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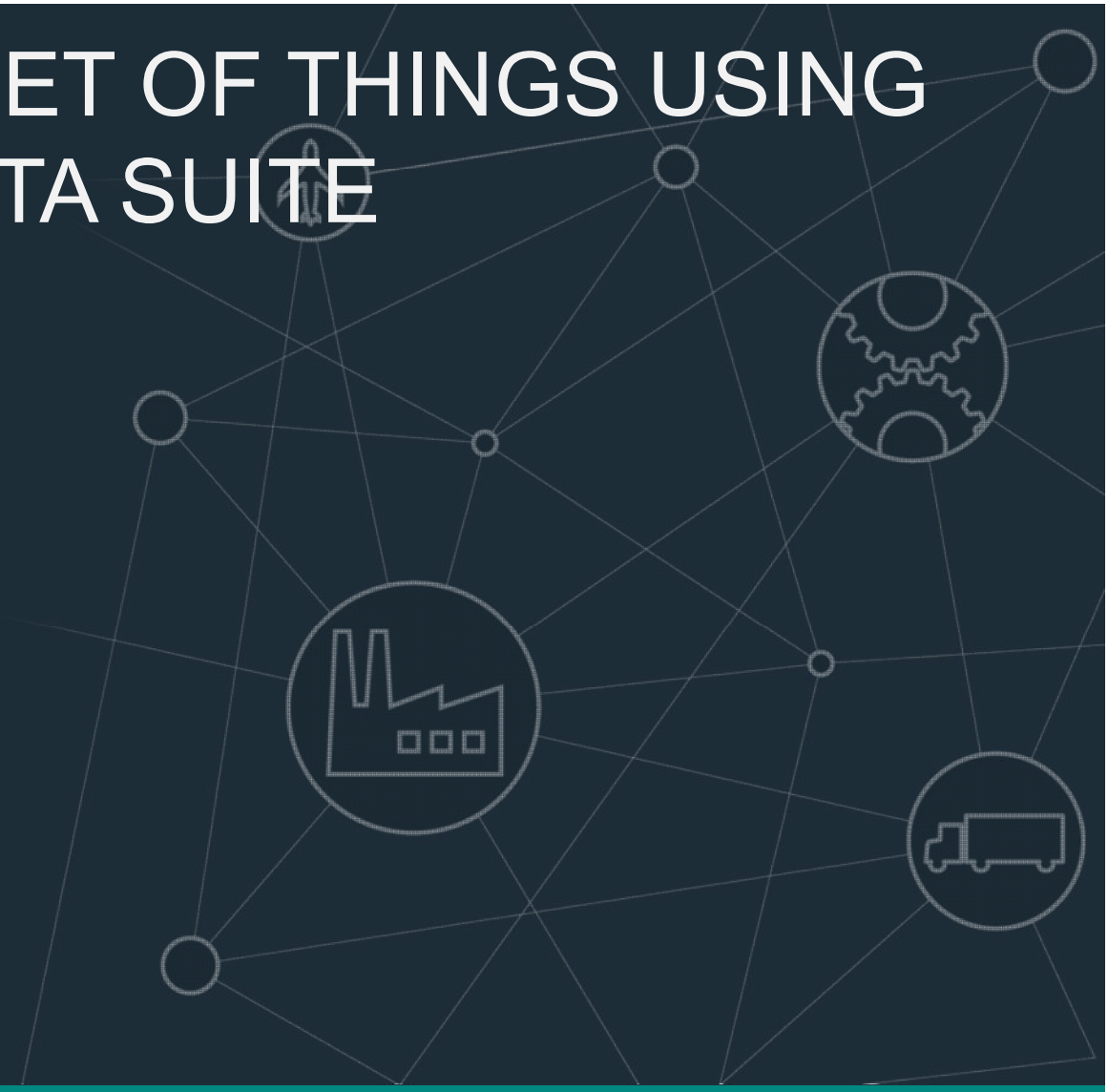
ANALYZING INTERNET OF THINGS USING BIG DATA SUITE



Internet of Things matter for...

- Industrial Manufacturers
- Transportation
- Healthcare, Life Sciences
- Financial Services
- Retail
- Telecom and Media

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THE POWER OF 1

Driving Outcomes That Matter

Increasing
Freight Utilization Rail

Predictive
Maintenance Healthcare

Predictive
Diagnostics Power

One Percent Improvement Equals

$27B
Industry Value by Reducing System Inefficiency

$63B
Industry Value by Reducing Process Inefficiency

$66B
Industry Value with Efficiency Improvements In Gas-fired Power Plant Fleets

Source: General Electric

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THE INTERNET OF THINGS JOURNEY

STORE	ANALYZE	DEVELOP	INNOVATE
• Structured • Unstructured • High Volume • High Velocity	• Predictive Analytics • Machine Learning • Advance Data Science • Realtime Analytics	• Advanced Analytic Pipelines • Realtime Analytical Applications • Global Scale Data-Driven Applications • Enterprise, Consumer, IoT, and Mobile	• Agile Dev Expertise • DevOps • Hybrid Cloud • Continuous Delivery • Closed Loop Applications

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LARGE ENTERPRISE BIG DATA TROUBLE

80% of CEOs thinking data mining and analysis are strategically important (1)

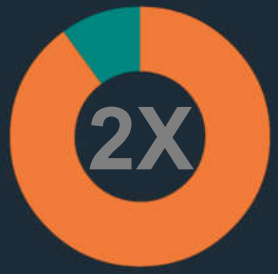
0% of CIOs think their IT infrastructure is fully prepared for big data (3)

44% of new applications failed to meet performance expectations (5)

But…

4% of companies use analytics effectively (2)

30% of companies have deployed advanced analytics, 11% big data analysis (4)



90% of companies allocate at least 2X more cloud capacity than needed to ensure performance (6)

(1) 2015 PWC CEO Survey; (2)2013 Baine and Company - The Value of Big Data; (3) 2014 IT Infrastructure Conversation - IBM; (4) Ernest and Young - 2014 Enterprise IT Trends and Investments; (5) 2014 Riverbed Tecnologies - The Transformers; (6) 2014 ElasticHosts CIO Study

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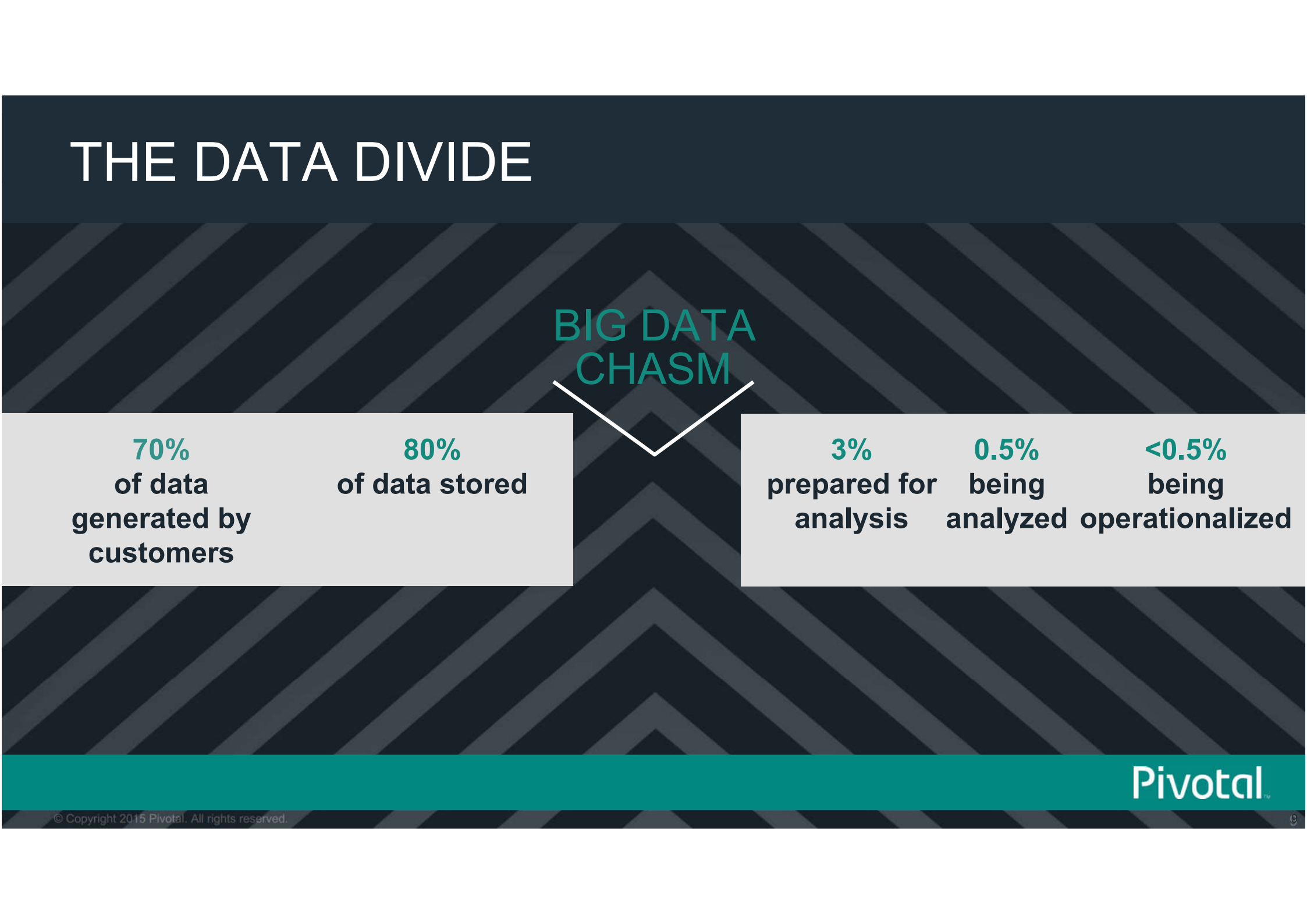
THE DATA DIVIDE



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SOFTWARE IS EATING THE WORLD





Data Is Fueling Software

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ACROSS INDUSTRIES

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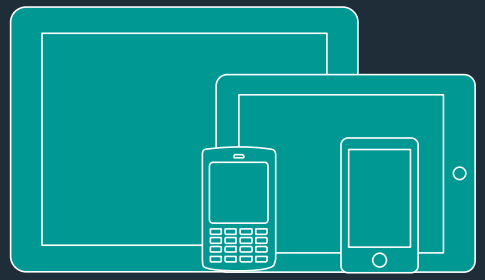
THE NEW DATA IMPERATIVES

Converged
Data & Cloud



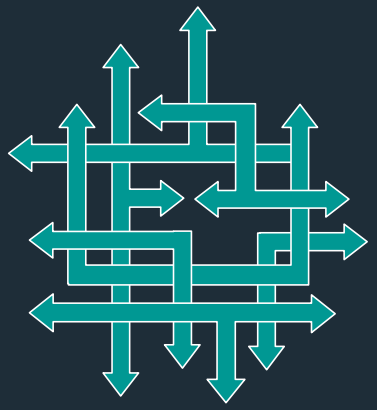
Data-Driven
Apps

Open

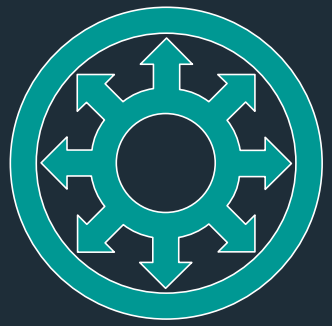
Pivotal

THE BIG DATA PROBLEM

Fragmentation



Complexity



Constraints

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GUIDING PRINCIPLES IN THE NEW ERA

OPEN	AGILE	CLOUD-READY
• Remove Lock-in • Leverage Ecosystem • Co-innovate	• Shorten innovation cycles • Reduce TCO • Improve TTM	• Solve business problems • Avoid lock-in • Appropriate security

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JOURNEY TO A DATA-DRIVEN ENTERPRISE

Perform advanced analytics
Discover insights

Deploy analytic apps and
automate at scale

Modernize data
infrastructure

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DATA-DRIVEN COMPANIES:

USE MODERN DATA INFRASTRUCTURE

Perform advanced analytics
Discover insights

Deploy analytic apps and
automate at scale

Modernize data
infrastructure

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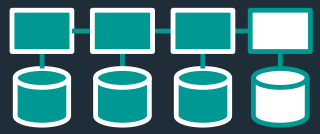
MODERNIZE DATA INFRASTRUCTURE

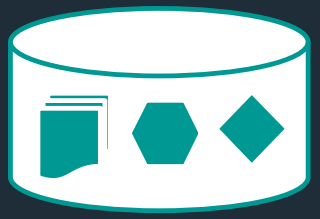
REQUIREMENTS



Elastic, Scale-out
storage and processing

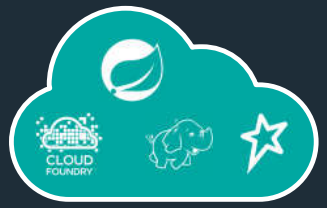
BENEFITS

Higher quality analytics
Lowered storage/processing cost



Flexible data types and
pipelining

ETL on demand: low operational cost
Expanded use cases



Cloud friendly and
open-source based

Less fragmented ecosystem
Reduced vendor lock-in

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DATA-DRIVEN COMPANIES:

STRATEGICALLY USE ADVANCED ANALYTICS

Perform advanced analytics
Discover insights

Deploy analytic apps and automate at scale

Modernize data infrastructure

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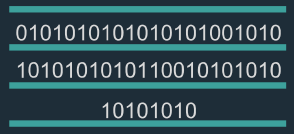
ADVANCED ANALYTICS

REQUIREMENTS



Massive stream processing

SQL- compliant batch and interactive queries

Machine learning and advanced analytics

BENEFITS

Internet of Things use cases
Rapid time to insights

Leverage existing skills and tools
Rapid time to insights

Solve business problems
Predictive insights: proactive execution

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DATA-DRIVEN COMPANIES:

INNOVATE AT SCALE

Perform advanced analytics
Discover insights

Deploy analytic apps and
automate at scale

Modernize data
infrastructure

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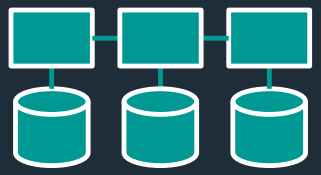
ANALYTIC APPS AND AUTOMATION AT SCALE

REQUIREMENTS



Resilient, scale-out
messaging and object storage

Agile analytic app-dev
with enterprise PaaS

Low-latency, distributed
in-memory transactions

BENEFITS

Reduced time to insights
Flexible ingestion: low operating cost

Reduced time to action
Low ‘analytics ⇔ app-dev’ integration cost

High performance: low operating cost
Transactional safety: business critical ops

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JOURNEY TO A DATA-DRIVEN ENTERPRISE

Perform advanced analytics
Discover insights

Pivotal Data Science
helps you move from BI to Data Science

Deploy analytic apps and automate at scale

Pivotal Labs
helps you move to an agile development of apps at scale

Modernize data infrastructure

Pivotal Data Engineering
helps you move from data administration to data engineering

Pivotal

GUIDING PRINCIPLES IN THE NEW ERA

OPEN	AGILE	CLOUD-READY
• Remove Lock-in • Leverage Ecosystem • Co-innovate	• Shorten innovation cycles • Reduce TCO • Improve TTM	• Solve business problems • Avoid lock-in • Appropriate security

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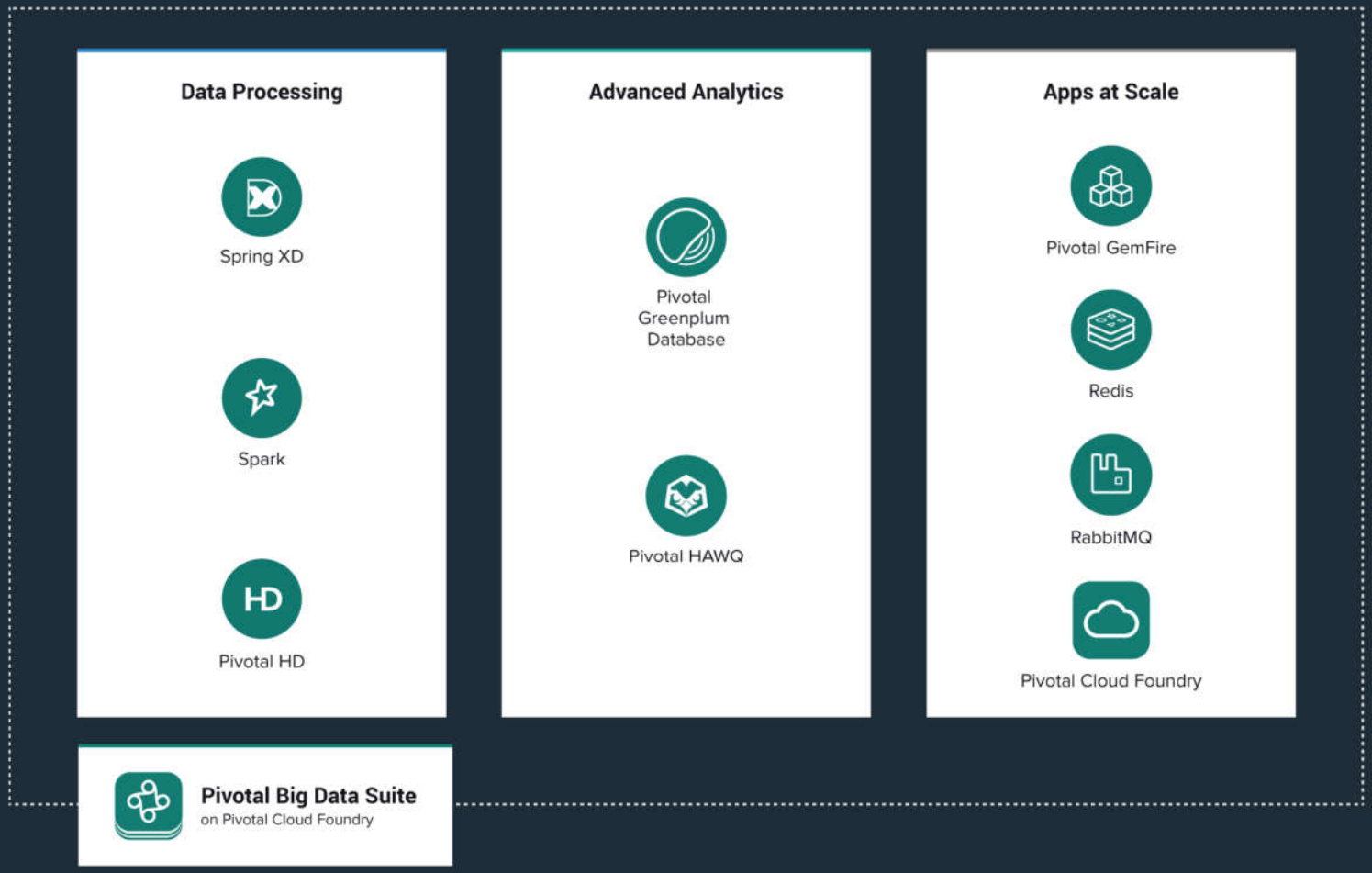
PIVOTAL BIG DATA SUITE

OPEN	AGILE	CLOUD-READY
World's First Open Sourced, Enterprise-Class Data Portfolio + Open Data Platform	Modern Data Infrastructure + Advanced Analytics + Apps at Scale	Multiple Cloud Deployment Models + Big Data Suite on Pivotal Cloud Foundry

Pivotal

PIVOTAL BIG DATA SUITE



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WORLD'S FIRST OPEN SOURCED BIG DATA PORTFOLIO

BUILDING ON SUCCESS OF CLOUD FOUNDRY FOUNDATION

Open sourcing all Pivotal Big Data Suite components including:

Pivotal **GemFire**

Pivotal
Greenplum Database

Pivotal **HAWQ**

BUILT FOR ENTERPRISES

Pivotal

BUILT FOR ENTERPRISES

Value added features: enterprise grade performance + robustness without lock-in

- Advanced Query Optimization in analytics
- WAN replication and continuous query in transactional processing

Flexible Deployment models: align to business objectives and needs

- Balance cost objectives with policy and compliance requirements
- Leverage Pivotal's pre-integration + certification on supported configurations

Enterprise grade support: one throat to choke for the suite

- Focus on business problems – not on lifecycle management
- Expert support on Big Data Suite means reduced business risk

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OPEN

- Common core for Hadoop ecosystem
- Rapidly accelerated certifications, ecosystem development and enterprise-grade quality

OPEN DATA PLATFORM

OpenDataPlatform.org

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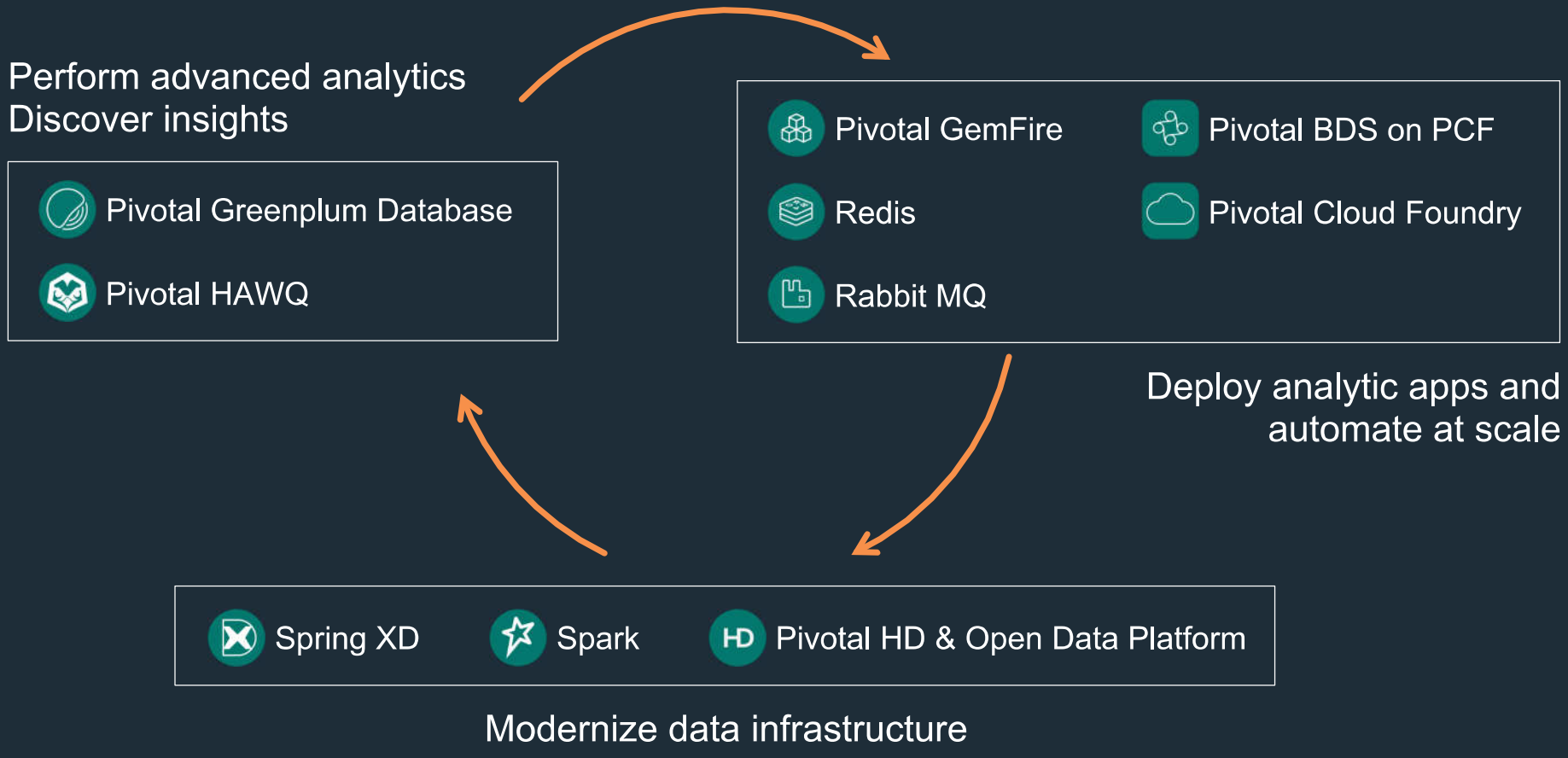
AGILE



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CLOUD-READY

COMMODITY HARDWARE

APPLIANCE

CLOUD

HYBRID CLOUD

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THE INTERNET OF THINGS JOURNEY WITH PIVOTAL BIG DATA SUITE

STORE	ANALYZE	DEVELOP	INNOVATE
• Structured • Unstructured • High Volume • High Velocity	• Predictive Analytics • Machine Learning • Advance Data Science • Realtime Analytics	• Advanced Analytic Pipelines • Realtime Analytical Applications • Global Scale Data-Driven Applications • Enterprise, Consumer, IoT, and Mobile	• Agile Dev Expertise • DevOps • Hybrid Cloud • Continuous Delivery • Closed Loop Applications
Data Engineering	Data Science	Pivotal Labs	
Spring XD Spark Pivotal HD & Open Data Platform	Spring XD Pivotal Greenplum Database Pivotal HAWQ	Spring XD Pivotal GemFire Redis Rabbit MQ	Spring IO Groovy Pivotal BDS on PCF Pivotal Cloud Foundry

ENTERPRISE PAAS

AGILE DEVELOPMENT

PREDICTIVE ANALYTICS

BIG DATA

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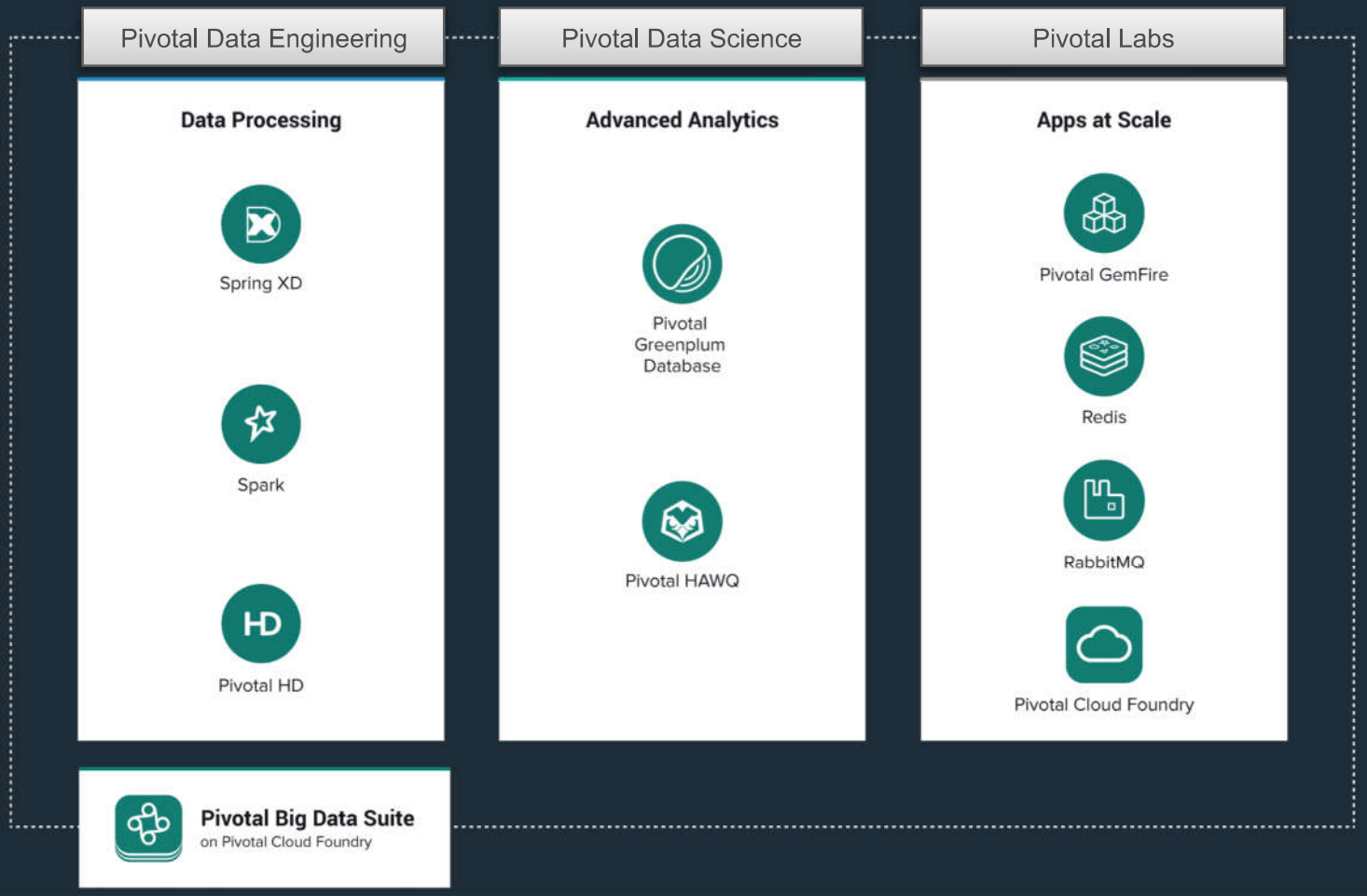
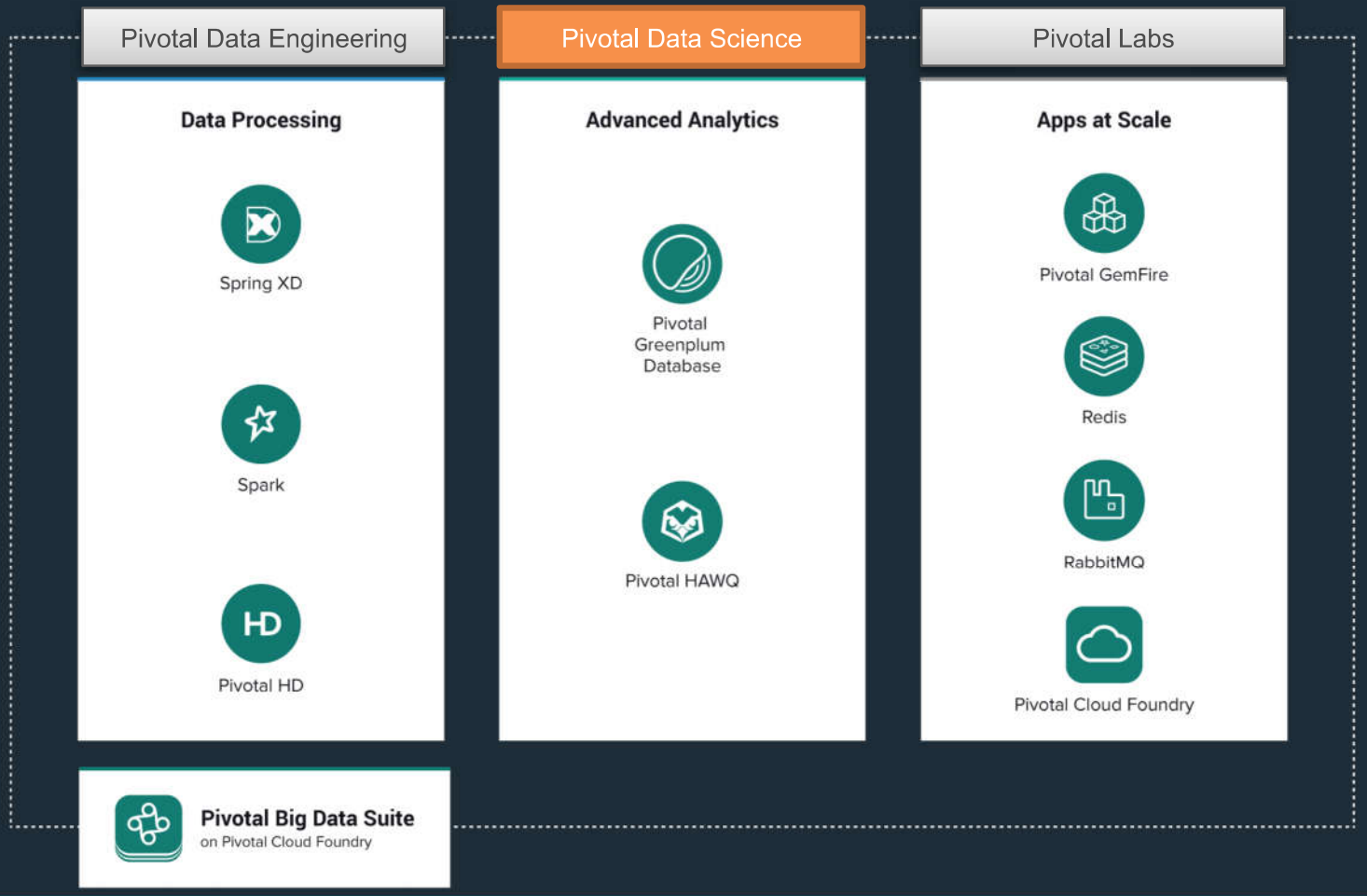
WHY PIVOTAL FOR BIG DATA ?



- Complete platform
- SQL on Hadoop leadership
- Deployment options
- Open source
- Flexible licensing
- Advanced data services

Pivotal

WHY PIVOTAL FOR BIG DATA ?



- Complete platform
- SQL on Hadoop leadership
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FOR FURTHER INFO, CHECKOUT…

- Pivotal Data Product Info, Docs and Downloads @ http://pivotal.io/big-data
- Pivotal Blog @ http://blog.pivotal.io
- Pivotal Data Science Blog @ http://blog.pivotal.io/data-science-pivotal
- Pivotal Academy @ https://pivotal.biglms.com

Or reach out to your local Pivotal Account Executive…

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Pivotal Data Science Overview and Use Cases

Pivotal Big Data Roadshow

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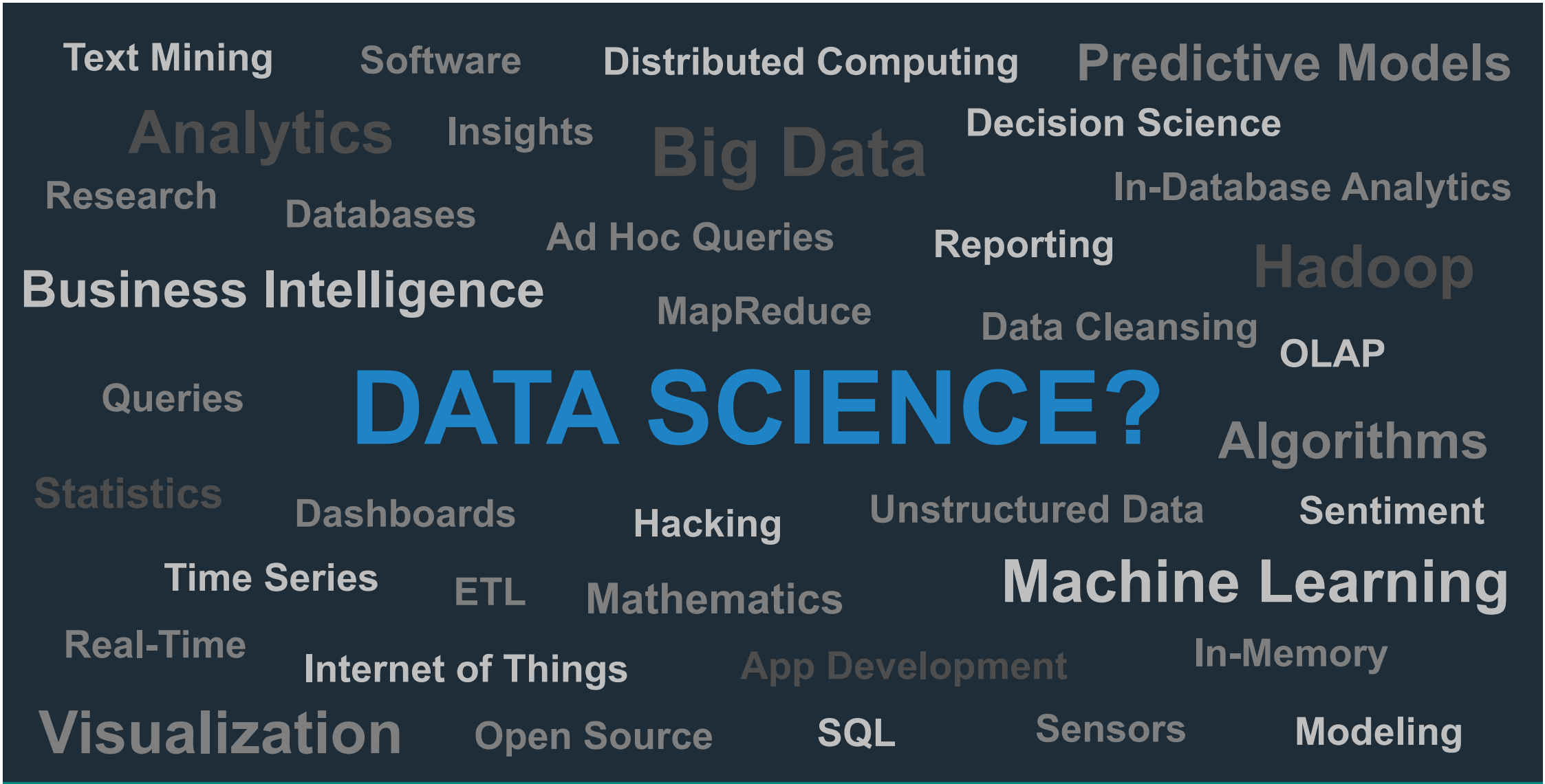

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Business Intelligence	Fields of Study & Techniques	Data Related	Implementation	Industry Buzzwords
• Dashboards • Insights • Visualization • Ad Hoc Queries • Reporting	• Algorithms • Mathematics • Time Series • Statistics • Predictive Modeling • Machine Learning • Text Mining • Sentiment • Map Reduce	• ETL • Unstructured • Data Cleansing • Sensors	• Software • In-Database Analysis • Distributed Computing • Hadoop • Open Source	• Big Data • Decision Science • Internet of Things • Real-Time • Hacking • In-Memory

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What is Data Science?

The use of statistical and **machine learning** techniques on **big multi-structured data** in a **distributed computing environment** to identify correlations and causal relationships, classify and predict events, identify patterns and anomalies, and infer probabilities, interest, and sentiment.

DRIVE AUTOMATED, LOW-LATENCY ACTIONS IN RESPONSE TO EVENTS OF INTEREST

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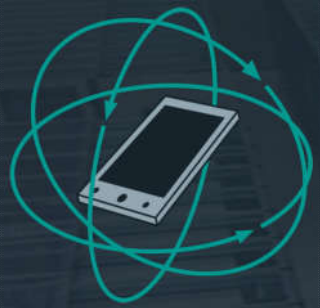
Billions of Data Points



Mobile Sensors

Video Surveillance

FACEBOOK UPLOADS
250 MILLION
PHOTOS EACH DAY

Social Media

READING SMART METERS
EVERY 15 MINUTES IS
3000X MORE
DATA INTENSIVE

Smart Grids

Medical Imaging

OIL RIGS GENERATE
25000
DATA POINTS
PER SECOND

Oil Exploration

Stock Market

COST TO SEQUENCE
ONE GENOME
HAS FALLEN FROM
$100M IN 2001
TO $10K IN 2011
TO $1K IN 2014

Gene Sequencing

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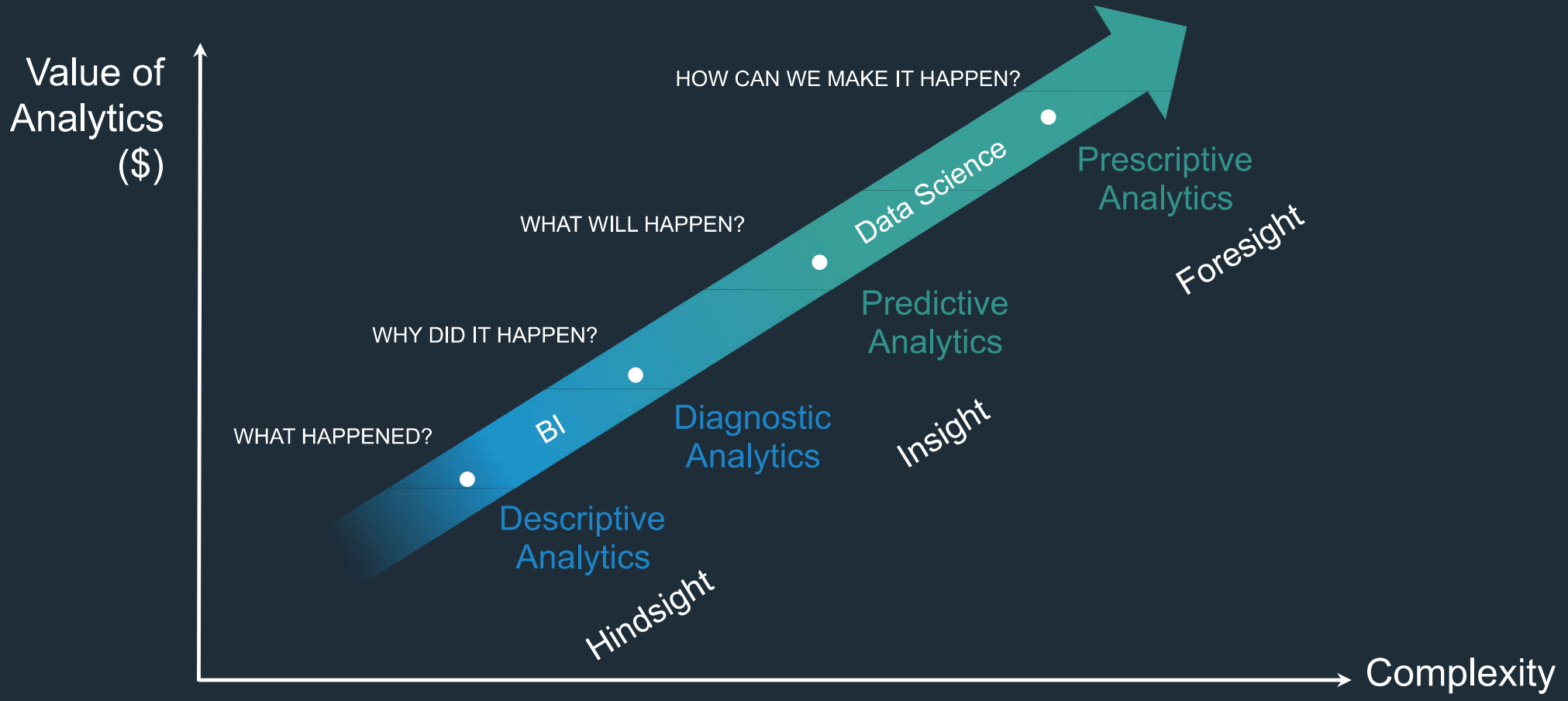
What is Big Data Analytics?



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Data Science Toolkit

KEY TOOLS

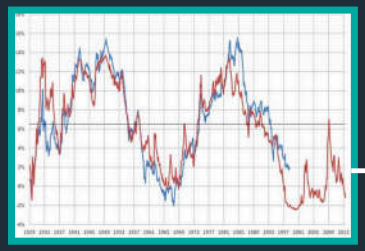
KEY LANGUAGES

PLATFORM

Pivotal

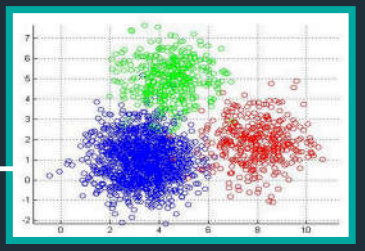
Analytics with Pivotal

A single address for everything analytics

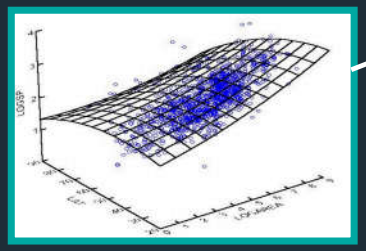


FORECASTING

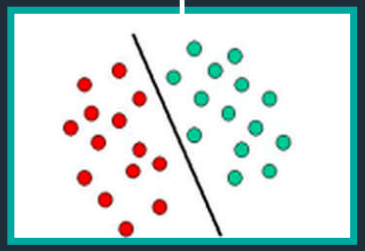
Time-to-Insights



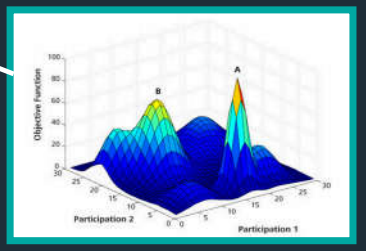
CLUSTERING



REGRESSION



CLASSIFICATION



OPTIMIZATION

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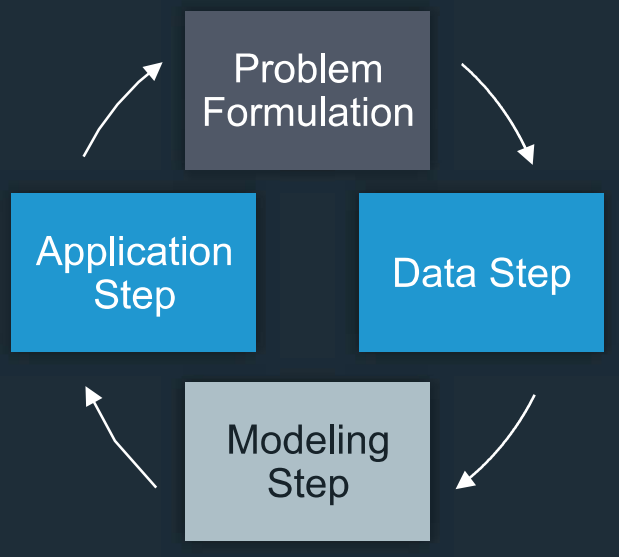
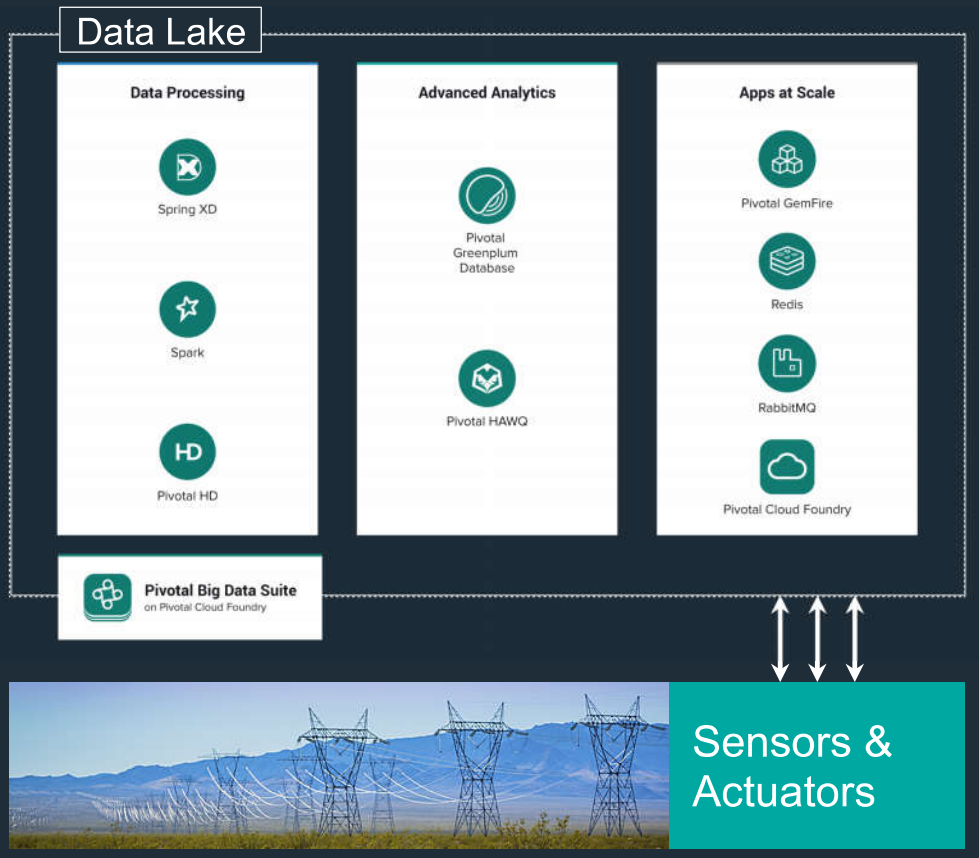
Smart Systems = Sensors + Digital Brain + Actuators



Data Science for Building Models



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Data Science Use Cases

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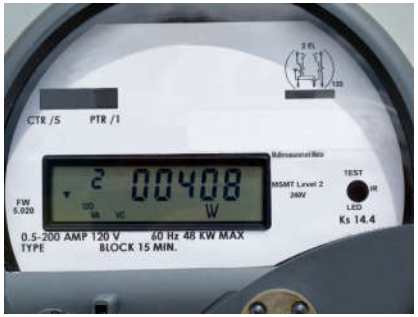
Smart Meter
Analytics

The Digital Brain: Making a Smart Grid Smarter!

Input:
Data from smart meters



The Digital Brain:
Uses Fourier transform extracts patterns and flags outliers/anomalies

Action:
Where (and when) to send trucks, preventive maintenance

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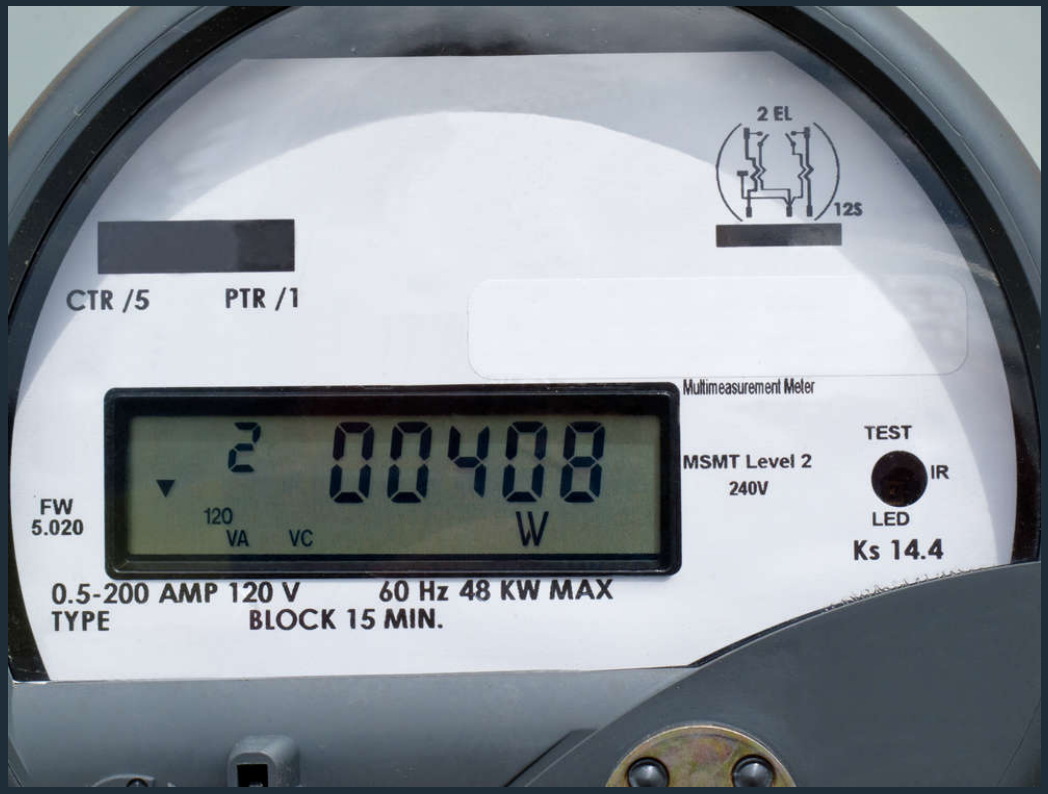
Smart Meter Analytics – Significant Use Cases

- Load profiling
- Theft prevention
- Demand prediction
- Load forecasting
- Root cause of power failures
- Black-out warning
- Anomaly detection
- Network topology error detection



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Electricity Network Load Profiling and Outlier Detection

CUSTOMER

A major smart grid infrastructure provider

BUSINESS PROBLEM

Profile power consumption patterns based on smart meter data and flag anomalous usage

CHALLENGES

- Large volume of smart meter data (several months of data from 100s of thousands of meters) could not be analyzed effectively by legacy system
- Timely business insights on large scale smart grid infrastructure demand fast processing of data

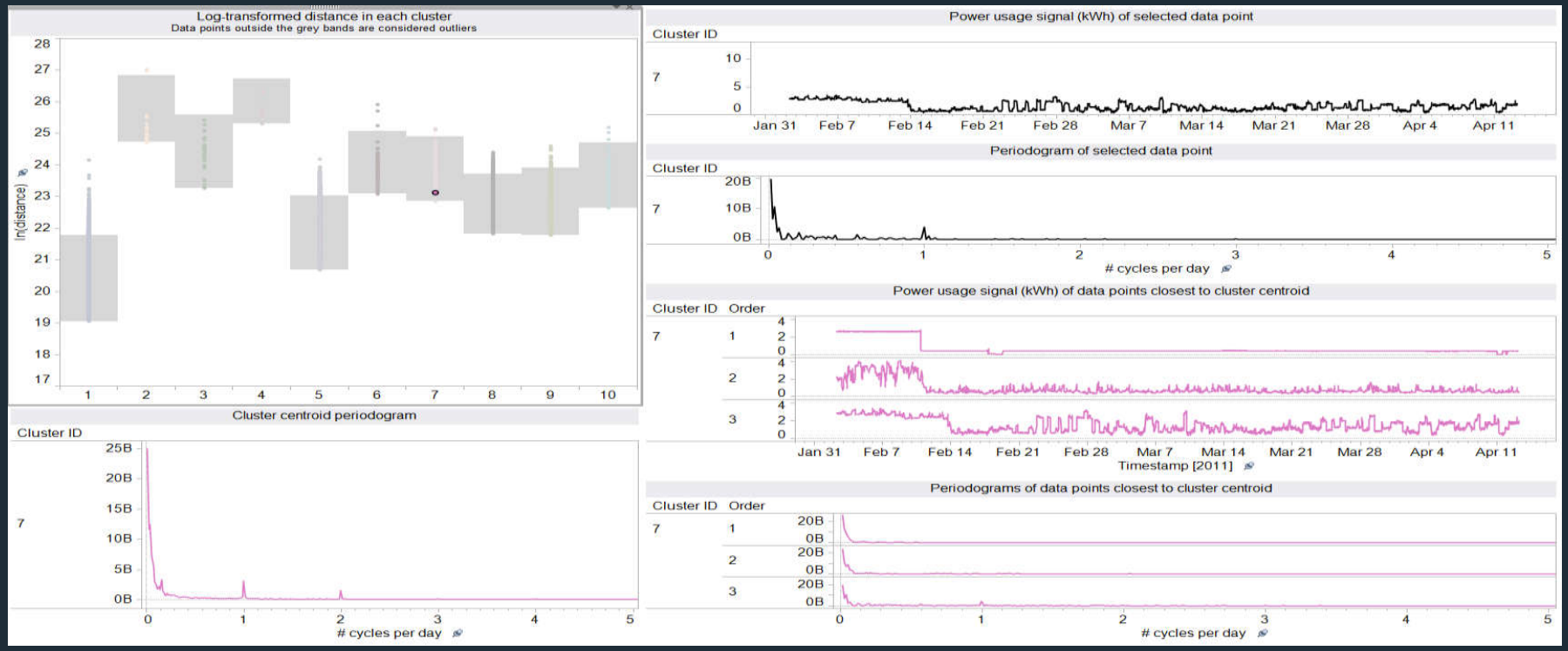
SOLUTION

- Analyze smart meter power data using unsupervised clustering techniques and **detect anomalies** based on distance metric in clusters
- **Reduce time** required to monitor and improve grid efficiencies
- Leveraged the MPP architecture of **Pivotal GPDB** and **MADlib in-database machine learning library** for fast computation at scale

Pivotal

Electricity Network Load Profiling and Outlier Detection

Dashboards for navigating clusters and outliers



Network Topology Error Detection

CUSTOMER

A major utility

BUSINESS PROBLEM

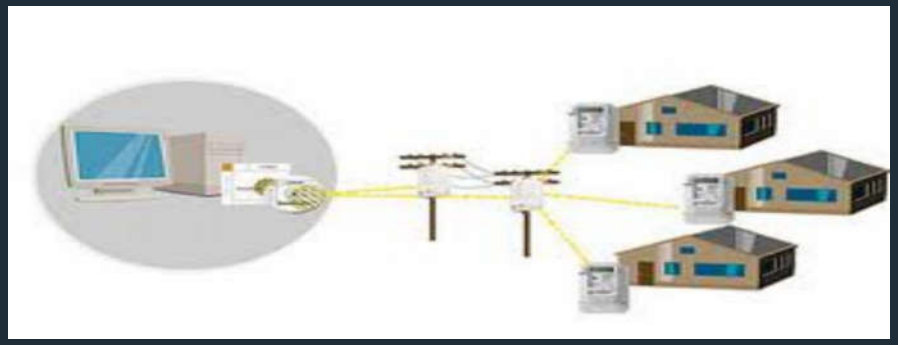
Use load and voltage meter readings to determine errors in transformer network topologies

CHALLENGES

- Time consuming process to detect network topology errors on entire network in legacy system
- Timely detection of network topology errors requires big data infrastructure and analytical capabilities

SOLUTION

- For each transformer network in parallel, solve an LP to determine scale of topology error, which can be used to flag and rank anomalous network topologies
- Reduce time for topology error detection from **several days/weeks to few minutes!**



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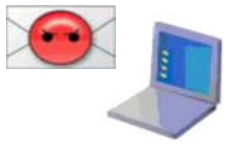
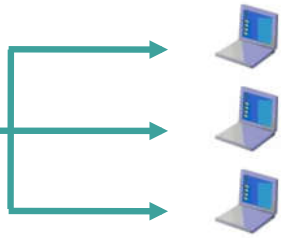
Security and Fraud
IT Security Detection

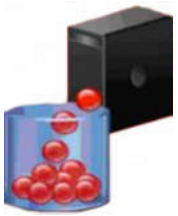
APT Kill Chain

Advanced Persistent Threat (APT)

1	2	3	4	5
Phishing & Zero Day Attack	**Back Door**	**Lateral Movement**	**Data Gathering**	**Exfiltrate**
A handful of users are targeted by two phishing attacks: one user opens Zero day payload (CVE-02011-0609)	The user machine is accessed remotely by Poison Ivy tool	Attacker elevates access to important user, service and admin accounts, and specific systems	Data is acquired from target servers and staged for exfiltration	Data is exfiltrated via encrypted files over ftp to external, compromised machine at a hosting provider







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Anomalous User-to-Resource Access Detection

BUSINESS PROBLEM

Detect anomalous user behaviors in the global enterprise computer network

SUMMARY

Given local-to-local communication data, identify anomalous users within an enterprise.

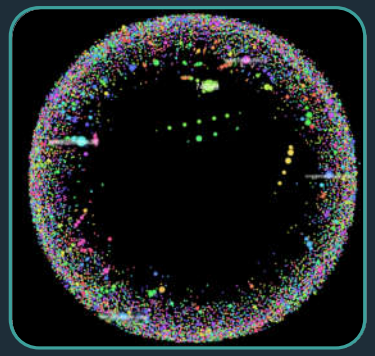
- Reduce malware-dwell time, typical 243 days
- Signature-based approaches cannot detect such behavior

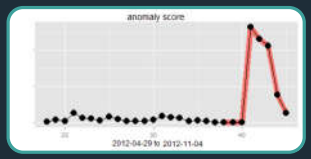
CHALLENGES

10 Billion events in 6 months; 15K+ network devices; No existing SIEM solutions can model user behavioral resource access baseline and enable anomaly detection in an adaptive and scalable architecture.

SOLUTION

An innovative Graph Mining based algorithmic framework with advanced Machine Learning. Network topology and temporal behaviors are both modeled. (Patent pending). Implemented in MPP and PL/R, enabling parallel model training and behavior risk scoring. Successfully identified DLP violating anomalous users.





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Financial
Services

Identifying and Pricing Cross-Sell Opportunities

CUSTOMER

A global financial services provider

BUSINESS PROBLEM

Identify cross-sell opportunities between two business arms of a financial institution.

CHALLENGES

Integration of large-scale data originating from multiple data warehouses. Developing predictive models to identify novel cross-sell opportunities within the financial institution. Evaluate the identified cross-sell opportunities by their revenue potential.

SOLUTIONS

- Fast integration of data in Pivotal Greenplum Database.
- Predictive models and evaluation of profitability:
  - Association rule.
  - Logistic regression for each product offered.
  - Estimation of revenue opportunity.
- On-demand reporting and visualization via custom dashboards connected to in-database models.

Pivotal

Credit Risk Assessment and Stress Testing

CUSTOMER

A global financial services provider

BUSINESS PROBLEM

Speed up the process of compliance reporting and stress testing for Basel III.

CHALLENGES

Running the calculation procedures on the customer's legacy database were time-consuming, therefore had to be done in overnight batch mode.

SOLUTION

- Implement risk asset calculation and stress testing on Pivotal Greenplum Database.
- Three years of data was processed in well under 2 minutes, significantly faster than the customer's current procedures.
- Connect an "in-database" visualization tool to Pivotal Greenplum Database via ODBC for on-demand reporting and visualization.

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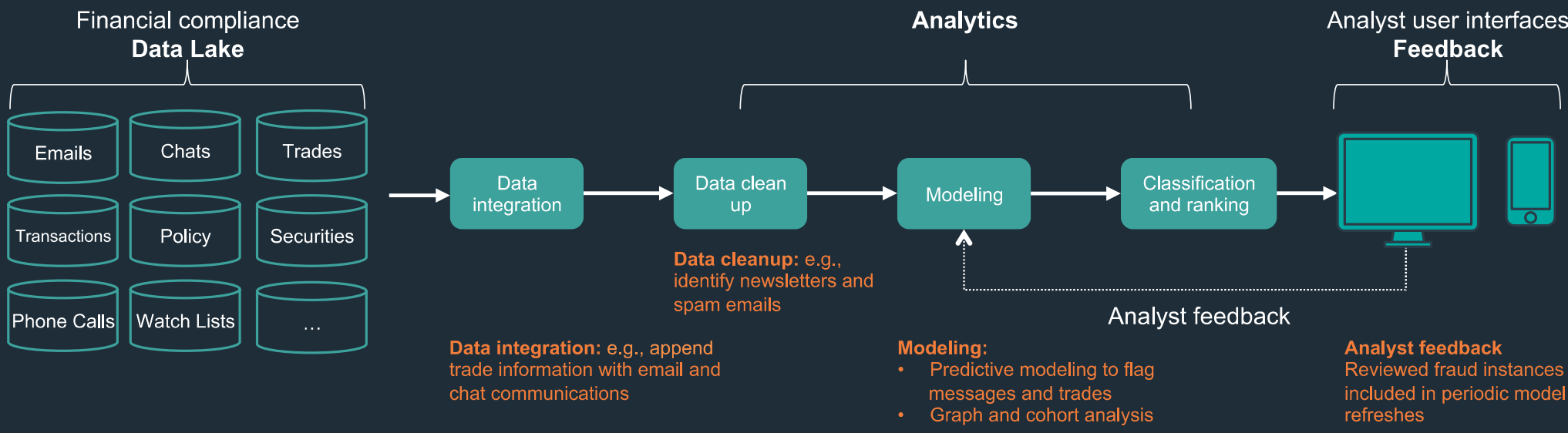
Financial Compliance

BUSINESS PROBLEM

- Ensure compliance with Dodd-Frank and Basel Committee regulations
- Identify underlying risk and fraud while reducing the compliance department's overburdened

SOLUTION

- A data lake platform coupled with cutting edge data science techniques
- Flexible user interface to promote an adaptive, continuously learning compliance framework



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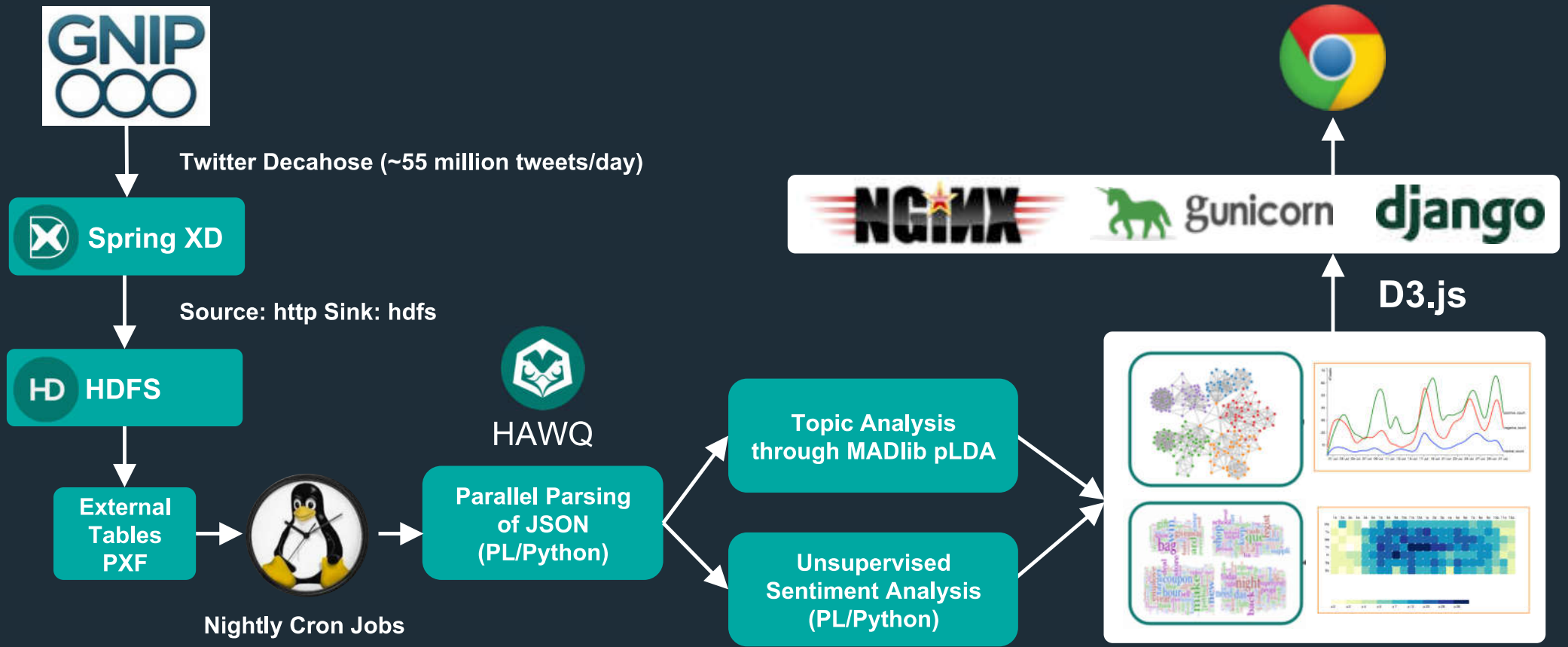
Pivotal Topic & Sentiment Analysis Engine



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Check out the Pivotal Data Science Blog!

http://blog.pivotal.io/data-science-pivotal

FOR FURTHER INFO…

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Data Streaming and IoT

Using Pivotal Big Data Suite

Pivotal™

The Journey to the Data-Driven Enterprise

Converging Trends

Innovation

New Data ***New Processes*** ***New Insights***

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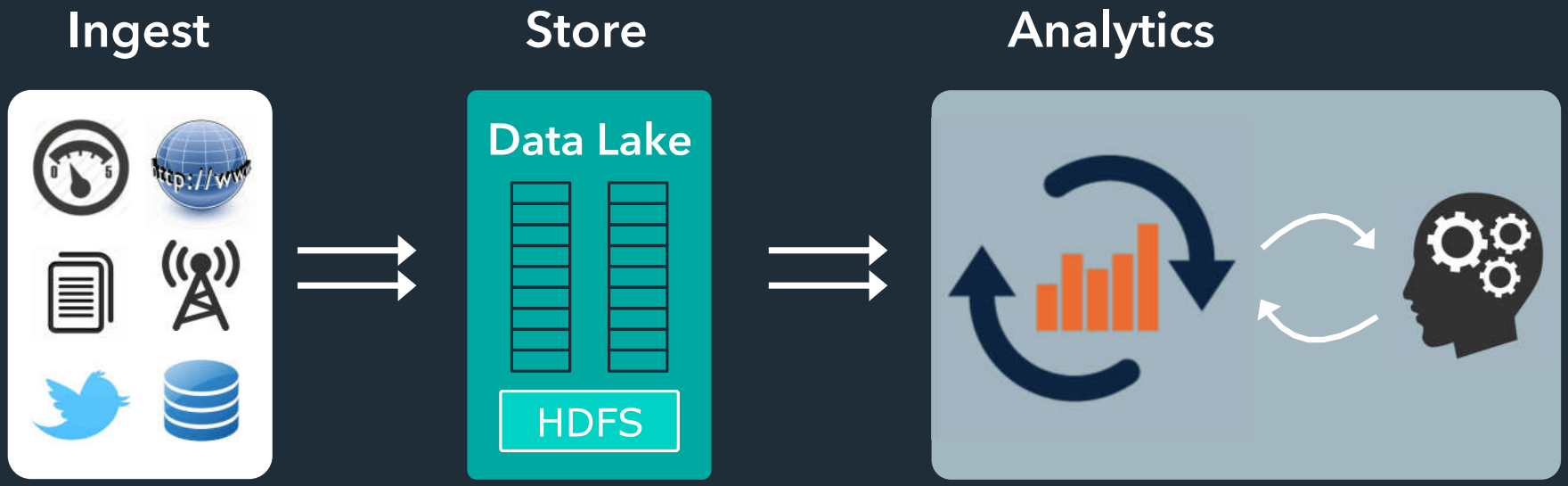
Migrating from a Reactive, Static and Constrained Model…



Coding based
No real-time information
Based on expensive ETL

Hard to change
Labor intensive
Inefficient

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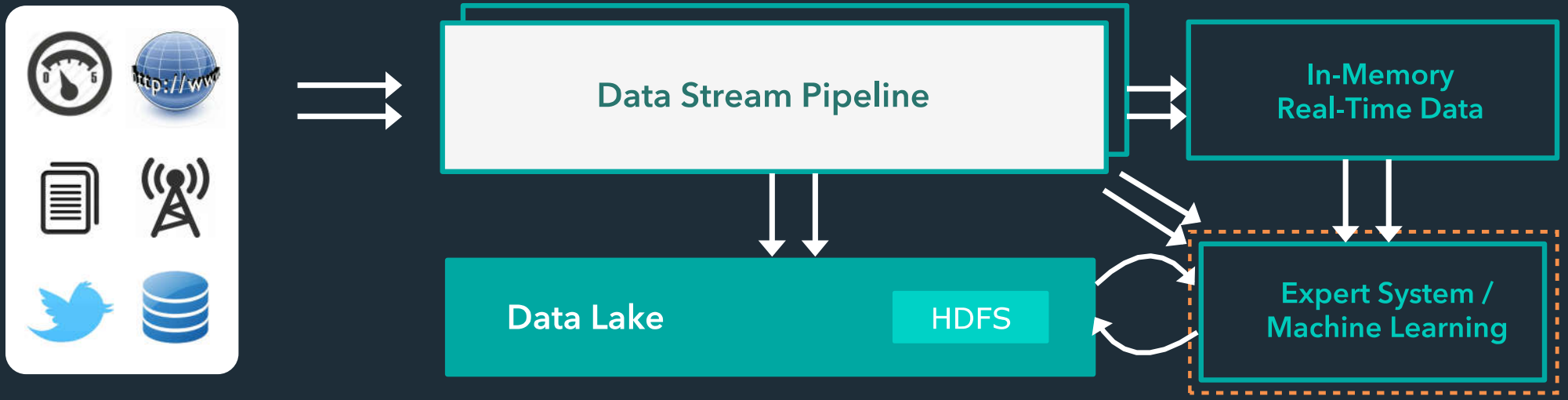
To Pro-Active, Self-Improving, Machine Learning Systems



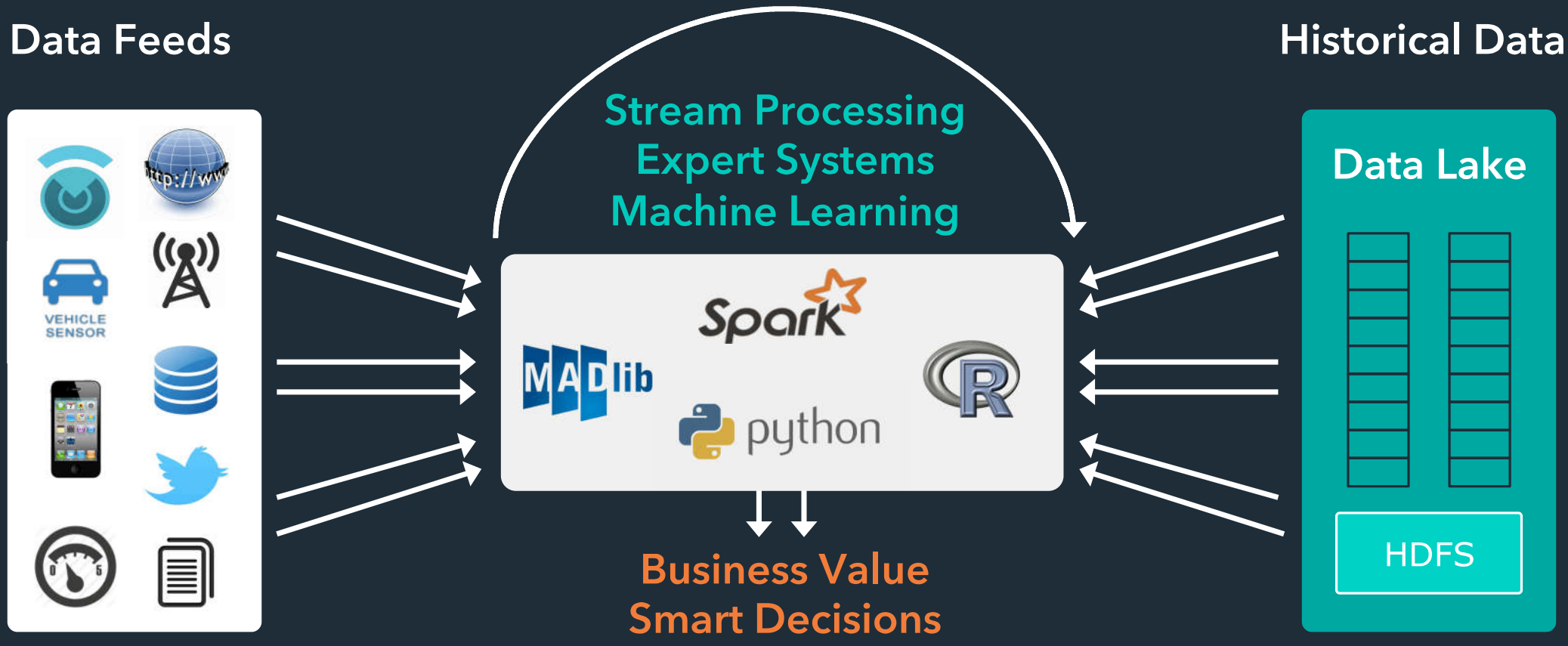
Multiple Data Sources
Real-Time Processing
Store Everything

Continuous Learning
Continuous Improvement
Continuous Adapting

Pivotal


“
50-80% OF THE TIME ON DATA SCIENCE PROJECTS IS SPENT ON DATA WRANGLING
”
New York Times Research: http://www.nytimes.com/2014/08/18/technology/for-big-data-scientists-hurdle-to-insights-is-janitor-work.html

Still…



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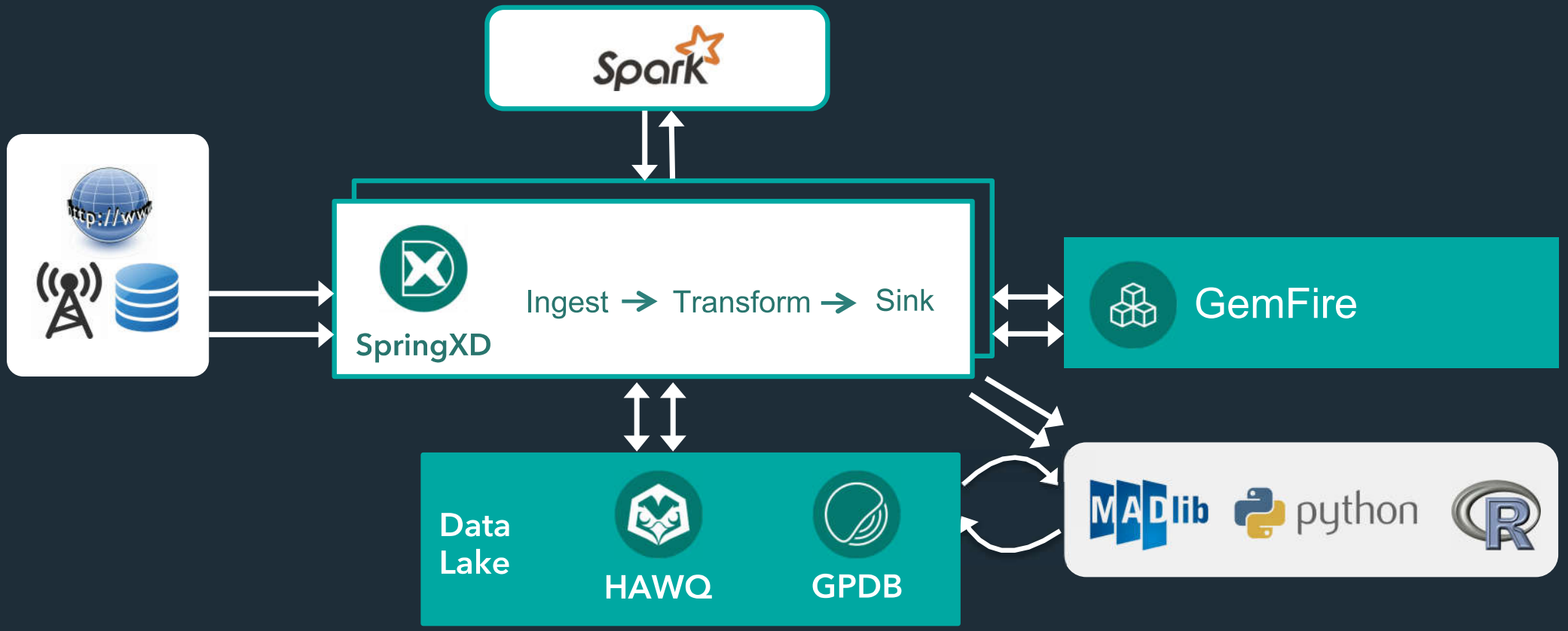
Data Stream Needs an Agile, Scalable and Fast Solution



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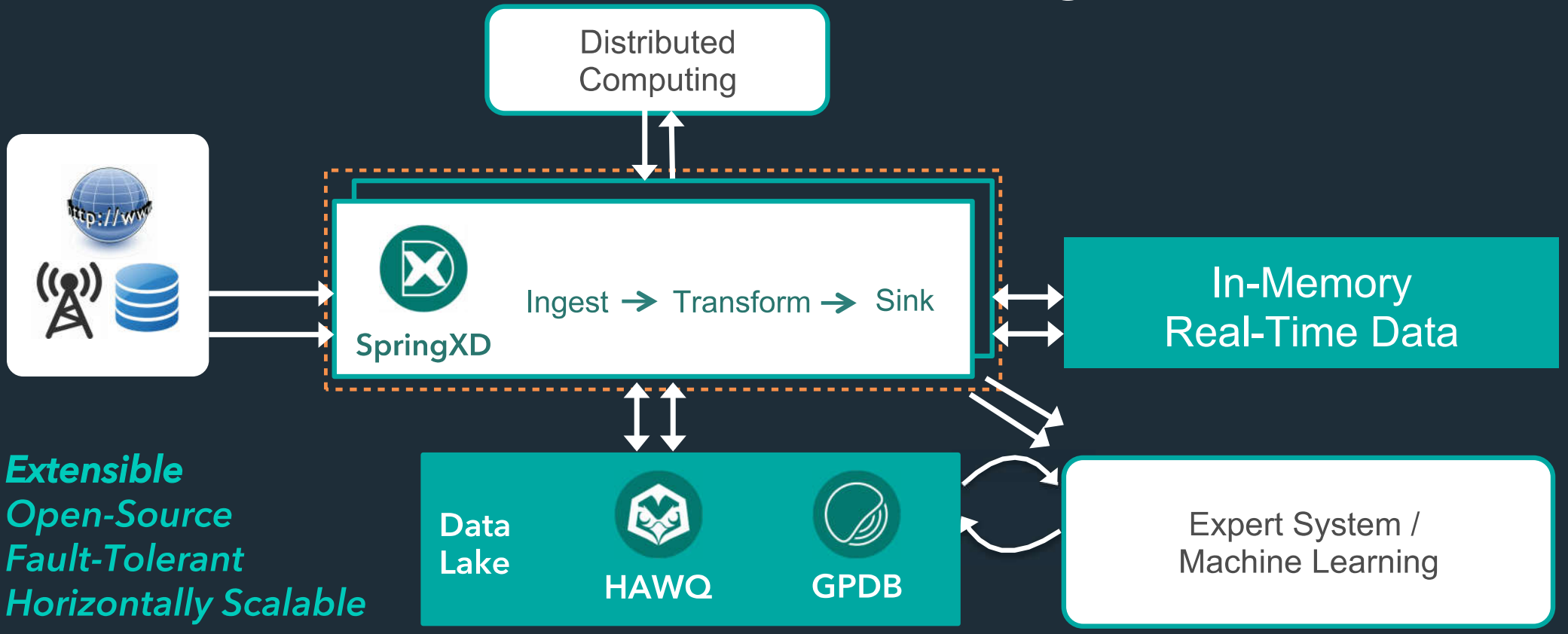
Spring XD Orchestrates and Automates all the Steps on Data Stream Pipelining



Extensible
Open-Source
Fault-Tolerant
Horizontally Scalable

Pivotal

Spring XD

State of the Art Data Pipeline Automation

INGEST / SINK

- No coding required
- Dozens of built-in connectors
- Seamless integration with Kafka, Sqoop
- Create new connectors easily using Spring

PROCESS

- Call Spark, Reactor or RxJava
- Built-in configurable filtering, splitting and transformation
- Out-of-box configurable jobs for batch processing

ANALYZE

- Import and invoke PMML jobs easily
- Call Python, R, Madlib and other tools
- Built-in configurable counters and gauges

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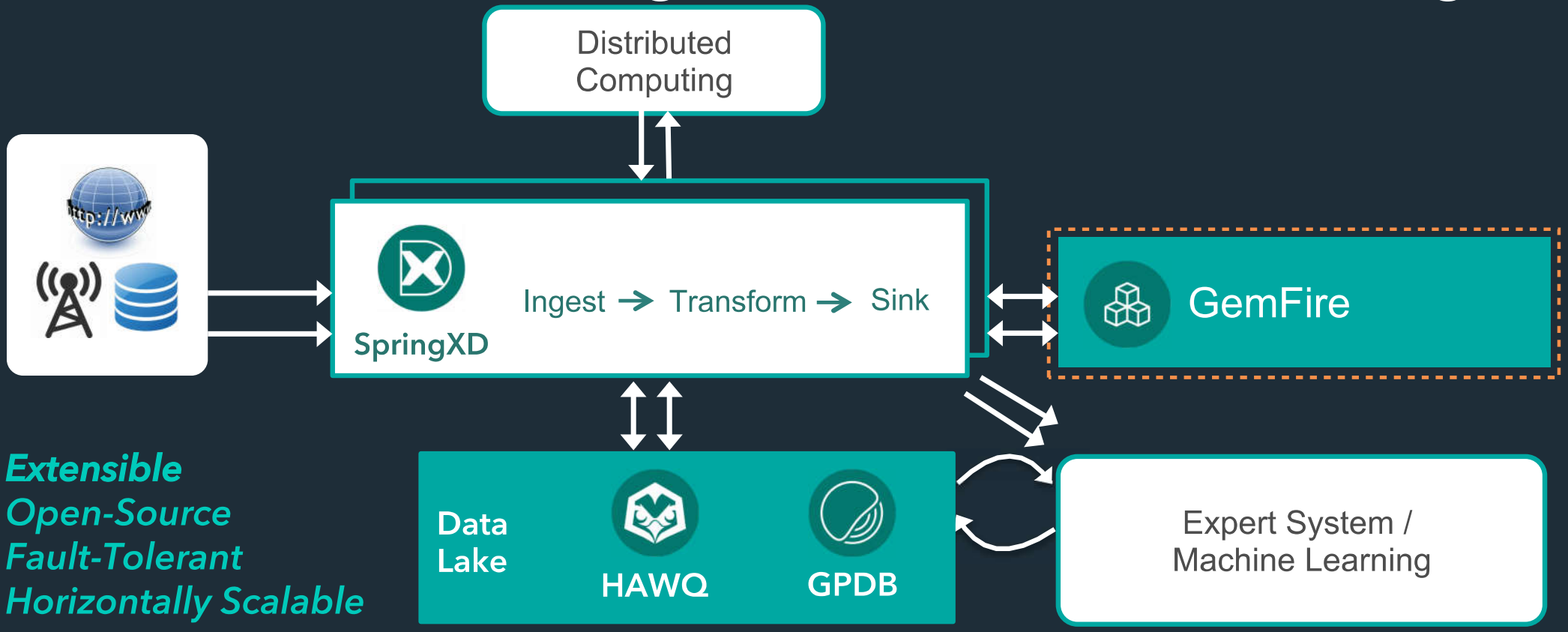
GemFire Provides Scalable, Low-Latency Data Access, Storage and Event Processing



Extensible
Open-Source
Fault-Tolerant
Horizontally Scalable

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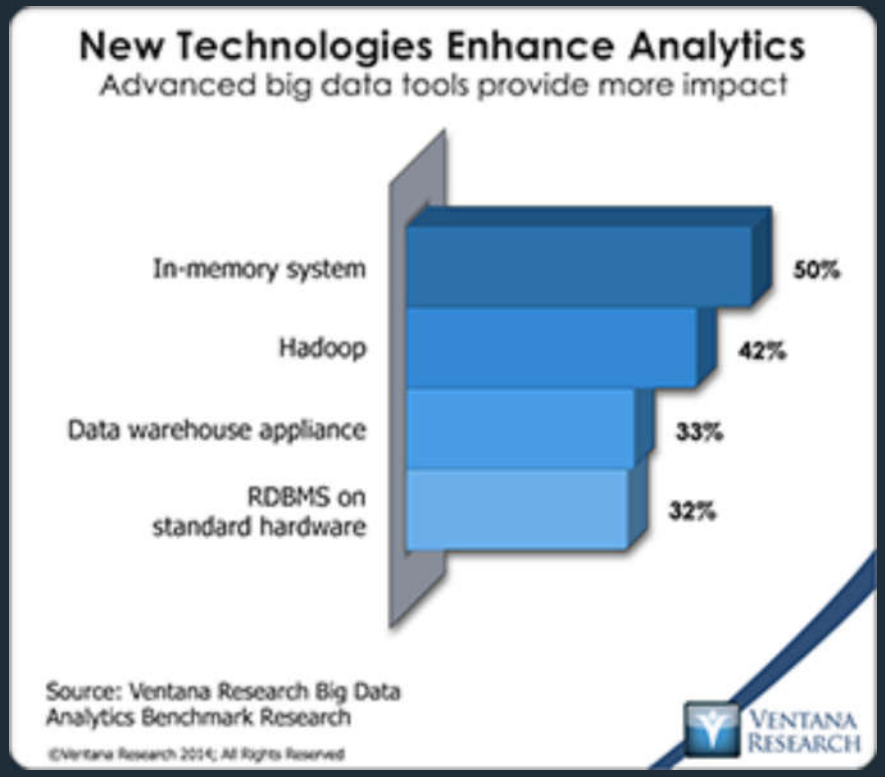
GemFire

In-memory Real Time Data

- In-Memory Enterprise Data Grid
- Horizontally Scalable, Consistent, Highly Available
- Event handling
- Continuous Queries
- Enterprise Data Geo Distribution



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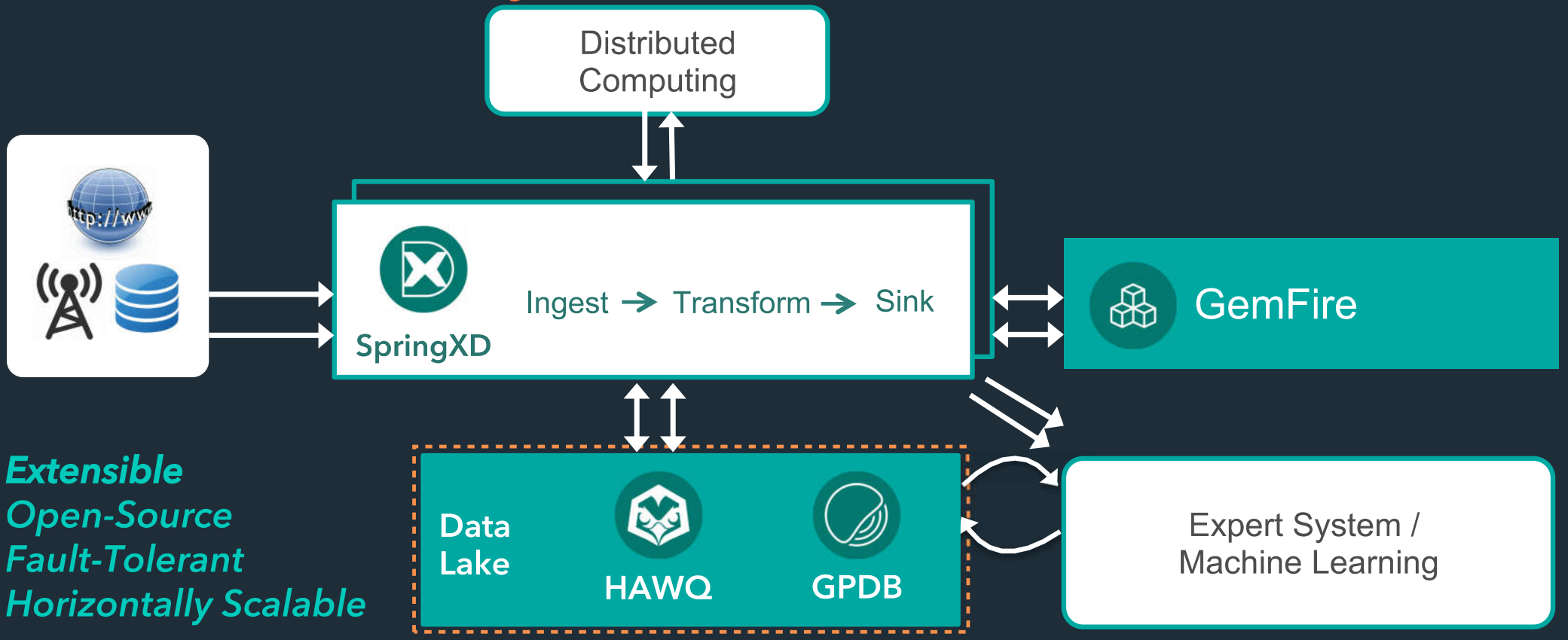
Pivotal Provides SQL Based Advanced Analytics



Extensible
Open-Source
Fault-Tolerant
Horizontally Scalable

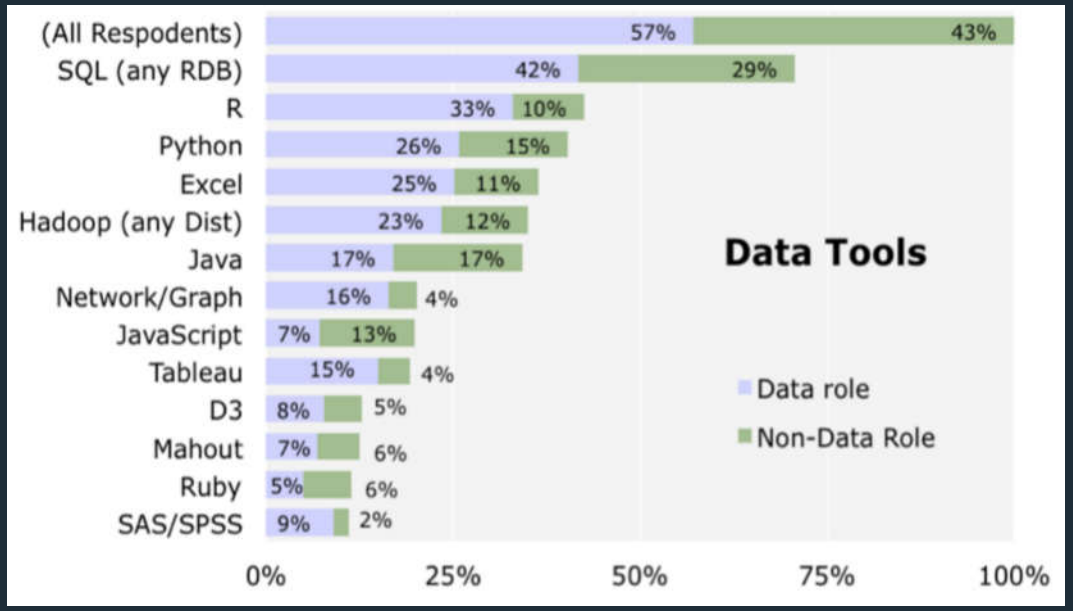
Pivotal

HAWQ

Advanced SQL analytics in Hadoop

- Massively Parallel Processing RDBMS on HADOOP
- ANSI SQL on Hadoop
- Extremely high performance for analytics (not like Hive)
- Stores all data directly on HDFS
- Open-Source

SQL remains #1 choice for Data Science



Combining SQL with Hadoop is key for analytics

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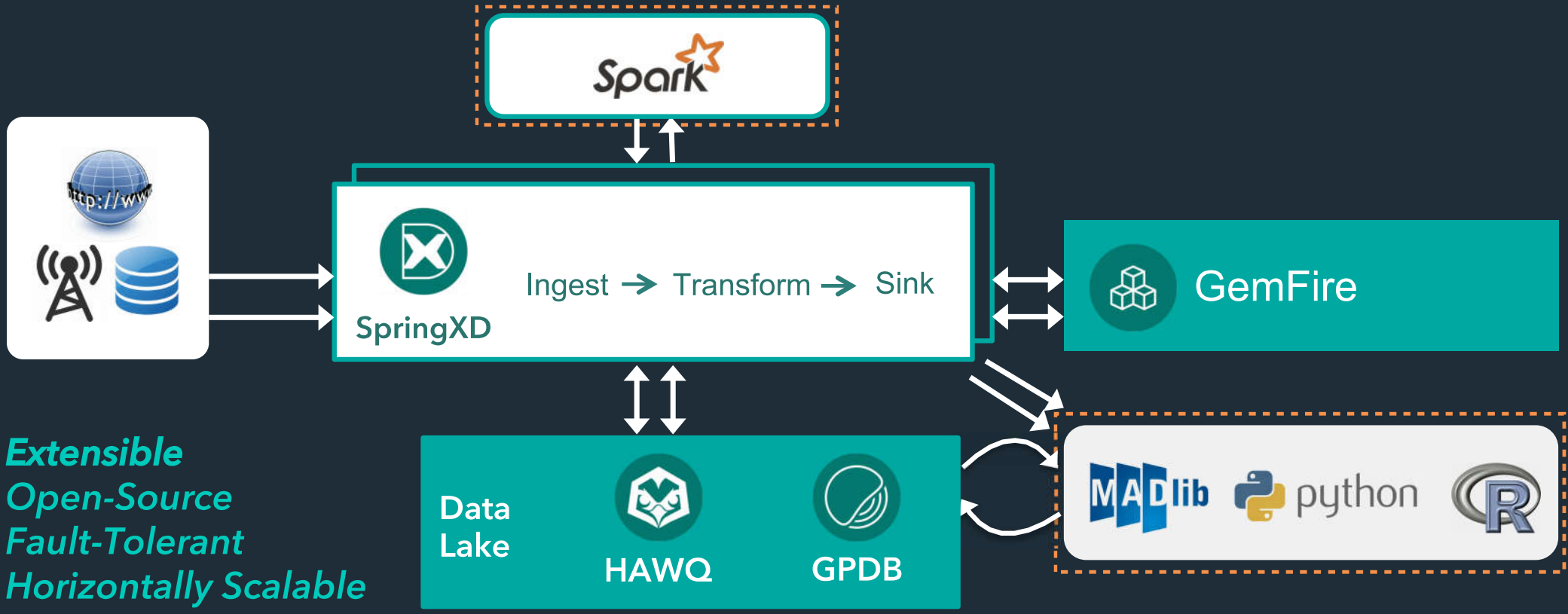
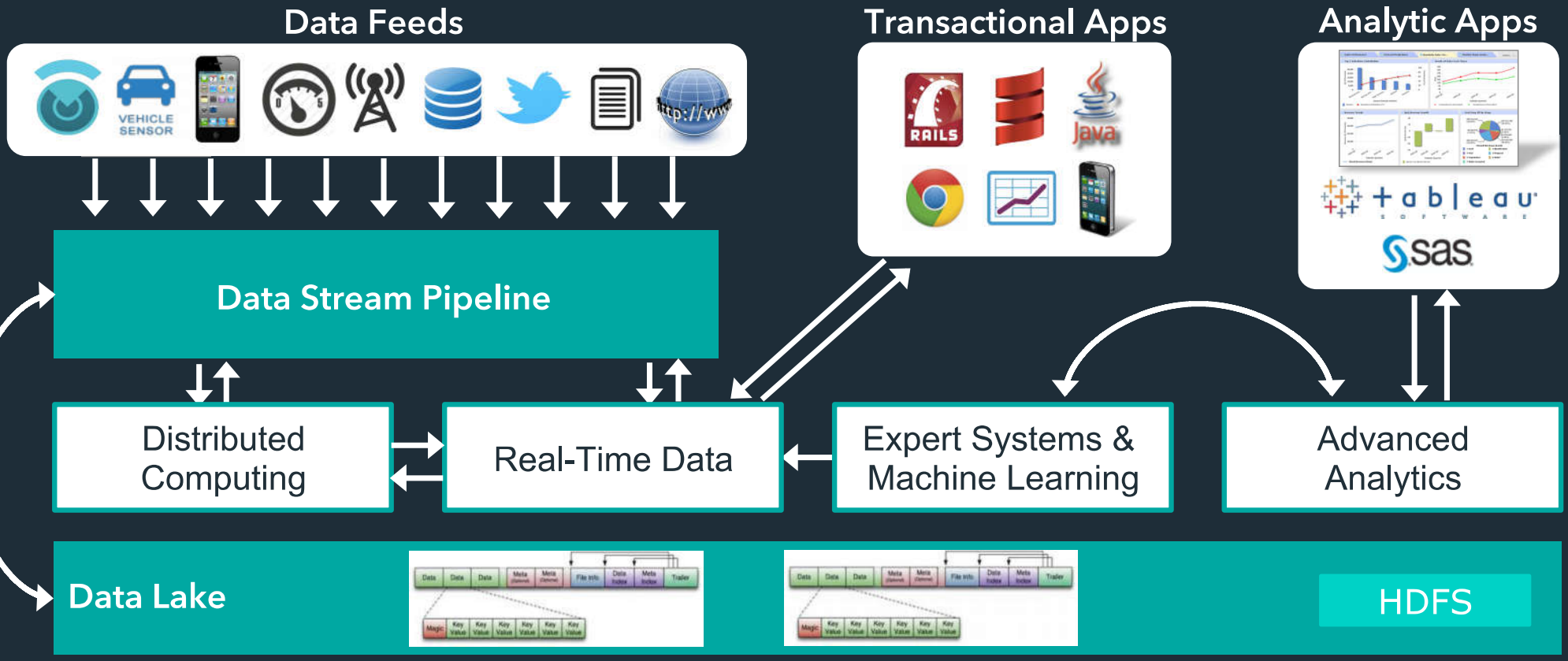
Developers and Data Scientists Can Focus on the Business Value of Data



Extensible
Open-Source
Fault-Tolerant
Horizontally Scalable

Pivotal

Data Streaming Reference Architecture



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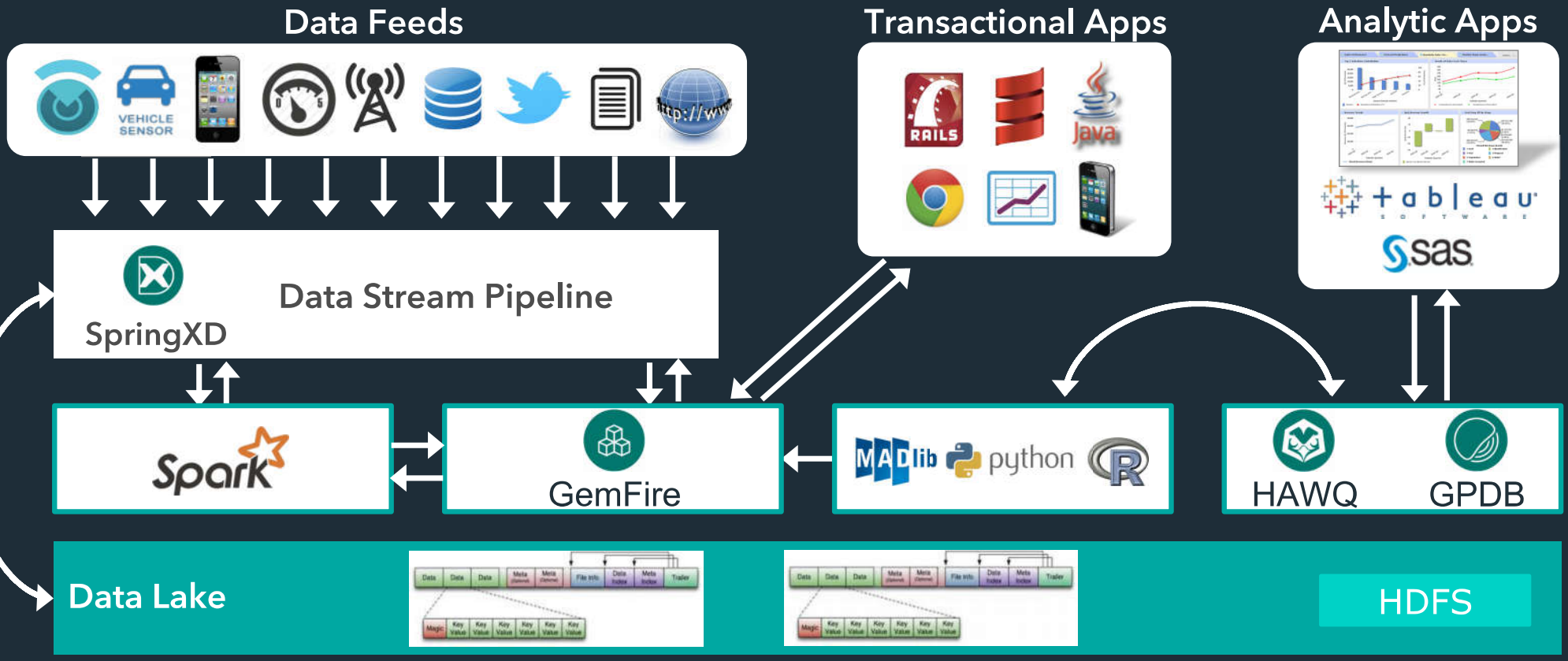
Data Streaming Reference Architecture



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“

SO WE ARE MOVING TO A WORLD WHERE THE MACHINES WE WORK WITH ARE NOT JUST INTELLIGENT; THEY ARE BRILLIANT.THEY ARE SELF-AWARE, THEY ARE PREDICTIVE, REACTIVE AND SOCIAL. IT'S A WORLD WHERE INFORMATION ITSELF BECOMES INTELLIGENT AND COMES TO US AUTOMATICALLY WHEN WE NEED IT WITHOUT HAVING TO LOOK FOR IT.

”

MARCO ANNUNZIATA, GE

The IoT Market Verticals

Diversified Industrial Manufacturers

Agriculture, Security, Retail

Auto Manufacturers

Media (via Mobile devices)

Urban Infrastructure, Cities

Consumer, Connected Home etc.

Healthcare, Life Sciences

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“
THE MAGIC HAPPENS WHEN YOU MARRY THE TRADITIONAL ENGINEERING APPROACH WITH THE DATA SCIENCE ENABLED BY THE DATA LAKE. IT OPENS UP A WHOLE NEW WORLD OF POSSIBLE ‘WHAT IF’ QUESTIONS.
”
DAVE BARTLETT, GE AVIATION

GE Aviation – Big Data & IoT

- Goal
  - Improve jet engine efficiency and increase service profitability
  - Unable to store & analyze massive amounts of data for analytics
- Solution
  - **LARGE DATA SETS** ingested via batch
  - Store 100s TB of engine data in Hadoop (PHD)
  - Open doors for industrial engineers to poke at data (HAWQ)
  - **FAST MACHINE LEARNING** based algorithms
    - 2000x faster, 10x cheaper
  - Customer portals for visibility

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“
THE REAL OPPORTUNITY FOR CHANGE...SURPASSING THE MAGNITUDE OF THE CONSUMER INTERNET...IS THE INDUSTRIAL INTERNET, AN OPEN, GLOBAL NETWORK THAT CONNECTS PEOPLE, DATA AND MACHINES.
”
JEFF IMMELT, CEO, GE

GE Energy – Fast Data & IoT

- Goal
  - Failing gas turbines causing issues with power generation
  - Unable to store & process fire-hose of data
- Solution
  - **HIGH VELOCITY** data ingestion from Gas Turbines
  - Store 10 TB of turbine data in memory (GemFire)
  - **VERY LOW LATENCY** and **HIGH SPEED** data access
  - “Predictive” Maintenance

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“
… YOU USE THOSE DEVICES TO INSPECT CARS AND KEEP TRACK OF INSPECTION RECORDS. THAT CAN THEN FLOW INTO ASSET MANAGEMENT SOFTWARE TO PROVIDE PREDICTIVE ANALYSIS OF WHEN THE ASSET NEEDS TO BE MAINTAINED ... WHEN YOU BOIL THAT DOWN TO BUSINESS, IT’S ABOUT COMPETITIVE ADVANTAGE.
”
BRAD HOWELL, LODESTAR LOGISTICS

GE Transportation – Big & Fast Data

- Goal
  - Help rail companies manage locomotives better
  - Fast data from tracks & Big data from sensors in locomotives
- Solutions
  - **MACHINE LEARNING MODEL** built from combined data set (MADLib)
  - **REAL TIME SCORING** of rail sensor data (Spring XD)
  - **REAL-TIME ALERTING** of critical events via email & a **REAL TIME DASHBOARD** (Spring)

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“
WE EXPECT THE PRECISION AGRICULTURE SPACE TO CONTINUE TO GROW QUICKLY AS DATA BECOMES CHEAPER TO STORE AND EASIER TO MOVE FROM PLATFORM TO PLATFORM. WE ARE JUST BEGINNING TO EXPLORE ALL THE VALUE WE CAN CREATE FOR FARMERS WITH THESE TOOLS.
”
BRETT BEGEMANN, MONSANTO

Monsanto – Agriculture & IoT

- Goal
  - Help farmers maximize crop yields
- Solution
  - Use of Big Data to collect & store data from farm equipment
  - Combine with climate and other information
  - Build custom apps using an agile app dev platform (PCF)

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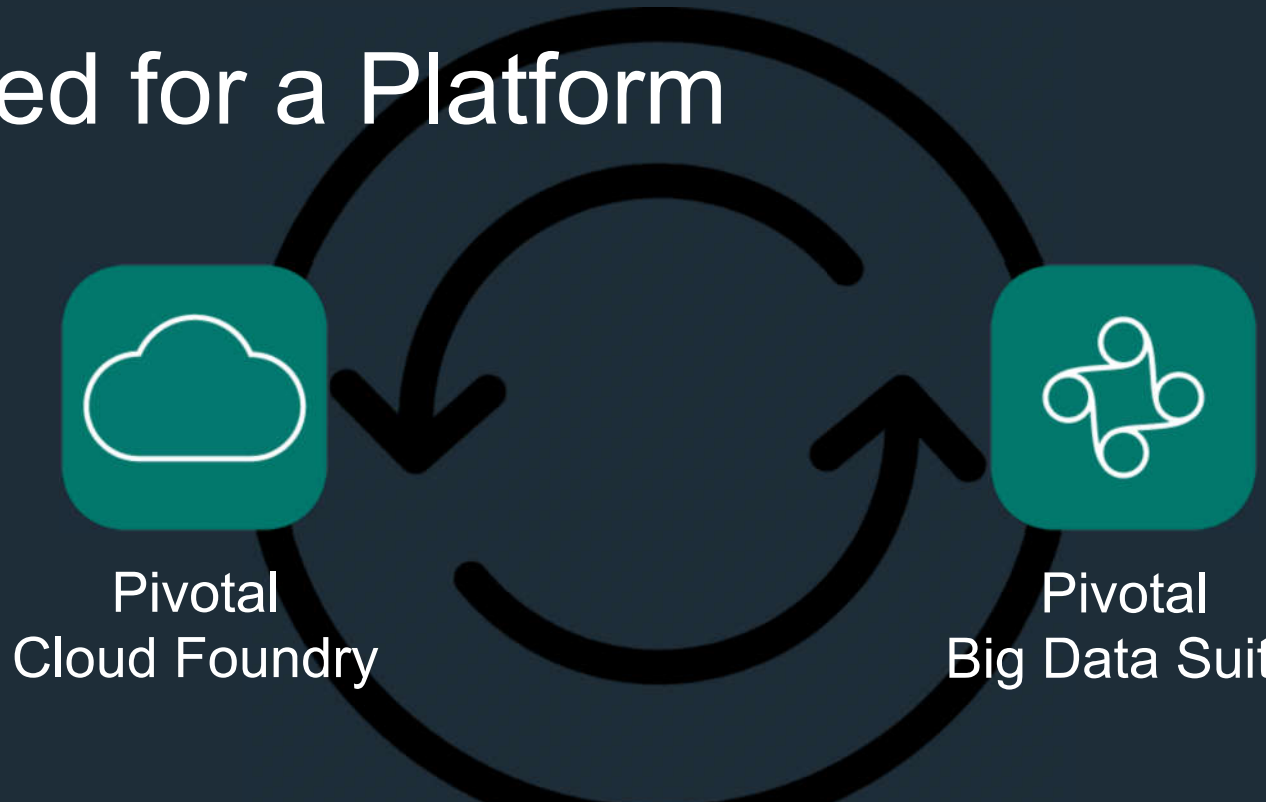
IoT - Need for a Platform



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Cloud Foundry

Pivotal
Big Data Suite

A Better Customer Experience
Using Innovative **Data-Driven Apps**
On a **Integrated Platform**

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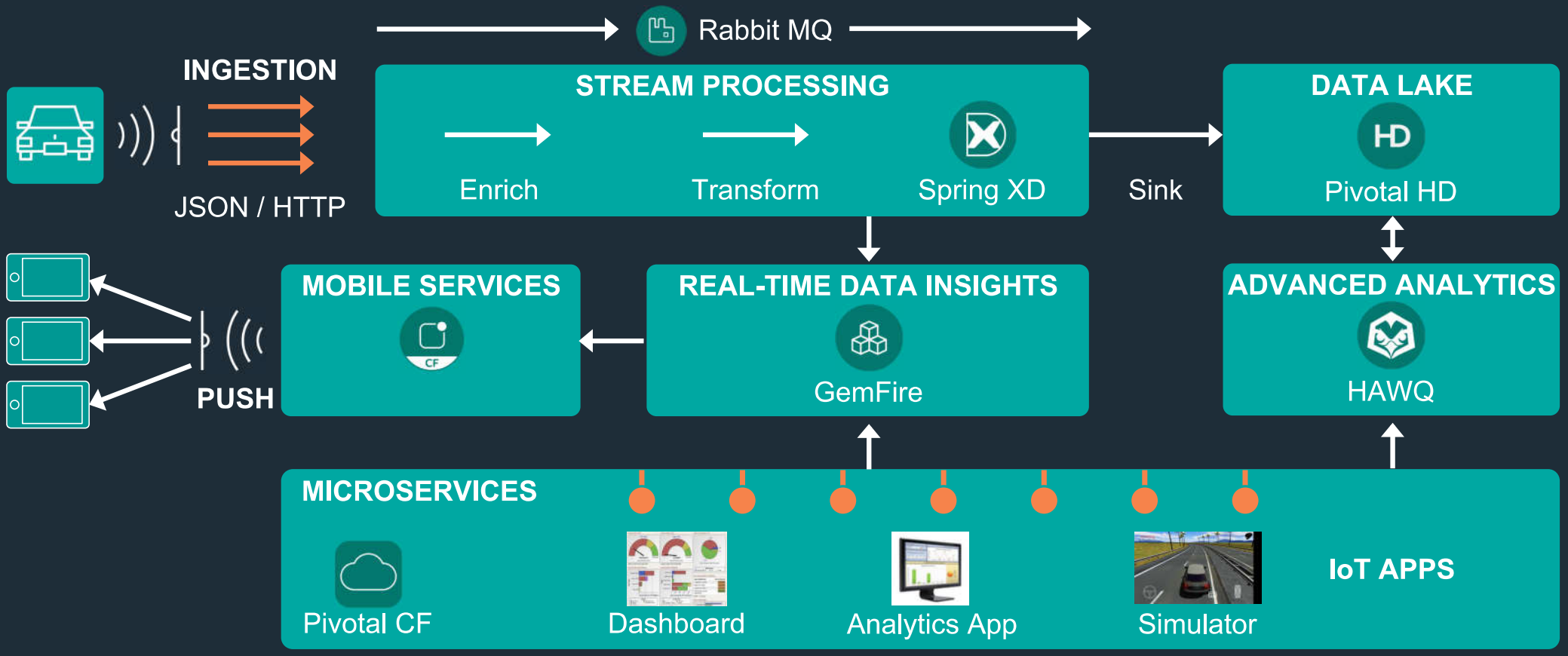
The Connected Car Architecture



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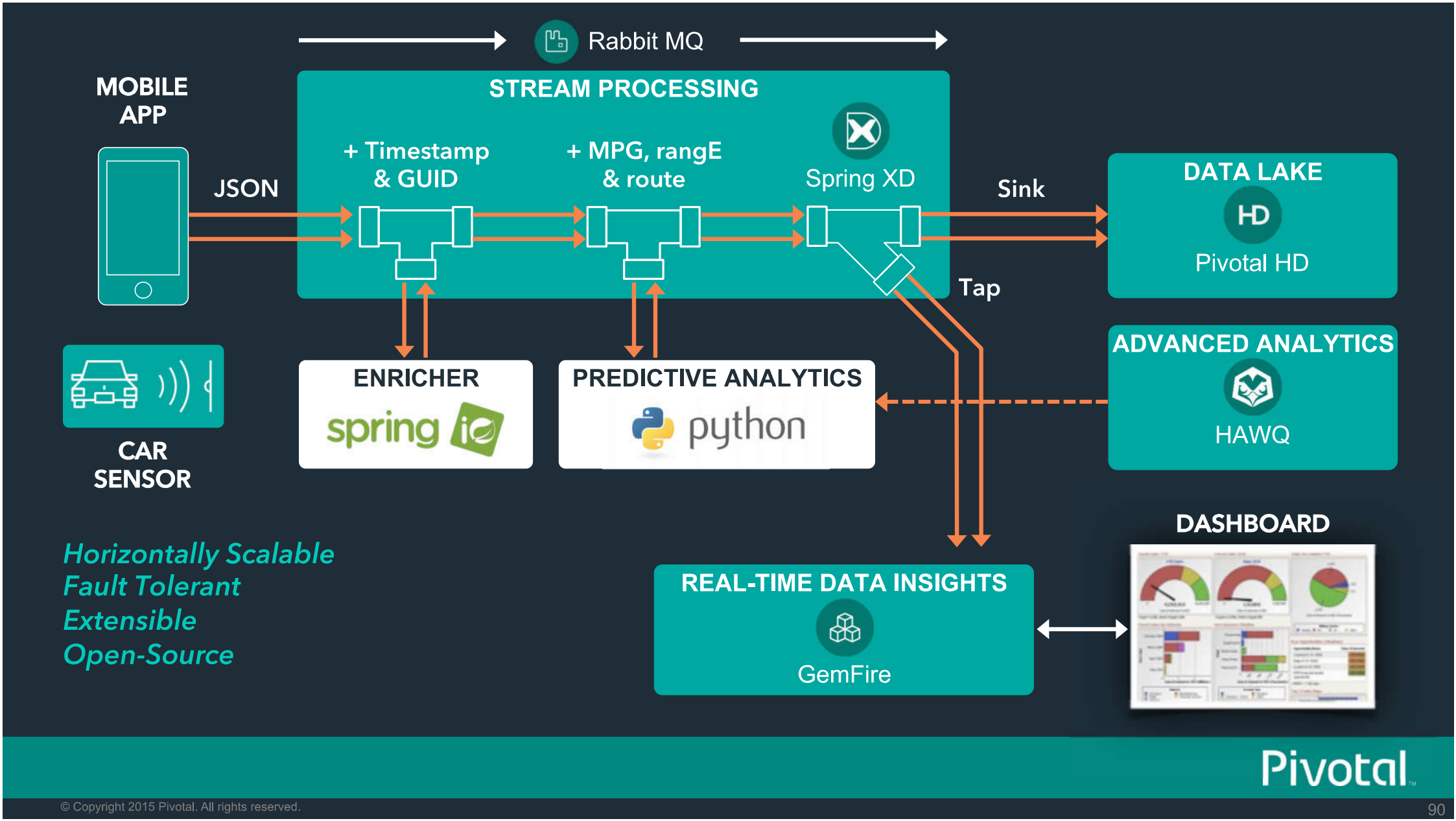

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BUILT FOR THE SPEED OF BUSINESS