Enhancing operational efficiency with MLaaS for Lexmark

Instructor : Professor M. Ghiassi

Team Members: Dhanashree Mane, Ji-Ying Lu, Rachel Lee, Sahil Sawhney, Yogendra Sahu

Version 3.1

Executive Summary

Lexmark, a B2B printing solutions company headquartered in Lexington, Kentucky, has been having declining revenues since 2015 and losing market share in the industry. Lexmark has been plagued by various incidents in its operations and IT department and are looking to use machine learning to analyze and predict these problem incidents, with the aim to enhance operational efficiency.

Upon comparing the various MLaaS offerings by the major players in the market, we are proposing the use of Microsoft Azure's Machine Learning Studio and setting up an IT-centric, centralized machine learning team due to cost-effective implementation, technical requirements and the ability to leverage on existing partnership with Microsoft and their cloud ecosystem.

Agenda

1. About Us
2. Problem Statement
3. Industry Need
4. Use Cases
5. Objectives
6. Ecosystem
7. Technical Functionalities
8. Proposed Solution
9. Proposed Development Plan

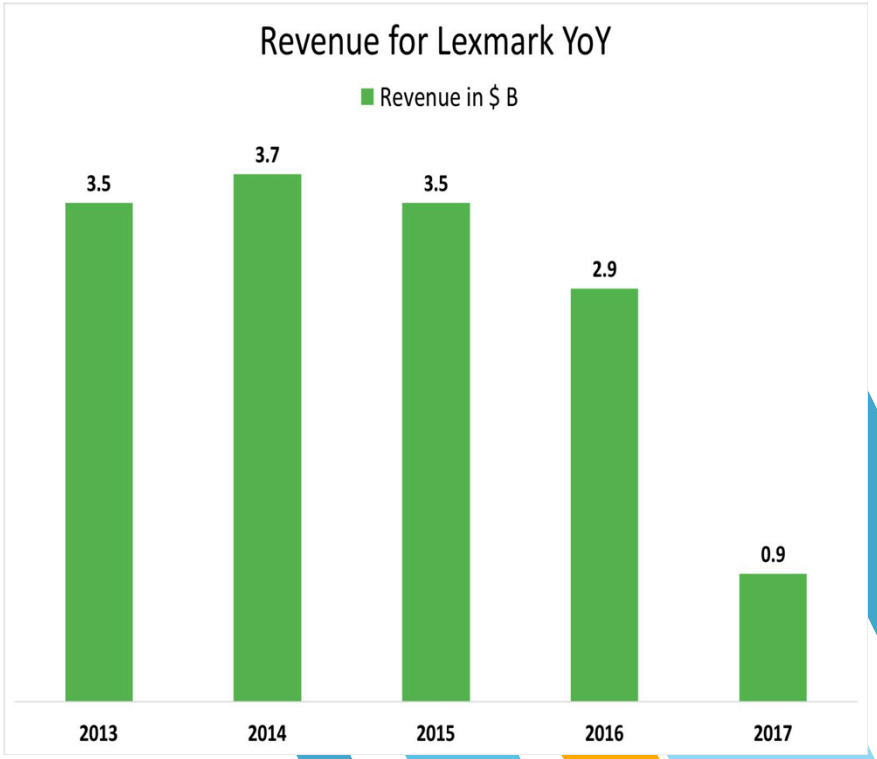
About Us

We are a B2B printing solutions company headquartered in Lexington, Kentucky.

- A Leader in Global Imaging Solutions and Technologies.
- Manufacture laser printers and imaging products.
- Over 9,000 Global Employees/Contractors, 70,000 end-users.
- Market Capitalization as of 2016: $2,000 million.

Problem Statement

- Lexmark's revenue has been steadily declining year over year.
- Lexmark' is plagued by various incidents in its operations and IT department.
- Through the means of machine learning, we aim to analyze and predict these problem incidents.
- Our end goals is to enhance our operational efficiency.



Source: https://en.wikipedia.org/wiki/Lexmark

Industry Need

Machine learning powered IT operations

Simplify Service Operation

Leverage machine learning to detect anomalies and highlight events that matter

Prioritize incidents with context

Deliver business & service context to prioritize incident investigation & action

Redefine the role of IT

Support decisions & communicate results with powerful service-level insights

Source: https://www.slideshare.net/Splunk/rage-with-the-machine-not-against-it-machine-learning-for-event-management

Use Cases

In order to address its declining revenue and to catch up with the competition, Lexmark has decided to make some strategic business decisions that includes:

- Implementing a Risk Management & Analysis portal for IT Operations.
- Apply text classification to categorize incident reports for cost of service analysis using SVM model.
- Anomaly Detection for Lexmark's private data centers to monitor them for abnormal CPU, memory and data usage incidents.

Financial and Political Objectives

- Financial
  - Well-controlled budget plan.
    - Improve company operating processes, customer service, sales strategies with minimum costs.
    - Implement solution without hiring expensive experienced talents.
- Political
  - Maintain a strong relationship with current business partners and clients.
  - Any changes generated from new service should not affect current services.

Technical Objectives

- Provides the cloud services which cover data processing, model training, model deployment, etc.
- According to Lexmark's needs, new tool needs to support ML Package for forecasting, text analytics, and predictive analytics.
- Comprehensive user supports.
- Security of Lexmark and customers' data.

Proposed Solutions - MLaaS

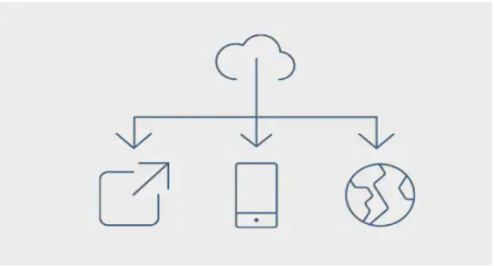
Why MLaaS (Machine Learning as a Service)?

Budget

- ➔ Pay as you go!
- ➔ No need for hard core skills in machine learning.

Hardware Setup

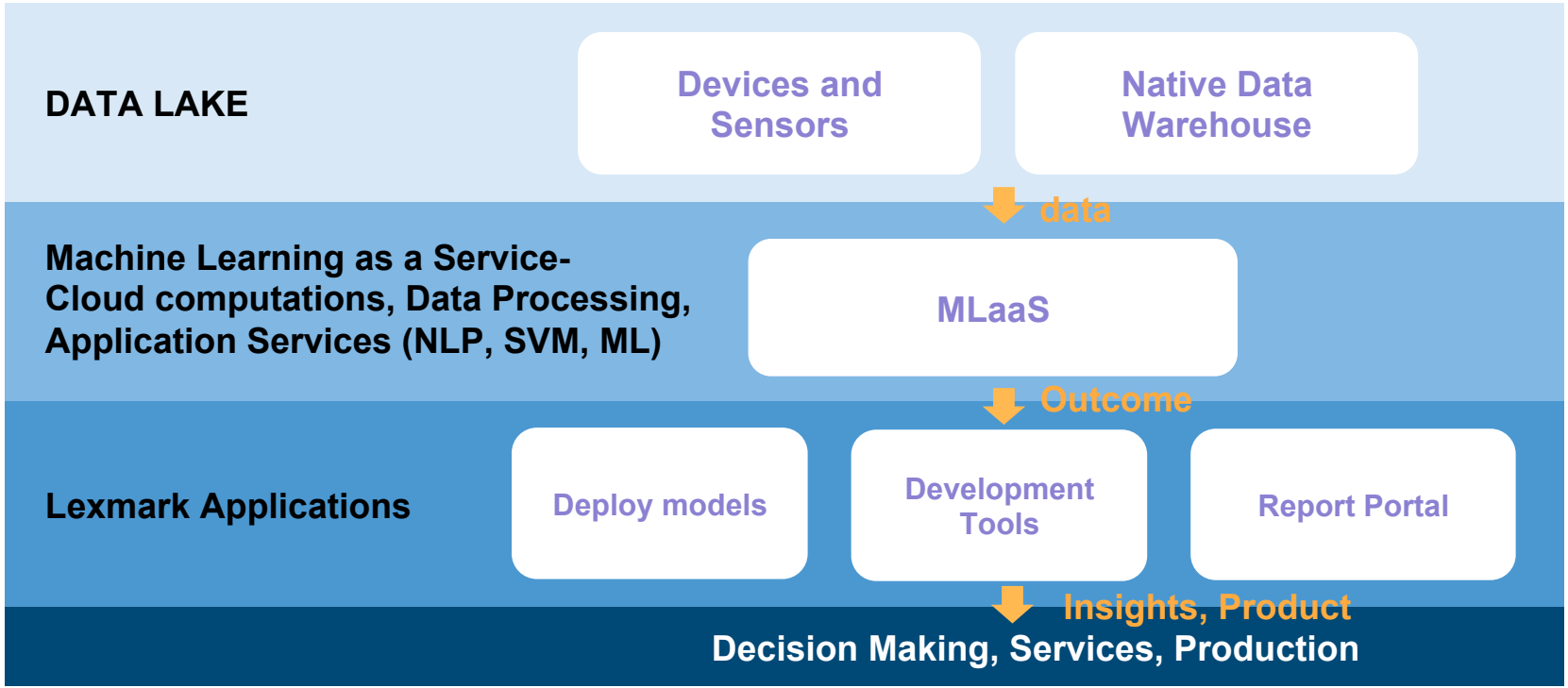
- ➔ Data management and storage capabilities.
- ➔ Relatively easy setup



Tech Spec

- ➔ Scalable technology
- ➔ Offers Personalized Services.

Ecosystem

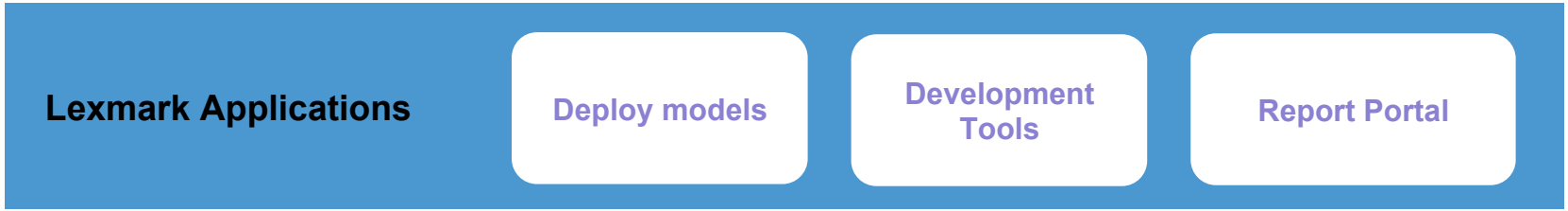

DATA LAKE
Devices and Sensors
Native Data Warehouse
data
Machine Learning as a Service-
Cloud computations, Data Processing,
Application Services (NLP, SVM, ML)
MLaaS
Outcome
Lexmark Applications
Deploy models
Development Tools
Report Portal
Insights, Product
Decision Making, Services, Production

Upstream

- **Devices and Sensors - collecting data**
  - Printers' sensors.

- **Databases - where Lexmark stores data**
  - Incident Reports.
  - Transactional Data.
  - Server logs.

Downstream

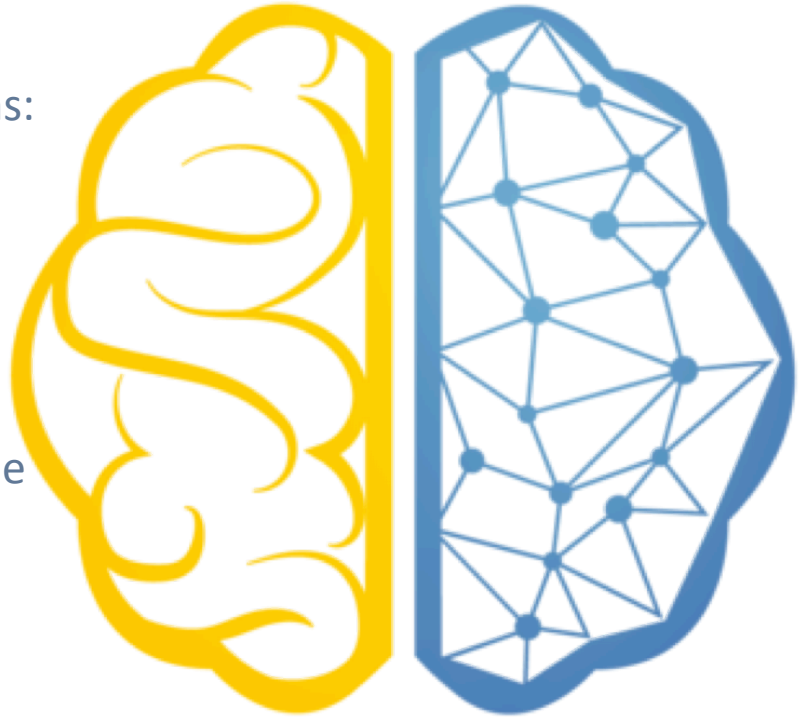


- **Deploy models**
  - To deploy the optimized models for production uses and improve business operations.
- **Development Tools**
  - Jupyter Notebook, Julia, Python Packages, GitHub Enterprise, Docker, Jira etc.
- **Report Portal**
  - Utilize the result from MLaaS to build report portal (i.e. Tableau, Power BI)

Required Technical Functionality

To resolve the current problems we will be needing following machine learning algorithms:

- **Bayesian linear Regression** : To predict incidents.
- **Two Class Support vector machine** : to analyze text reports using classification algorithms.
- **Multi class decision forest**: To analyze the behavior of the reports.
- **One class support vector machine** : for anomaly detection.



Required Technical Functionality

- Bayesian Linear Regression
- One-class Support Vector Machine

Required Technical Functionality

- Two-class Support Vector Machine
- Multi-class Decision Forest

Cloud War

Cloud Offerings

	Amazon AWS	Microsoft Azure	Google Cloud
Compute	• EC2 • Elastic Container Service • Elastic Container Registry • Lightsail • Batch • Elastic Beanstalk • Fargate • Auto Scaling • Elastic Load Balancing • VMware Cloud on AWS	• Virtual Machines • Virtual Machines Scale Sets • Azure Container Services (AKS) • Container Instances • Batch • Services Fabric • Cloud Services	• Compute Engine • Kubernotes
Storage	• Simple Storage (S3) • Elastic Block Storage (EBS) • Elastic File System (EFS) • Storage Gateway • Snowball • Snowball Edge • Snowmobile	• Blob Storage • Queue Storage • File Storage • Disk Storage • Data Lake Store	• Cloud Storage • Persistent Disk • Transfer Appliance • Transfer Service
Network	All three typically offer excellent networking capabilities with automated server load balancing and connectivity to on premise systems.		
Database Services	• Aurora • RDS • DynamoDB • ElastiCache • Redshift • Neptune • Database Migration services	• SQL Database • Database for MySQL • Data Warehouse • Server Stretch Database • Cosmos DB • Table Storage • Redis Cache • Data Factory	• Cloud SQL • Cloud Bigtable • Cloud Spanner • Cloud Database


amazon
web services

Amazon ML

- Amazon Machine Learning for predictive analytics is one of the most automated and feature rich MLaaS solutions on the market.
- The service can load data from multiple sources.
- All data preprocessing operations are performed automatically.
- Prediction capacities of Amazon ML are limited to three options: *binary classification, multiclass classification*, and *regression*.

Amazon SageMaker

- Provides an ML environment that's simplifies the work of a fellow data scientist by providing tools for quick model building and deployment.
- For example : It provides Jupyter Notebook and has built-in algorithms that are optimized for large datasets and computations in distributed systems.
- Allows the user to add own methods and run models via SageMaker leveraging its deployment features.

Amazon - Pros & Cons

Pros

- High level of automation.
- Can accommodate both new and experienced data scientists with wide variety of features like built-in libraries, deployment features.
- Highly configurable and feature rich.

Cons

- It has a high initial learning curve.
- Not ideal if the company is a heavy windows server user.


Microsoft
Azure

About Product

- Azure offers AI services, infrastructure and tools that are easy to use and scale.
- A powerful playground for both newcomers and experienced data scientists.
- Flexible in terms of out-of-box algorithms.
- Services from Microsoft Azure are categorized as follows:
  - Microsoft Azure Machine Learning Studio.
  - Microsoft Azure Machine Learning Services.

Microsoft Azure Machine Learning Studio

Features:

- Main MLaaS package.
- All operations are completed using a graphical drag-and-drop interface.
- Includes: Data Exploration, Preprocessing, Choosing Methods,Validating Modeling results.

Microsoft Azure ML Service

Features:

- Next generation infrastructure for building and deploying models at scale.
- Provide end-to-end lifecycle management.
- Track of all experiments across entire team, storing code, config, parameter settings, and environment details.

Microsoft Azure

Pros:

- Graphical interface helps newcomers to visualize each step within the workflow.
- Supports 100 methods that address classification (binary+multiclass), anomaly detection, regression, recommendation, and text analysis. Supports clustering algorithm (K-Means).
- Cortana Intelligence Gallery: collection of ML solutions provided by the community.

Cons:

- There is a learning curve in terms of understanding of all major techniques in the field.
- Infrastructure services are not as big as that of Amazon's.

Google Cloud Platform

About Product

- Google provides AI services on two levels:
  - a machine learning engine for savvy data scientists.
  - highly automated Google Prediction API.
- Google Prediction API is not in use anymore.
- Google AutoML is still in beta phase which offers 3 different features:
  - AutoML translation
  - Vision
  - Natural Language

Google Cloud ML Engine

- Features:
  - Suggests using cloud infrastructure with TensorFlow as a machine learning driver.
  - Supports popular frameworks like XGBoost, scikit-learn, and Keras.
  - Similar to SageMaker.
  - Caters to experienced data scientists.
  - Serves classification, regression, clustering, and dimensionality reduction models.

Google Cloud ML Engine

Pros:

- Supports Tensorflow, open source machine learning library of various data science tools rather than ML-as-a-service.
- Tuning hyperparameters option is available.
- Can send raw data to models in production and reduce local computation.

Cons:

- Tensorflow supports deep learning frameworks only.
- It doesn’t have visual interface and the learning curve for TensorFlow would be quite steep.

Automated and Semi-automated ML services

	Amazon ML	Microsoft Azure ML Studio	Google Prediction API
Classification	✓	✓	Deprecated
Regression	✓	✓	
Clustering	✓	✓	
Anomaly Detection	✗	✓	
Recommendation	✗	✓	
Ranking	✓	✓	

Platforms for Custom Modeling

	Amazon SageMaker	Azure ML Services	Google ML Engine
Built-in algorithms	✓	✗	✗
Supported frameworks	TensorFlow, MXNet, Keras, Gluon, PyTorch, Caffe2, Chainer, Torch	TensorFlow, Scikit-learn, Microsoft Cognitive Toolkit, Spark ML	TensorFlow, Scikit-learn, XGBoost, Keras

*Google has introduced new custom modeling platform - Google AutoML (Beta version).

Pricing

Amazon	Azure	Google
SageMaker: $218.54 Instance: Ml.p2.xlarge (4 vCPU, 1 GPU - K80, 61 GB CPU memory, 12 GB GPU memory) $1.26 per hour General Purpose (SSD) Storage: $0.14 per GB-month of provisioned storage	**Azure ML Studio: $1,019.94** Tier: Standard Feature: Workspace Billing option: Pay as you go Seats: 6 ($9.99 per month) Studio Usage: 160 Experiment Hours per seat ($1.00 per month) **Azure ML Services: $53.44** Instance: D3 v2: 4 Cores, 14GB RAM, $0.254/hour Virtual Machine: 160 hours → $40.64 per month ML service surcharge: $0.02 per Core/hour * 4 core * 160 hours = $12.80	**Google ML Engine: $355.21** ML Training Units: 0.566 Job run time: 57,600 minutes Prediction Mode: online Total node hours: 960 USD $355.21

* Pricing per month for team of 6 and running hours of 160 hrs/mth.

Comparison Summary

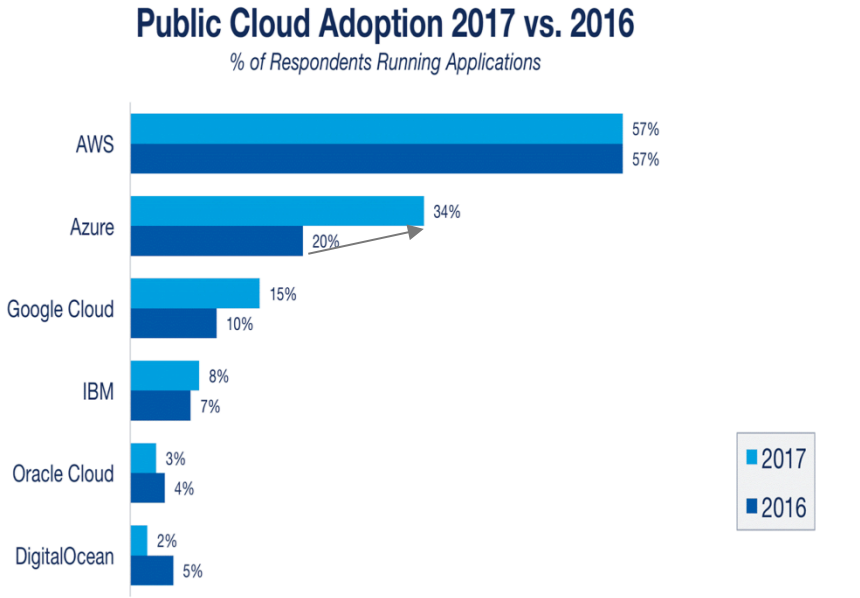
Vendor	Strengths	Weaknesses
AWS	• Dominant market position • Extensive, mature offerings • Support for large organizations • Extensive training • Global reach	• Difficult to use • Cost management • Overwhelming options
Microsoft Azure	• Second largest provider • Integration with Microsoft tools and software • Broad feature set • Hybrid cloud • Support for open source	• Less "enterprise-ready" • Incomplete management tooling
Google	• Designed for cloud-native businesses • Commitment to open source and portability • Deep discounts and flexible contracts • DevOps expertise	• Late entrant to IaaS market • Fewer features and services • Fewer worldwide data centers

Source: https://www.datamation.com/cloud-computing/aws-vs.-azure-vs.-google-cloud-comparison.html

Proposed Solution: Microsoft Azure

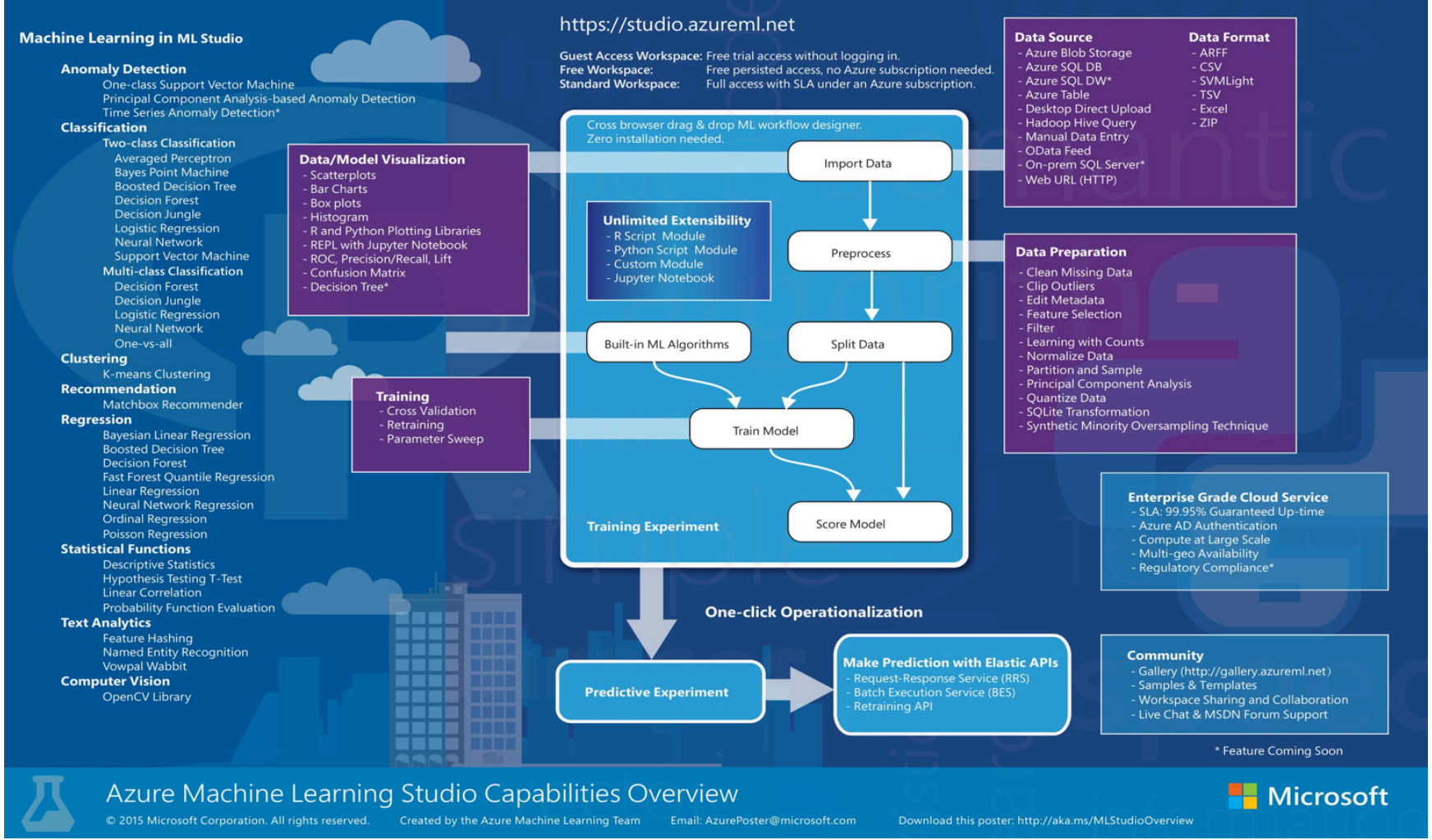
Reasons:

- Lower Operating Cost vs on-premise setup.
- Shorter setup time vs on-premise setup.
- Meets technical requirements and use cases.
- Existing partnership.
- Cost-effective for Lexmark to implement Azure and leverage the Microsoft ecosystem.
- Azure also makes it simple to integrate on-premises Windows servers with cloud instances to create a hybrid cloud environment.

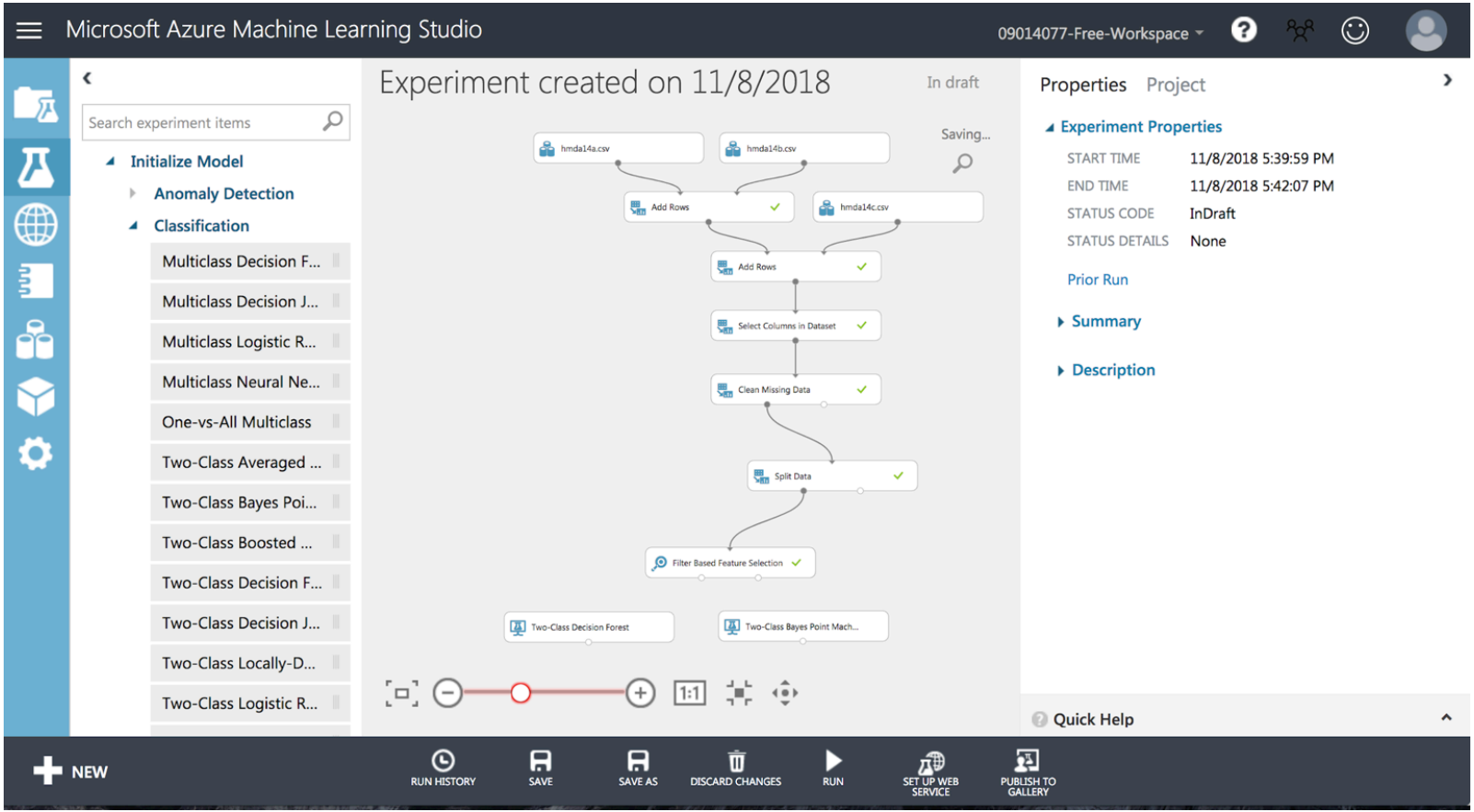


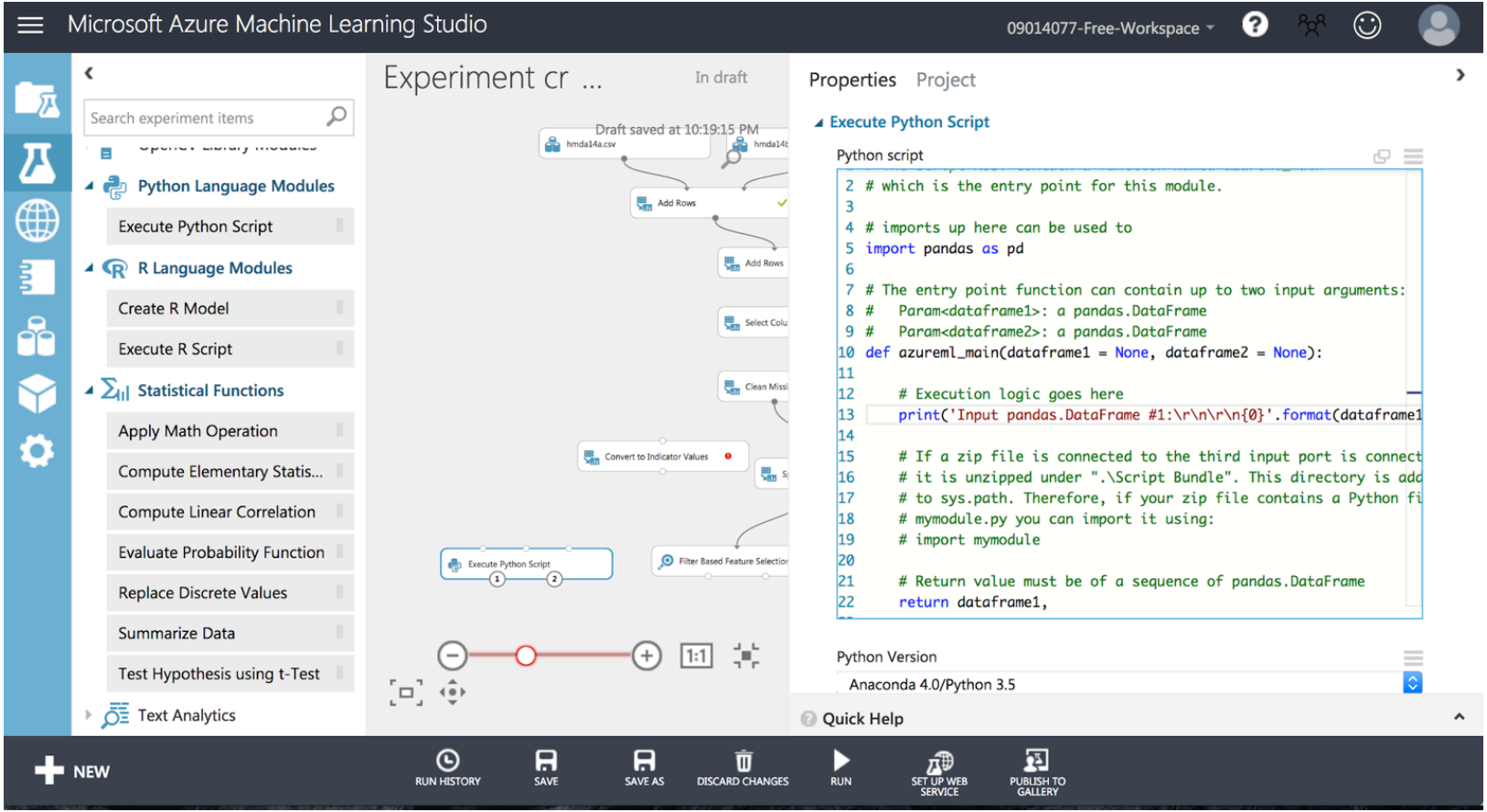
Source: RightScale 2017 State of the Cloud Report

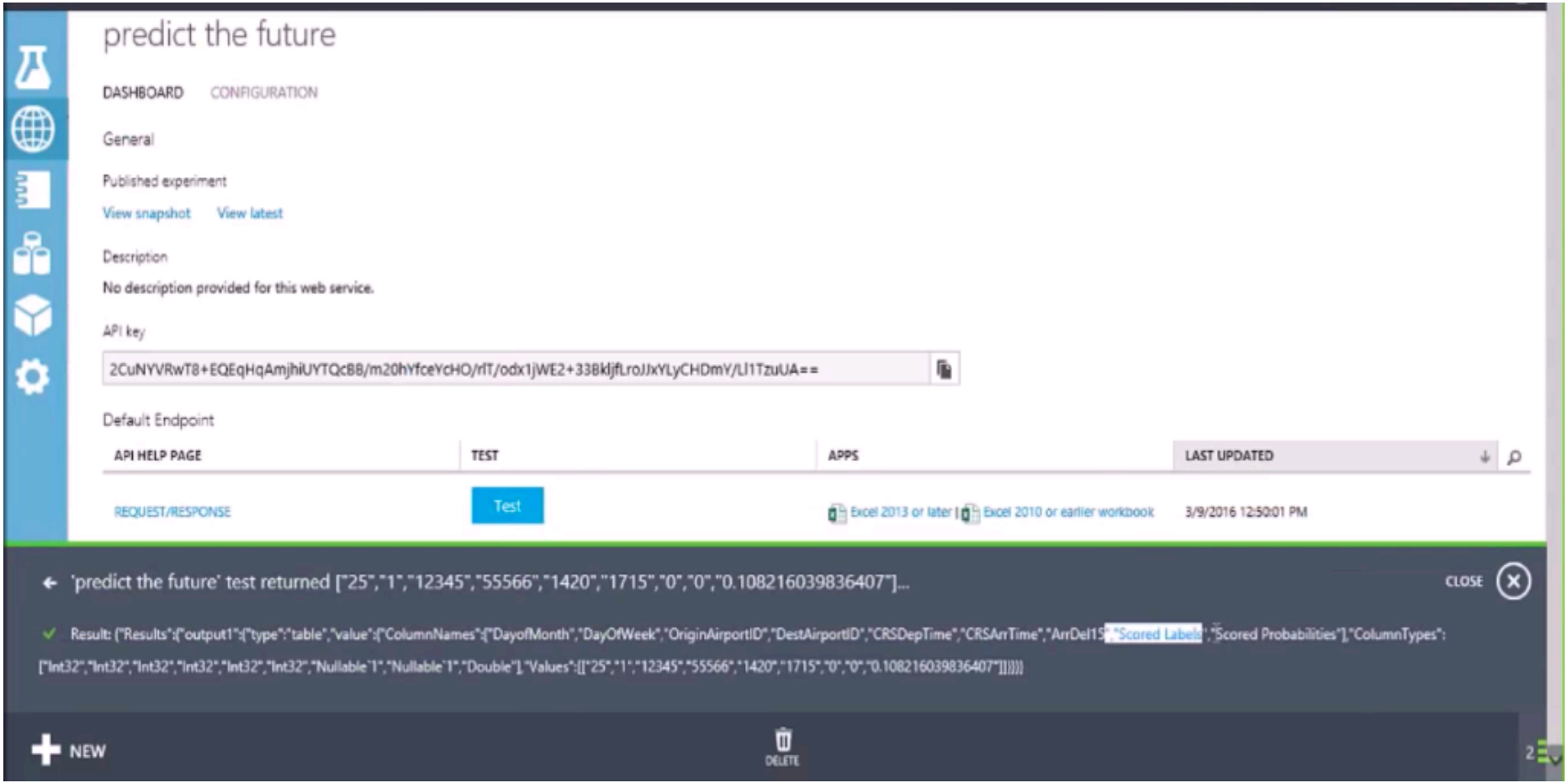
How Azure ML Studio works



Source: https://docs.microsoft.com/en-us/azure/machine-learning/studio/studio-overview-diagram


Microsoft Azure Machine Learning Studio
09014077-Free-Workspace
Search experiment items
Initialize Model
Anomaly Detection
Classification
Multiclass Decision F...
Multiclass Decision J...
Multiclass Logistic R...
Multiclass Neural Ne...
One-vs-All Multiclass
Two-Class Averaged ...
Two-Class Bayes Poi...
Two-Class Boosted ...
Two-Class Decision F...
Two-Class Decision J...
Two-Class Locally-D...
Two-Class Logistic R...
Experiment created on 11/8/2018
In draft
Saving...
hmda14a.csv
hmda14b.csv
Add Rows
hmda14c.csv
Add Rows
Select Columns in Dataset
Clean Missing Data
Split Data
Filter Based Feature Selection
Two-Class Decision Forest
Two-Class Bayes Point Mach...
1:1
Properties
Project
Experiment Properties
START TIME 11/8/2018 5:39:59 PM
END TIME 11/8/2018 5:42:07 PM
STATUS CODE InDraft
STATUS DETAILS None
Prior Run
Summary
Description
Quick Help
NEW
RUN HISTORY
SAVE
SAVE AS
DISCARD CHANGES
RUN
SET UP WEB SERVICE
PUBLISH TO GALLERY


Microsoft Azure Machine Learning Studio
09014077-Free-Workspace
Experiment cr ...
In draft
Search experiment items
Python Language Modules
Execute Python Script
R Language Modules
Create R Model
Execute R Script
Statistical Functions
Apply Math Operation
Compute Elementary Statis...
Compute Linear Correlation
Evaluate Probability Function
Replace Discrete Values
Summarize Data
Test Hypothesis using t-Test
Text Analytics
Draft saved at 10:19:15 PM
Add Rows
Convert to Indicator Values
Execute Python Script
Properties
Project
Execute Python Script
Python script
# which is the entry point for this module.
# imports up here can be used to
import pandas as pd
# The entry point function can contain up to two input arguments:
#   Param<dataframe1>: a pandas.DataFrame
#   Param<dataframe2>: a pandas.DataFrame
def azureml_main(dataframe1 = None, dataframe2 = None):
    # Execution logic goes here
    print('Input pandas.DataFrame #1:\r\n\r\n{0}'.format(dataframe1
    # If a zip file is connected to the third input port is connect
    # it is unzipped under ".\Script Bundle". This directory is add
    # to sys.path. Therefore, if your zip file contains a Python fi
    # mymodule.py you can import it using:
    # import mymodule
    # Return value must be of a sequence of pandas.DataFrame
    return dataframe1,
Python Version
Anaconda 4.0/Python 3.5
Quick Help
NEW
RUN HISTORY
SAVE
SAVE AS
DISCARD CHANGES
RUN
SET UP WEB SERVICE
PUBLISH TO GALLERY


predict the future
DASHBOARD
CONFIGURATION
General
Published experiment
View snapshot
View latest
Description
No description provided for this web service.
API key
2CuNYVRwT8+EQEqHqAmjhiUYTQcBB/m20hYfceYcHO/rlT/odx1jWE2+33BkljfLroJJxYLyCHDmY/Ll1TzuUA==
Default Endpoint
API HELP PAGE
TEST
APPS
LAST UPDATED
REQUEST/RESPONSE
Test
Excel 2013 or later
Excel 2010 or earlier workbook
3/9/2016 12:50:01 PM
'predict the future' test returned ["25","1","12345","55566","1420","1715","0","0","0.108216039836407"]...
CLOSE
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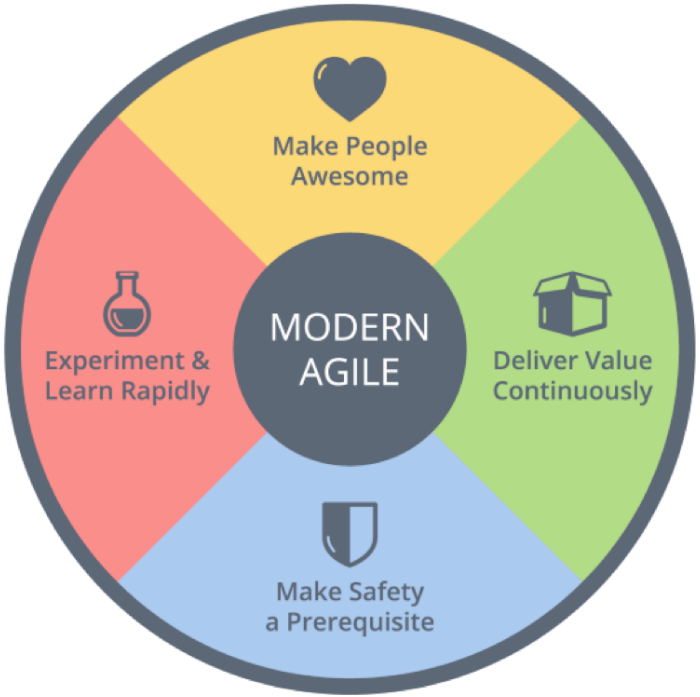
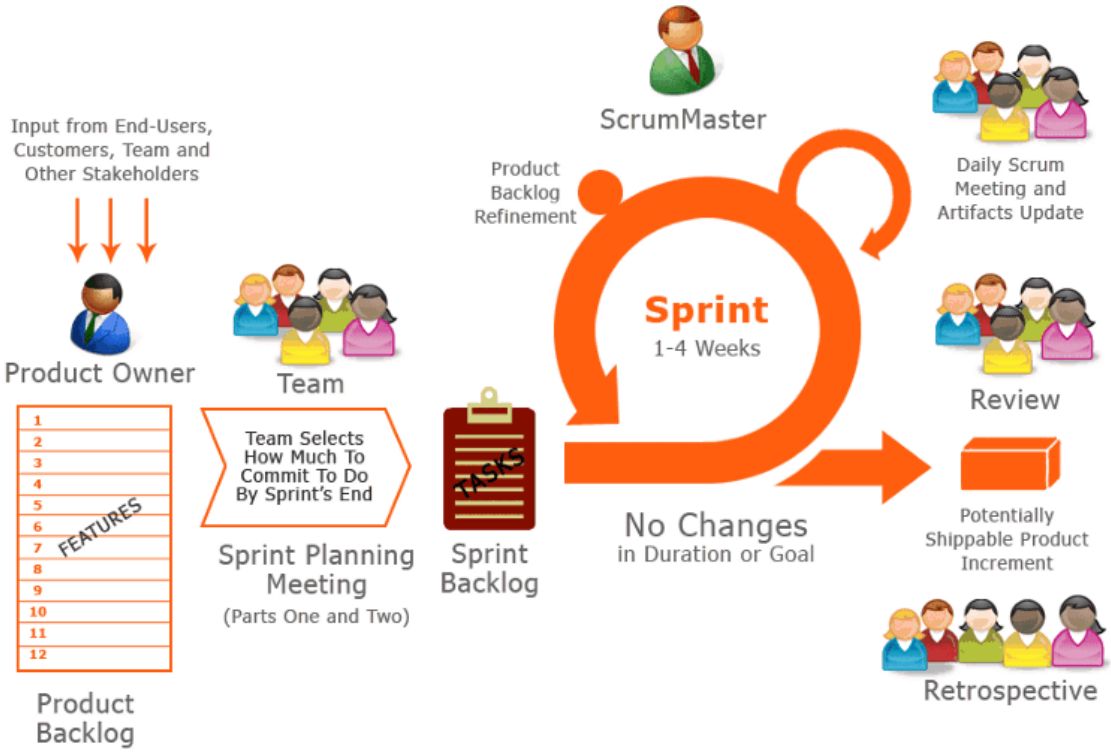
NEW
DELETE

Implementation Plan

Software Development Model

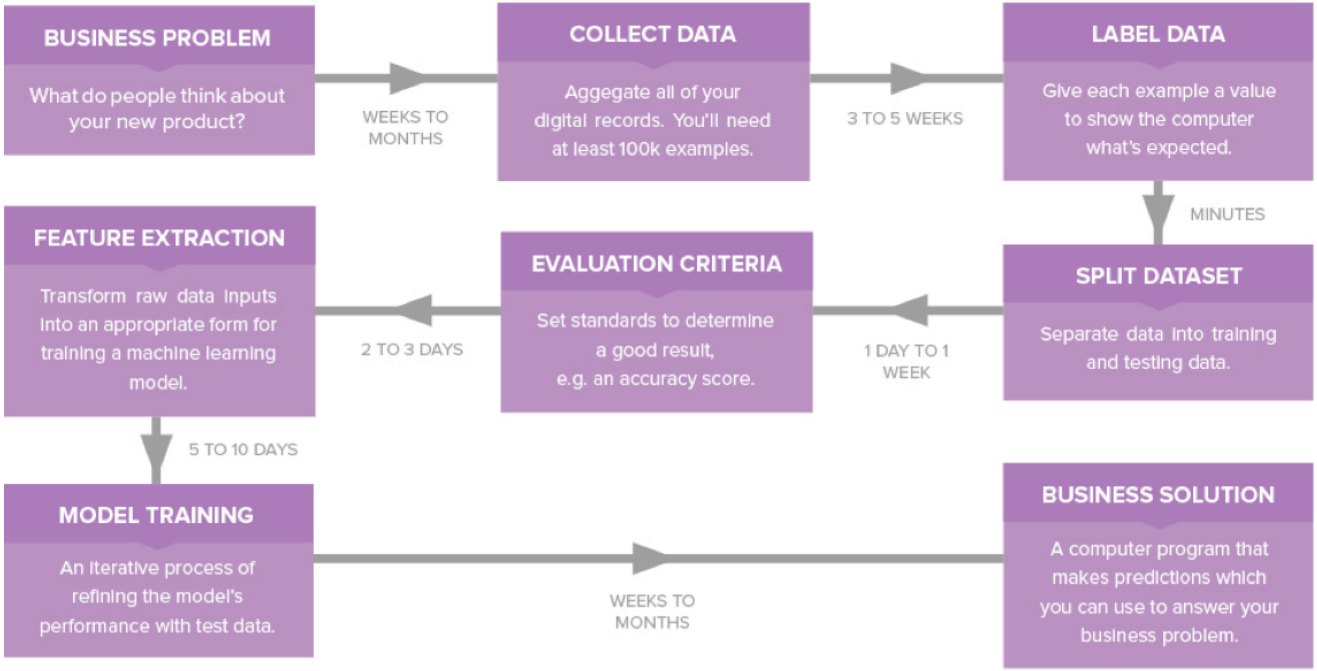


Software Development Model



Source: https://medium.com/chingu/a-short-introduction-to-the-scrum-methodology-7a23431b9f17

Machine Learning Project Timeline

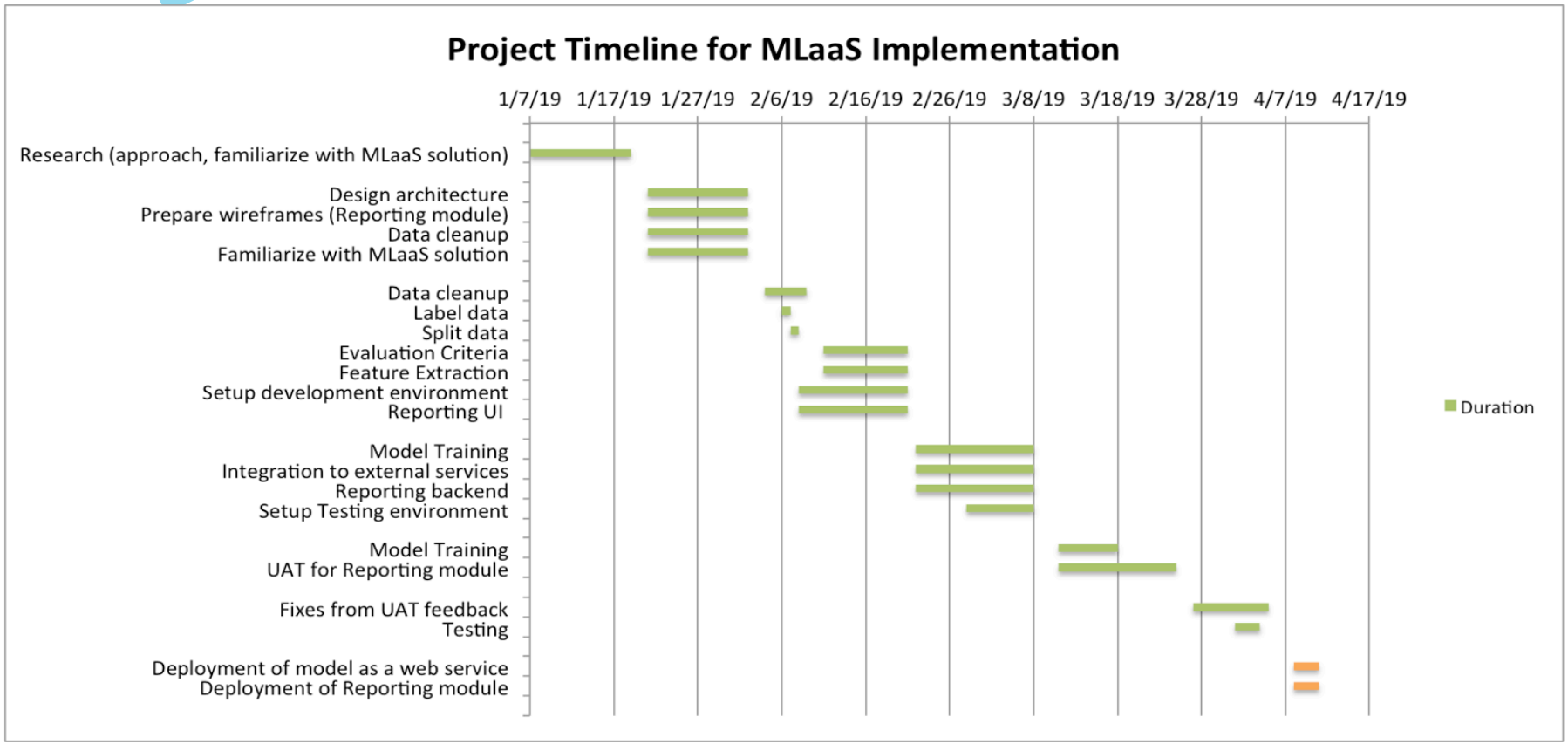


Source: https://indico.io/blog/the-founders-guide-to-machine-learning-why-you-shouldnt-build-your-own-models/

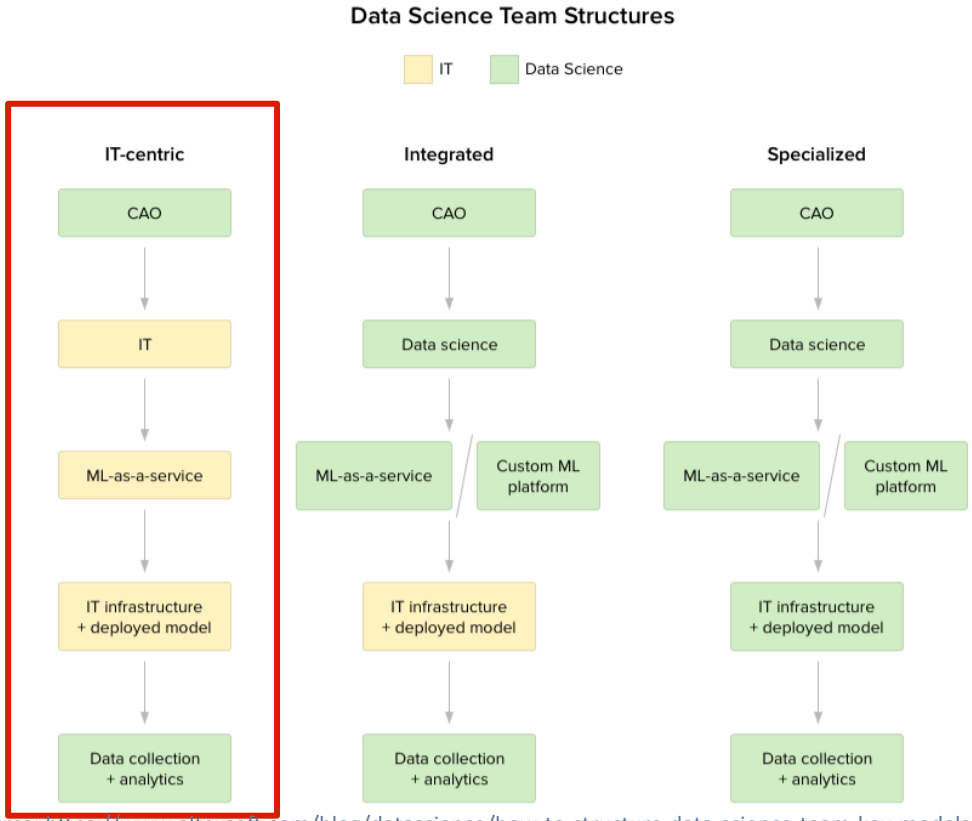
Estimated MLaaS Project Timeline

Proposed Project Schedule						
Sprint	**Module/Task**	**Start Date**	**End Date**	**Working Days**	**Duration**	**Holidays**
1		**1/7/19**	**1/18/19**	**10**	**12**	
	Research (approach, familiarize with MLaaS solution)	1/7/19	1/18/19	10	12	
2		**1/21/19**	**01/02/2019**	**9**	**12**	
	Design architecture	1/21/19	2/1/19	9	12	1/21 MLK Jr. Day
	Prepare wireframes (Reporting module)	1/21/19	2/1/19	9	12	
	Data cleanup	1/21/19	2/1/19	9	12	
	Familiarize with MLaaS solution	1/21/19	2/1/19	9	12	
3		**2/4/19**	**2/20/19**	**11**	**17**	
	Data cleanup	2/4/19	2/8/19	5	5	2/5 CNY Day 1
	Label data	2/6/19	2/7/19	1	1	2/6 CNY Day 2
	Split data	2/7/19	2/8/19	1	1	2/14 Valentine's Day
	Evaluation Criteria	2/11/19	2/20/19	8	10	2/18 President's Day
	Feature Extraction	2/11/19	2/20/19	8	10	
	Setup development environment	2/8/19	2/20/19	7	13	
	Reporting UI	2/8/19	2/20/19	7	13	
4		**2/22/19**	**3/7/19**	**10**	**14**	
	Model Training	2/22/19	3/7/19	10	14	
	Integration to external services	2/22/19	3/7/19	10	14	
	Reporting backend	2/22/19	3/7/19	10	14	
	Setup Testing environment	2/28/19	3/7/19	6	8	
5		**3/11/19**	**3/25/19**	**10**	**14**	
	Model Training	3/11/19	3/25/19	5	7	3/21 Holi
	UAT for Reporting module	3/11/19	3/25/19	10	14	
6		**3/27/19**	**4/4/19**	**7**	**9**	
	Fixes from UAT feedback	3/27/19	4/2/19	7	9	
	Testing	4/1/19	4/3/19	3	3	
7		**4/8/19**	**4/10/19**	**3**	**3**	
	Deployment of model as a web service		**4/10/19**			
	Deployment of Reporting module		**4/10/19**			

Estimated MLaaS Project Timeline



Team Structure



Source: https://www.altexsoft.com/blog/datascience/how-to-structure-data-science-team-key-models-and-roles/

Staff/Team Members

- **Team Size:** 4 - 6
- **Roles:**

Dedicated	Shared
Chief Analytics Officer (CAO)*	Project Managers
Data Scientists	UI/UX Designers
Data Engineers	DevOps
Software Engineers	

- **OPTION 1**: Open positions to existing IT staff, with training; hire remainder over time (within 3-6 months).
- **OPTION 2**: Hire new talent with experience.
- Responsibilities of roles to overlap in initial phase (“wear many hats”) until project/team is in a more mature phase.

Necessary and Preferred Data Science Skills

Fields	Skills	Preference
Analytics	R/SAS	Necessary
Coding	R, Python, Java, C/C++	Necessary
Database	SQL, NoSQL, (MongoDB, CouchDB, Cassandra, MemcacheDB, etc.)	Necessary
Big Data Processing	Hadoop, Spark, Flink	Preferred
Algorithms and models	Regression models, Hidden Markov models, Support Vector MAchines, Dimensionality Reduction algorithms, Ensemble algorithms, Decision Trees, Clustering	Necessary
Frameworks and Libraries	TensorFlow, Theano, CNTK, scikit-learn, Caffe, Spark MLib, etc.	Preferred
Domain Knowledge	Understanding of company goals, industry fundamentals, business problems, findings new ways to leverage data	Preferred
Other	Intellectual curiosity, communication and interpretation skills	Preferred

Source: https://www.altexsoft.com/blog/datascience/how-to-structure-data-science-team-key-models-and-roles/

Estimated Budget (12-mth)

	Amount / Annum (USD)	
	OPTION 1	OPTION 2
Team Salaries (6 members)	$500,000.00[1]	$690,000.00[1]
MLaaS Operational Cost (servers, service fees)	$9,000.00[2]	$5,000.00[3]
Misc (training, tools subscription, etc)	$24,000.00[4]	$15,000.00[4]
TOTAL	**$533,000.00**	**$710,000.00**

[1]Based on Indeed & Glassdoor data
[2]Based on ***Azure Machine Learning Studio*** Pricing Calculator
[3]Based on ***Azure Machine Learning Service*** Pricing Calculator

Summary

Proposed Solution: Microsoft Azure Machine Learning Studio

Proposed Team Structure: 4-6 people, IT-centric, centralized team

Proposed Timeline: 3.5 months (1.5 months development)

Proposed 12-mth Budget: $533,000.00

Proposed Future Works:

- Improve OCR image-to-text conversion
- Ink reorder prediction
- Marketing

Additional References

https://www.lexmark.com/en_xc/solutions.html

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THANKS!

Any questions?