IBM Industry Solutions

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Predictive Maintenance & Machine Learning: Best Practices and Approach for industrial client

AGENDA

- Digital Transformation in Industry : AI & ML as disruptive technology
- Predictive Maintenance & Machine Learning: Illustration
- Q/A

More or less all industrial companies need to cover the **same cycle** and address similar challenges

Virtual & Digital Space

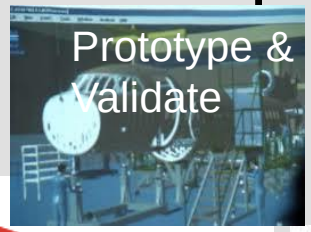
« World of plans, requirements, simulations, forecast ..”

Physical Space

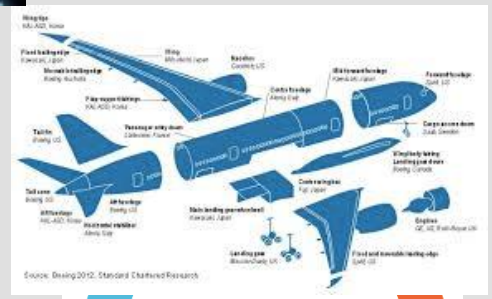
« World of Things, Machines, humans, objects … »

Within 2 to 3 years, leading industrial companies will have in place a **near real-time feedback loop** between product usage & engineering

Data as „intangible assets“



Decentralized, self-controlled Systems & processes



Supply Chain

ECR/ECO

Efficient Change Management Processes & Impact Analysis

IoT Feedback Loop

Efficient information flow

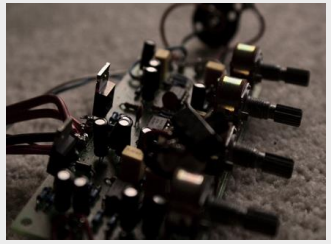
Physical Space

IBM

Technology is leading the digital transformation

Data, Infrastructure, Computational Power & Connectivity

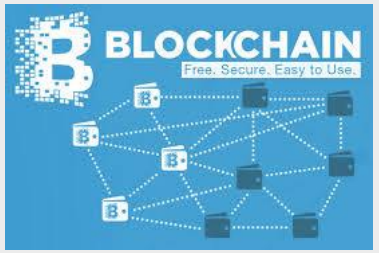
Internet of Things & Devices



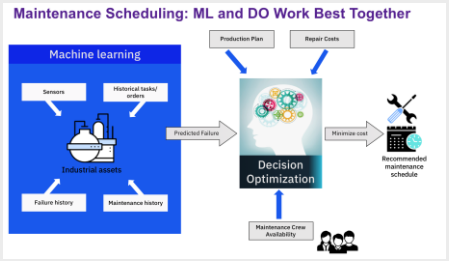
Big Data & Object Storage

Container Approach, server-less, hybrid-cloud

Blockchain



Analytics & Intelligence



Optimization Engine

Human-Machine interaction

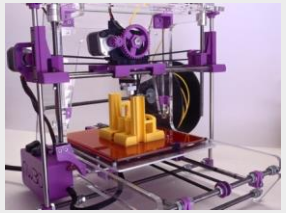
Mobile

Virtual Reality & Immersion

Augmented Reality

Digital-to-Physical Conversion

Advanced robotics



Additive Manufacturing & 3D printing

Embracing Industrial IoT through logical steps of value

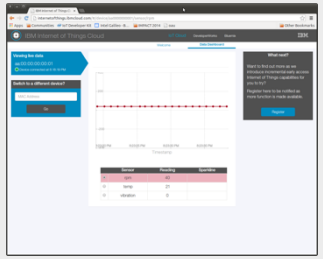
Gather the data

- Instrument your equipment/assets to collect data
- Gather already existing data from various sources

Connect assets, outfitted with sensor or data gathered

Visualize the patterns

- Visualize your data in meaningful dashboards
- Start to see patterns
- Build with Watson IoT solutions



Quickly build dashboards for data & process visualization

Advance to analytics

- Gain insights from the data
- Produce models, prediction, issue detection patterns
- Propose resolution and recommendations

Use analytical models to predict equipment failures and provide recommendations

Infuse with cognitive

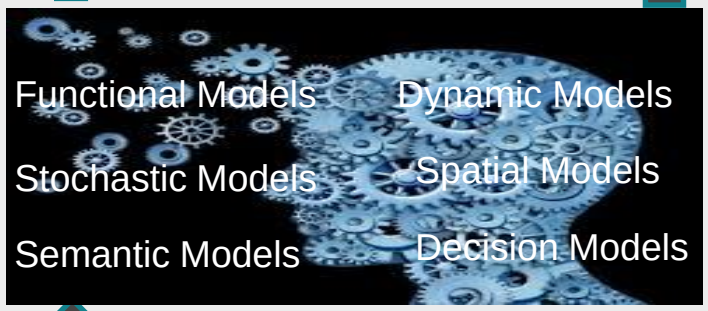
- Refine models with cognitive machine learning
- Utilize other cognitive functions to improve engagement

Use speech, video, image to diagnose complex problems

A mathematical view of data analytics and cognitive

What has happened? What could happen? How to achieve the best outcome?

Descriptive **Predictions** **Prescriptions**



Cognitive

How can we understand and learn?

Optimization
Data Mining

Statistics
Machine Learning

Structured data – continuous, discrete, categorical

Unstructured data

Text Processing **Signal Processing**

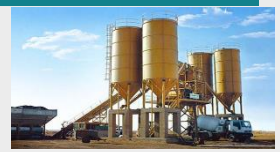
Natural Lang **Images, Video, Voice**

Extreme "Unstructuredness"

Source/Quarries

Assets

Plants



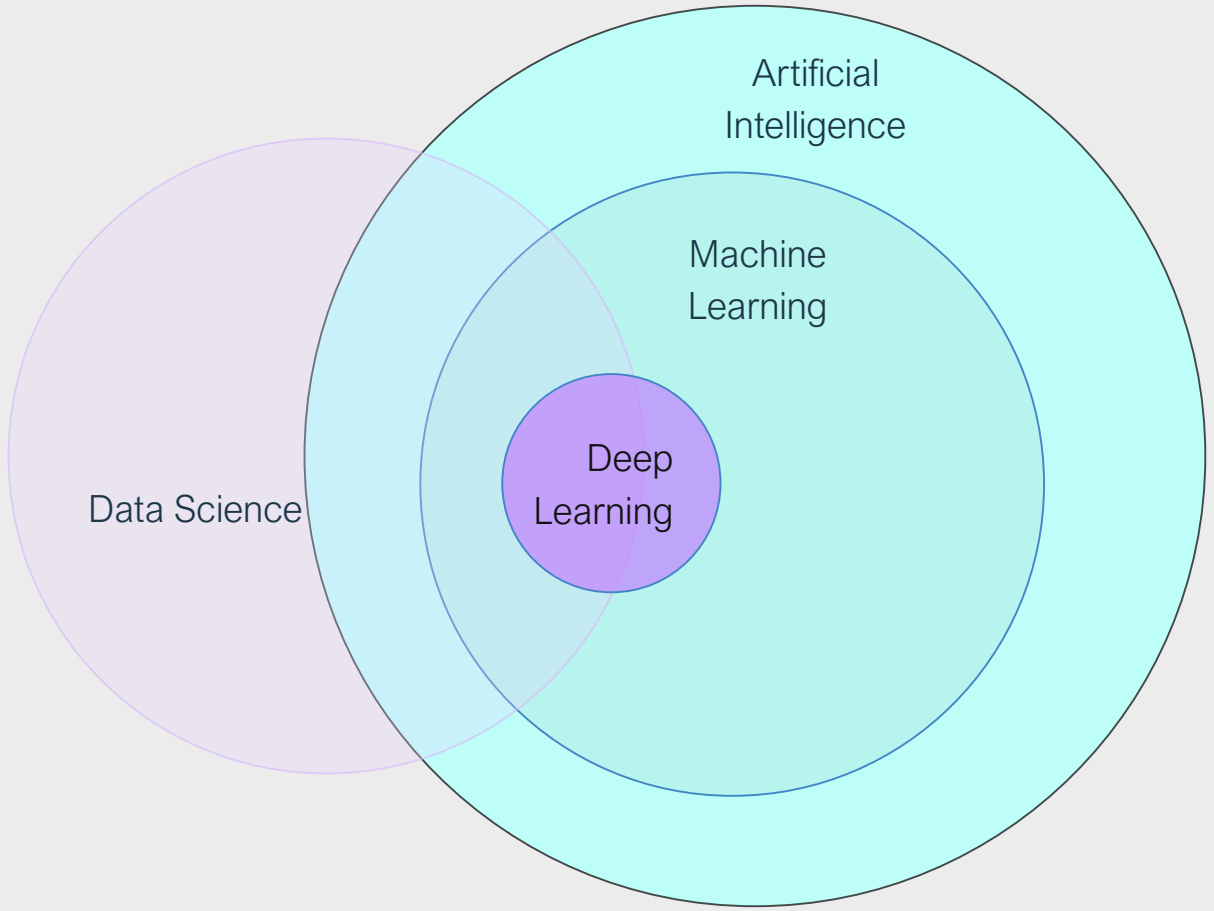
Ready-Mix Plants

Transportation

Clients

Deep Learning & Machine Learning

- Machine learning is a set of algorithms that learn patterns in data without explicit programming to optimize an internal representation then make predictions about a target state.



The Value of Analytics & AI

Image Analytics

Enables monitoring of unstructured data from images snapshots to identify quality defects and failure patterns

Machine Learning

Automates data processing, identifies the best model for the data and continuously monitors new data to learn and improve results

Textual Analytics

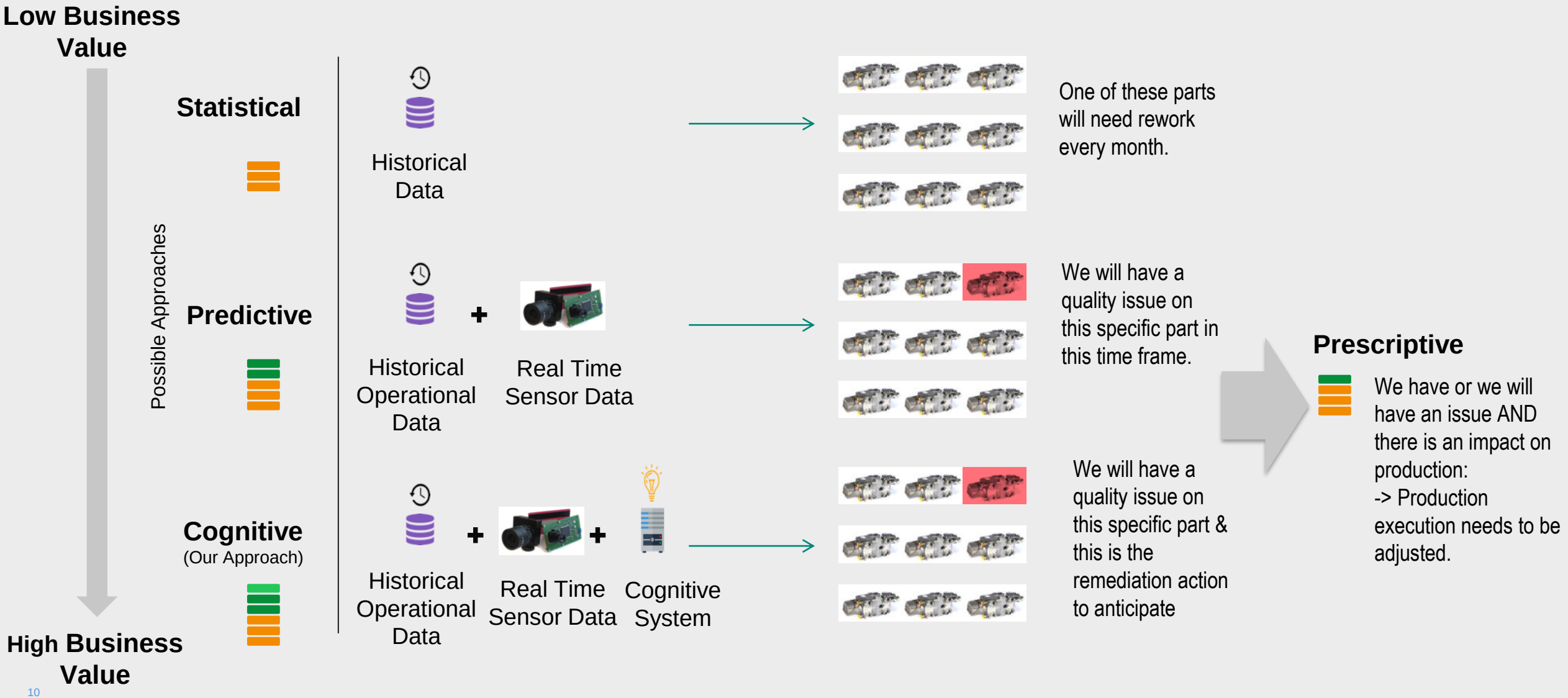
Enables mining of textual sources to find correlations and patterns in structured and unstructured text such as logs and notes

Acoustics Analytics

Utilizes audio as an additional source of unstructured data to enable anomaly detection and pattern recognition

From data to actionable items to deliver business value

Example of Predictive Quality



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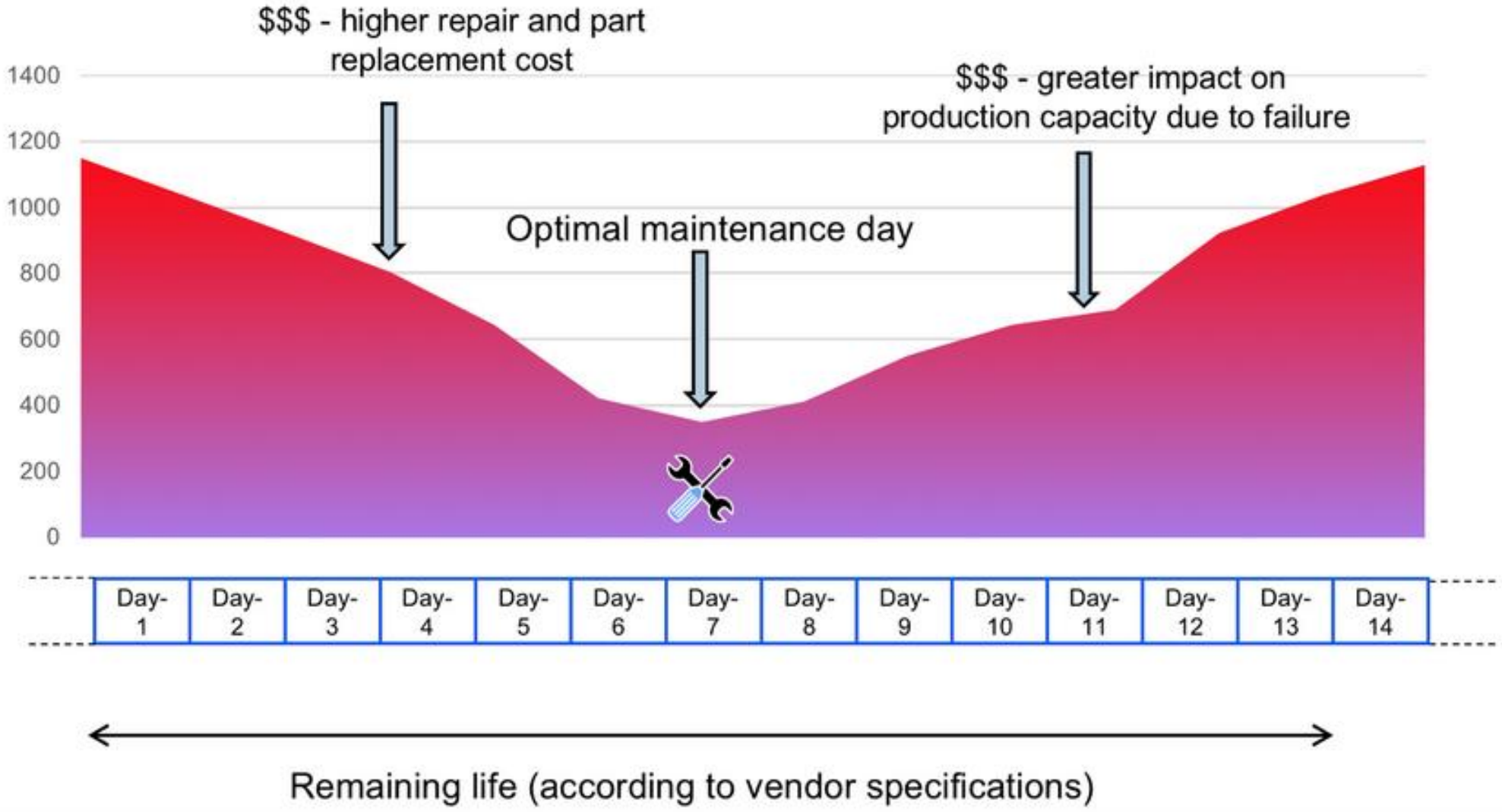
Minimize expected maintenance cost



Maintenance Scheduling: What ML Can Do Well

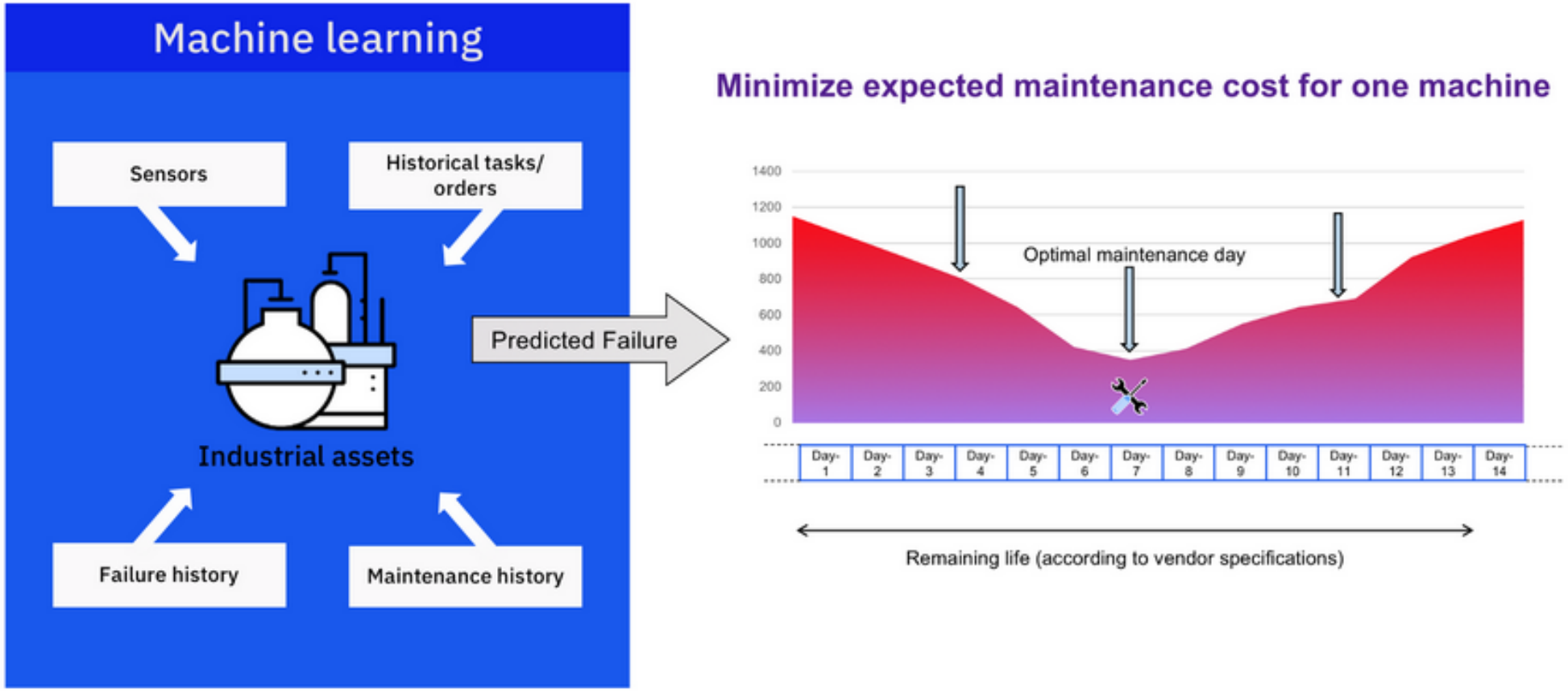


Figure 2: Predicting optimal maintenance day using ML (one machine at a time)

Maintenance Scheduling: Where ML Faces Challenges

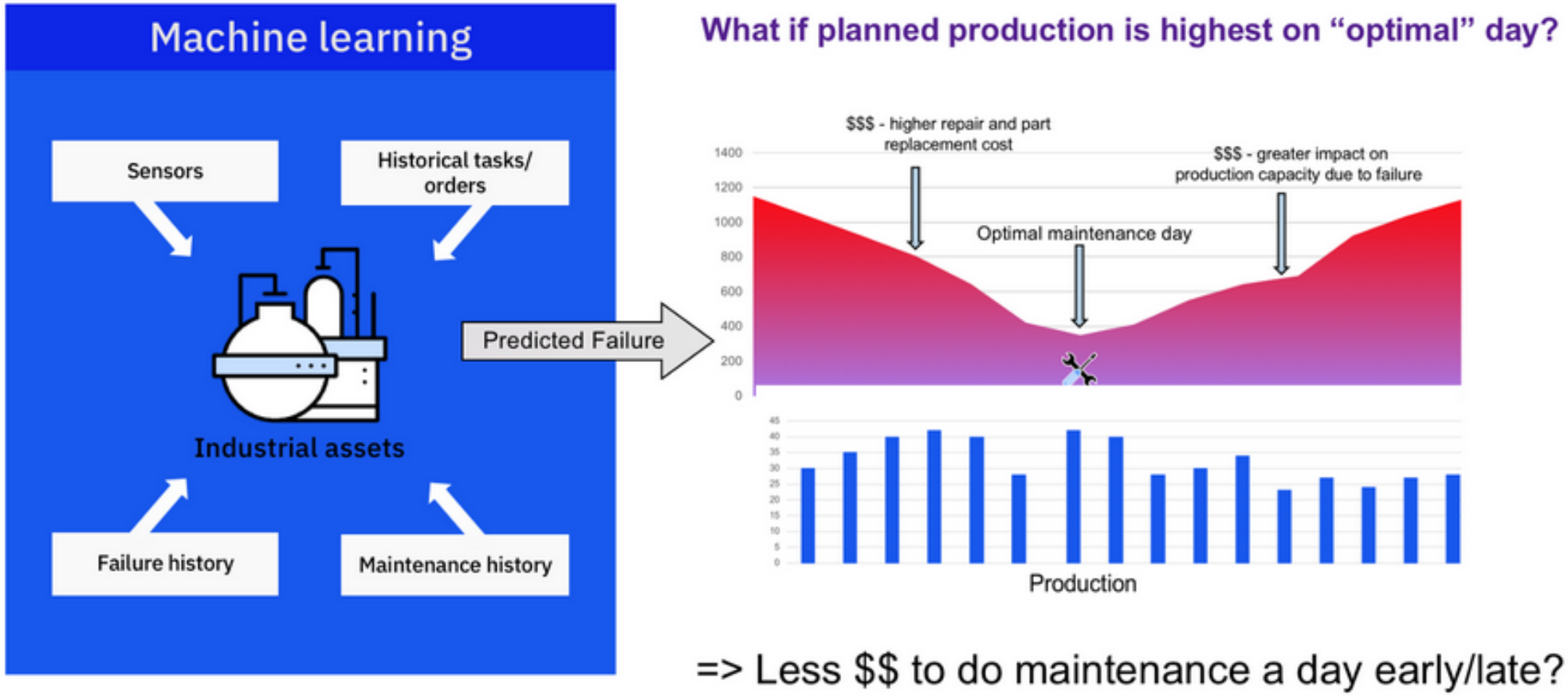
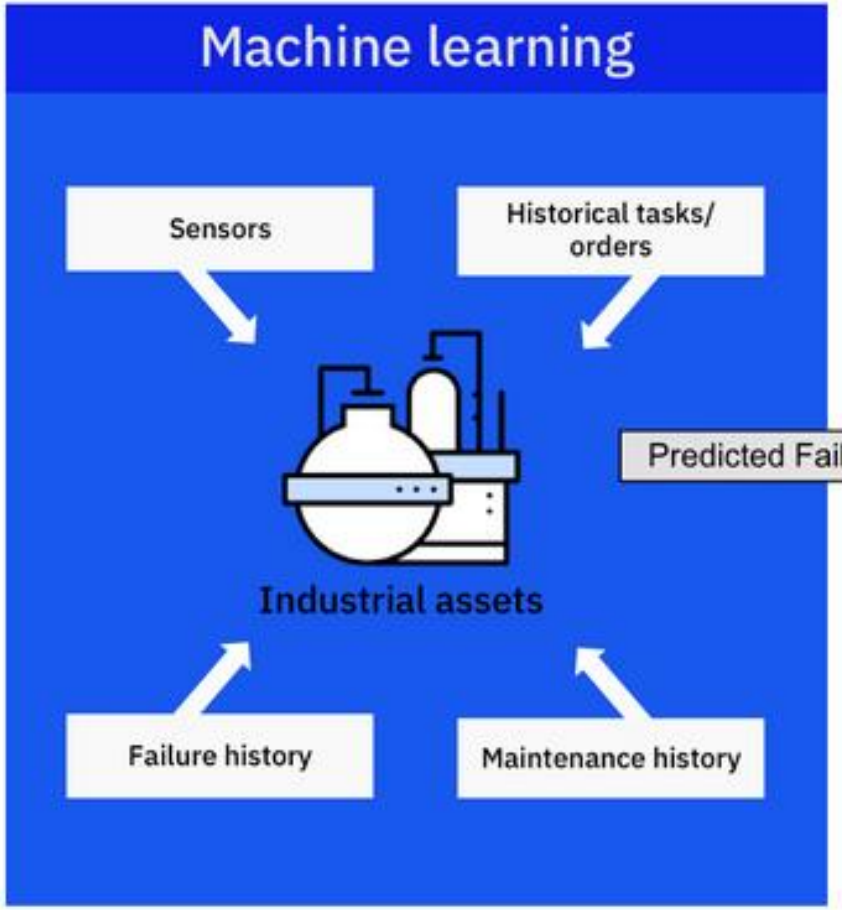


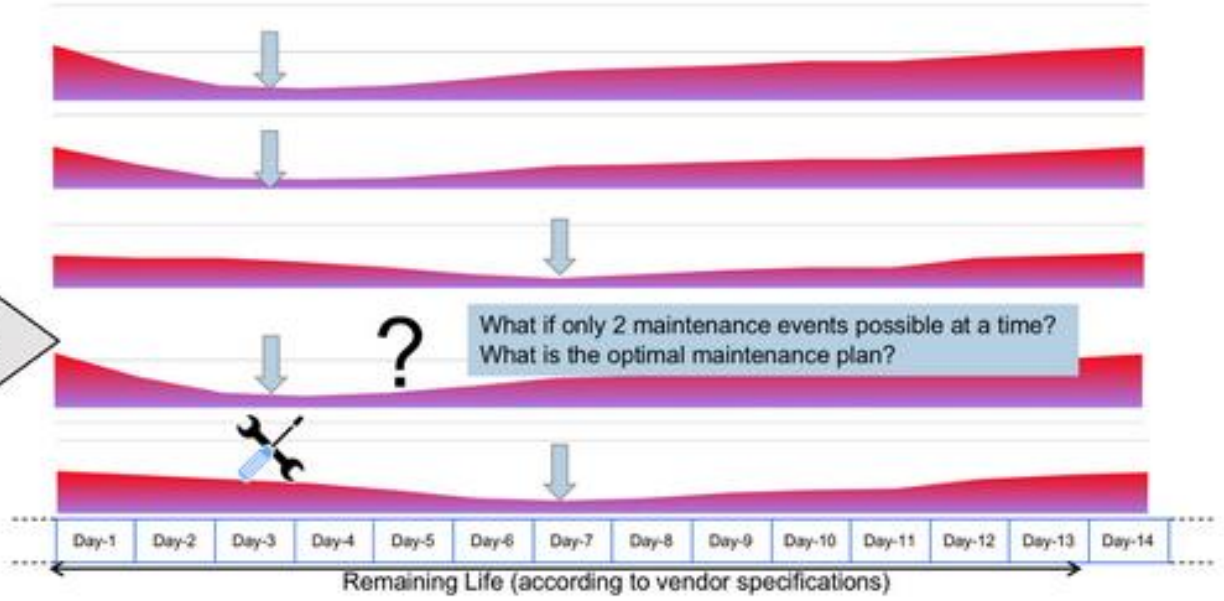
Figure 3: An ”optimal” maintenance day may not be optimal if scheduled production numbers are high

Maintenance Scheduling: Where ML Faces Challenges



Predicted Failure

Minimize maintenance cost for a set of machines



How to deal with limited resources?

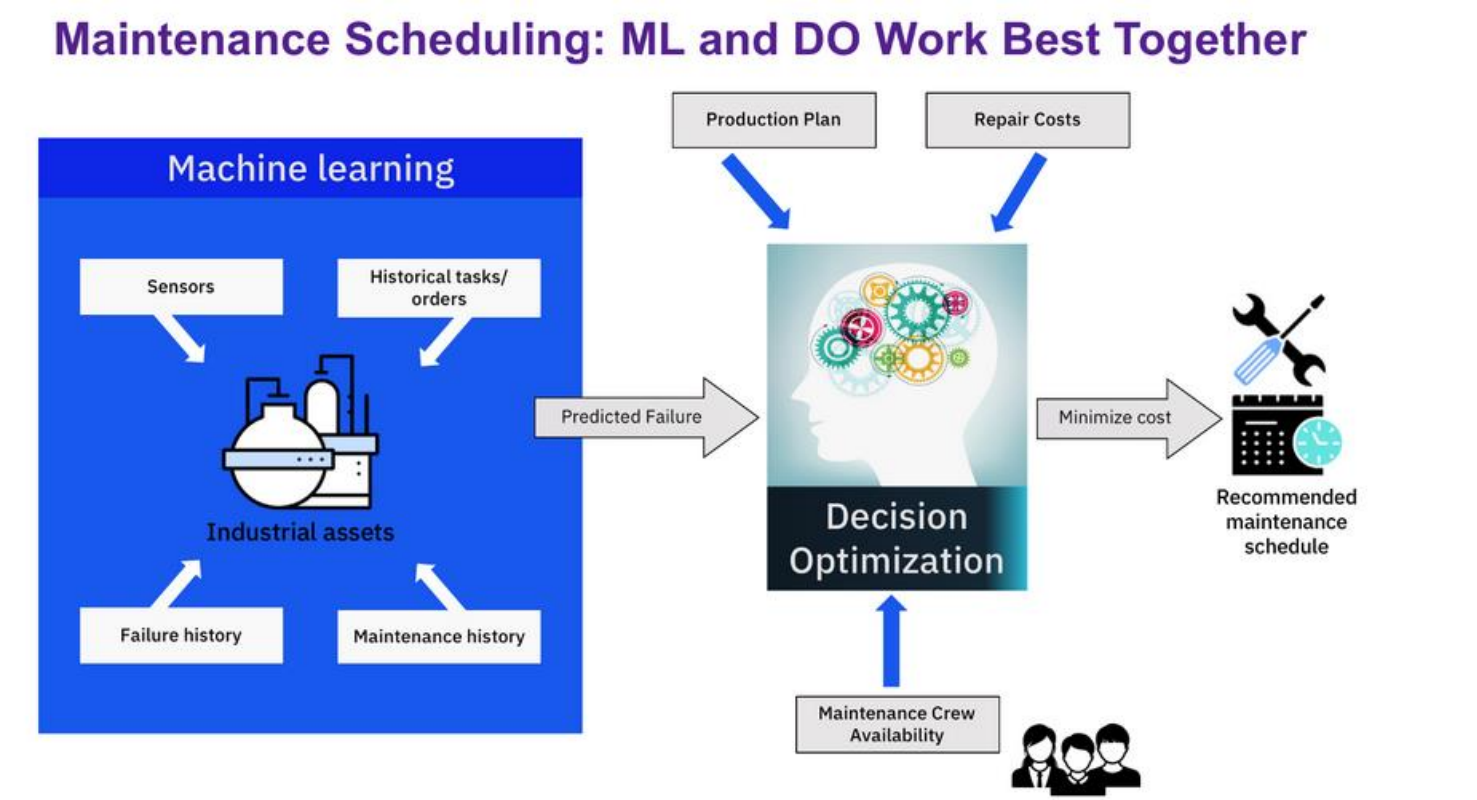


Figure 5: Combining the Power of Machine Learning & Decision Optimization for Maintenance Scheduling

- According to a study by the World Economic Forum and Accenture, the business value of a predictive maintenance solution is:

  -12% scheduling costs
  -30% maintenance costs
  -70% unplanned downtime

Optimization & ML Combined Approach for predictive maintenance

STEP 1 : Model Business Requirements

What are the variables which explain a given failure event ?

Input

Historical Information

Failures Rates

Sensor Data

Maintenance Log

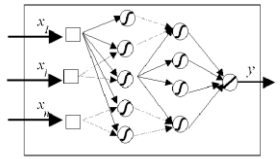
Other variables

ML Model
Clustering, Sequence, Random Forest model

Equipment classified by category
Scoring per equipment : probability, time window

Likelihood of Failure

Model to optimize



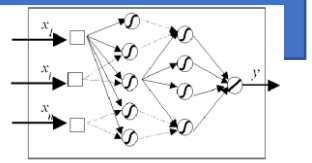
Optimization Metrics

- minimize cost (maintenance, labor)
- minimize late maintenance
- maximize production
- maximize customer satisfaction

Constraints

- **Predicted likelihood of machine failure (output of the ML model)**
- The impact of maintenance on production (we may want to avoid doing maintenance on days with highest planned production levels)
- Maintenance crew availability
- Machine characteristics (cost of repair, cost of remaining component life, etc.)

Decision Optimization Model



Scoring

STEP 2 : Visualize and compare scenarios side by side

Scenario 1
Decision Variables

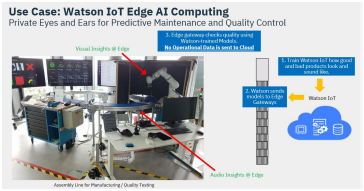
Scenario 2
Decision Variables

Scenario 3
Decision Variables

Day / Time when machine is scheduled to maintenance

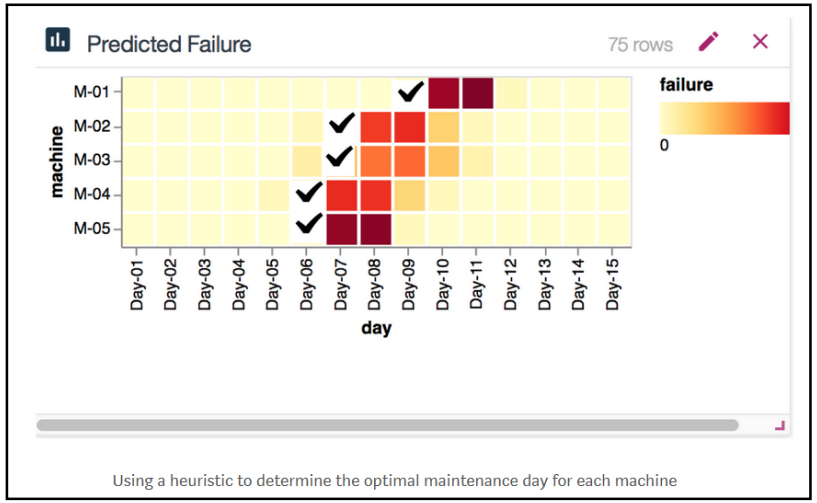
Day / Time when machine is scheduled to maintenance

STEP 3 : Deploy the Models and embed them in your application



STEP 2 : Visualize and compare scenarios side by side

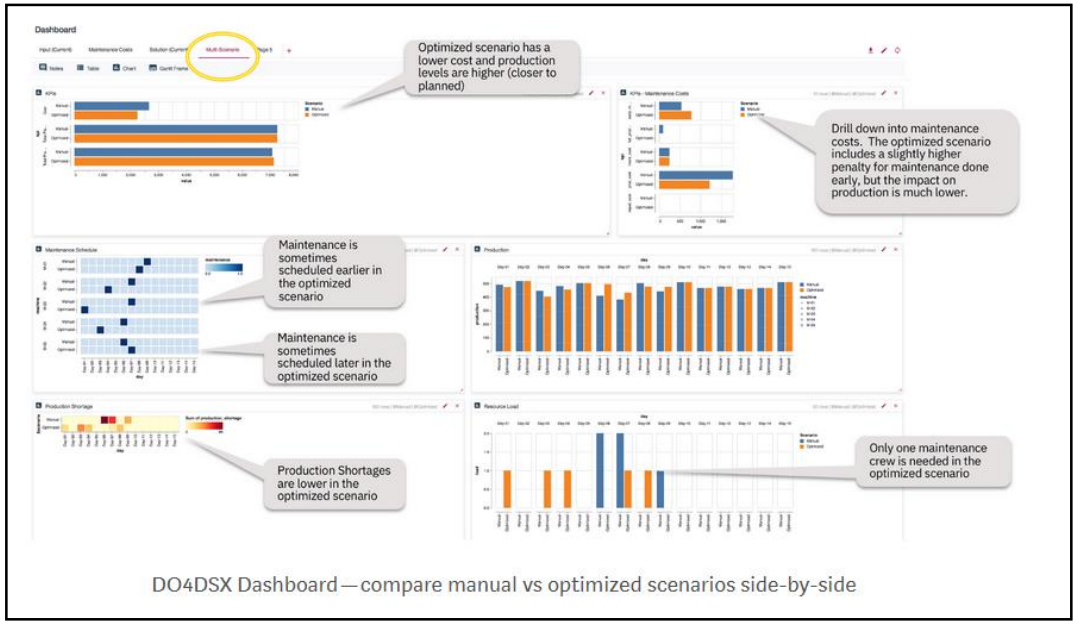
ML Model
Clustering, Sequence, Random Forest model



Using a heuristic to determine the optimal maintenance day for each machine

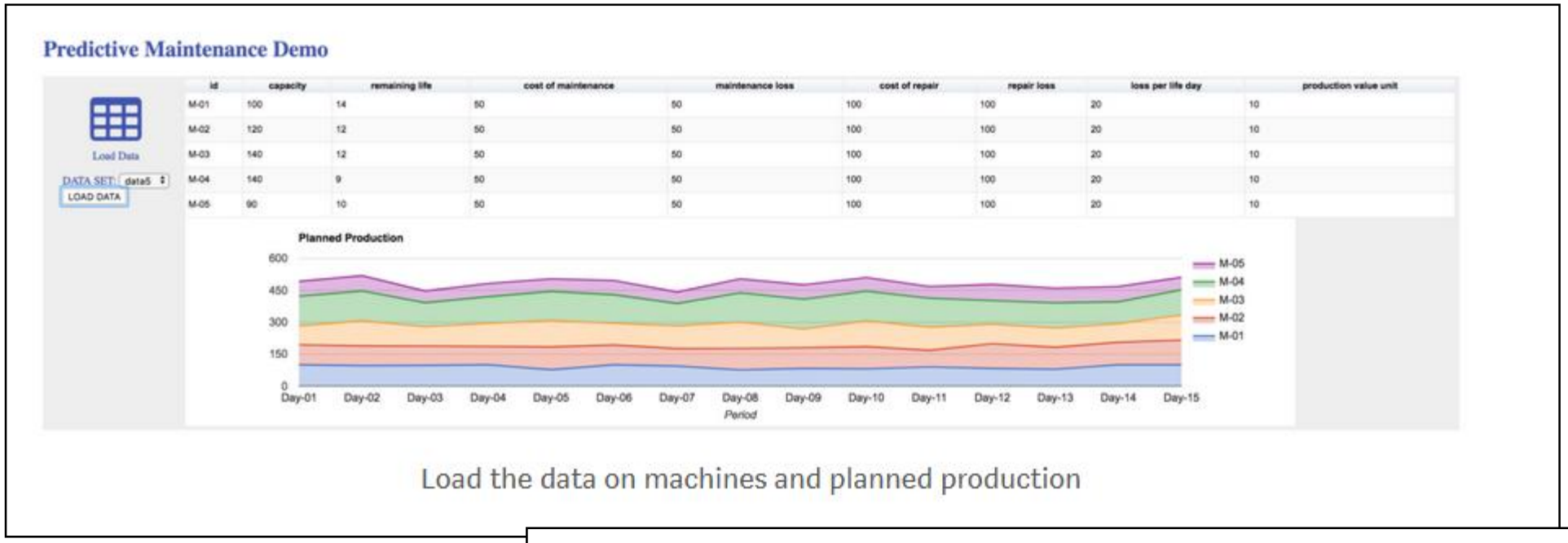
Let's say we wanted to use a heuristic and schedule "right before it gets too red", meaning the day before the machine is very likely to fail. We will treat this as our "Manual" scenario and define maintenance events as follows (checkmark indicates a maintenance event):

We also define an "Optimized" scenario with no fixed maintenance events and let the optimization engine determine the schedule automatically. After solving the two scenarios, we can compare the solutions side-by-side in the multi-scenario tab of the Dashboard:

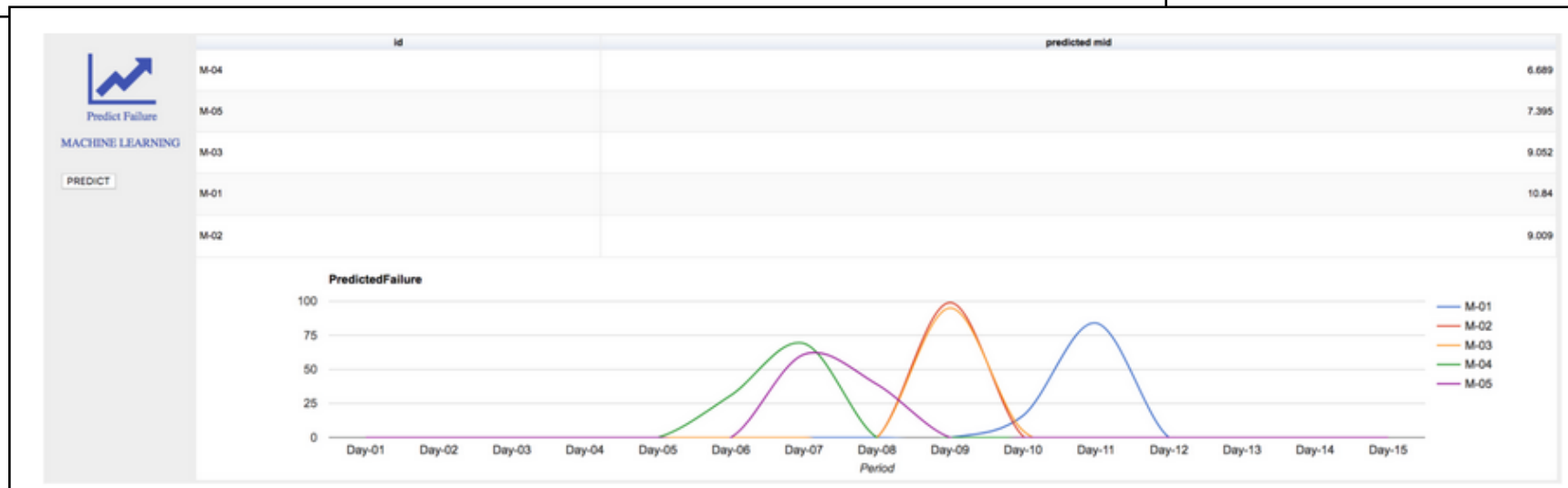


DO4DSX Dashboard—compare manual vs optimized scenarios side-by-side

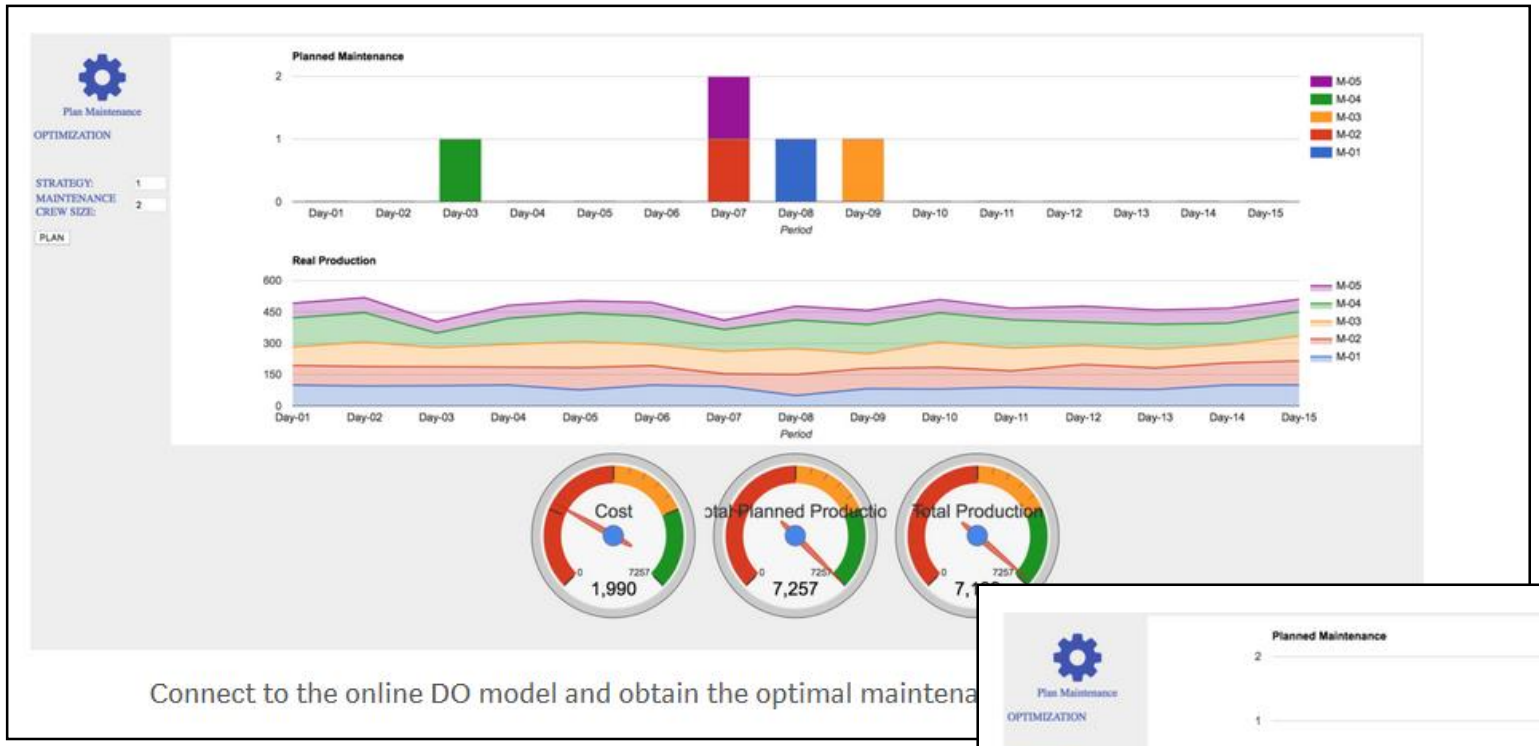
STEP 3 : Deploy the Models and embed them in your application



Load the data on machines and planned production

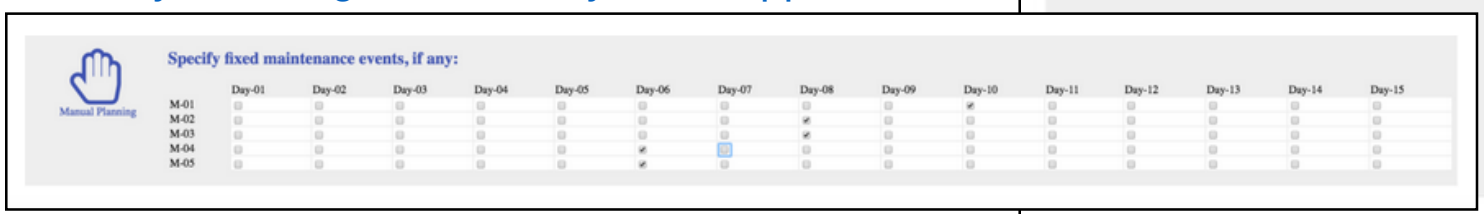


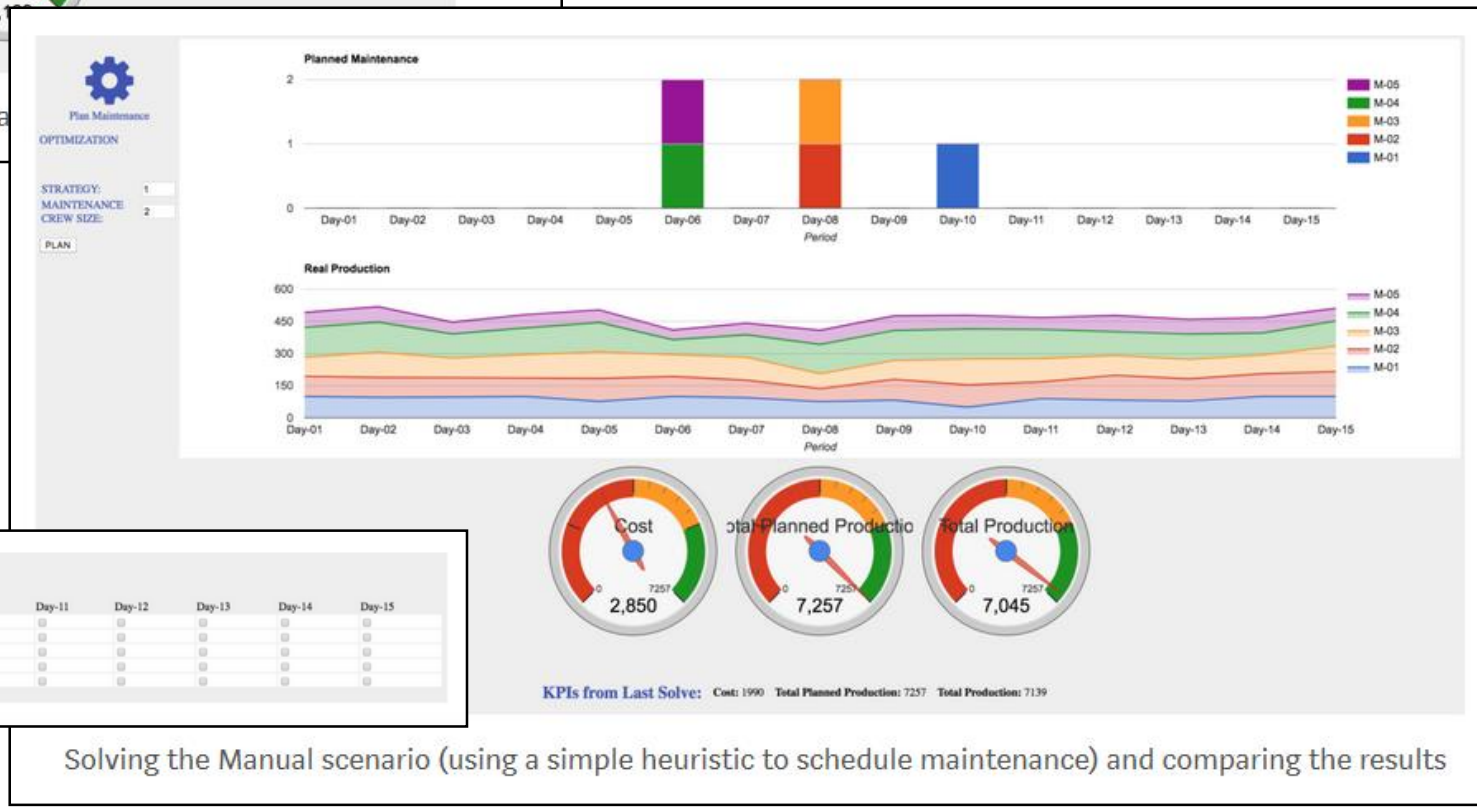
Connect to the executable ML service and obtain failure predictions



- Finally, we are ready to invoke the optimization service and generate the optimal predictive maintenance schedule in one click of a button:

- Now that we have obtained the optimal maintenance schedule, we can easily fix some maintenance events manually (equivalent to the “Manual” scenario in DO4WSL Dashboard, discussed above) by selecting them directly in the app:





Solution : Equipment Advisor Show Case

Demo

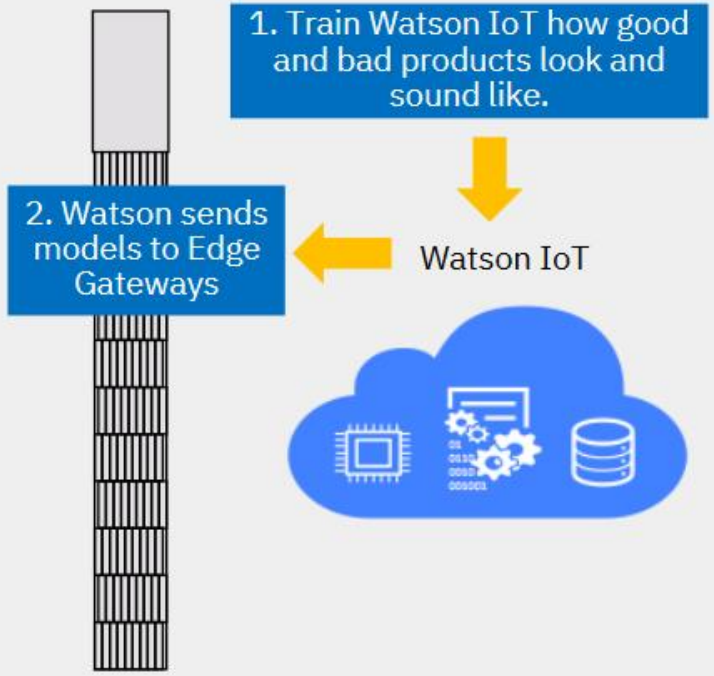
Use Case: Watson IoT Edge AI Computing

Private Eyes and Ears for Predictive Maintenance and Quality Control

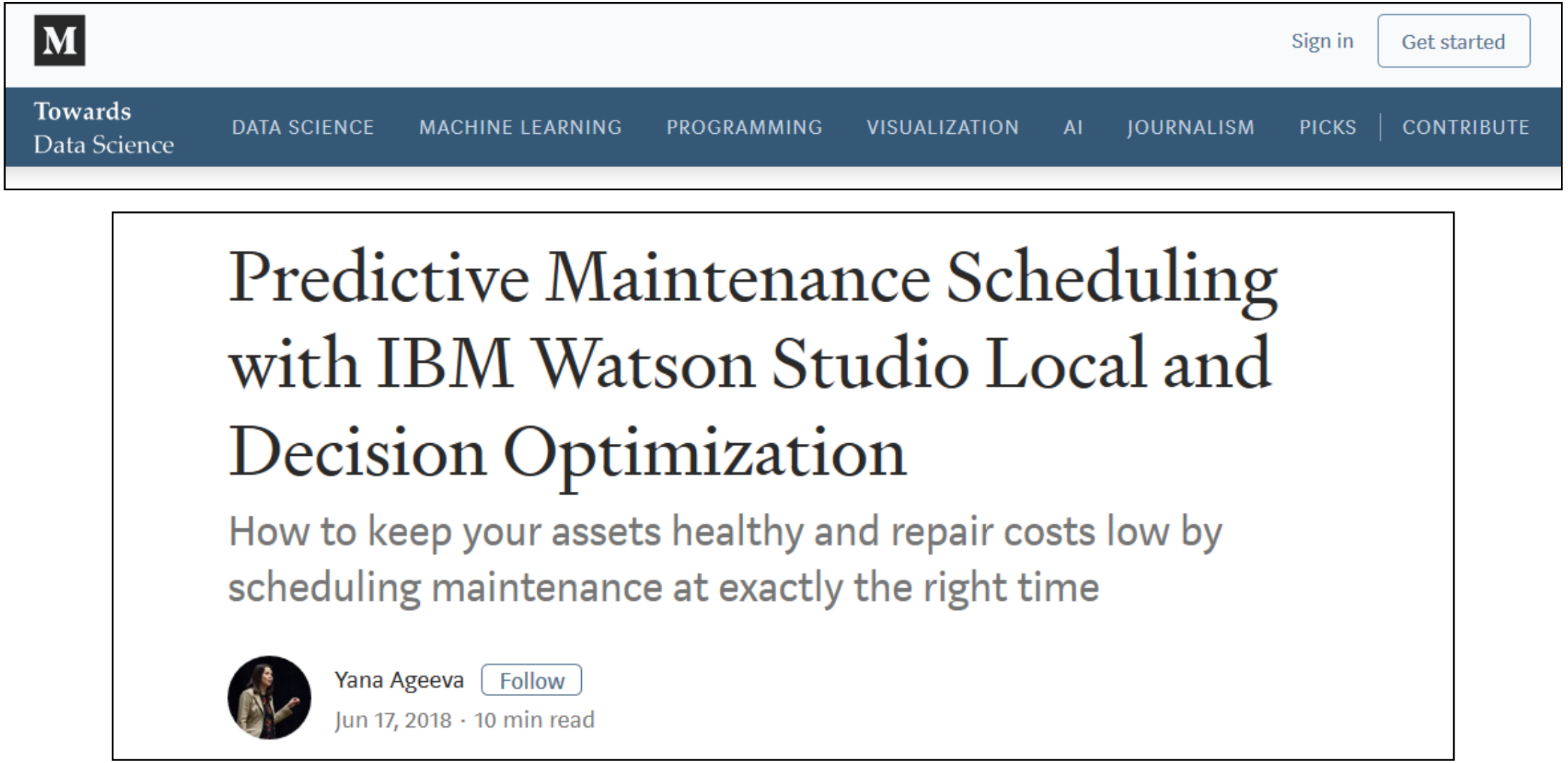
3. Edge gateway checks quality using Watson-trained Models.
No Operational Data is sent to Cloud

Visual Insights @ Edge

Assembly Line for Manufacturing / Quality Testing



Audio Insights @ Edge



https://towardsdatascience.com/predictive-maintenance-scheduling-with-ibm-data-science-experience-and-decision-optimization-25bc5f1b1b99

Thank You

Thank You
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Dhanyavadagalu
Vinaka
köszönöm
Suksama
Maake
Asante
Kiitos
ارك شكر
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Dankon
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Dziekuje
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Diolch i Chi
Gratias Tibi
Terima Kasih
Taiku
Grazie
Juspaxar
Arigato
Najis Tuke
Gracias
Matur Nuwun
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Bedankt
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Grazas
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Di Ou Mèsi
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