

Power Systems



Data Science Experience (DSX)

Predictive Maintenance demo with IoT, Asset Management and AI
IBM Power Systems & IBM Cloud

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IBM Client Center Montpellier, France



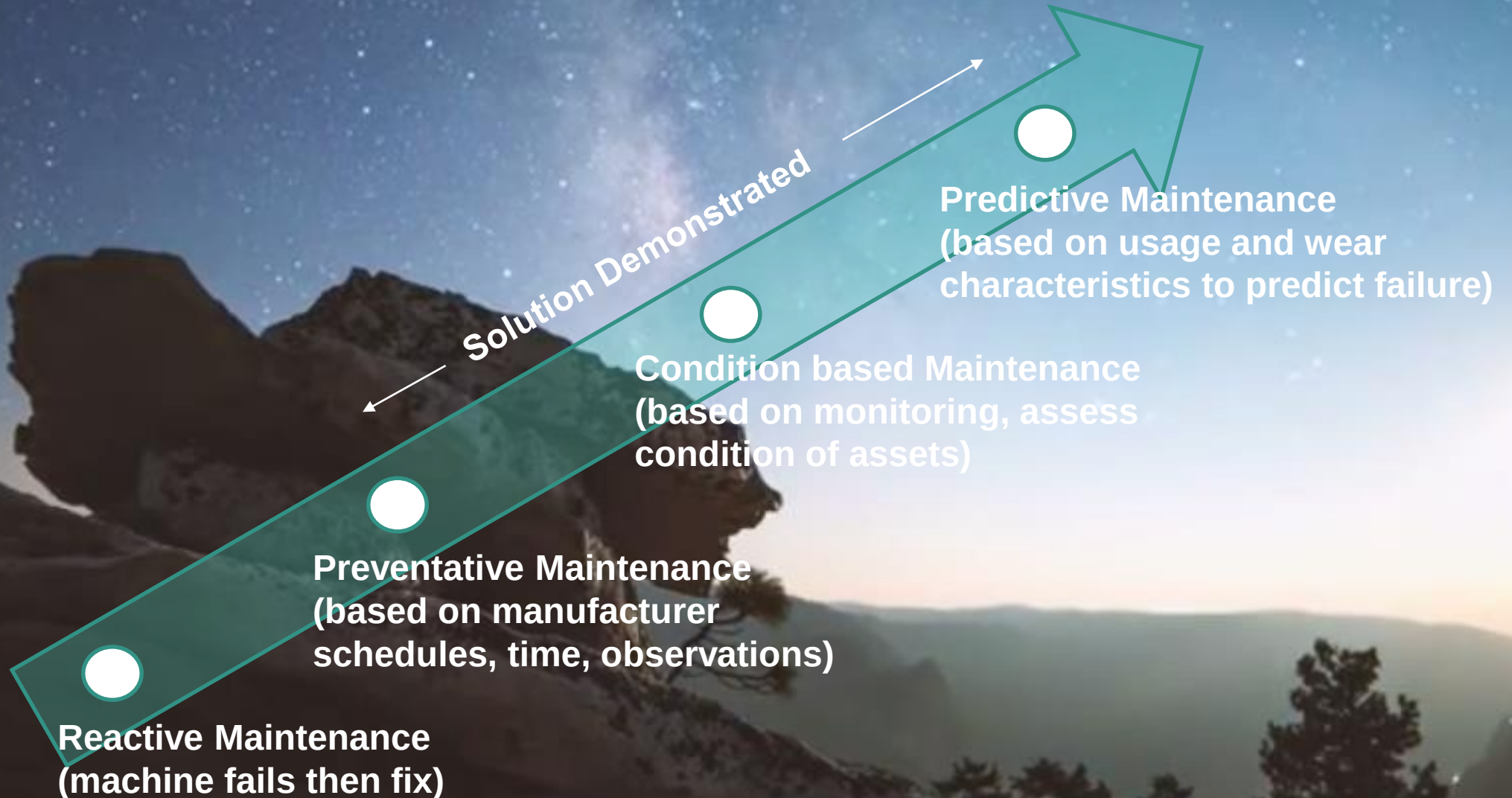
@ : Benoit.marolleau@fr.ibm.com

 [linkedin.com/in/benoitmarolleau](https://www.linkedin.com/in/benoitmarolleau)

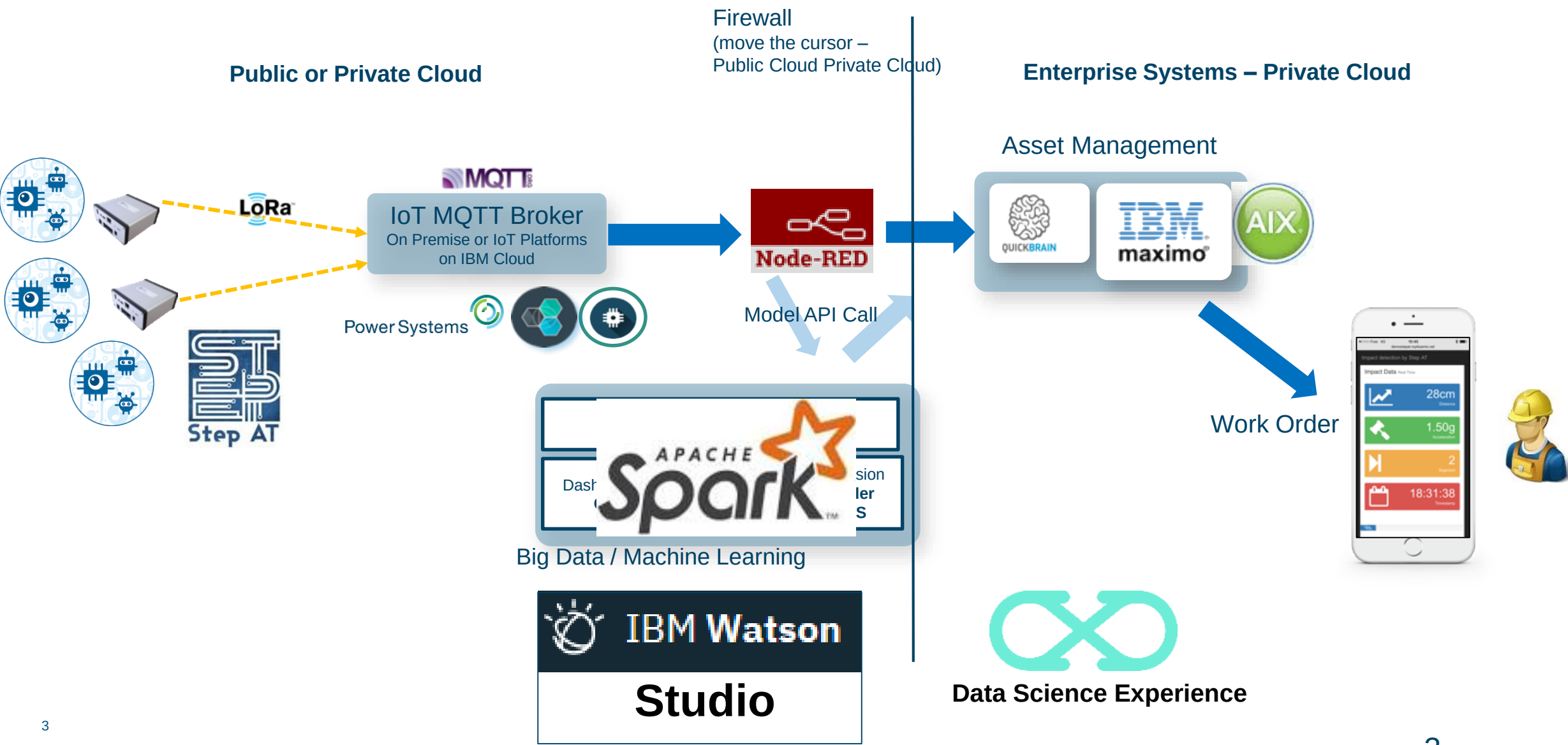
 MarolleauBenoit



Online version & video : [WW Demo Portal](#)



Predictive Maintenance Demonstration



Predictive Maintenance Demo

Sensor data from 100 engines of the same model

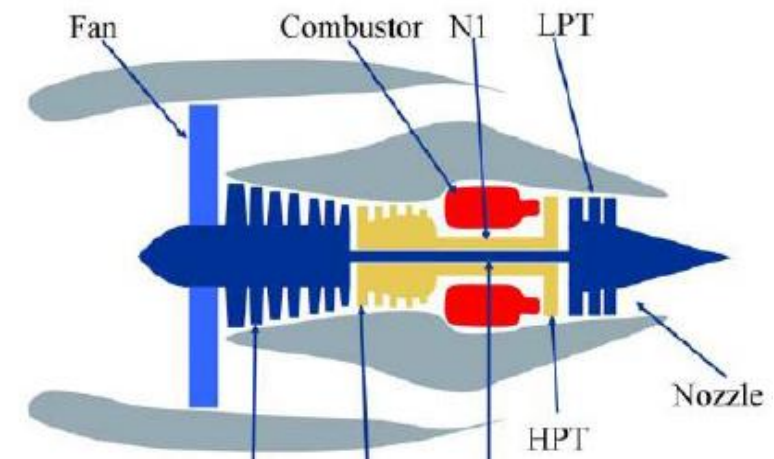
- Maintenance scheduled every 125 cycles
- Only 4 engines needed maintenance after 1st round

Predict and fix failures before they arise

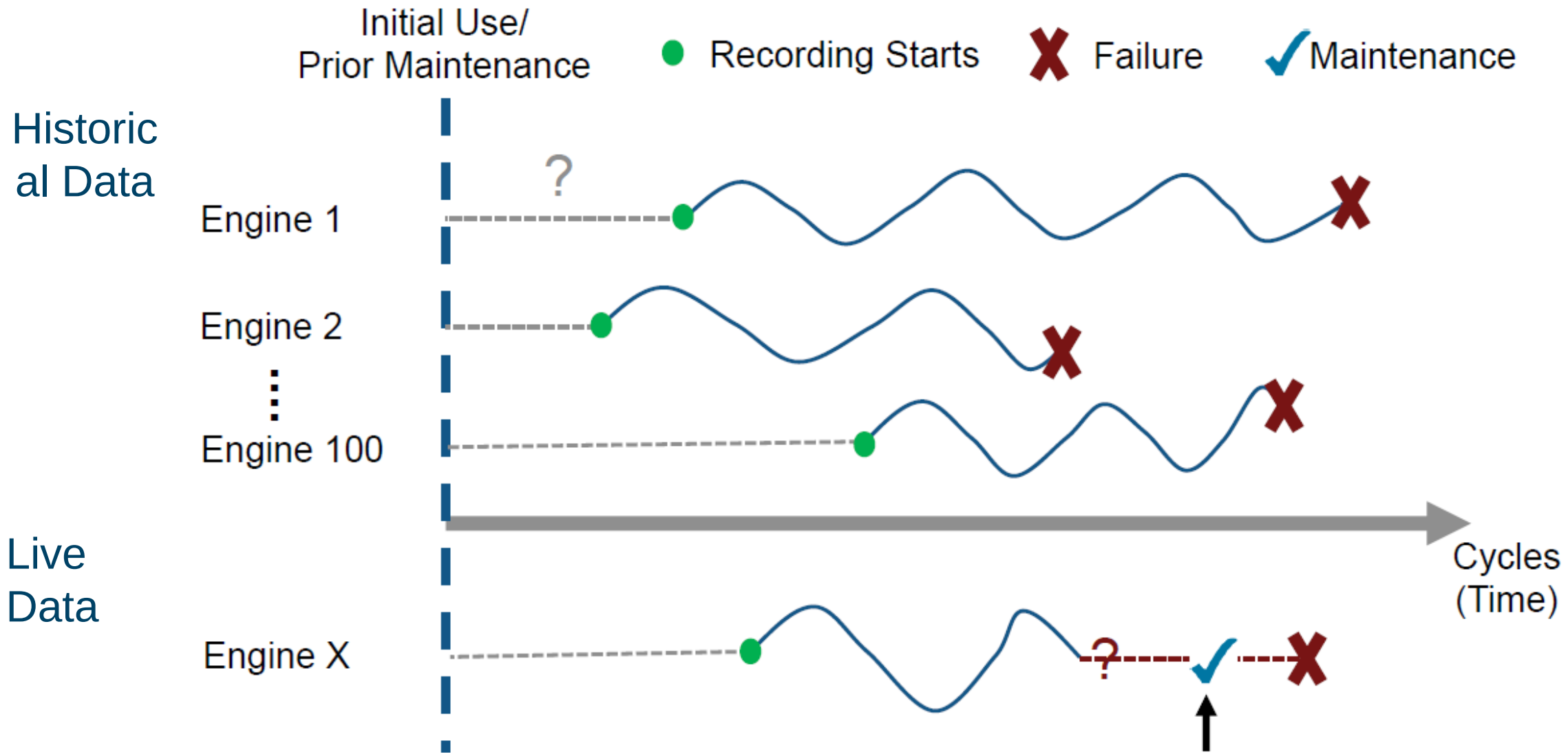
- Import and analyze historical sensor data
- Train model to predict when failures will occur
- Deploy model to run on live sensor data
- Predict failures in real time

Data provided by NASA PCoE

<http://ti.arc.nasa.gov/tech/dash/pcoe/prognostic-data-repository/>



Predictive Maintenance Demo

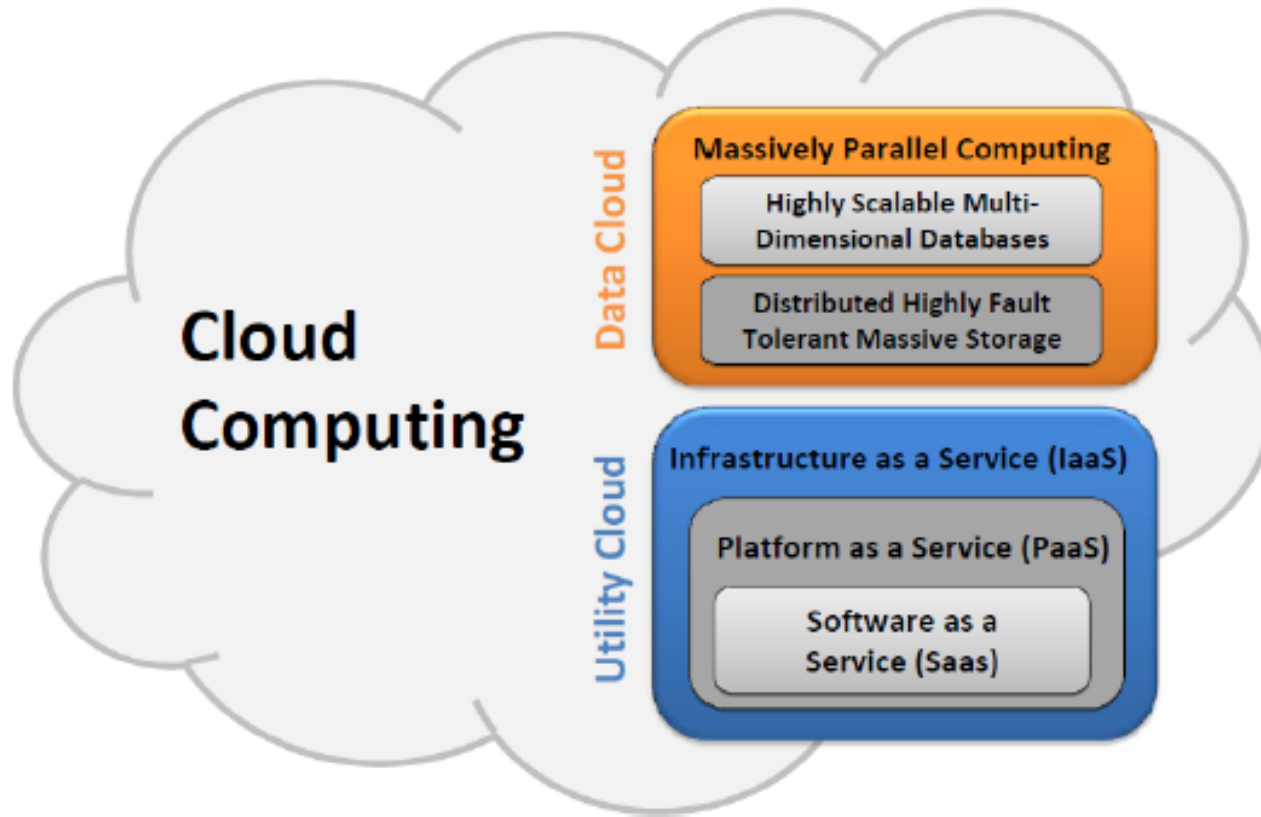


Predictive Maintenance Use case : Steps with DSX / Watson Studio

1. Data collected by NASA – 100 engines / 20 sensors each / hundreds of cycles recorded until failure
<https://ti.arc.nasa.gov/tech/dash/groups/pcoe/prognostic-data-repository/>
 - ❑ Damage Propagation [study](#)
2. Data cleaning, normalization, feature engineering (rolling avg , rolling sd) , RUL (Remaining useful life or TTF) with DSX (R , Jupyter Notebooks)
3. **Modeling with DSX**
 - Spark 2.0 via R notebook (Jupyter) & Watson ML
 - Regression models: How many more cycles an in-service engine will last before it fails?
//Random Forrest Regression, Gradient Boosting Tree , etc.
 - Binary classification: Is this engine going to fail within w1 cycles?
 - Multi-class classification: Is this engine going to fail within the window [1, w0] cycles or to fail within the window [w0+1, w1] cycles, or it will not fail within w1 cycles?
4. Training with default hyperparameters – can be tuned
5. Evaluation, **Publish** Model as a Service.
6. Integration to existing IoT Asset Management solution for predicting asset failure

DSX

IBM Cloud Private : the private Data Cloud



Think2018 Announcement: IBM Cloud Private for Data
<https://www.ibm.com/analytics/cloud-private-for-data>



March 20, 2018

Posted In: AI, Cloud Computing, IBM Research-Zurich, Systems

**IBM Sets Tera-scale
Machine Learning
Benchmark Record with
POWER9 and NVIDIA
GPUs; Available Soon in
PowerAI**

IBM Cloud Private for Data

Make your data ready for AI

Radically simplify data collection, organization and analysis, now. No assembly required

IBM Cloud Private : Content available by Edition – Data Cloud Focus

Discover and Try software available in all editions

Toolchain & Runtimes

Microclimate Beta
Microservice Builder
Jenkins (open source)
IBM WebSphere Liberty
Open Liberty (open source)
IBM SDK for Node.js
Swift runtime sample (open source)
Nginx (open source)

Messaging

MQ Advanced for Developers
RabbitMQ (open source)

Integration

IBM Integration Bus for Developers
IBM DataPower Gateway for Developers

Data Services

IBM Db2 Dev-C
IBM Db2 Warehouse Dev-C
IBM Data Server Manager (for Db2 Dev-C)
IBM Cloudant Developer Edition
MongoDB (open source)
PostgreSQL (open source)
MariaDB (open source)
Galera clustering with MariaDB (open source)
Redis HA Topology (open source)

Data Science

IBM Data Science Experience Developer Edition

Data Governance and Integration

IBM InfoSphere Information Server for Evaluation

App Modernization Tooling

IBM Transformation Advisor

Digital Business Automation

IBM Operational Decision Manager Developer Edition

Connectivity

IBM Voice Gateway Developer Trial

Management

IBM Netcool -integration (Probe for ICP Services -Logging events & Monitoring alerts)

HPC / HPDA

IBM Spectrum LSF Community Edition
IBM Spectrum Symphony Community Edition
IBM Spectrum Conductor Tech Preview

Tooling

Web Terminal (open source)
Skydrive Network Analyzer (open source)

IBM Cloud Private Cloud Native

Catalog of Discover & Try content, plus ...

Toolchain & Runtimes

Microservice Builder ^[1]
IBM WebSphere Liberty ^[1]
IBM SDK for Node.js ^[1]

Multi-Cloud Management

IBM Cloud Automation Manager ^[1]

^[1] IBM Software bundled with Cloud Native or Enterprise editions is entitled for production use with subscription and support.

Optional add-ons to Cloud Native or Enterprise

Data Services

IBM Db2 Direct Advanced Edition
IBM Db2 Warehouse Enterprise (in ICP for Data Science PN)

Data Science

IBM Data Science Experience Local

Messaging

IBM MQ Advanced

Integration

IBM Integration Bus
IBM DataPower Gateway Virtual Ed

Digital Business Automation

IBM Operational Decision Manager

Available a la carte
Separate purchase or bring your existing license

IBM Cloud Private Enterprise

Cloud Native content, plus...

Toolchain & Runtimes

IBM WebSphere Application Server ND ^[1] ^[2]

Messaging

IBM MQ Advanced ^[1]

Integration

IBM API Connect Professional ^[1] ^[2]

^[2] Runs on VMs outside of Kubernetes

Toolchain

IBM UrbanCode Deploy (now on ICP)

Cloud Foundry

Includes select buildpacks

Data Services

IBM Db2 Direct Advanced Ed. / AESE with IBM Data Server Manager
IBM Db2 Warehouse Enterprise

Mobile

IBM Mobile Foundation

Watson

IBM Watson Compare & Comply: Element

Classification

Catalog content is not distributed with IBM Cloud Private. Content is distributed separately, licensed under separate terms and conditions.

Data Science is a Team Sport

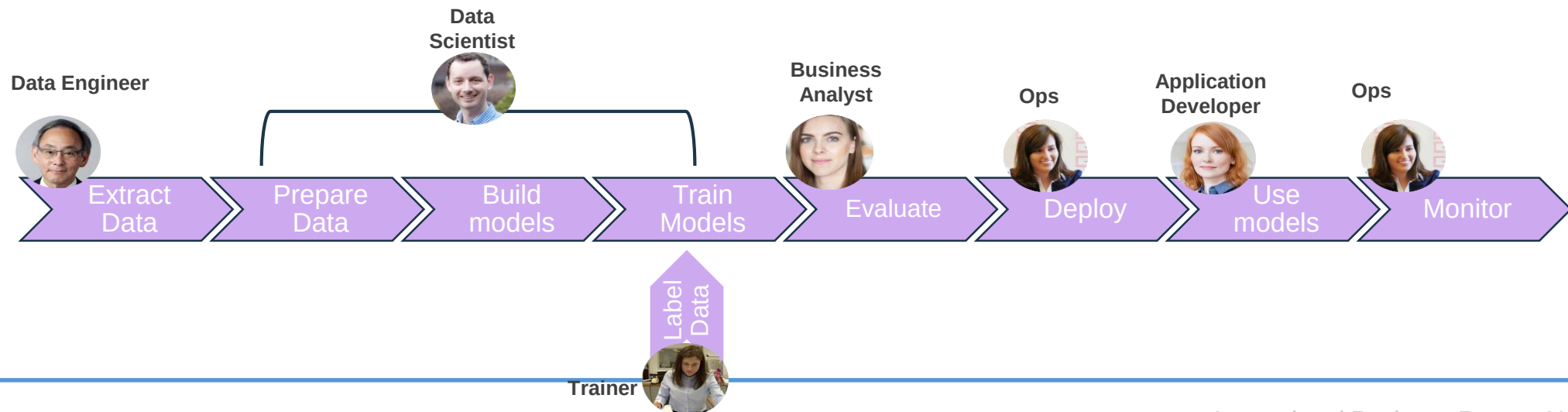
Building ML-infused apps requires multiple skillsets:

Define an ML model

Store, manage, update training data

Manage lifecycle of the trained model

Ability to do inferencing on the trained model(s)



Big Data: Machine Learning techniques

Classification: predict class from observations

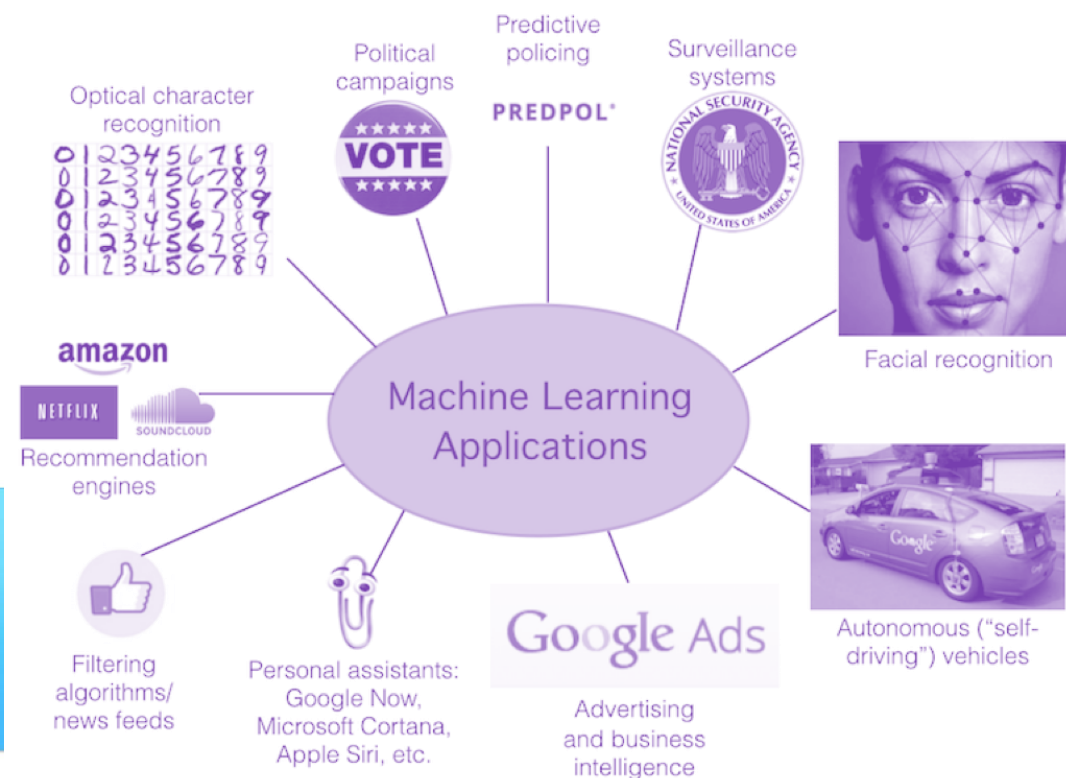
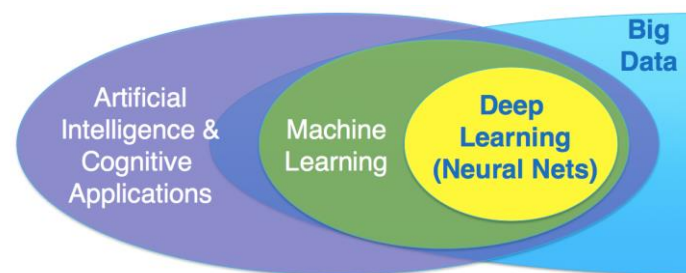
- E.g. Spam Email Detection

Clustering: group observations into “meaningful” groups

- E.g. Amazon Recommendations

Regression (prediction): predict value from observations

- E.g. Energy consumption prediction



and many different technologies and libraries are available:

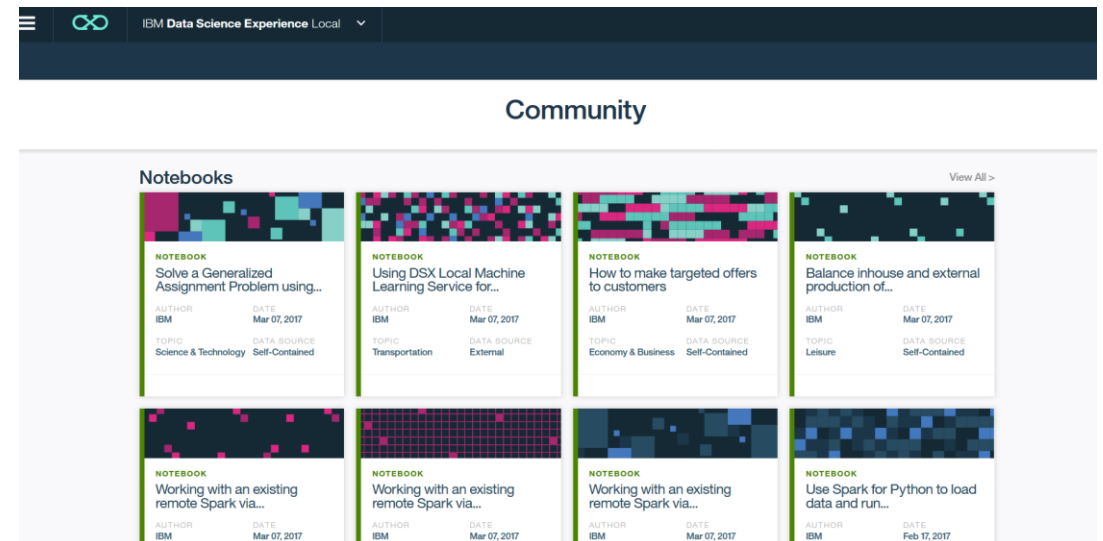


Data Science Experience

IBM Data Science Experience (DSX) is a **platform** for developing and deploying analytical applications
Supports development, deployment, and model management

DSX is available

- ☐ As a cloud offering aka **Watson Studio**
- ☐ As an on-premises solution
 - **DSX Local** on x86/Power
 - Power: Scale-out LC Systems with PowerAI + GPU / Nvlink acceleration
- ☐ As a desktop application
 - Free, disconnected mode



Data Science Experience

- **Data Science as a Team Sport**

Lets *data scientists/engineers, analysts, stakeholders collaborate* to collect, share, explore, *analyze data* in order to *derive insights and train models*, and *share or deploy resulting assets*

- **Projects** - collaborate as team or work individually

- **Jupyter Notebooks + IBM value add**

- Integrated in Projects with access control
- *Spark integration with R/Python/Scala kernels*
- *Versions, comments, share link, publish to GitHub*
- *PixieDust, Brunel, ...*

- **Machine Learning** *integrated in Projects:*
Use ML Wizard and Flows to train Models

- **RStudio** *integrated with Spark*

- **DSX Integrates with Data in many places**

- Object Storage (SWIFT now, new Cloud Object Storage soon)
- Watson Data Platform Services and WDP Catalog
- Message Hub and IBM Streaming Analytics
- Can call any IBM service, e.g. Watson, Quantum, etc
- Third party data services on premise or on other clouds

- **Built on the IBM Cloud platform**

Master the art of data science

Solve your toughest data challenges with the best tools and the latest expertise
in a social environment built by data scientists.

 **Watch Now (2:31)**

[Sign Up For a Free Trial](#)

Coming Soon! Watson Machine Learning

Machine Learning lets you create and train predictive analytics models. [Learn More](#)



Learn

Get started or get better with built-in learning.



Create

Use the best of open source tooling with IBM
innovation.

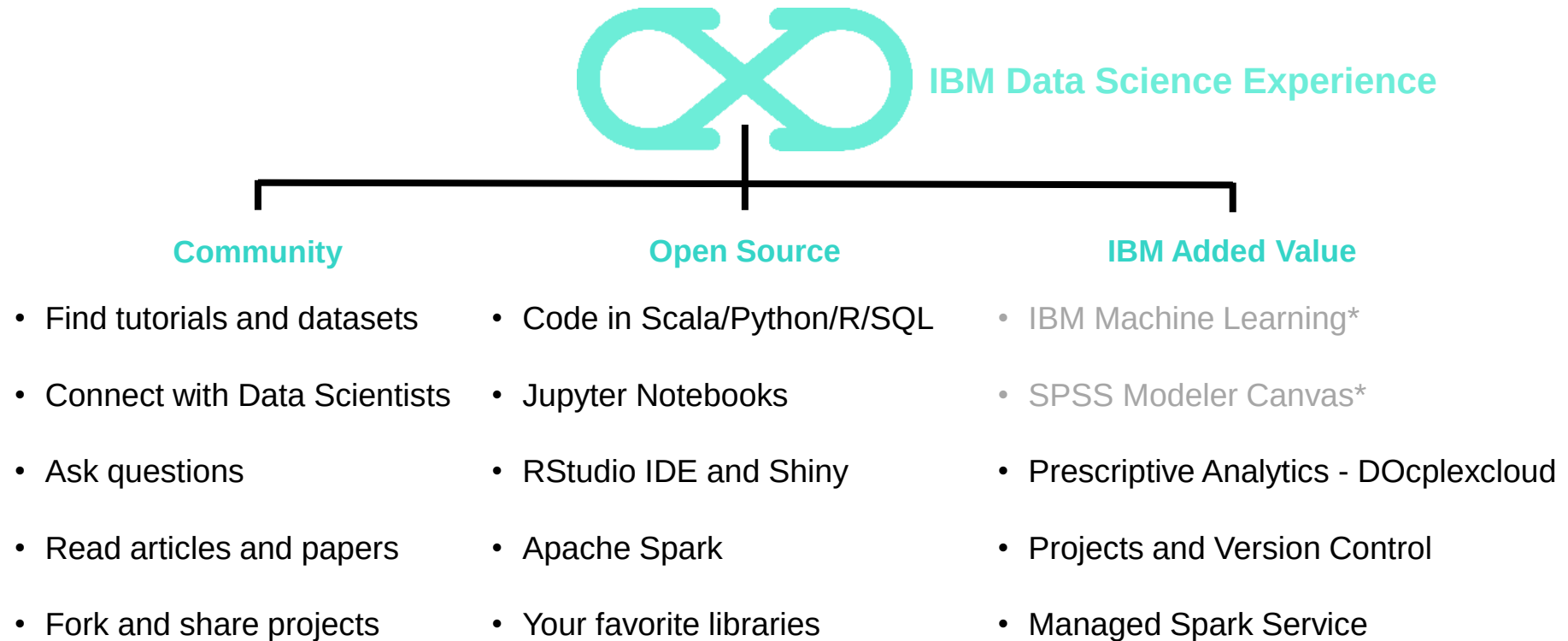


Collaborate

Work smarter using community, work faster with
your team.

Try it yourself at <https://datascience.ibm.com>

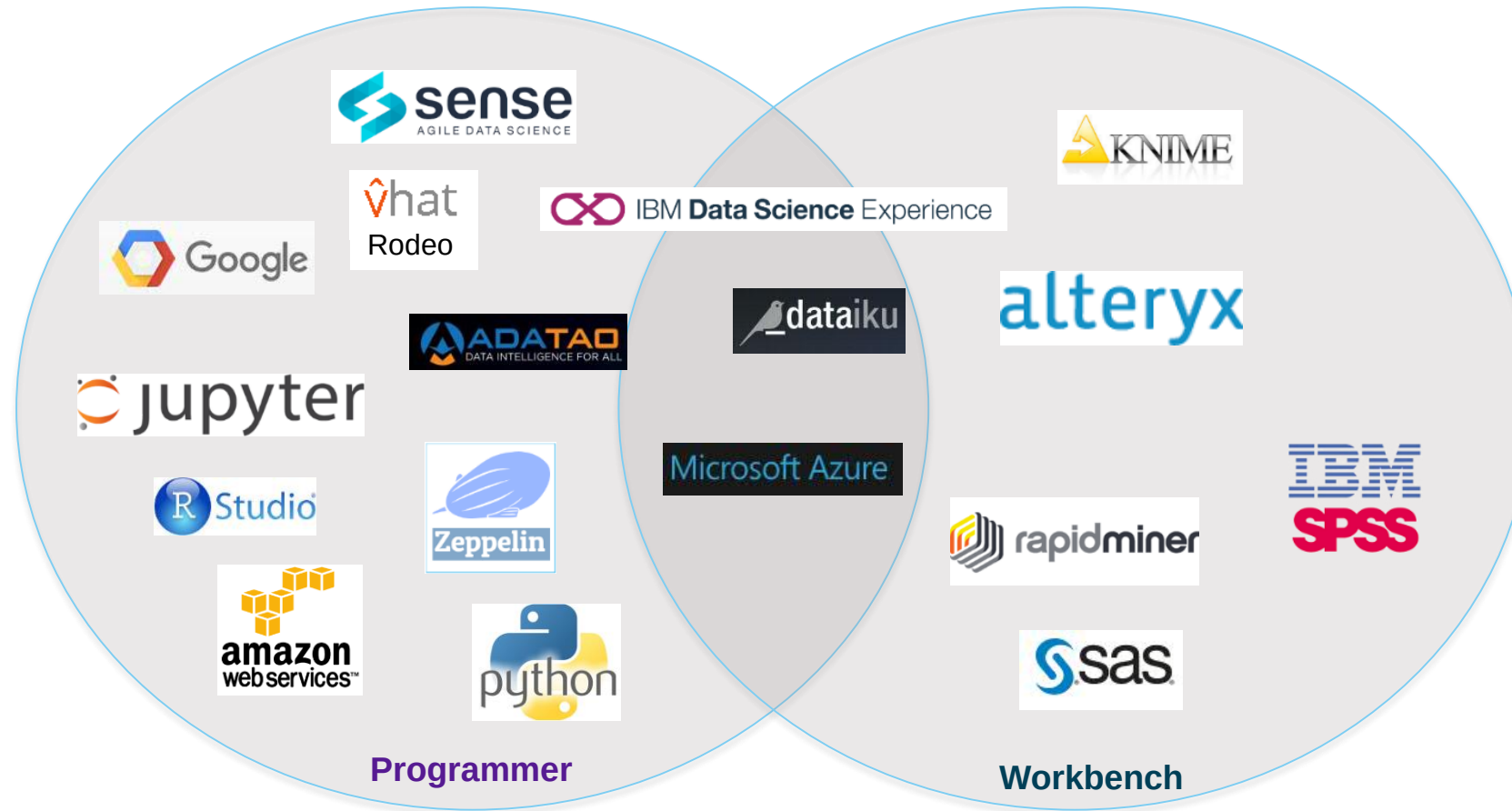
Core Attributes of the Data Science Experience



Powered by IBM **IBM Power**

* beta

Ecosystem



We've been recognized for our vision

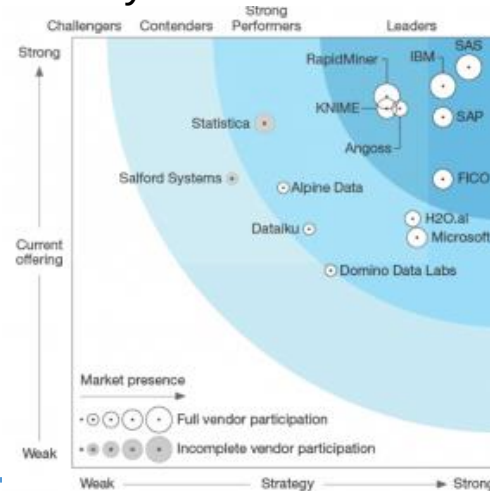
Gartner Magic Quadrant 2017 Data Science Platforms



DeveloperWeek 2017 Devie



Forrester Wave 2017 Predictive Analytics & Machine Learning



IBM® Data Science Experience Collaboration



Data Science Experience

Projects

Tools

Data Services

Community

US South

My Projects

Find in my projects

All Projects

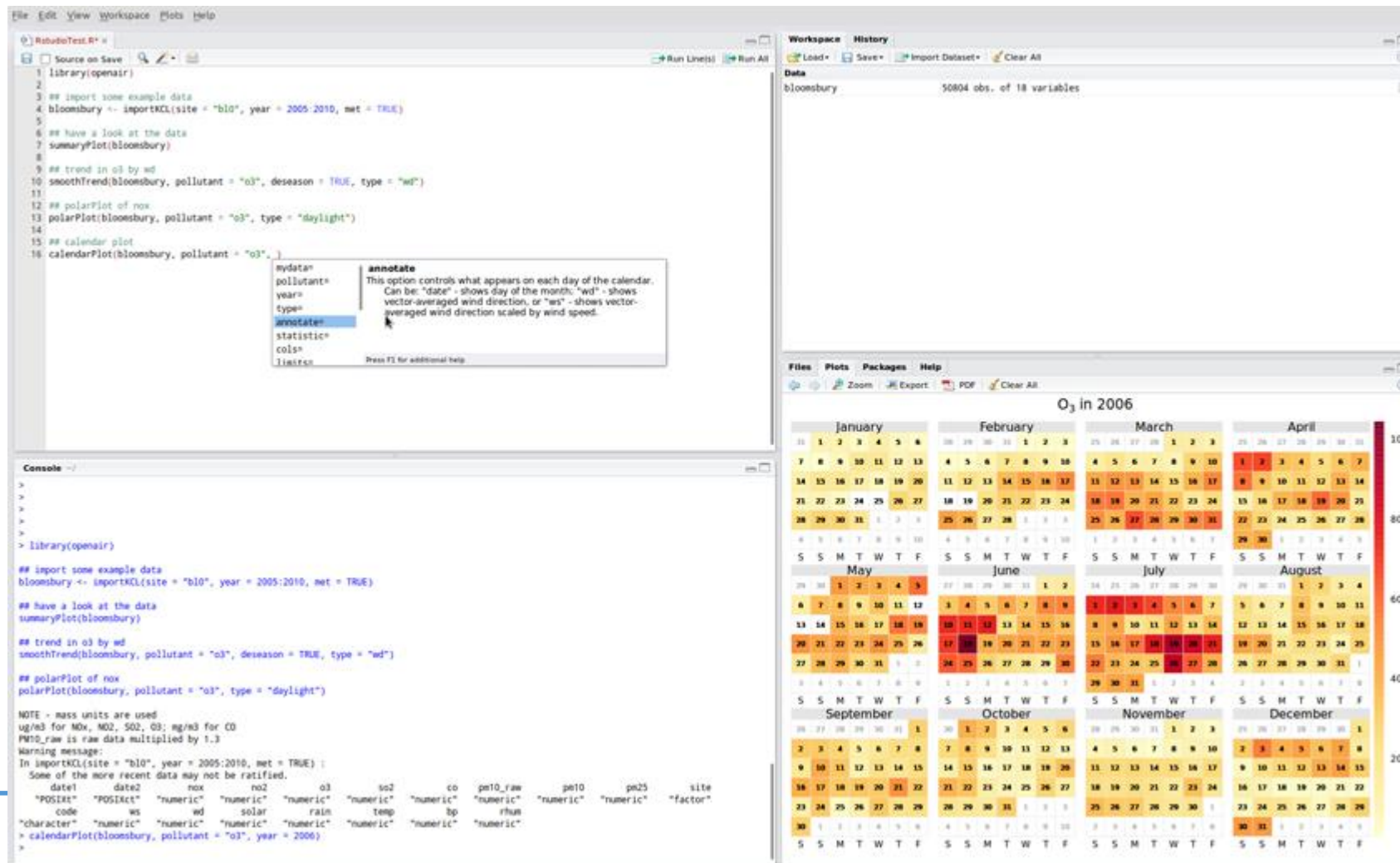
NAME	ROLE	COLLABORATORS	CREATOR	LAST MODIFIED
Projet Watson Analytics	Admin		Serge Retkowsky	9 May 2017
IncidentsPaiements	Admin		Serge Retkowsky	9 May 2017
IBM Streams	Admin	BC ZA +2	Serge Retkowsky	9 May 2017
Formation DSX	Admin	ZA BC +3	Serge Retkowsky	9 May 2017

Collaborators

Add collaborators

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Serge Retkowsky	serge.retkowsky@fr.ibm.com	Admin	
ZA Zied Abidi	zied.abidi@fr.ibm.com	Editor	

DSX has RStudio built into the experience thanks to our strategic partnership



IBM® Data Science Experience

Integration with services Watson (NLP/Deep Learning, ...)



My Projects > DSX Features > Watson API Alchemy Language



```
In [35]: print(json.dumps(alchemy_language.targeted_emotion(text='I love apples. I hate bananas', targets=['apples', 'bananas'], language='english'), indent=2))
```

```
{
  "status": "OK",
  "usage": "By accessing AlchemyAPI or using information generated by AlchemyAPI, you are agreeing to be bound by the AlchemyAPI Terms of Use: http://www.alchemyapi.com/company/terms.html",
  "totalTransactions": "1",
  "results": [
    {
      "text": "apples",
      "emotions": {
        "anger": "0.01915",
        "joy": "0.759622",
        "fear": "0.022622",
        "sadness": "0.07209",
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      }
    },
    {
      "text": "bananas",
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        "joy": "0.000599",
        "fear": "0.061471",
        "sadness": "0.120308",
        "disgust": "0.091096"
      }
    }
  ]
}
```

IBM® Watson Machine Learning Automatic Machine Learning & Deployment API



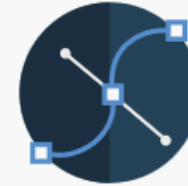
SIMPLE

IBM Watson Machine Learning guides you through the steps to create, train, evaluate, and deploy based on your desired outcome.



POWERFUL

Select the algorithms best suited for your needs, or get help selecting the ones that would work best for your data.



FLEXIBLE

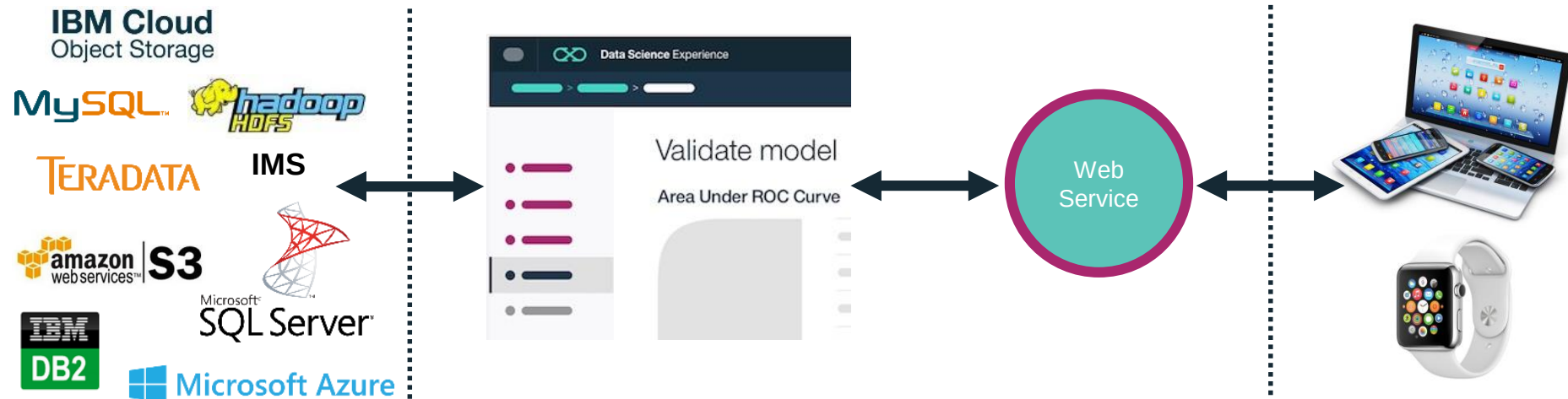
Test and deploy your models as APIs for application development, share with colleagues, and retrain as needed.

<http://datascience.ibm.com/features#machinelearning>

Build Predictive models with DSX

DSX Local with IBM Machine Learning

IBM Machine Learning



Data Access:

- Easily connect to Behind-the-Firewall and Public Cloud Data
- Catalogued and Governed Controls through Watson Data Platform

Creating Models:

- Single UI and API for creating ML Models on various Runtimes
- Auto-Modelling and Hyperparameter Optimization

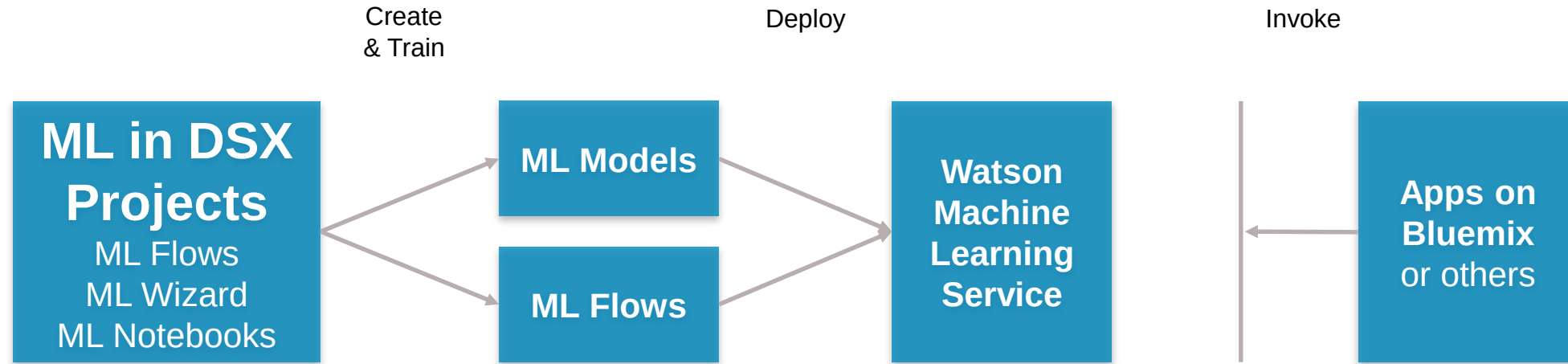
Web Service:

- Real-time, Streaming, and Batch Deployment
- Continuous Monitoring and Feedback Loop

Intelligent Apps:

- Integrate ML models with apps, websites, etc.
- Continuously Improve and Adapt with Self-Learning

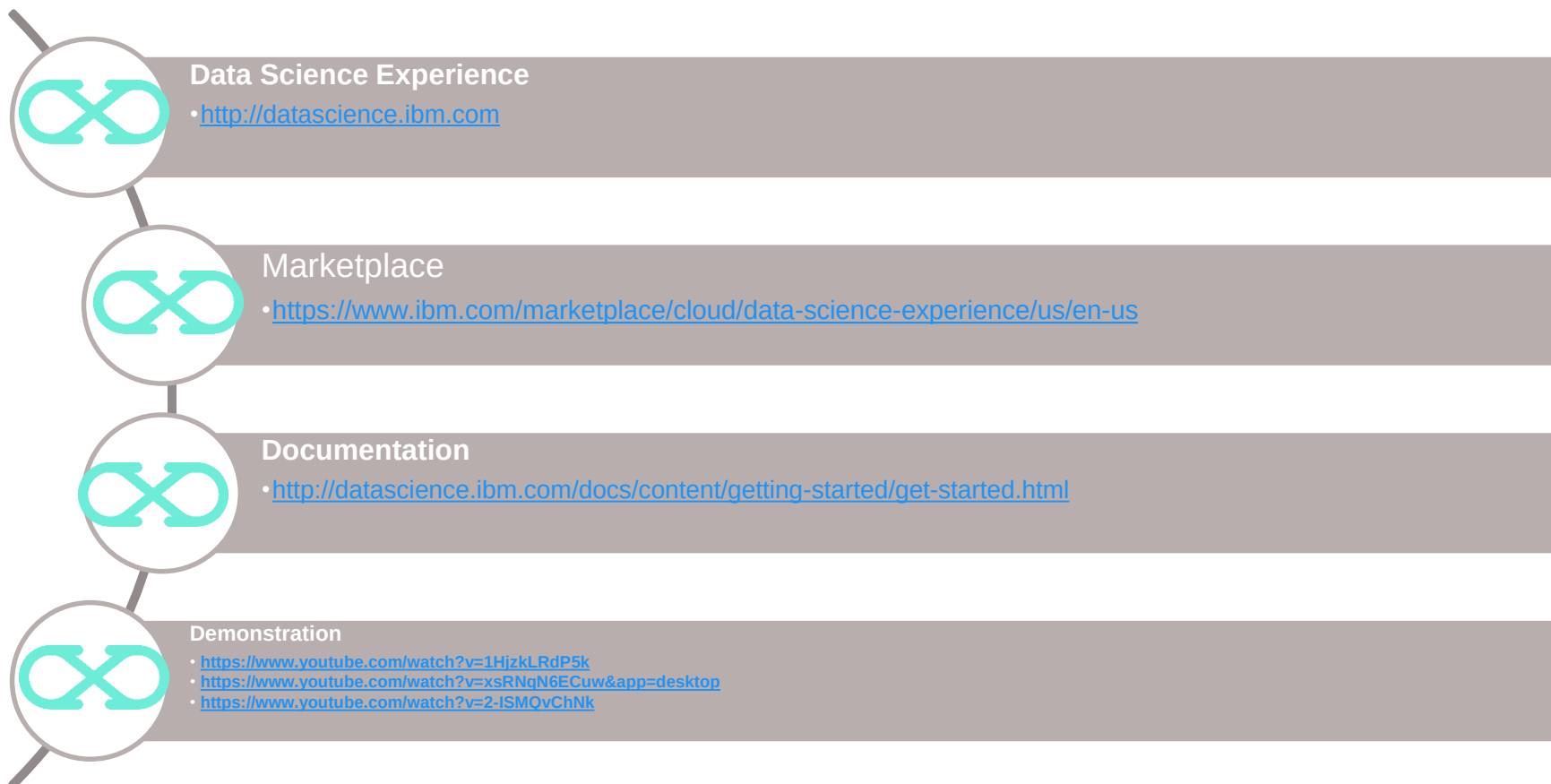
DSX - Machine Learning in Projects, deploying to WML



- Data Scientists can train ML models in DSX using data in Projects to create and train models
- Use ML Wizard for assisted creation and training of models using common patterns and algorithms
- Use Notebooks or Flows to train models for more advanced use cases and more flexibility
- Deploy models to Watson Machine Learning (WML) service in Bluemix to run them in production
- Use WML REST API to invoke your models for online scoring / predictions

IBM® Data Science Experience

Useful Links



DSX Local on Power Hardware

- **Available today.**
- **Data Science Experience is one product, with multiple distribution methods**
Similar functionality and user experience between DSX in Public cloud and on DSX local platforms including DSX on Power Linux
- **DSX local leverages the additional capabilities available through Power hardware**
Uses PowerAI Deep Learning libraries and frameworks optimized for Power HW
Transparently supports GPUs when available on S822 LC HPC hardware
Drives performance for deep learning Workloads

Drivers for an On Premises Offering

- While organizations are increasingly embracing the public cloud, many require analytics operating locally within their firewall.
- There are a number of reasons customers require this:
 - Sensitivity of corporate data
 - Gravity of enterprise data sources
 - Performance from low latency, local data access
 - Industry specific security requirements
 - Conservatism
 - Etc.
- **DSX Local leverages IBM's competitive differentiator of deep domain expertise within verticals and our proprietary data.**
- **DSX Local brings the power and flexibility of DSX to the customer premises.**

Architecture



IBM Cloud Private

Catalogue

DSX with GPU

GPU as a Service
On demand

GPU as a Service
Dedicated

Kubernetes

Worker Node: Power AI

Deep Learning Framework

Supporting Libraries

GPU

GPU

GPU

GPU

Worker Node: Power AI

Deep Learning Framework

Supporting Libraries

GPU

GPU

GPU

GPU

X86 and VMWare

Master Node

Worker Node

DSX Dev & Local in ICP

- ❑ DSX Dev (desktop like version) is available out of the box in the ICP Catalog (x86 only). Equivalent to the DSX Desktop offering.
- ❑ DSX Local is the end to end collaborative & complete DSX Solution on premises.
It can be deployed standalone or using ICP (Helm Chart).

 IBM Cloud Private

Create resource Docs Support

Catalog

Filter

Deploy your applications and install software packages

**ibm-cloudant-dev**
Cloudant for Linux.
[ibm-charts](#)

**ibm-datapower-dev**
IBM DataPower Gateway
[ibm-charts](#)

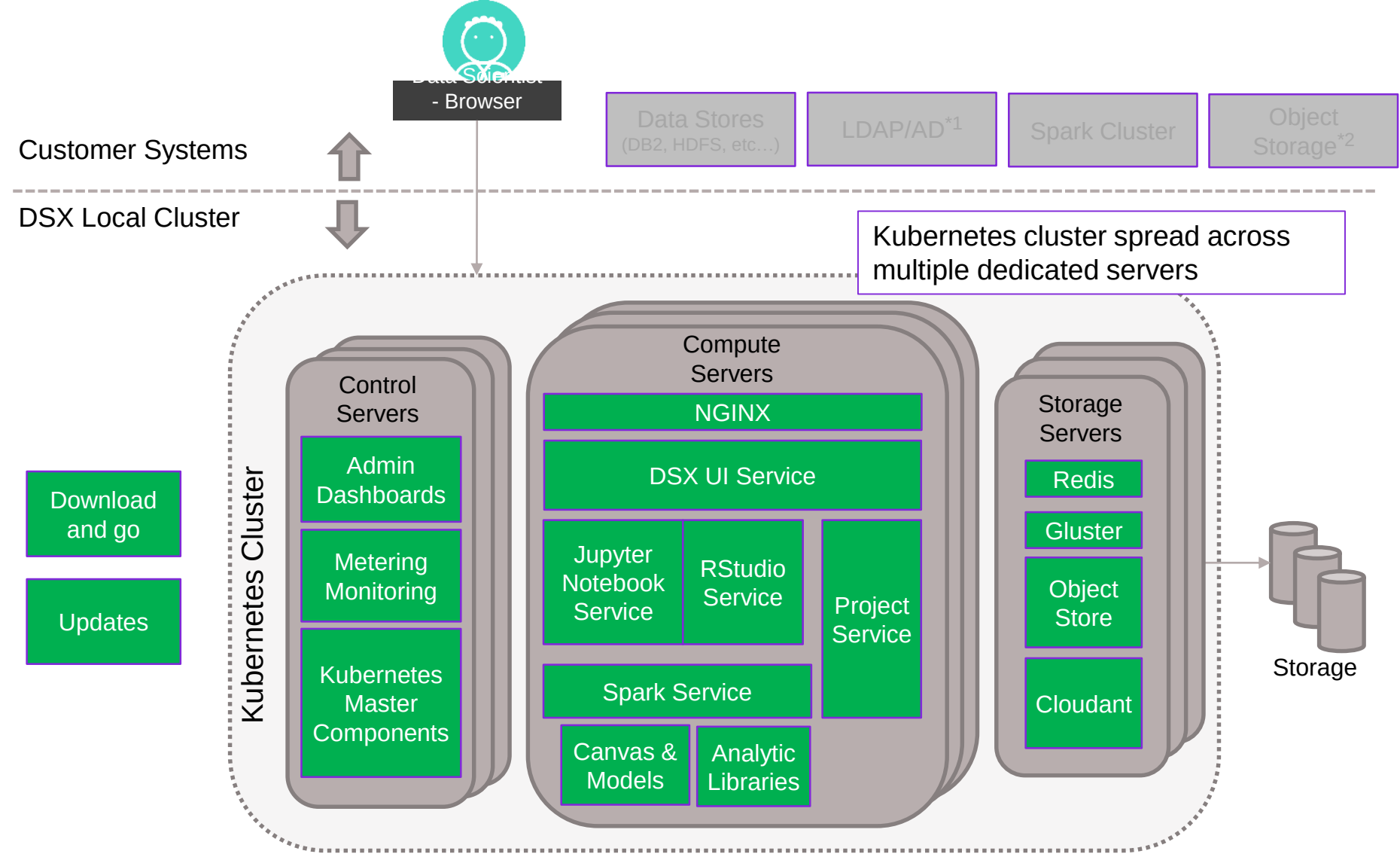
**ibm-db2oltp-dev**
IBM Db2 Developer-C Edition 11.1.3.3
[ibm-charts](#)

**ibm-db2warehouse-dev**
Db2 Warehouse Developer-C for Non-Production v2.5.0
[ibm-charts](#)

**ibm-dsm-dev**
IBM Data Server Manager Developer-C Edition.
Note that there can only be one DSM deployed per
[ibm-charts](#)

**ibm-dsx-dev**
IBM Data Science Experience (DSX) Developer Edition brings together best of breed open source
[ibm-charts](#)

DSX Local Cluster Architecture



DSX Local Cluster & ICP – Internals (as of today: DSX 1.1.1.00 ppc64le)

Namespaces:

sysibmadm-data , sysibm-adm , dsxl-ml , ibm-private-cloud

PODs:

cloudant, redis, usermgmt, dsx-core, and ibm-nginx

Images:

27 images

Listing of key Components in DSX Local

(see under /wdp/k8s in the master node)

- **devtest-helpers** - Utility scripts to help with deployments
- **dsx-local-proxy** - the primary NGINX based server- serves up port 443 and reverse proxies to all other DSX Local service URLs
- **docker-registry** - Docker registry running as a Daemon Set in all hosts and service all needed docker images
- **cloudant-repo** - Cloudant repository database used to house metadata and projects etc.
- **redis-repo** - Redis in-memory Key value store – used for session storage in the web/UI micro services
- **swift-objectstore** - Openstack Swift container used to store csv data assets
- **usermgmt** - Supports management of users, authentication and working an external LDAP server
- **spark** - Spark cluster – master & worker daemon set
- **wdp-deploy-dashboard** – Backend and Front-end Admin components (IBM Data Platform Manager)
- **wdp-logs-elk** - Elastic Search, LogStash and Kibana – for Logging, Indexing
- **wdp-metrics-prometheus** - Monitoring metrics with Prometheus
- **dsx-local-k8s** - web-ui and api microservices (such as portal-main, projects api etc.)
- **docplexcloud-service** - Decision optimization / Deep Learning deployment

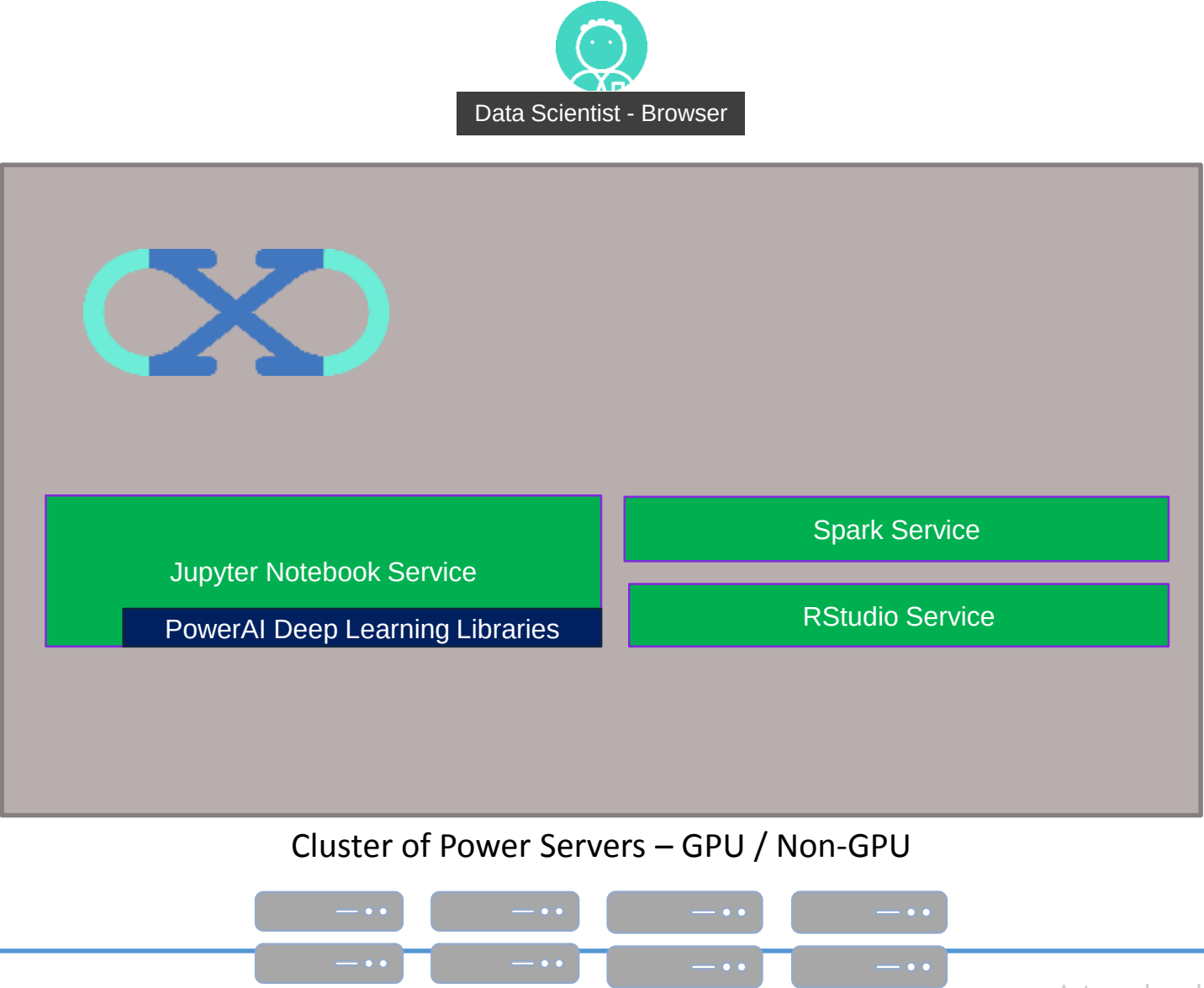
19

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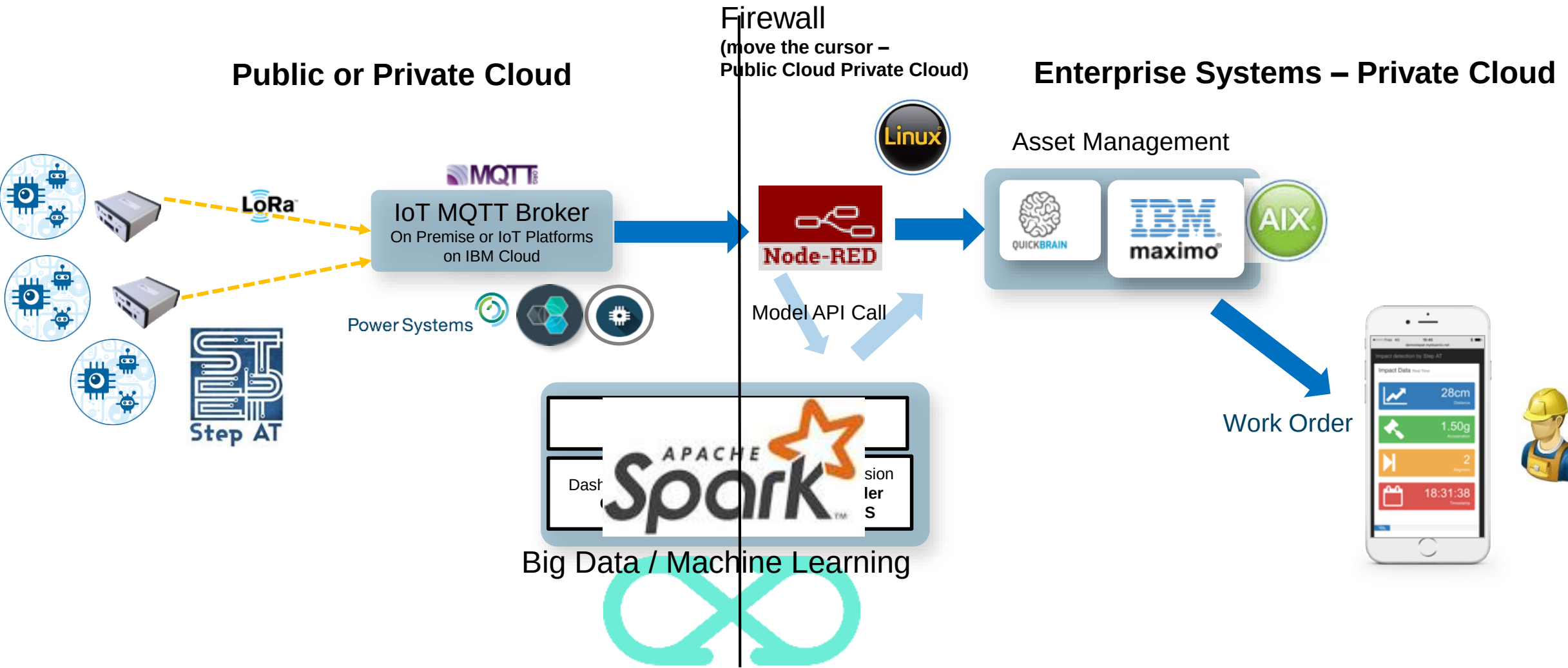
Prefix/Suffix	image.repository	image.tag
cloudantRepo	privatecloud-cloudant-repo	v3.13.428
dsxConnectionBack	dsx-connection-back	1.0.4
dsxCORE	dsx-core	v3.13.10
dsxScriptedML	privatecloud-dsx-scripted-ml	v0.01.2
filemgmt	filemgmt	1.0.2
hdpzeppelinDsxD8a2ls2x	hdpzeppelin-dsx-d8a2ls2x	v1.0.10
jupyterDsxD8a2ls2x	jupyter-dsx-d8a2ls2x	v1.0.11
jupyterDsxD8a3ls2x	jupyter-dsx-d8a3ls2x	v1.0.7
jupyterGpuPy35	jupyter-gpu-py35	v1.0.9
mlOnlineScoring	privatecloud-ml-online-scoring	v3.13.6
mlPipelinesApi	privatecloud-ml-pipelines-api	v3.13.4
mllib	ml-lib	v3.13.30
nginxRepo	privatecloud-nginx-repo	v3.13.6
pipeline	privatecloud-pipeline	v3.13.3
portalMachineLearning	privatecloud-portal-machine-learning	v3.13.20
portalMlaas	privatecloud-portal-mlaas	v3.13.17
redisRepo	privatecloud-redis-repo	v3.13.431
repository	privatecloud-repository	v3.13.2
rstudio	privatecloud-rstudio	v3.13.8
spark	spark	1.5.1
sparkClient	spark-client	v1.0.2
sparkaasApi	sparkaas-api	v1.3.14
spawnerApiK8s	privatecloud-spawner-api-k8s	v3.13.5
usermgmt	privatecloud-usermgmt	v3.13.5
utilsApi	privatecloud-utils-api	v3.13.5
wmlBatchScoring	wml-batch-scoring	v3.13.2
wmlIngestion	privatecloud-wml-ingestion	v3.13.2

Good news: ICP/K8s manages everything for you ☺

DSX and PowerAI worker node – High-Level View

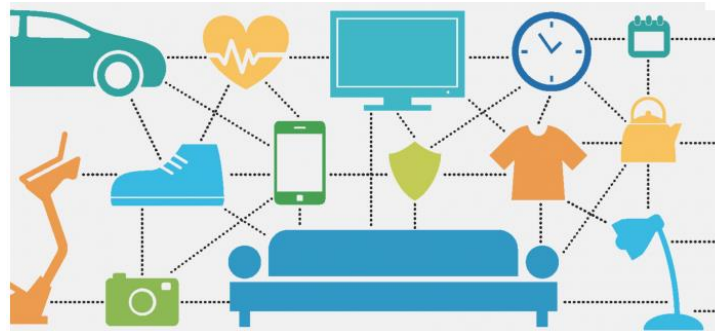


Predictive Maintenance Demonstration



Demonstration Video Replay:

<https://ibm.ent.box.com/v/power-iot-dsx-video-mp4>

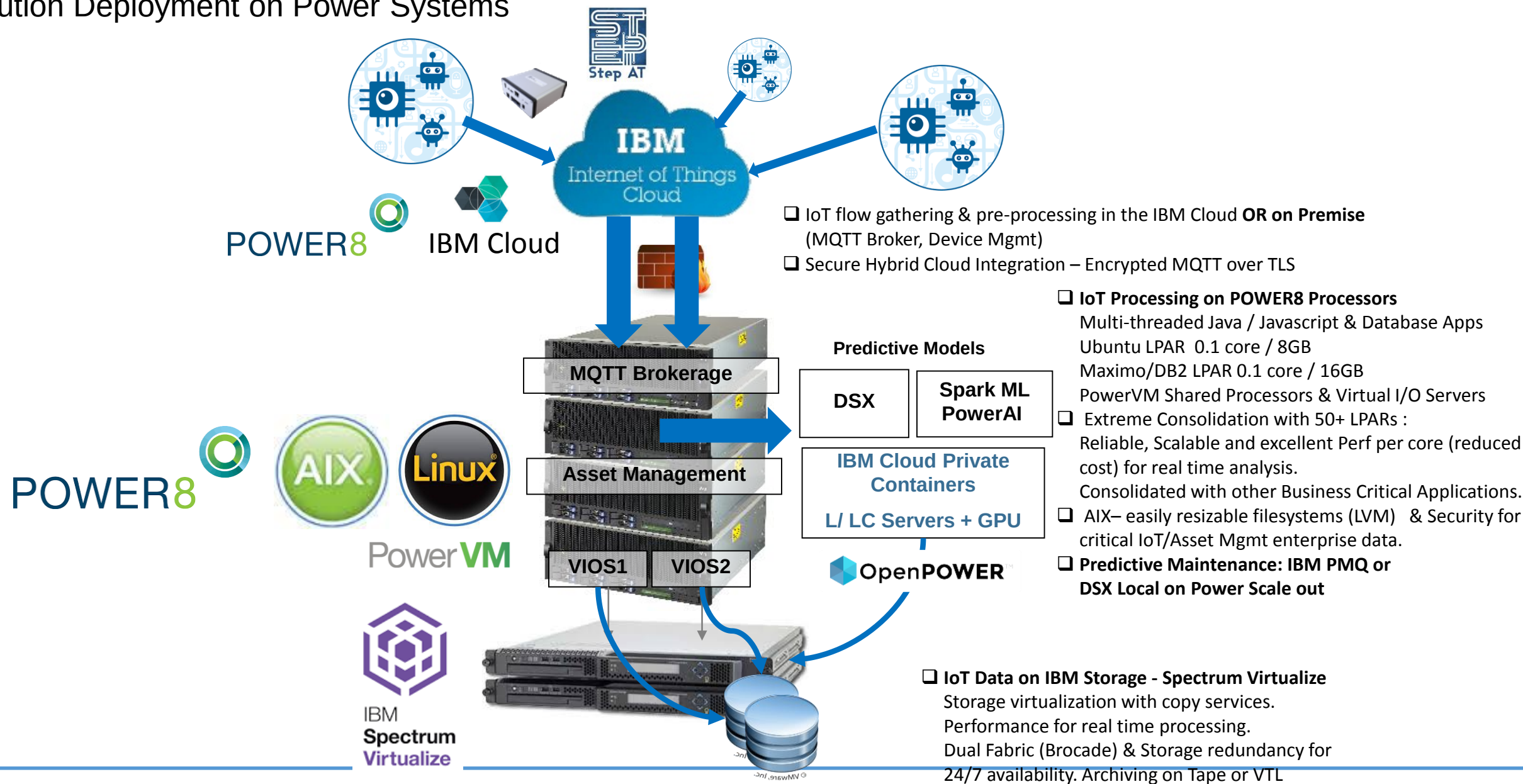


Demo: Predictive Maintenance on Power with DSX

IIoT + Predictive Maintenance solution augmented with AI & predictive capabilities

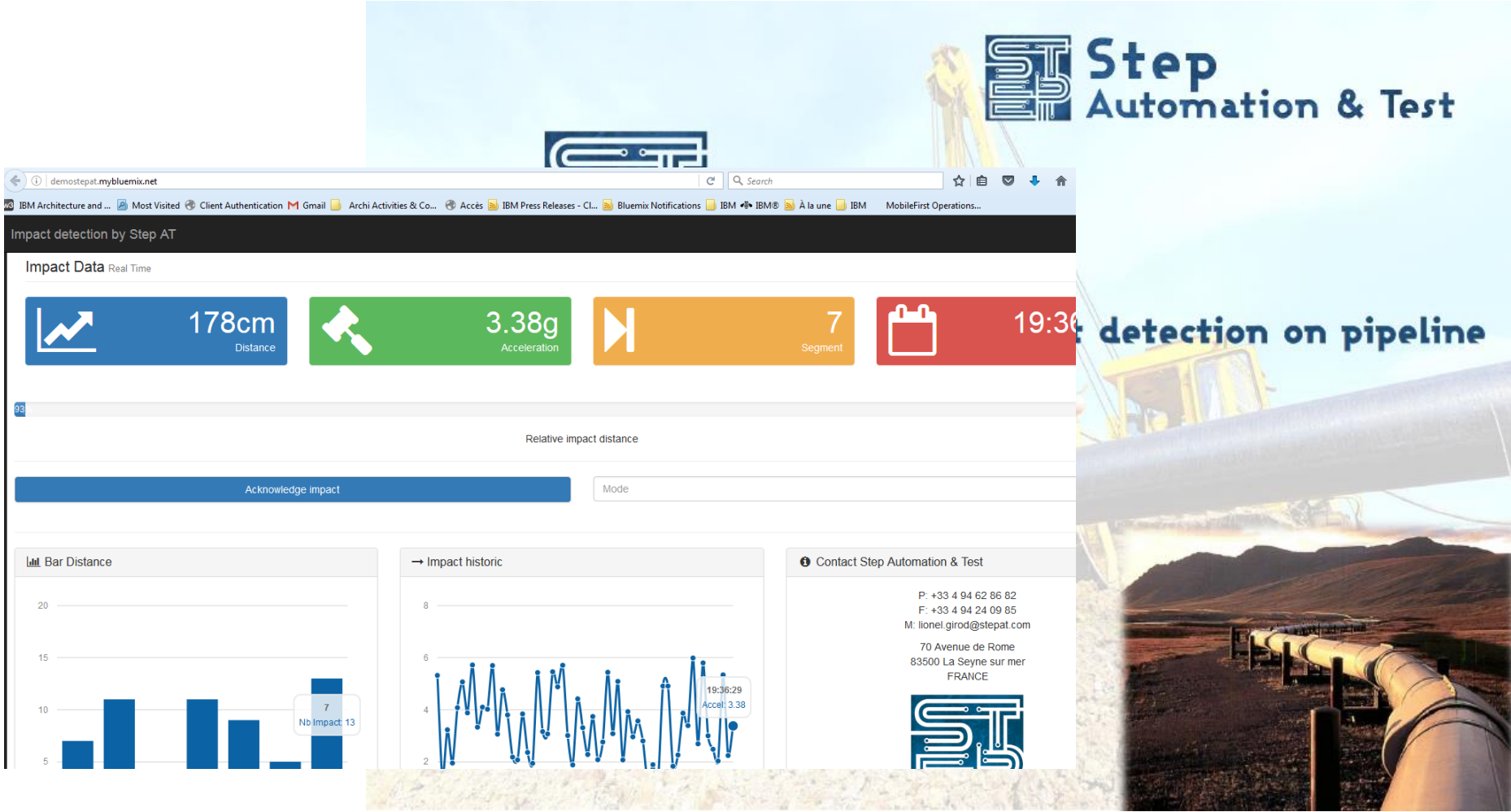
1. Data Collection & Asset Instrumentation
 - ❑ Sensors, LoRa, IoT Box & MQTT – IBM Cloud & Watson IoT – Node.RED
2. Asset Management with hybrid Cloud integration
 - ❑ IBM Maximo Asset Management on AIX (rock solid & secure)
 - ❑ Avoid a majority of outages with Condition Based Maintenance + Preventative Maintenance
3. AI , ML/DL for Predictive Maintenance : Bespoke ML/DL models with the good precision vs. Business objectives
 - ❑ Predict an Engine outage using DSX & Spark ML on Power Systems
 - ❑ Use of collaborative tools, Jupyter notebooks (R or Python)
 - ❑ Training, Test & validation using DSX, IBM Machine Learning & Spark ML
 - ❑ Model Inference: asset failure predictive model as a service – REST API

Solution Deployment on Power Systems



- ☐ IoT flow gathering & pre-processing in the IBM Cloud **OR on Premise** (MQTT Broker, Device Mgmt)
- ☐ Secure Hybrid Cloud Integration – Encrypted MQTT over TLS
- ☐ **IoT Processing on POWER8 Processors**
 - Multi-threaded Java / Javascript & Database Apps
 - Ubuntu LPAR 0.1 core / 8GB
 - Maximo/DB2 LPAR 0.1 core / 16GB
 - PowerVM Shared Processors & Virtual I/O Servers
- ☐ Extreme Consolidation with 50+ LPARs : Reliable, Scalable and excellent Perf per core (reduced cost) for real time analysis. Consolidated with other Business Critical Applications.
- ☐ AIX– easily resizable filesystems (LVM) & Security for critical IoT/Asset Mgmt enterprise data.
- ☐ **Predictive Maintenance: IBM PMQ or DSX Local on Power Scale out**
- ☐ **IoT Data on IBM Storage - Spectrum Virtualize**
 - Storage virtualization with copy services.
 - Performance for real time processing.
 - Dual Fabric (Brocade) & Storage redundancy for 24/7 availability. Archiving on Tape or VTL

Connection to the Pipeline Dashboard



Watson IoT Platform



IBM Watson™ IoT Platform for Bluemix gives you a versatile toolkit that includes gateway devices, device management, and powerful application access. By using Watson IoT Platform, you can collect connected device data and perform analytics on real-time data from your organization.



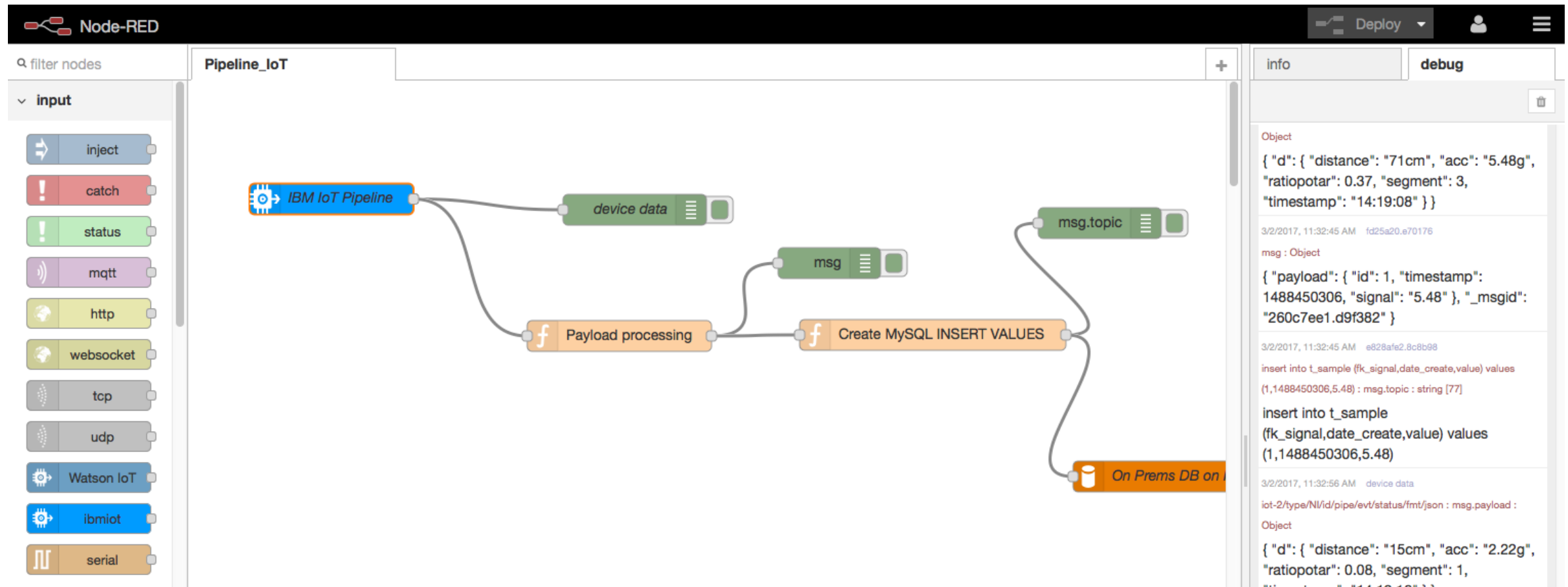
Welcome to Watson IoT Platform

The collage displays four screenshots of the IBM Watson IoT Platform interface:

- Navigation Menu:** A vertical sidebar on the left with options: BOARDS, DEVICES, MEMBERS, APPS, USAGE, RULES, SECURITY, SETTINGS, and EXTENSIONS.
- Devices Page:** A table listing devices with columns: Device ID, Device Type, Class ID, and Date Added. Two devices are shown: PAHO-TEST (PAHO, Device, Aug 17, 2016 5:28:41 PM) and pipe (NI, Device, Apr 5, 2016 2:32:19 PM).
- Apps Page:** A table listing applications with columns: Key, Roles, Last Edited By, Expiry Date, and Comment. Three applications are shown, all of type 'Standard Application'.
- Device-Centric Analytics Dashboard:** A dashboard for a device named 'pipe'. It includes sections for 'Devices I Care About', 'Device Info' (showing firmware and hardware versions), 'Device Properties' (showing various sensor data like altitude, name, and speed), and 'Rule Alerts For That Device'.

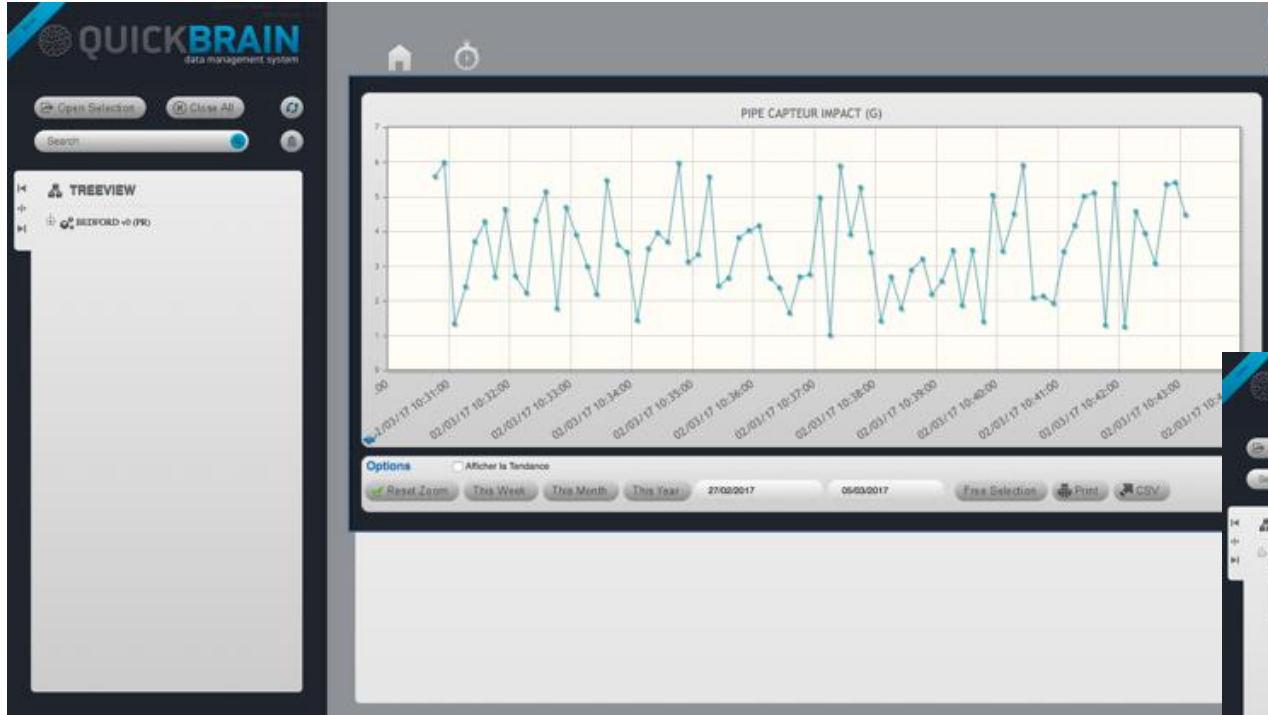
Integration with Node-Red

Node.js visual scripting tool that runs on premise on Ubuntu POWER8. Use an IBM IoT Client node to get the events from the Watson IoT Service, parse them, and insert them in the QUICKBRAIN MySQL database.



Ennovia QuickBrain

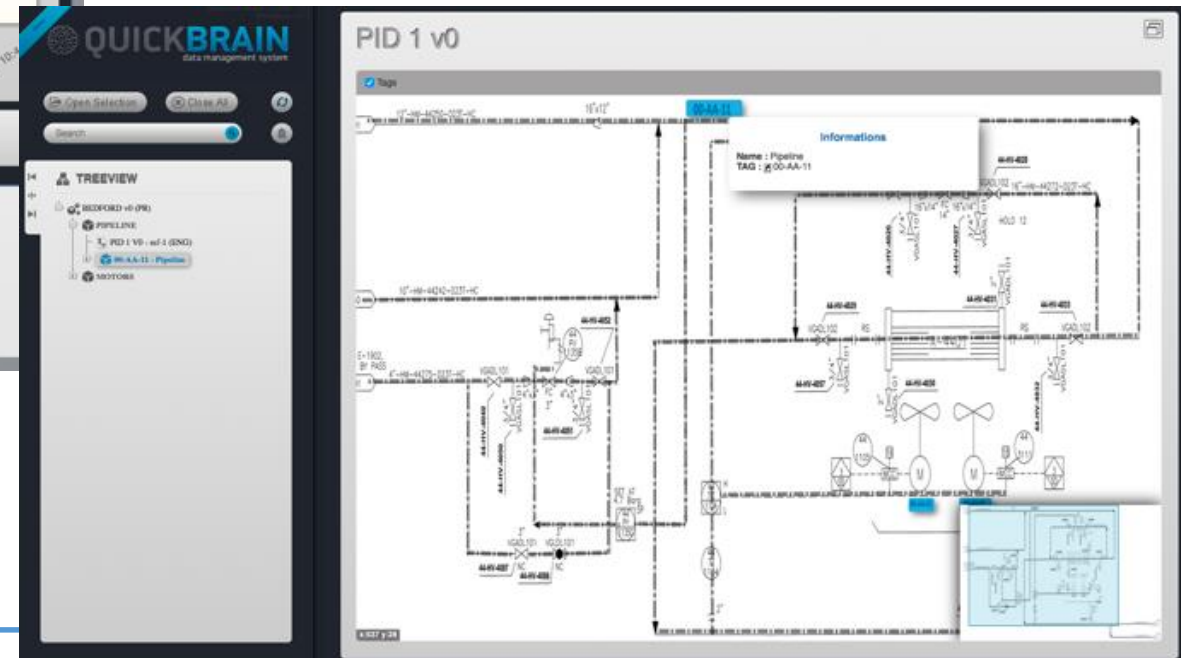
A complete solution for interactive documentation & maintenance management and includes an integration module to Maximo.



ENNOVIA Smart Industrial Solutions

QB4MX Quickbrain feature:

- Easy import of data from a plant or any industry (assets, items, sensors) in Maximo
- Easy connection between IoT Sensors (from the IoT box) and Maximo Meters
- Connection & import done via IBM Maximo REST API.



IBM Maximo

IBM® Maximo® Asset Management is a comprehensive solution for managing physical assets on a common platform in asset-intensive industries. Integrated in Ennovia solutions.

Welcome, Mike Wilson

IMPACT FORCE 1= WARNING 2= WORK ORDER

Last Run: 3/2/17 11:38 AM

Status	Last Reading	Actual	Target	Variance
—	2.35	2.35	0	2.35

IMPACT FORCE



Mobile Start Center

COUNT NEW WORK ORDER

Last Run: 3/2/17 11:38 AM

Status	KPI
—	

Applications

- Assets
- Condition Monitoring
- Work Order Tracking

Assets

Find Asset

Select Action

List View

Asset

Spare Parts

Safety

Meters

Specifications

Relationships

Work

Topology

Service Address

Map

Asset: PIPELINE 1 Pipeline Site: BEDFORD From: 0.00 To: 200.00 Meter Group: >>

Meters > Filter > 1 - 1 of 1

Sequence	Meter	Description	Meter Type	Unit of Measure	Active?	Start Measur	End Measur
>>	IMPACT FORCE METER	>>	GAUGE	G	✓	0.00	0.00

Meter Details

Sequence: >> Meter: IMPACT FORCE METER >> Meter Type: GAUGE

Last Reading: 2.83

Last Reading Date: 3/2/17 11:42 AM

Last Reading Inspector: UPTIMIZER >>

Condition Monitoring

Find Point

Select Action

List View

Condition Monitoring

Point: 1008 IMPACT FORCE Location: >> Site: BEDFORD Meter: IMPACT FORCE METER Meter Type: GAUGE Unit of Measure: G

Attachments

Upper Limits

Lower Limits

Upper Limit PM: 1020 >> PIPE INSPECTION

Lower Limit PM: 1020 >> PIPE INSPECTION

IBM Partners Solutions

Step AT – IoT Solution with IBM Cloud



- ❑ **Sensors** to instrument a facility. In that case, a connected pipeline reporting events after a first filtering by the **IoT Box** (Step AT) algorithms running on FPGA. 2 Accelerometers are placed on the pipe for that demo for shock detection AND localization.
- ❑ **Step AT IoT Box**: a MQTT device which subscribes to a specific topic on the MQTT Broker running in Bluemix (can be on premise). The role of the IoT Box is to make a first real time (high performance) filtering close to the sensors with specific algorithms (specific to the pipeline shock detection) and only report 'real shocks' events to the MQTT Broker. Compatible with many kinds of sensors/machine tool.
- ❑ **In the Real life**: sensors = microphones dispatched every 10 km, each attached to an IoT Box on the pipeline (desert, extreme temperatures). Communication = LoRa (Long Range) radio connection + MQTT (lightweight). All IoT Boxes are synchronized for a more accuracy shock detection (complex algorithms)

Ennovia / Crazylog – Predictive Maintenance on Power Systems



- ❑ **Node-Red**: Node.js visual scripting tool that runs on premise on Ubuntu POWER8. This app uses an IBM IoT Client node to get the events from the **Bluemix IoT Platform Service**, parse them, and insert them in the **QUICKBRAIN** MySQL database.
- ❑ **QuickBrain**: This Web App is a complete solution for documentation management (including 2D 3D views, maps), event & maintenance management and includes an integration module to **IBM Maximo Asset Management** for alerting and maintenance tasks.
- ❑ Possible Integration with **IBM Cognos**, **IBM PMQ** ...for further analysis & asset productivity.

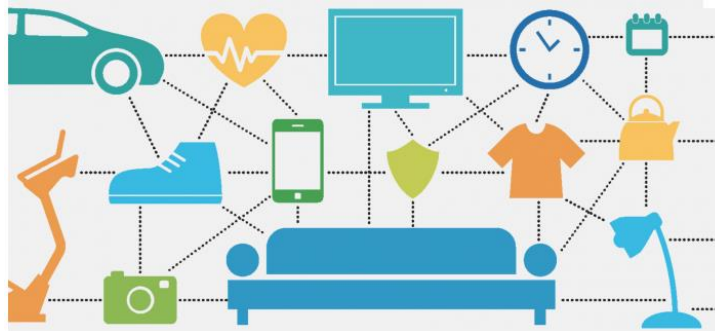
Predictive Maintenance Use case : Steps with DSX

1. Data collected by NASA – 100 engines / 20 sensors each / hundreds of cycles recorded until failure
<https://ti.arc.nasa.gov/tech/dash/groups/pcoe/prognostic-data-repository/>
 - ❑ Damage Propagation [study](#)
2. Data cleaning, normalization, feature engineering (rolling avg , rolling sd) , RUL (Remaining useful life or TTF) with DSX (R , Jupyter Notebooks)
3. **Modeling with DSX**
 - Spark 2.0 via R notebook (Jupyter) & Watson ML
 - Regression models: How many more cycles an in-service engine will last before it fails?
//Random Forrest Regression, Gradient Boosting Tree , etc.
 - Binary classification: Is this engine going to fail within w1 cycles?
 - Multi-class classification: Is this engine going to fail within the window [1, w0] cycles or to fail within the window [w0+1, w1] cycles, or it will not fail within w1 cycles?
4. Training with default hyperparameters – can be tuned
5. Evaluation, **Publish** Model as a Service.
6. Integration to existing IoT Asset Management solution for predicting asset failure

DSX

Backup Slides

Demonstration Screenshots



Data Science Experience

Import or use Raw data (csv files, object storage, jdbc ...) using connectors

The screenshot displays the IBM Data Science Experience interface for a project named 'Predictive Maintenance v1'. The top navigation bar includes links for 'My Projects', 'Projects', 'Tools', 'Data Services', and 'Community'. The 'Predictive Maintenance v1' project is selected, and the 'Assets' tab is active. A search bar prompts 'What assets are you looking for?'. Below this, the 'Data assets' section shows a table of CSV files stored in Object Storage (Swift API). The files are 'train_FD001.csv', 'RUL_FD001.csv', and 'test_FD001.csv'. The 'Notebooks' section shows a table of notebooks, with 'PrepareData' highlighted. The 'Models' section is partially visible at the bottom.

IBM Data Science Experience | Projects Tools Data Services Community

My Projects > Predictive Maintenance v1 + Add to project

Overview Assets Bookmarks Deployments Collaborators Settings

What assets are you looking for?

▼ Data assets

NAME	TYPE	SERVICE	LAST MODIFIED	ACTIONS
 train_FD001.csv	CSV	Object Storage (Swift API)		⋮
 RUL_FD001.csv	CSV	Object Storage (Swift API)		⋮
 test_FD001.csv	CSV	Object Storage (Swift API)		⋮

▼ Notebooks + New notebook

NAME	SHARED	SCHEDULED	STATUS	LANGUAGE	LAST EDITOR	LAST MODIFIED	ACTIONS
 PrepareData			○	R 3.3.2	BENOIT MAROLLEAU	14 Nov 2017	✎ ⋮

▼ Models + New model

Data Science Experience

Work on your data (Statistics, Analytics, Plots,...) & prepare your models using R or Python libraries – R Studio / Jupyter Notebooks

 IBM Data Science Experience | Projects Tools Data Services Community

My Projects > Predictive Maintenance v1 > PrepareData

```
df <- data.frame(matrix(unlist(m), nrow=length(m), byrow=T), stringsAsFactors=FALSE)

# generate column names for the data frame
colnames <- c("id","cycle","setting1","setting2","setting3","s1","s2","s3","s4","s5","s6","s7",
              "s8","s9","s10","s11","s12","s13","s14","s15","s16","s17","s18","s19","s20","s21")
names(df) <- colnames

# generate output data
data.set <- df

# Select data.frame to be sent to the output Dataset port
#maml.mapOutputPort "data.set";
```

In [2]:

```
#Raw Data from Sensors CSV file
#dataset
#Formatted data
data.set
```

id	cycle	setting1	setting2	setting3	s1	s2	s3	s4	s5	...	s12	s13	s14	s15	s16	s17	s18	s19	s20
1	1	0.0023	0.0003	100.0	518.67	643.02	1585.29	1398.21	14.62	...	521.72	2388.03	8125.55	8.4052	0.03	392	2388	100.00	38.8
1	2	-0.0027	-0.0003	100.0	518.67	641.71	1588.45	1395.42	14.62	...	522.16	2388.06	8139.62	8.3803	0.03	393	2388	100.00	39.0
1	3	0.0003	0.0001	100.0	518.67	642.46	1586.94	1401.34	14.62	...	521.97	2388.03	8130.10	8.4441	0.03	393	2388	100.00	39.0
1	4	0.0042	0.0000	100.0	518.67	642.44	1584.12	1406.42	14.62	...	521.38	2388.05	8132.90	8.3917	0.03	391	2388	100.00	39.0
1	5	0.0014	0.0000	100.0	518.67	642.51	1587.19	1401.92	14.62	...	522.15	2388.03	8129.54	8.4031	0.03	390	2388	100.00	38.9
1	6	0.0012	0.0003	100.0	518.67	642.11	1579.12	1395.13	14.62	...	521.92	2388.08	8127.46	8.4238	0.03	392	2388	100.00	38.9
1	7	-0.0000	0.0002	100.0	518.67	642.11	1583.34	1404.84	14.62	...	522.01	2388.06	8134.97	8.3914	0.03	391	2388	100.00	38.8
1	8	0.0006	-0.0000	100.0	518.67	642.54	1580.89	1400.89	14.62	...	522.09	2388.06	8125.93	8.4213	0.03	393	2388	100.00	39.0
1	9	-0.0036	0.0000	100.0	518.67	641.88	1593.29	1412.28	14.62	...	522.03	2388.05	8134.15	8.4353	0.03	391	2388	100.00	39.0

Data Science Experience

IBM ML (Automatic Model Builder) demo
(Can be done programmatically
from a notebook or Flow Designer too)
Use of Spark & Spark ML
Input: clean dataset
Hyper parameters can be changed
Split dataset in test, training
Training, Evaluation, and Test
Create the model in your project
Publish your model as a REST API

 IBM Data Science Experience | Projects Tools Data Services Community

New model BETA

Name

PredictiveRUL

87

Description

Model description

300

Machine Learning Service

WatsonML

▼

Spark Service

DSX-Spark

▼

Automatic

Prepare my data and create a model automatically

Manual

Let me prepare my data and select which models to train

Data Science Experience

Features (input data from IoT sensors)

cycle	setting1	setting2	s2	s3	s4	s6	s7	s8	s9	s11	s12
0	0.45977	0.166667	0.183735	0.406802	0.309757	1	0.726248	0.242424	0.109755	0.369048	0.633262
0.00277	0.609195	0.25	0.283133	0.453019	0.352633	1	0.628019	0.212121	0.100242	0.380952	0.765458
0.00554	0.252874	0.75	0.343373	0.369523	0.370527	1	0.710145	0.272727	0.140043	0.25	0.795309
0.00831	0.54023	0.5	0.343373	0.256159	0.331195	1	0.740741	0.318182	0.124518	0.166667	0.889126
0.01108	0.390805	0.333333	0.349398	0.257467	0.404625	1	0.668277	0.242424	0.14996	0.255952	0.746269
0.01385	0.252874	0.416667	0.268072	0.292784	0.272113	1	0.776167	0.181818	0.125415	0.184524	0.637527
0.01662	0.557471	0.583333	0.38253	0.46392	0.261985	1	0.723027	0.181818	0.167818	0.303571	0.773987
0.019391	0.304598	0.75	0.406627	0.259865	0.316003	1	0.644122	0.151515	0.085569	0.232143	0.80597
0.022161	0.545977	0.583333	0.274096	0.434707	0.21185	1	0.618357	0.227273	0.110967	0.261905	0.660981

Close

Use This Data

NASA Source : <https://ti.arc.nasa.gov/tech/dash/groups/pcoe/prognostic-data-repository/>

Data Science Experience

Columns to predict (labels)

	sd9	sd11	sd12	sd13	sd14	sd15	sd17	sd20	sd21	RUL	label1	label2
	0	0	0	0	0	0	0	0	0	191	0	0
70464	0.118087	0.057199	0.488189	0.160656	0.508246	0.132258	0	0.130435	0.017365	190	0	0
99652	0.364881	0.492044	0.450405	0.120224	0.374753	0.116172	0.408248	0.169323	0.237961	189	0	0
48784	0.305764	0.694286	0.552267	0.133773	0.307559	0.427568	0.353553	0.234642	0.202745	188	0	0
61827	0.361364	0.610985	0.481694	0.11762	0.267278	0.394651	0.387298	0.226338	0.178837	187	0	0
4034	0.330369	0.572418	0.473725	0.106567	0.096645	0.391221	0.403113	0.157365	0.167828	186	0	0
94257	0.31812	0.380491	0.473987	0.098513	0.064834	0.356987	0.403113	0.266604	0.115497	185	0	0
18326	0.544759	0.374642	0.478738	0.098513	0.115857	0.341797	0.295804	0.265894	0.183678	184	0	0
2048	0.56648	0.296663	0.379835	0.040643	0.323137	0.315382	0.295804	0.237146	0.207884	183	0	0

Close

Use This Data

Data Science Experience

IBM Machine Learning Wizard:

Column to predict
Features

My Projects > Predictive Maintenance v1 > PredictiveRUL

Train

Evaluate

Column value to predict (Label Col)

RUL (Integer)

Feature columns

cycle (Decimal), setting1 (Decimal), setting2 (Decimal), s2 (Decimal), s3 (Decimal), s4 (Decimal), s6 (Integer), s7 (Decimal), s8 (Decimal), s9 (Decimal), s11 (Decimal), s12 (Decimal), s13 (Decimal), s14 (Decimal), s15 (Decimal), s17 (Decimal), s20 (Decimal), s21 (Decimal), a2 (Decimal), a3 (Decimal), a4 (Decimal), a6 (Decimal), a7 (Decimal), a8 (Decimal), a9 (Decimal), a11 (Decimal), a12 (Decimal), a13 (Decimal), a14 (Decimal), a15 (Decimal), a17 (Decimal), a20 (Decimal), a21 (Decimal), sd2 (Decimal), sd3 (Decimal), sd4 (Decimal), sd6 (Decimal), sd7 (Decimal), sd8 (Decimal), sd9 (Decimal), sd11 (Decimal), sd12 (Decimal), sd13 (Decimal), sd14 (Decimal), sd15 (Decimal), sd17 (Decimal), sd20 (Decimal), sd21 (Decimal)

sd15 (Decimal)

sd17 (Decimal)

sd20 (Decimal)

sd21 (Decimal)

label1 (Integer)

label2 (Integer)

Regression

Regression is a supervised technique. It predicts a continuous value from a set of values. It uses your label column and a large number of features.

Data Science Experience

IBM Machine Learning Wizard:

Assisted ML algorithms choice

My Projects > Predictive Maintenance v1 > PredictiveRUL

Train

Evaluate

Column value to predict (Label Col)

RUL (Integer) 

Feature columns

cycle (Decimal), setting1 (Decimal), setting2 (Decimal), s2 (Decimal), s3 (Decimal), s4 (Decimal), s6 (Integer), s7 (Decimal), s8 (Decimal), s9 (Decimal), s11 (Decimal), s12 (Decimal), s13 (Decimal), s14 (Decimal), s15 (Decimal), s17 (Decimal), s20 (Decimal), s21 (Decimal), a2 (Decimal), a3 (Decimal), a4 (Decimal), a6 (Decimal), a7 (Decimal), a8 (Decimal), a9 (Decimal), a11 (Decimal), a12 (Decimal), a13 (Decimal), a14 (Decimal), a15 (Decimal), a17 (Decimal), a20 (Decimal), a21 (Decimal), sd2 (Decimal), sd3 (Decimal), sd4 (Decimal), sd6 (Decimal), sd7 (Decimal), sd8 (Decimal), sd9 (Decimal), sd11 (Decimal), sd12 (Decimal), sd13 (Decimal), sd14 (Decimal), sd15 (Decimal), sd17 (Decimal), sd20 (Decimal), sd21 (Decimal) 

 Suggested technique.



Binary Classification

Classify new data into defined categories based on existing data. Choose if your label column contains two distinct categories.



Multiclass Classification

Classify new data into defined categories based on existing data. Choose if your label column contains a discrete number of categories.



Regression

Predict values from a continuous set of values. Choose if your label column contains a large number of values.

IBM Cloud

Internal and Business Partner Use Only

IBM

Data Science Experience

IBM Machine Learning Wizard:

- ML algorithm choice
- Pre-set but tunable Hyperparameters

Select estimator(s)

 What type of estimator are you looking for?



Linear Regression

Models the linear relationship between a scalar-dependent variable y and one or more explanatory variables (or independent...



Decision Tree Regressor

Maps observations about an item (represented in the branches) to conclusions about the item's target value (represented in...



Random Forest Regressor

Constructs multiple decision trees to produce the mean prediction of each decision tree. It supports both continuous and c...



Gradient Boosted Tree Regressor

Produces a regression prediction model in the form of an ensemble of decision trees. It supports both continuous and categ...



Isotonic Regression

Models the isotonic relationship of a sequence of observations by fitting a free-form line to the observations under the f...

Cancel

Add

Data Science Experience

IBM Machine Learning
Wizard:

Data Split
Training & Evaluation



My Projects > Predictive Maintenance v1 > PredictiveRUL

Select Data

Train

Evaluate

Select model

	ESTIMATOR TYPE	STATUS	PERFORMANCE	ROC CURVE
☒	GBTRegressor	Training...	...	...
☐	RandomForestRegressor	Queued...	...	...
☐	DecisionTreeRegressor	Queued...	...	...

Data Science Experience

IBM Machine Learning
Wizard:

Select a Spark model once trained & evaluated

 IBM Data Science Experience

ProjectsToolsData ServicesCommunity

My Projects > Predictive Maintenance v1 > PredictiveRUL

Select Data

Train

Evaluate

Select model

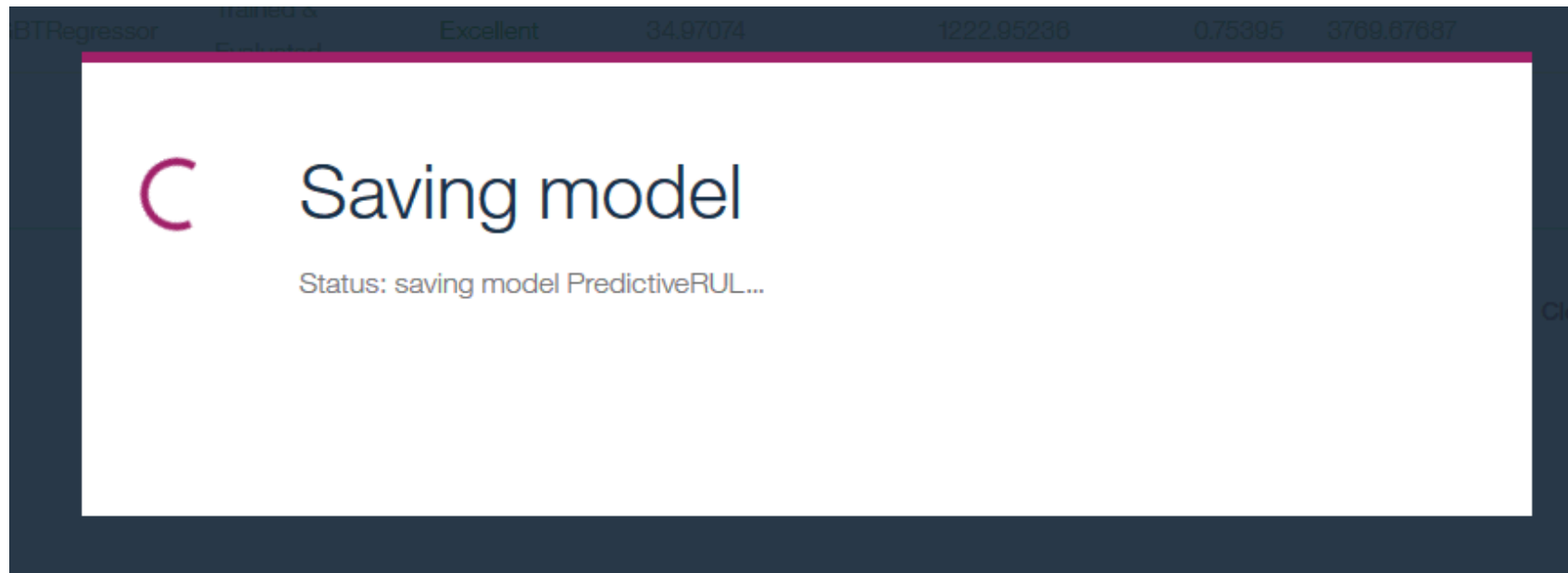
	ESTIMATOR TYPE	STATUS	PERFORMANCE	ROOT MEAN SQUARED ERROR	MEAN SQUARED ERROR	R2
☐	DecisionTreeRegressor	Trained & Evaluated	Excellent	36.54021	1335.1867	0.71254
☐	RandomForestRegressor	Trained & Evaluated	Excellent	35.56394	1264.79411	0.7277
☒	GBTRegressor	Trained & Evaluated	Excellent	34.44071	1186.16245	0.74463

Data Science Experience

IBM Machine Learning

Wizard:

Saving Model - Can be shared with other Data Scientists for use in their project



Data Science Experience

IBM Machine Learning

Wizard:

Model Deployment

The screenshot shows the 'PredictiveRUL' application interface with a 'Deploy model' dialog box open. The background interface has a dark blue header with the 'PredictiveRUL' logo and a trash icon. Below the header are four tabs: 'Overview', 'Evaluation', 'Deployments', and 'Test'. The 'Deployments' tab is selected. Under this tab, there is a section labeled 'NAME' with the text 'Your model is not deployed.' The 'Deploy model' dialog box is a white modal with a magenta border. It has a title bar 'Deploy model' and a scrollable content area. The content area contains two form fields: 'Deployment Type' with a dropdown menu showing 'Online' and a downward arrow, and 'Name' with a text input field containing 'PredictiveRUL'. At the bottom right of the dialog box are two buttons: 'Close' and 'Deploy'.

PredictiveRUL

Overview Evaluation Deployments Test

NAME

Your model is not deployed.

Deploy model

Deployment Type

Online

Name

PredictiveRUL

Close Deploy

Data Science Experience

IBM Machine Learning

Wizard: Model unit testing GUI



Data Science Experience

- IBM Machine Learning Wizard:
 - Deployment metadata

EstimateRUL

Overview	Implementation	Test
Deployment		
Name	EstimateRUL	
Type	online	
Deployment ID	cd750520-cd53-4af5-979b-c93c5ed2be19	
Status	ACTIVE	
Machine learning service	WatsonML	
Created	15 Nov 2017 06:24pm	
Last modified	15 Nov 2017 07:28pm	

Data Science Experience

IBM Machine Learning

Wizard:

- Deployment metadata: REST API Specs & Credentials (Endpoint, Bearer Token)
- Input = IoT sensor data for a particular cycle
- 3 Models deployed:
 - EstimatedRUL estimates the remaining number of cycles for a particular engine
 - EstimatedRULBinary (next slides) : will the asset fail within the next 30 cycles? Return 0 if no else 1 (yes)
 - EstimatedRULMulti : will the asset fail within the next [0 ;15] cycles: returns 2 , [15,30] cycles: 1 else 0

EstimateRUL

Overview **Implementation** Test

Implementation

[View API Specification](#)

Scoring End-point

https://ibm-watson-ml.mybluemix.net/v3/wml_instances/366f855c-745d-4820-9b10-975dac91d5f7/published_models/3b616609-2445-4e5b-9a36-df6e4156d264/deployments/cd750520-cd53-4af5-979b-c93c5ed2be19/online

Authorization: Bearer <token>

See code snippets below for information on how to retrieve the WML Authorization Token to be passed with scoring requests.

Content-type: application/json

Required if the request body is sent in JSON format.

Data Science Experience : Augment your apps with AI

Predictive Model Call – Input IoT sensor measurement data

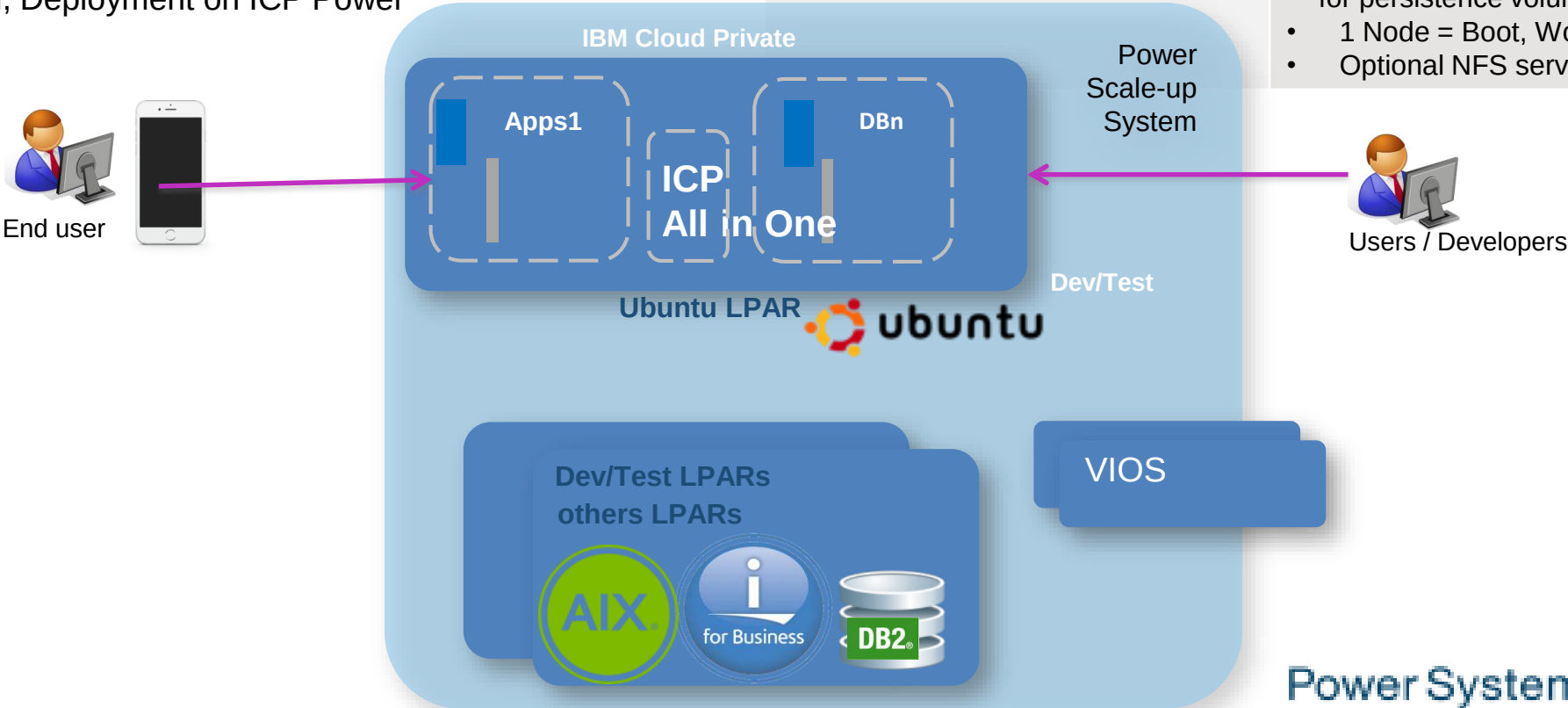
```
curl -X POST --header 'Content-Type: application/json' --header 'Accept: application/json' --header "Authorization: Bearer $WML_AUTH_TOKEN" -d '{"fields": ["cycle", "setting1", "setting2", "s2", "s3", "s4", "s6", "s7", "s8", "s9", "s11", "s12", "s13", "s14", "s15", "s17", "s20", "s21", "a2", "a3", "a4", "a6", "a7", "a8", "a9", "a11", "a12", "a13", "a14", "a15", "a17", "a20", "a21", "sd2", "sd3", "sd4", "sd6", "sd7", "sd8", "sd9", "sd11", "sd12", "sd13", "sd14", "sd15", "sd17", "sd20", "sd21", "RUL", "label2"], "values": [[0.265927977839335, 0.770114942528736, 0.5, 0.237951807228909, 0.304992369740571, 0.265530047265362, 1, 0.789049919484708, 0.1666666666666896, 0.203849950641659, 0.244047619047617, 0.66737739872069, 0.205882352941039, 0.260295180101149, 0.290111581377453, 0.25, 0.627906976744188, 0.642502071251035, 0.357976653696491, 0.324850213980028, 0.265546881852467, 1, 0.78114035087718, 0.206896551723752, 0.204432392758116, 0.196428571428568, 0.733582487987172, 0.230392156862669, 0.275497225442631, 0.324438996794269, 0.131578947368421, 0.707627118644065, 0.731805157593125, 0.378634290993906, 0.152807743951573, 0.179817603790296, 0, 0.361230495012475, 0.0905132666517087, 0.318190892880094, 0.288273458338208, 0.393968412975247, 0.0942273534372436, 0.485523113310845, 0.245122143639341, 0.25, 0.240706270185501, 0.419131972504728, 117, 0, 0]]}' https://ibm-watson-ml.mybluemix.net/v3/wml_instances/366f855c-745d-4820-9b10-975dac91d5f7/published_models/feaae33e-a74a-4916-b0fb-926f2479d9ea/deployments/c3ef5bfe-6ce7-4119-8654-abdbb182fc57/online
```

```
# "fields": ["cycle", "setting1", "setting2", "s2", "s3", "s4", "s6", "s7", "s8", "s9", "s11", "s12", "s13", "s14", "s15", "s17", "s20", "s21", "a2", "a3", "a4", "a6", "a7", "a8", "a9", "a11", "a12", "a13", "a14", "a15", "a17", "a20", "a21", "sd2", "sd3", "sd4", "sd6", "sd7", "sd8", "sd9", "sd11", "sd12", "sd13", "sd14", "sd15", "sd17", "sd20", "sd21", "RUL", "label2", "features", "rawPrediction # "values": [[0.265928, 0.770115, 0.500000, 0.237952, 0.304992, 0.265530, 1, 0.789050, 0.166667, 0.203850, 0.244048, 0.667377, 0.205882, 0.260295, 0.290112, 0.250000, 0.627907, 0.642502, 0.357977, 0.324850, 0.265547, 1.000000, 0.781140, 0.206897, 0.204432, 0.196429, 0.733582, 0.230392, 0.275497, 0.324439, 0.131579, 0.707627, 0.731805, 0.378634, 0.152808, 0.179818, 0.000000, 0.361230, 0.090513, 0.318191, 0.288273, 0.393968, 0.094227, 0.485523, 0.245122, 0.250000, 0.240706, 0.419132, 117, 0, [1.3858372301189021, 6.137294211639708, 2.0442528007214986, 1.5743842324075072, 2.270444989400484, 1.7352685519365865, 7.132404413499512, 5.472788623207081, 1.5360665375925249, 2.047746373350825, 1.524691921440861, 4.225160469473067, 1.9404556077524016, 2.633715376878515, 1.9960251857468427, 1.9332315364079888, 4.454150480629087, 4.271351272561937, 2.229689039057206, 2.3302412010807125, 1.4988769893773246, 13.682878158321932, 4.487810383336061, 1.3012637354915673, 1.9197620649955627, 1.0718279942503923, 4.07856478101555, 1.437191413438685, 2.699127347664428, 2.129592927281977, 0.7890349665359606, 4.350563257729689, 4.149962833905901, 2.8211137074043124, 1.352638078480411, 1.9799415569190923, 0.0, 3.3725274116603856, 1.6904999250413701, 2.6653696160236247, 2.008233527074979, 3.35098924917651, 1.9116635260590547, 4.200107552806071, 2.2617093622975357, 2.0765957924937637, 2.2561787756446097, 3.794347550287433], [13.446546747302442, -13.446546747302442], [0.9999985537668271, 0.0000014462331728372144], # Prediction 0.0, 0.0, [0.0, 1.0]]}]
```

How to get started?

Starter configuration – Single node “All in one”

- CE (Free) Edition. For Dev/Test, no HA.
- Cloud or Enterprise Edition not needed as no HA
- ICP on PowerVM (LPAR) or 1 Scale-out L / LC / CS System (VM)
- Cloud Foundry plugin not available in Q4 2017
- CF on IBM Cloud, Deployment on ICP Power



Current	Target*
IBM i / AIX / Linux LPARs production	IBM i / AIX / Linux LPARs production
IBM i / AIX / Linux LPARs dev/test	IBM i / AIX / Linux LPARs dev/test
	• ICP 2.1 on Power Community Edition • 1 Node: LPAR Ubuntu 16.04 LTS • 8 core / 16GB / disk 200+ GB - Documentation: 4 cores / 8GB • SAN Storage or internal disks • hosted by VIOS (SAN/LAN), NFS Server for persistence volumes (need storage) • 1 Node = Boot, Worker, Proxy, Master • Optional NFS server for persistence

IBM Cloud Private on Power Systems

Multi-VM config with HA

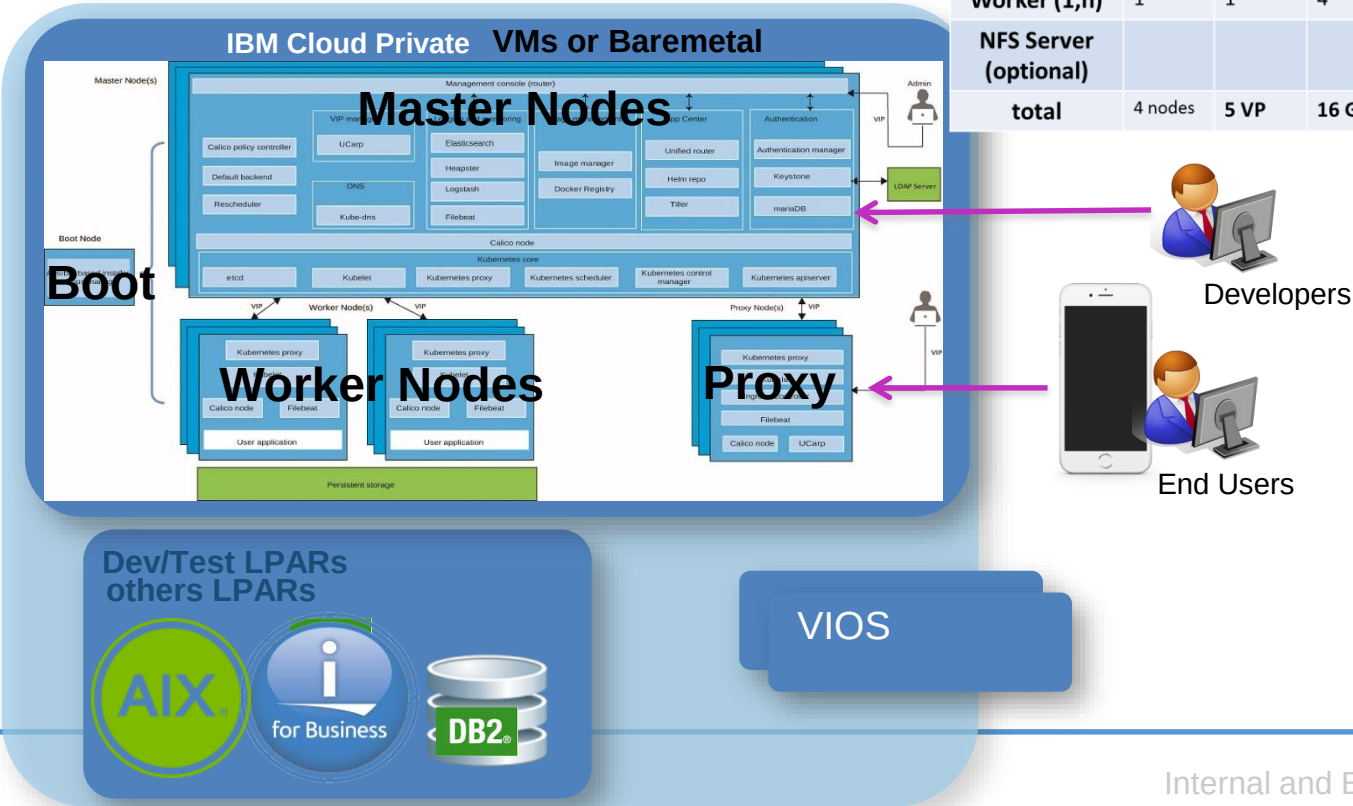
- ICP on PowerVM (LPARs) or Scale-out Systems / Nutanix HCI
- HA Mode for Master & Proxy nodes

Note: Worker nodes can support mixed architectures. You can add worker nodes into a single cluster that run on Linux™ 64-bit, Linux™ on Power® 64-bit LE and IBM® Z platforms.

- Persistence:
 - NFS v4
 - Prefer Glusterfs
- Node = VM (LPAR or KVM VM) or Baremetal
- Example on PowerVM:
 - 11 nodes on 11 LPARs
- Example on L / CS / LC servers:
 - 11 nodes on 4 servers

Current	Target*
IBM i / AIX / Linux LPARs production	IBM i / AIX / Linux LPARs production
	ICP 2.1 on Power - Cloud or Enterprise Edition 11 x OS: Ubuntu 16.04 LTS or RHEL 7.2+

	Minimal 4 Node Config				11 Node Config Example			
Role	#Nodes	CPU (VP)	Mem (GB)	Disk (GB)	#Nodes	CPU (VP)	Mem (GB)	Disk (GB)
Boot (1)	1	1	4	100	1	2	8	80
Master(1,3,5)	1	1	4	150	3	4	16	60
Proxy (1,3,5)	1	2	4	50	3	2	4	60
Management (1, optional)	0	4	8	100	1	8	16	150
Worker (1,n)	1	1	4	100	3	2	8	100
NFS Server (optional)					1	2	8	1024
total	4 nodes	5 VP	16 GB	400 GB	11 nodes	32 VP	116 GB	900 GB



Thank You
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CAPI/SNAP



Power Acceleration for ISV's

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Databases in the
Competition with Oracle.

Competitive & TCO Eagle Teams

Leverage TCO Eagle Team
Studies & Competitive
Expertise (X86/Oracle)

Software Defined Infrastructure

Leverage Software Define
Infrastructure to expend
Modern Data Platform
Capabilities (Spectrum
Scale, ESS, LSF...)



Modern Data Platform

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In Memory /
Accelerated Database

Spark/ Hadoop

Cognitive Systems Lab

Modern Data Platform to
Accelerated Workloads,
PowerAI & ML/DL



PowerAI

Machine Learning /
Deep Learning

HPC GPU/NVlink & CAPI Acceleration

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Competitive Discussions

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Hybrid Cognitive Solutions

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What we will deliver

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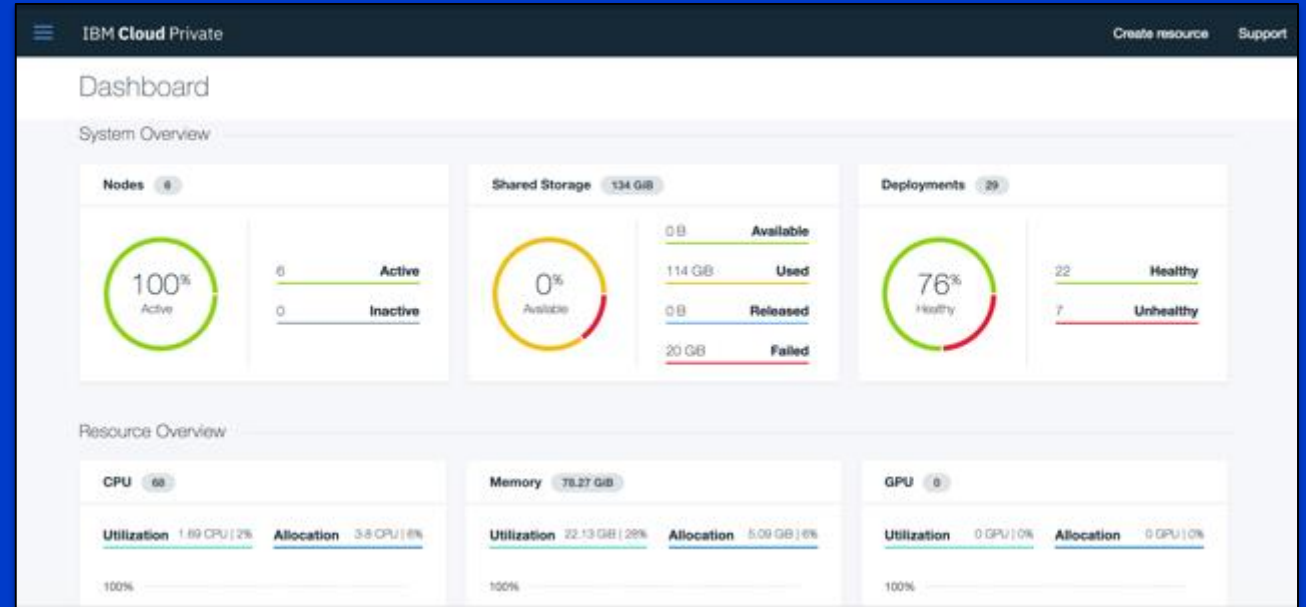
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