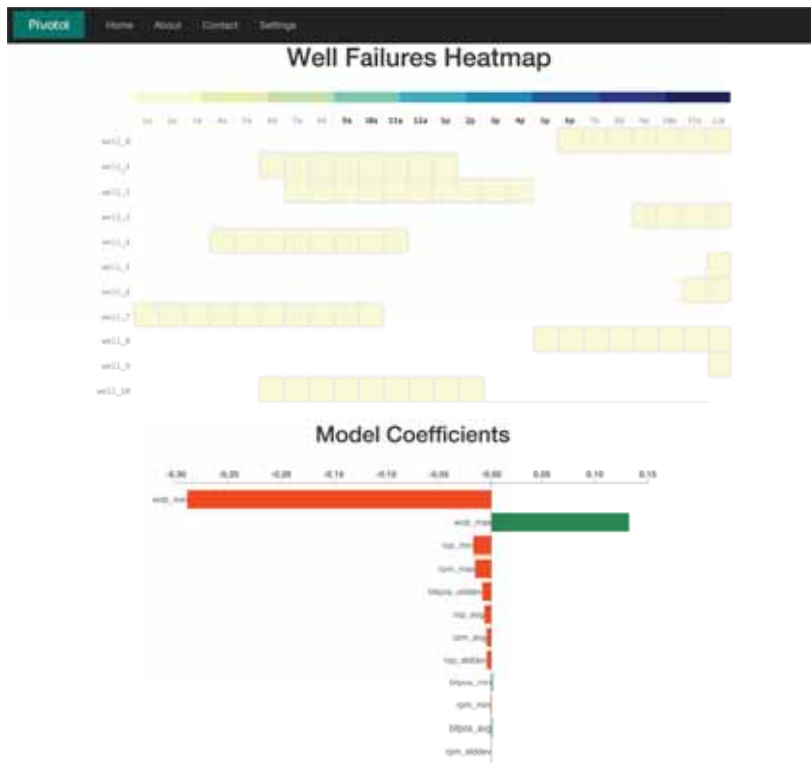


Operator icon: Created by Bjorn Andersson from the Noun Project  
Oil Rig icon: Created by Gabriele Malaspina from the Noun Project  
Domain Knowledge icon: Created by Till Teenck from the Noun Project

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# Demo



A photograph of the Golden Gate Bridge in San Francisco, viewed from a low angle looking down the length of the bridge towards the foggy horizon. The bridge's iconic orange-red towers and suspension cables are visible against a hazy, blue-tinted sky and water.

Let's build something  
**MEANINGFUL**

A dark, atmospheric photograph of the Golden Gate Bridge in San Francisco, viewed from a low angle looking up at the suspension tower. The bridge's red-orange structure contrasts with the dark, misty sky and the rugged, rocky cliffs in the foreground.

# Pivotal<sup>®</sup>

Transforming How The World Builds Software