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Developing and deploying NLP services on the cloud using Azure ML and the Team Data Science Process

Debraj GuhaThakurta
Cloud & AI
Algorithms and Data Science Group

Global Artificial Intelligence Conference
April 28, 2018, Santa Clara, CA

https://aka.ms/tdsp-presentations

Microsoft

Credits: Mohamed Abdel-Hady, Wei Guo, Raza Khan, Akshay Mehra, Zoran Dzunic

Agenda

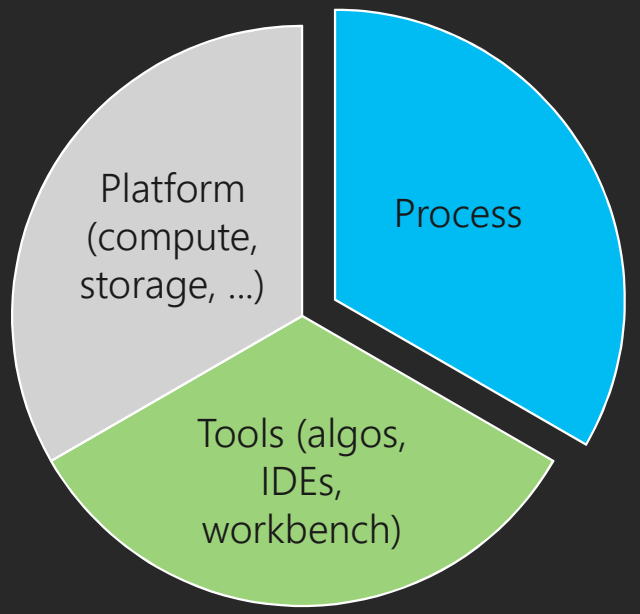
- Team Data Science Process (TDSP)
  - Principle and objective
  - Key components
  - Adoption and use
- Azure Machine Learning (AML)
  - Key features
  - Developing and deploying AI solutions
- Using AML and TDSP to develop & deploy NLP services

Team Data Science Process (TDSP)

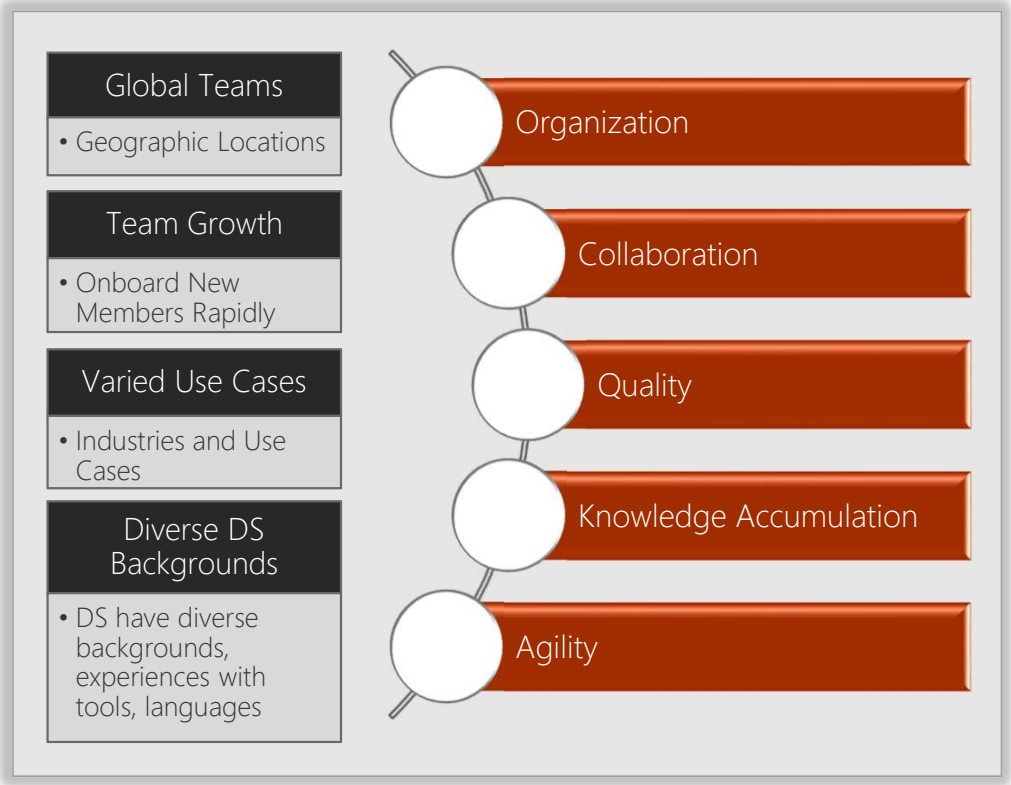
Agile and iterative process to develop, deploy and manage AI applications on the cloud

https://aka.ms/tdsp

tdsp-feedback@microsoft.com



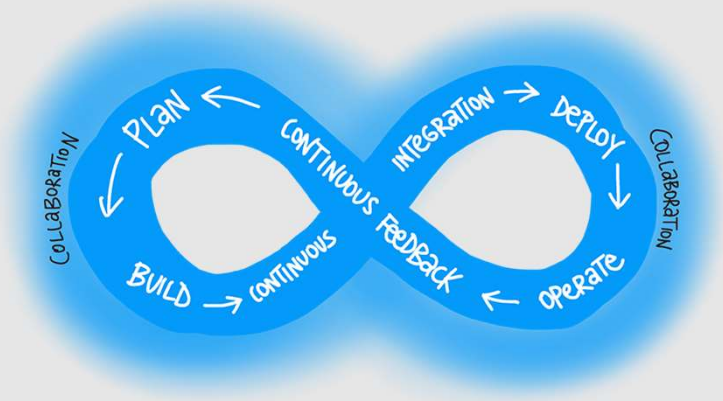
Process challenge in Data Science



"Intelligent" application (ML/AI) development has unique complexity not always encountered in other Software Development scenarios

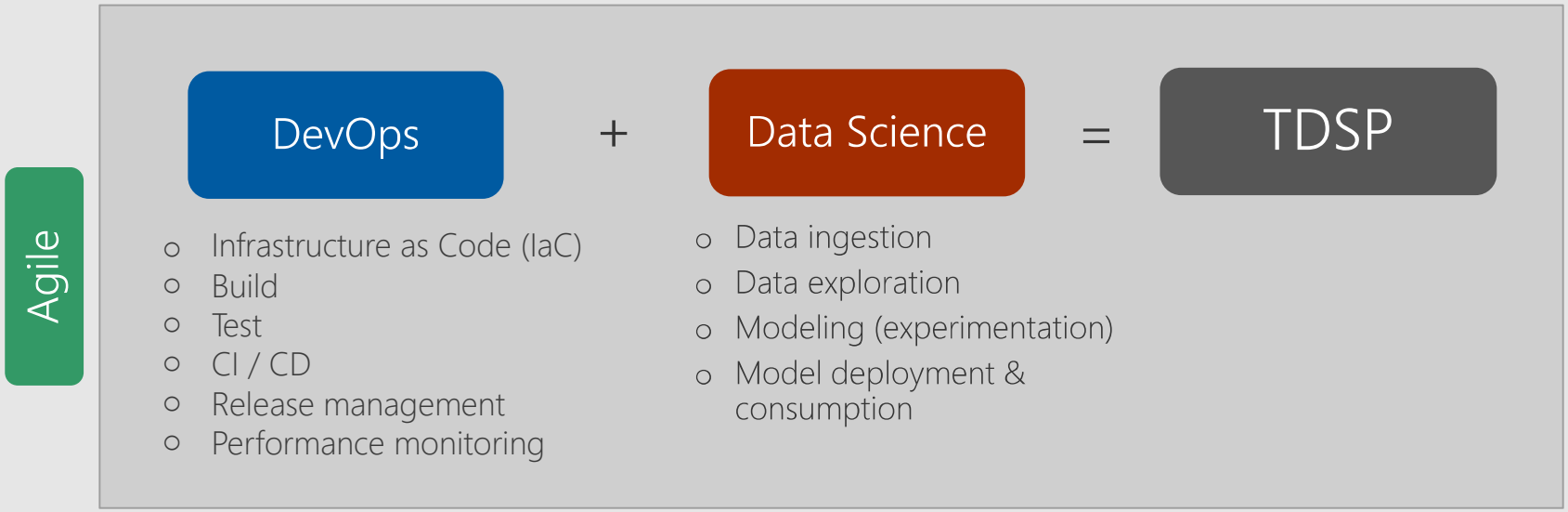
Data Science can borrow processes from DevOps

- Integrated Software Development & Operations (DevOps) has had much more time to mature, standardize, build in efficiency and develop best practices
- Data Science has unique complexity – but can learn standardized processes from DevOps

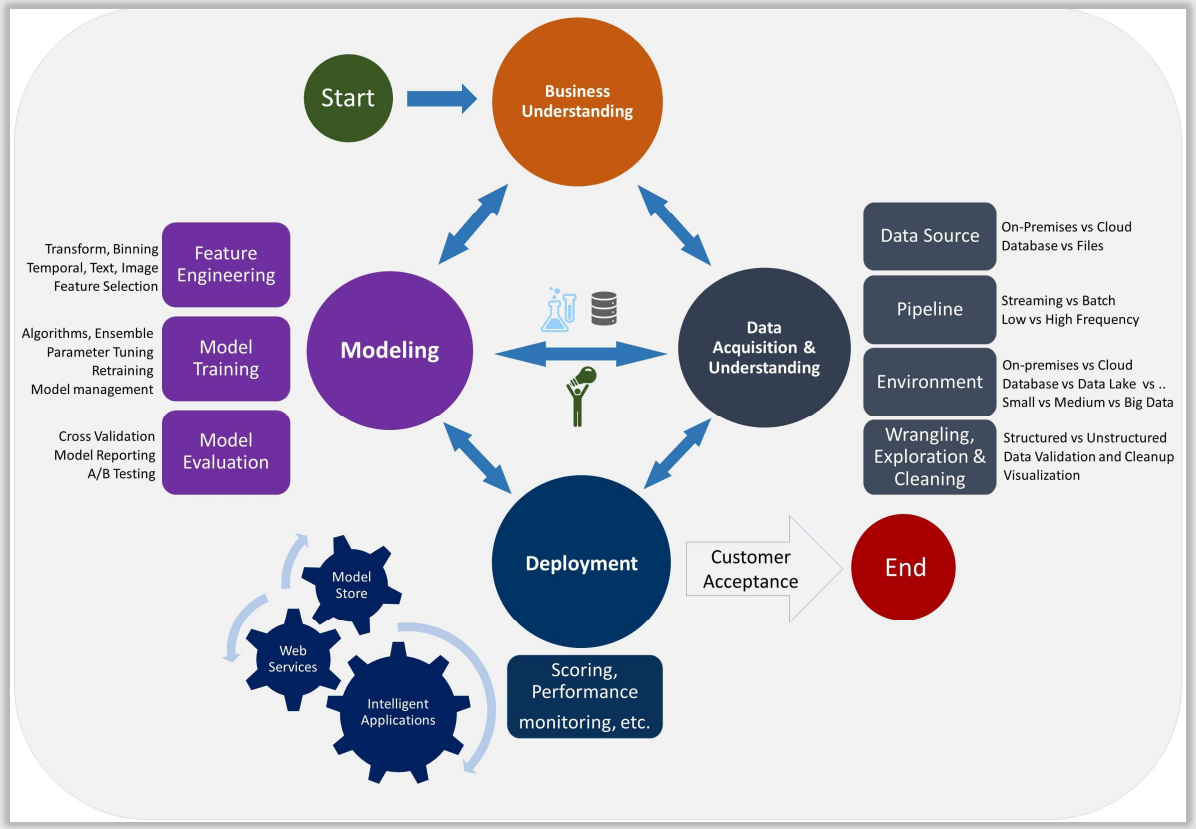


TDSP objective

Integrate DevOps with data science workflows to improve collaboration, quality, robustness and efficiency in data science projects

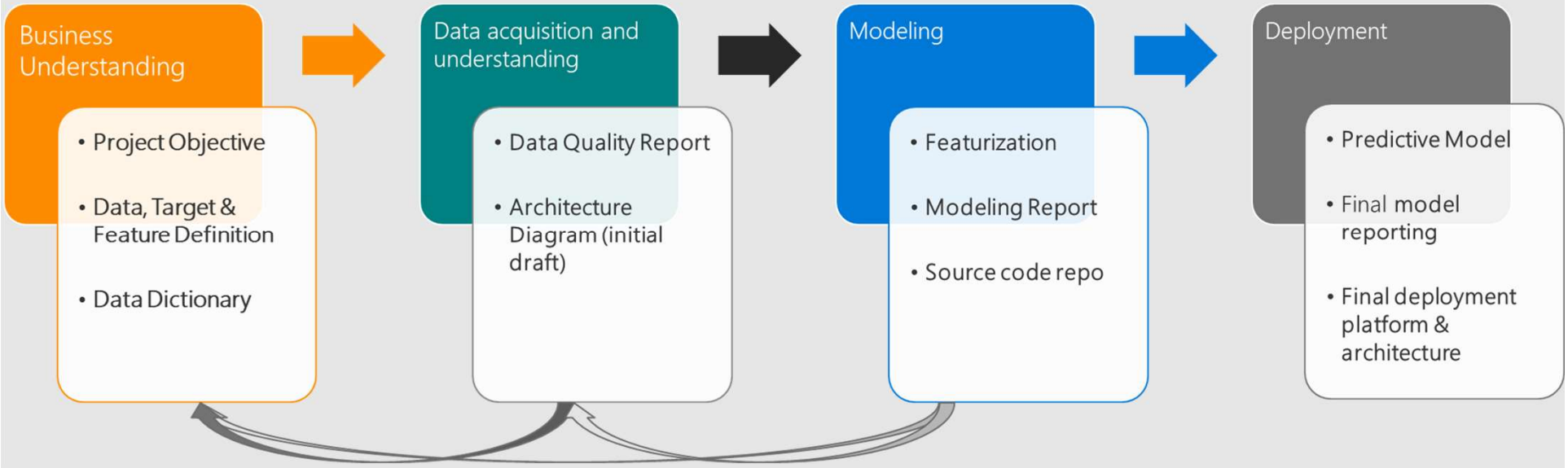


Data Science lifecycle

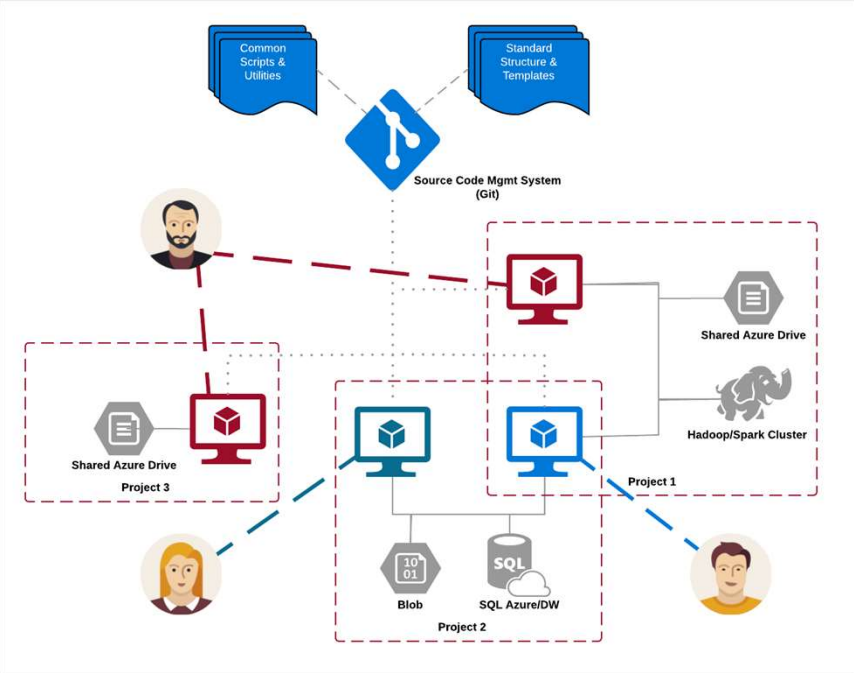


- Primary stages:
  - Business Understanding
  - Data Acquisition and Understanding
  - Modeling
  - Deployment

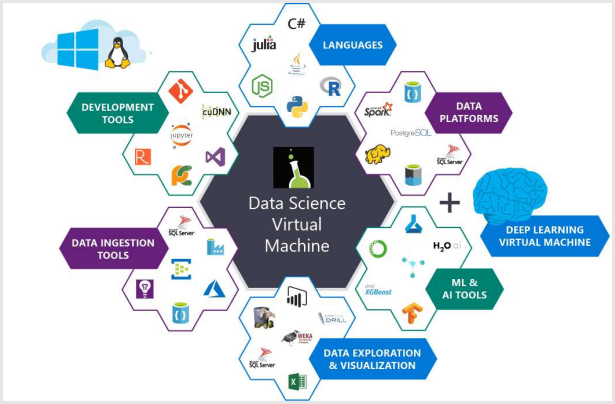
TDSP lifecycle stages can be integrated with specific deliverables & checkpoints – Templates available



Shared and distributed infrastructure & toolkits

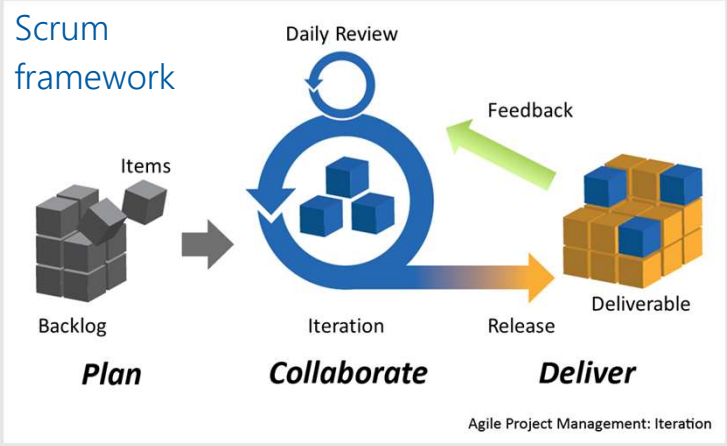


- Project artifacts & code stored in central git (version control) repositories.
- Data typically stored in cloud stores, such as blob or database
- Virtual machines (VMs), or clusters are disposable compute, added to projects as needed
- Many-to-many relationship between data scientists, compute and projects



Agile work planning and execution template

- Use Agile work planning & execution template (data science specific)
  - DS Projects: e.g. "Fraud Detection for Customer ABC"
  - DS Stages: correspond to the stages in TDSP lifecycle.
  - DS Stories: correspond to the life-cycle sub-stages.
  - DS Tasks: Tasks are assignable code or document work items to complete a specific data science story.

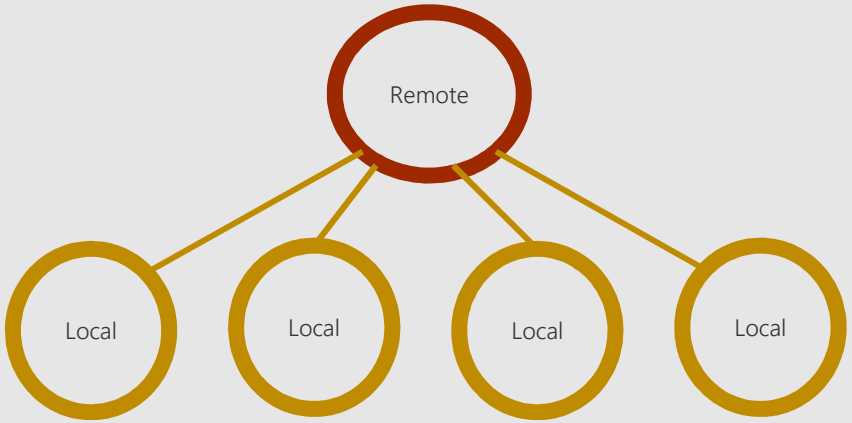


https://commons.wikimedia.org

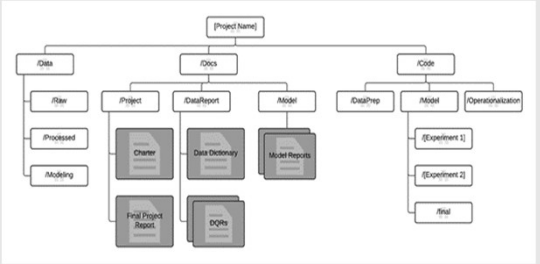
Work Item Type	Title	State
Data Science...	Fraud_Detection_CompanyABC	New
Business Und...	Define Objectives	Active
Data Science...	identify business variables	Active
Data Science...	Define success metrics	Active
Data Science...	define accuracy	New
Data Aquisition	Ingest Data	New
Data Aquisition	Explore First Derm data	New
Data Science...	Apply IDEAR to check data quality	New
Data Science...	Find missing data	New
Data Science...	Find numerical data distribution	New
Modeling	Feature Engineering	New
Data Science...	Compute various features	New
Data Science...	Compute categorical features	New
Data Science...	Compute text features	New
Deployment	Operationalize the model	New
Data Science...	Deploy model as a web services	New
Data Science...	set up web service with azure cloud services	New

Collaborative development guidelines

- Version control and review
  - Git is a Version Control System
  - Each repo contains the full change history
  - Used in a distributed way with a single remote repo and several local repos (on local machine or a VM)



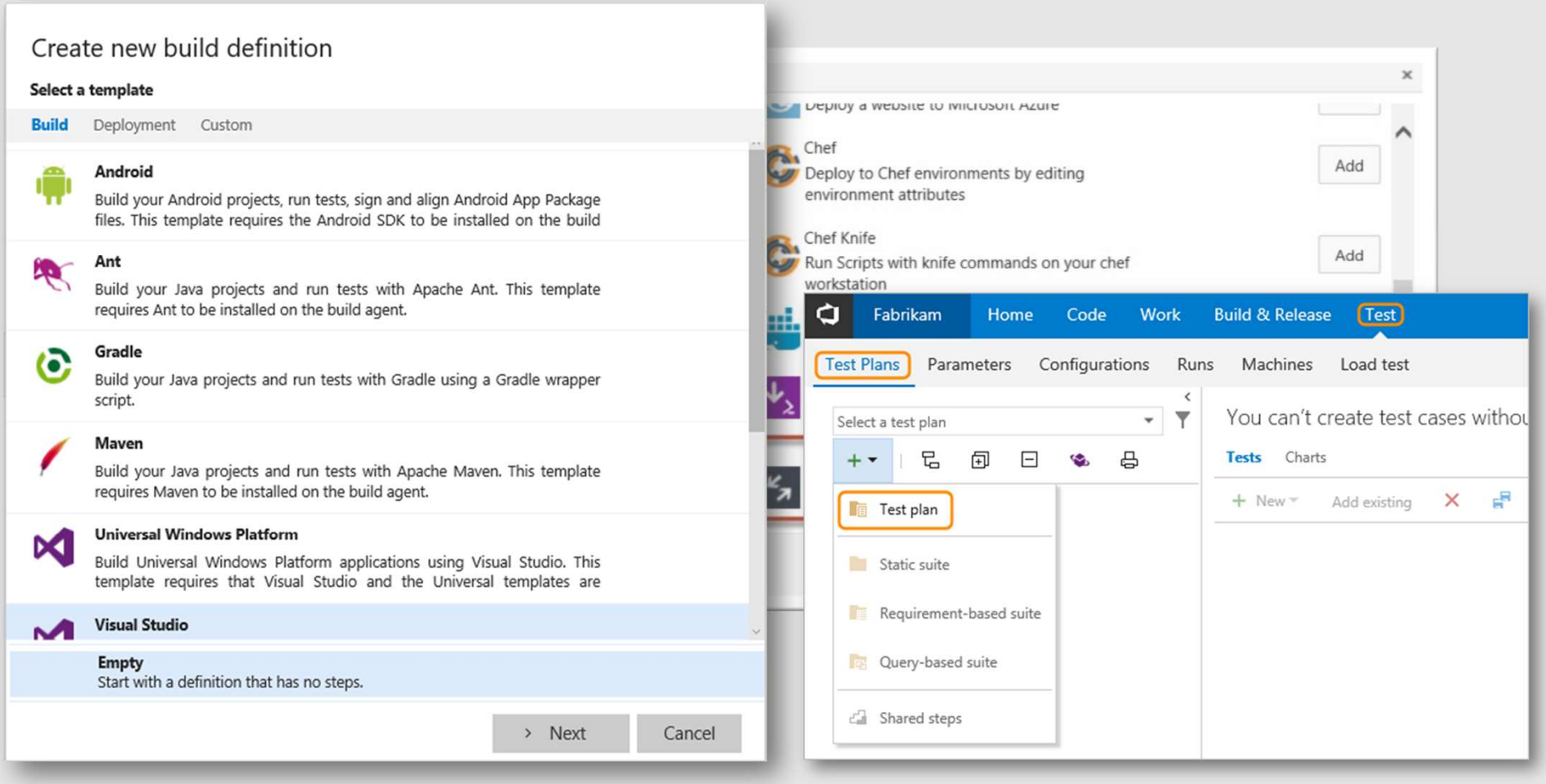
TDSP git Template



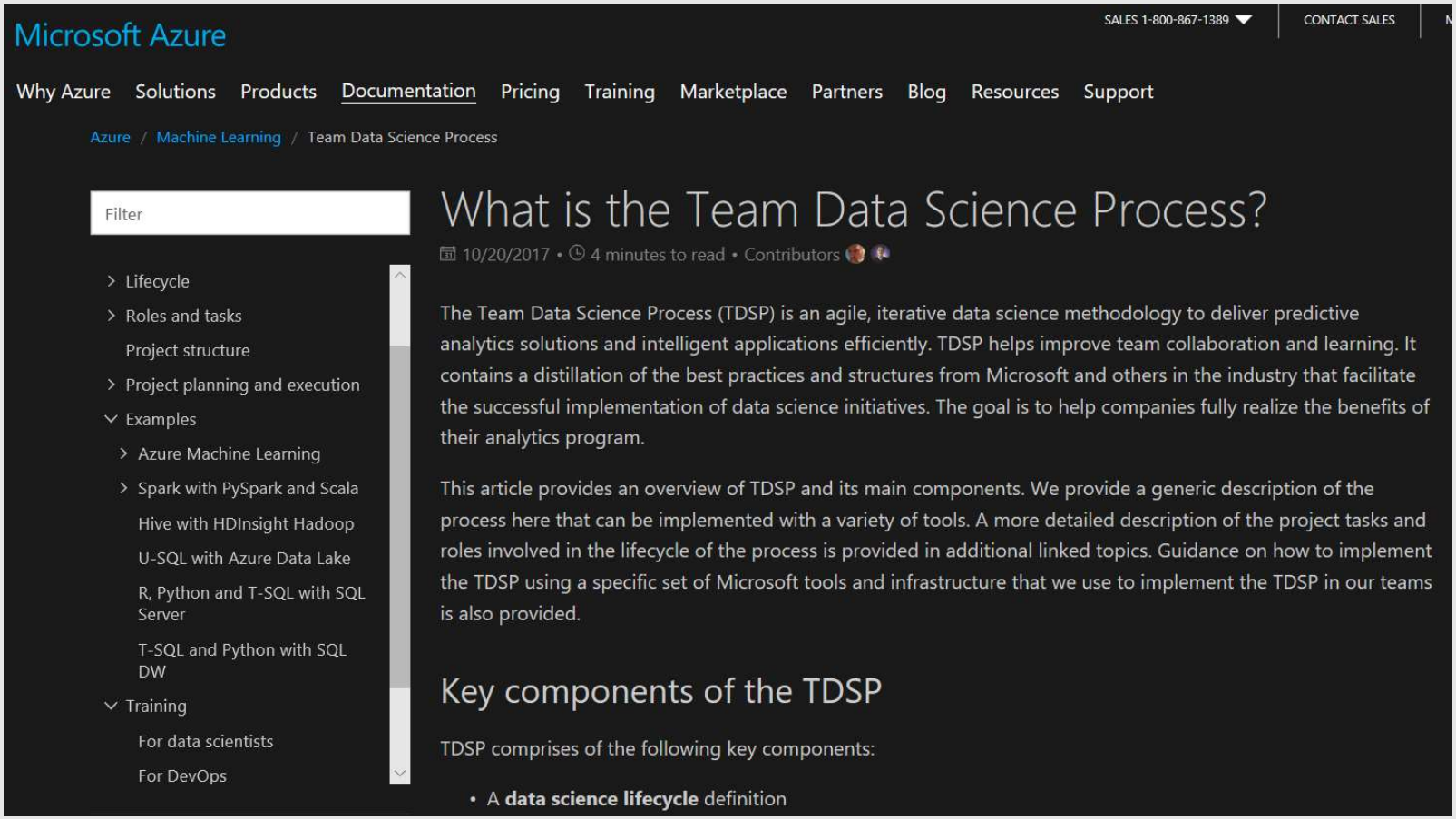
Integrated Agile planning & code development

	Order	Work Item Type	Title	State
+	1	Data Science...	Fraud_Detection_CompanyABC	New
		Business Und...	Define Objectives	Active
		Data Science...	identify business variables	Active
		Data Science...	Define success metrics	Active
		Data Science...	define accuracy	New

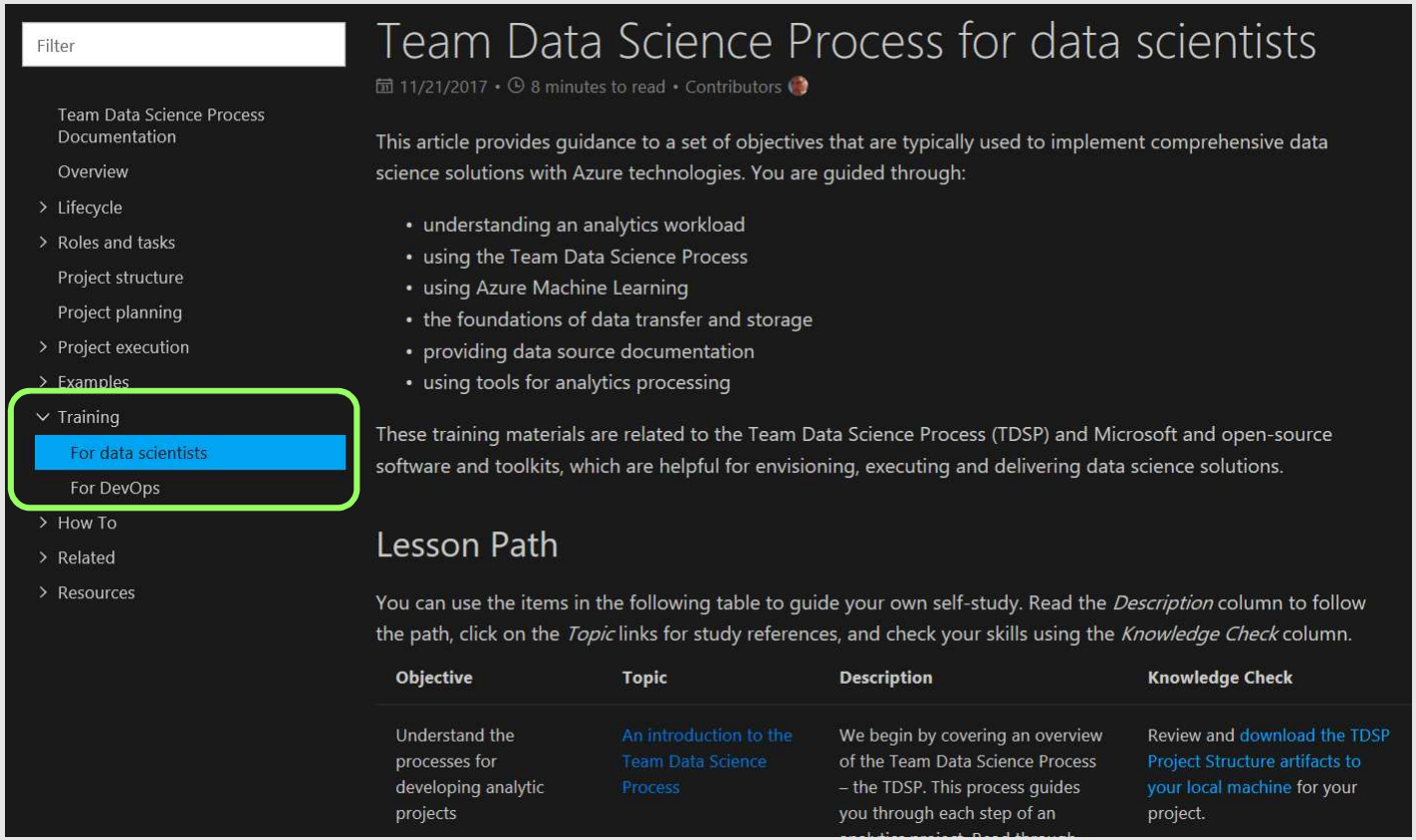
Integrating DevOps in projects



TDSP documentation: https://aka.ms/tdsp



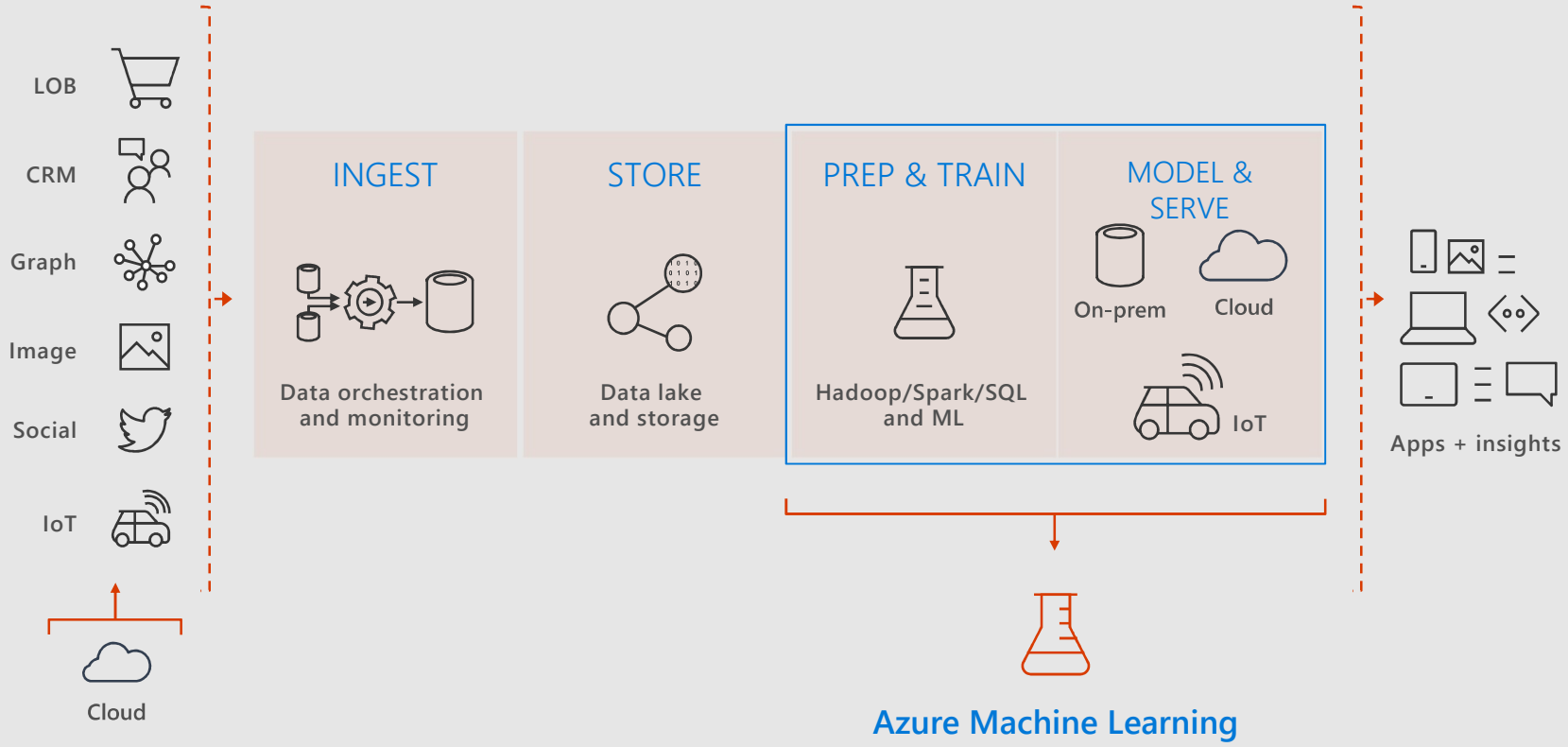
TDSP trainings



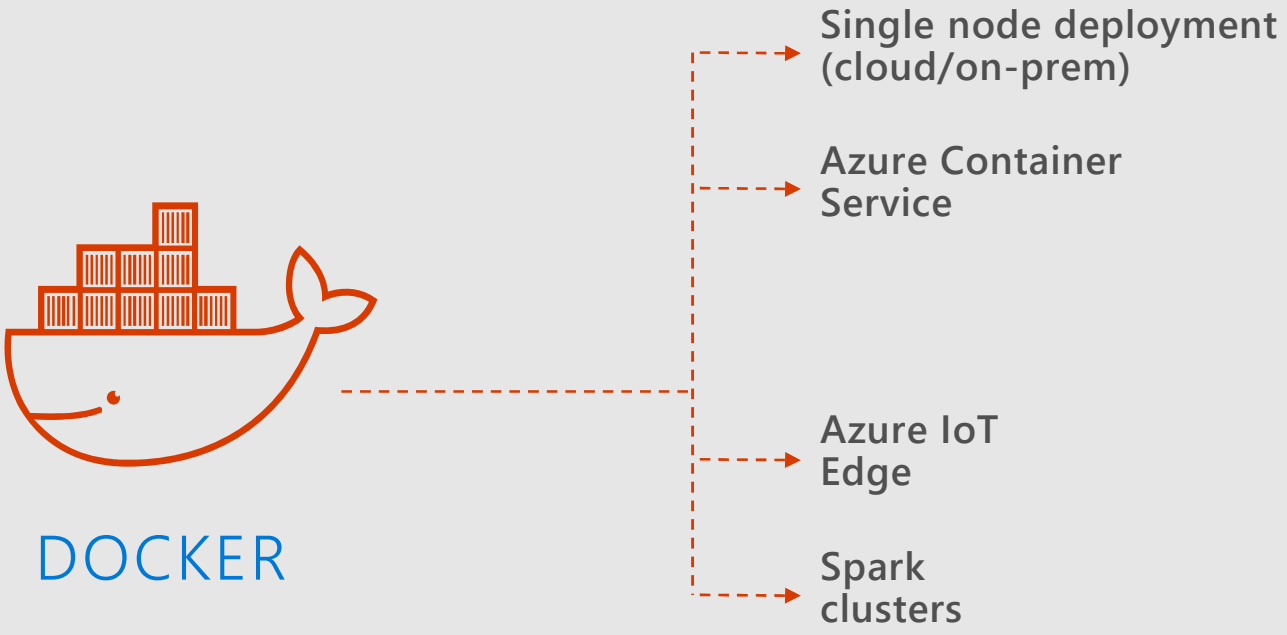
Azure Machine Learning

https://docs.microsoft.com/en-us/azure/machine-learning/service/

Azure Machine Learning



Deploy everywhere



Use what you want

Use your favorite IDE

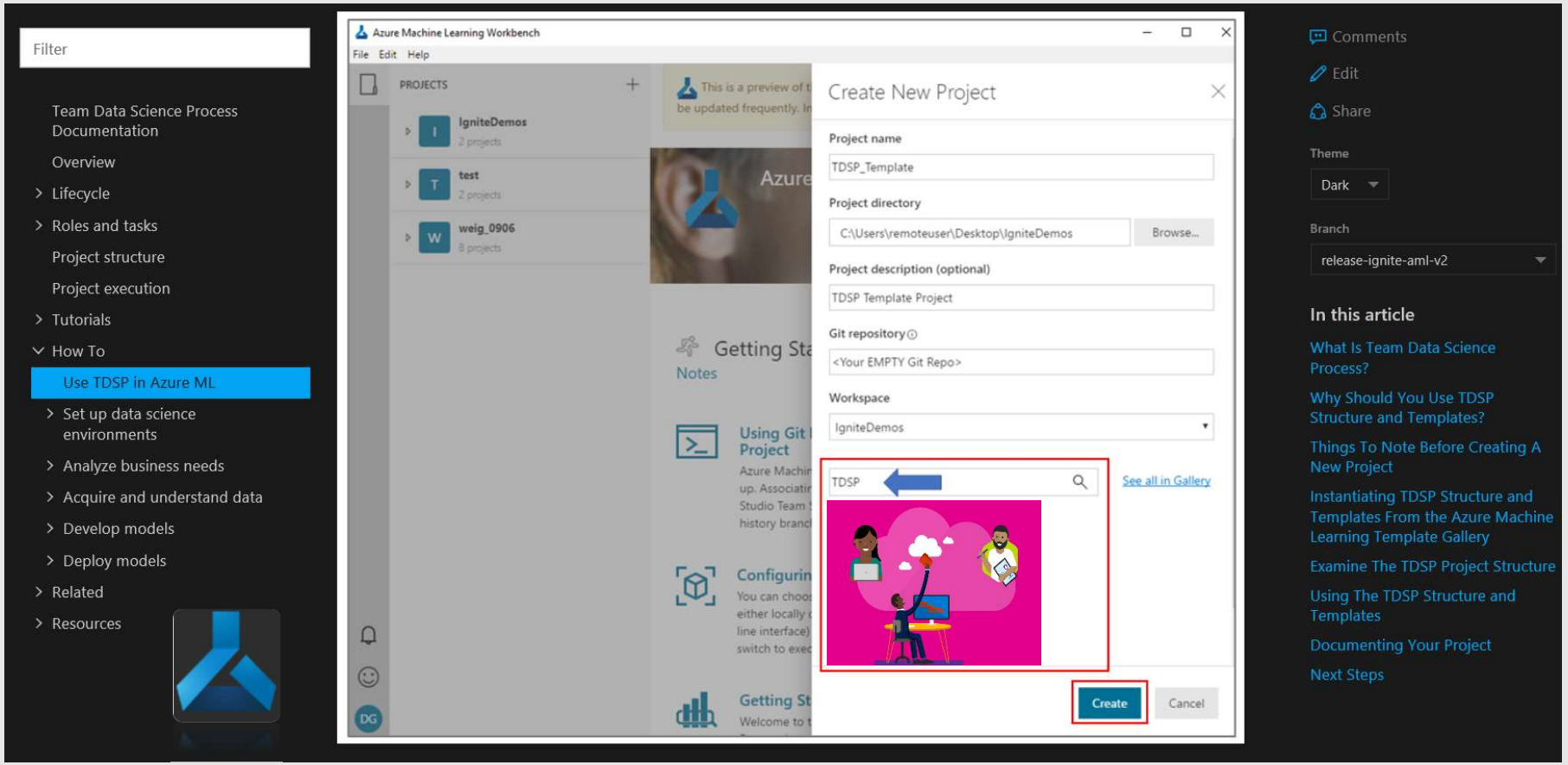
Leverage all types of platforms and tools/libraries

USE ANY FRAMEWORK OR LIBRARY

USE ANY TOOL

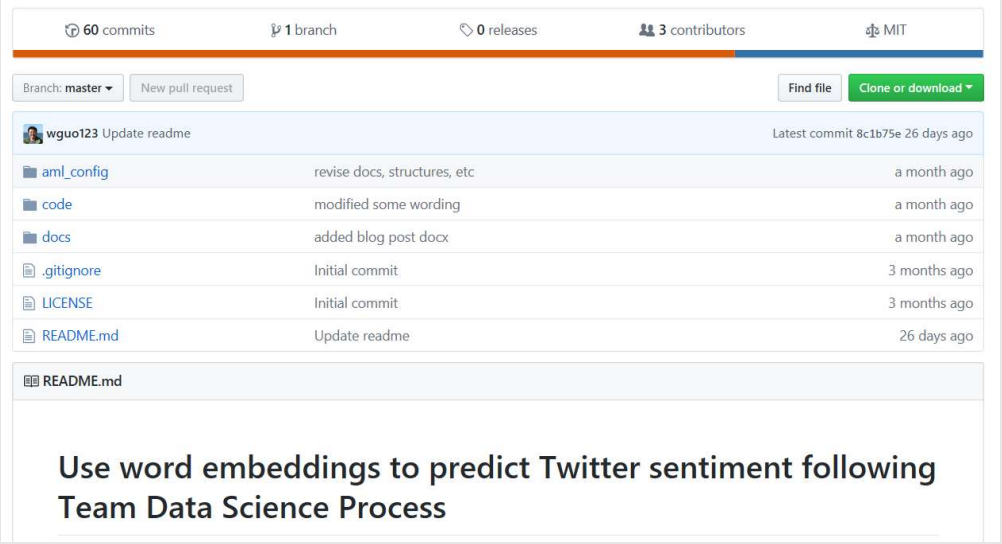
USE THE MOST POPULAR INNOVATIONS

Using TDSP with Azure Machine Learning



TDSP – AML worked-out samples in AI

- Unstructured data (NLP) modeling with deep-learning
  - Sentiment classification using supervised word-embeddings
  - Biomedical (PubMed) Named entity recognition using LSTM
- Structured data
  - Income classification
- Public Github repositories for each sample



https://docs.microsoft.com/en-us/azure/machine-learning/team-data-science-process/walkthroughs

Developing & deploying NLP services on Azure

Sentiment classification

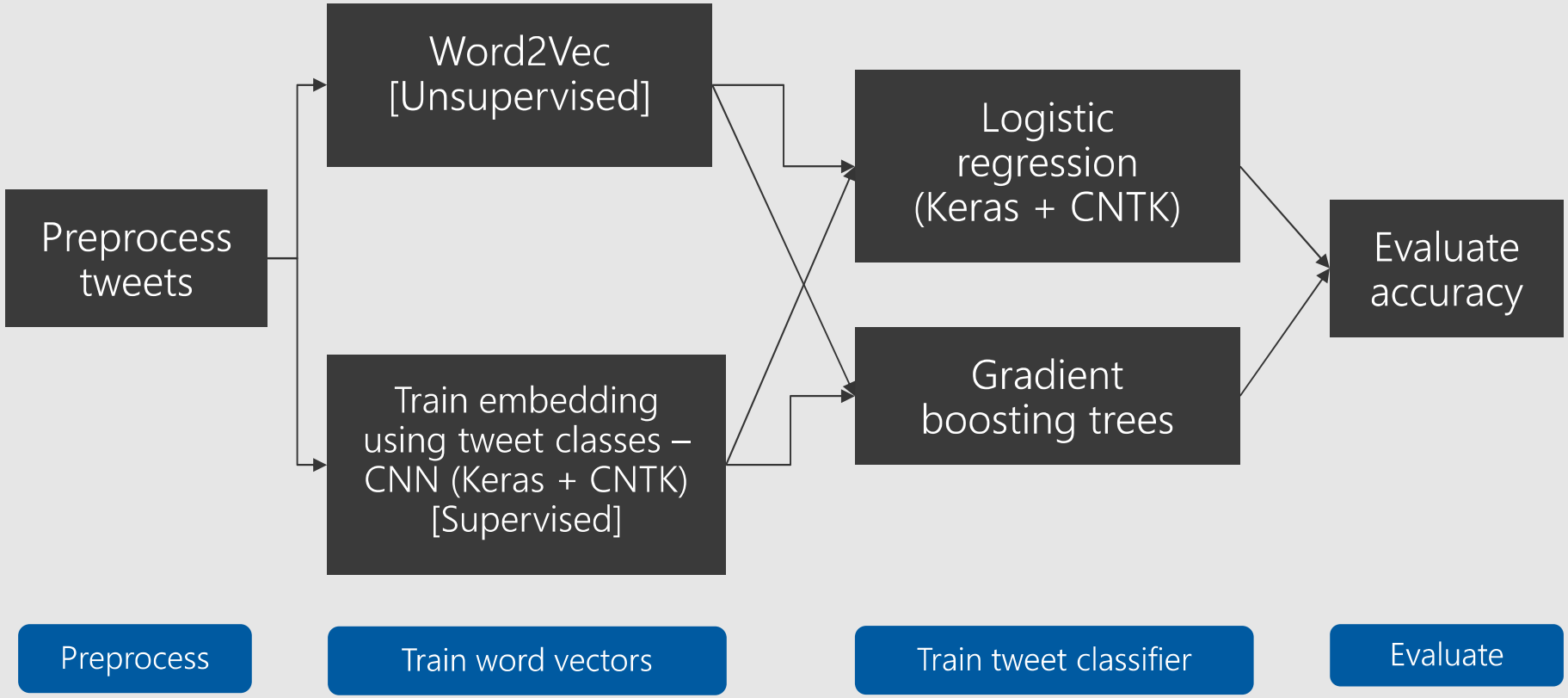
https://github.com/Azure/MachineLearningSamples-TwitterSentimentPrediction

Use case introduction: Twitter sentiment prediction

- Predict Twitter sentiment polarity using word embedding and DL for classification
- Objective & scientific question
  - Demonstrate how to develop and deploy sentiment classification service on Azure
  - Can supervised word embeddings improve accuracy of classification accuracy of sentiment class prediction?
- Dataset
  - "sentiment140"
  - 1.3 million tweets for training
  - 320,000 for testing
  - Classes - only two, positive and negative (neutral tweets were removed for this exercise)

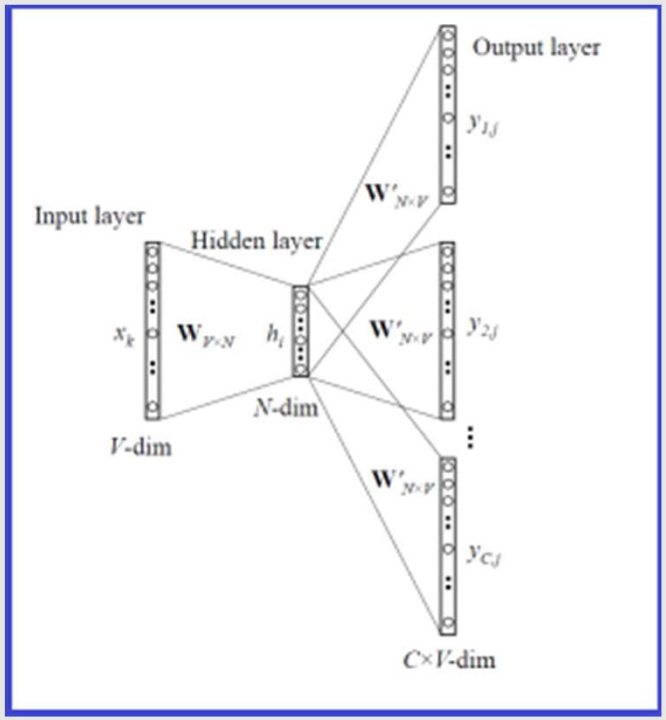
Analysis strategy

- Train word embeddings in 2 different ways
  - Unsupervised: Word2Vec
  - Supervised: Using CNN to generate classification based embeddings
- Train classifier (GBT, Logisitc regression using Keras)
- Evaluate accuracy on test set

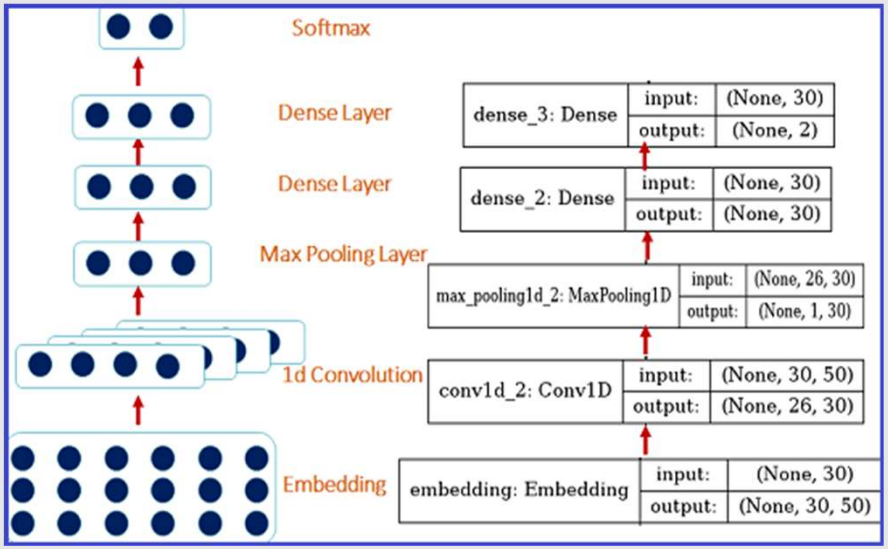


Word embedding generation

Word2Vec: skip-gram



Supervised word embeddings using CNN

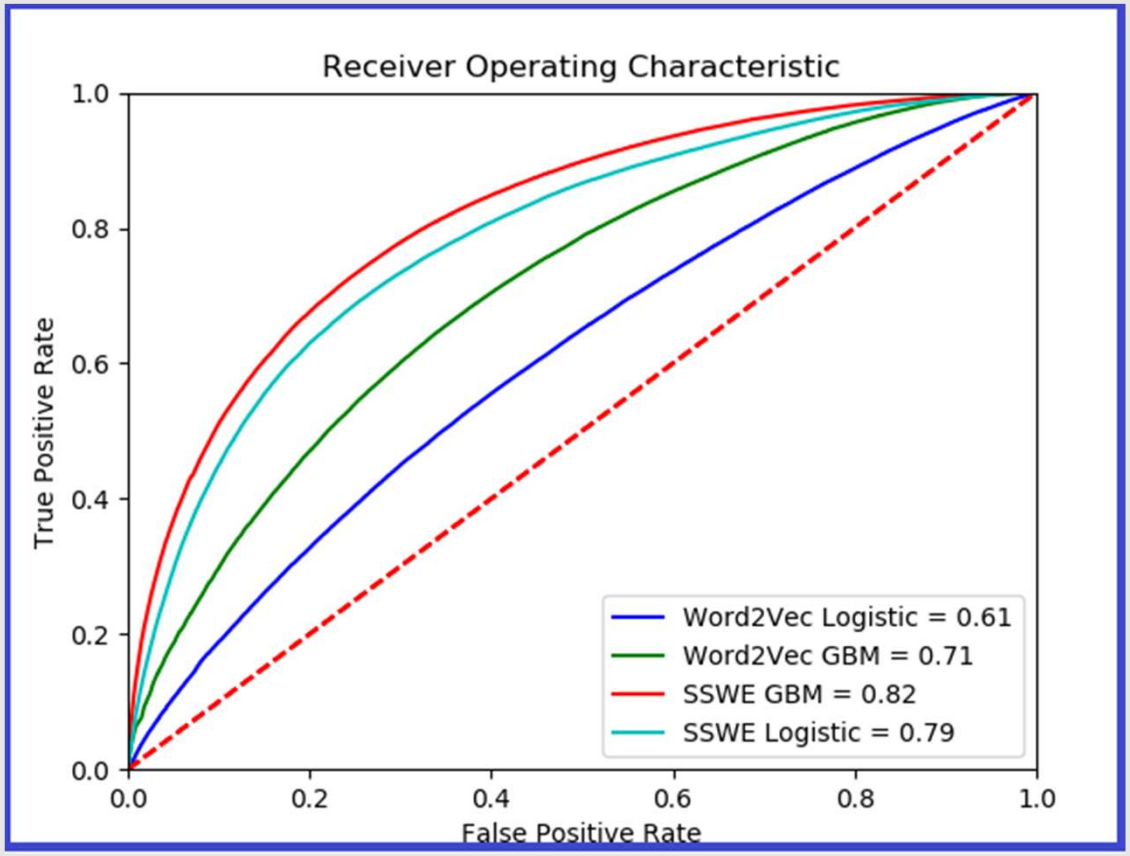


Supervised embedding generation using CNN

- code

```
# Model Instantiation
print ('Initializing the model')
mcp = ModelCheckpoint('./model_chkpoint', monitor="val_acc", save_best_only=True, save_weights_only=False)

#Creating network
model = Sequential()
model.add(Embedding(len(word_index)+2,
                            embedding_dim,
                            input_length=max_sequence_length,
                            trainable=trainable, name='embedding'))
model.add(Convolution1D(no_filters, filter_size, activation='relu'))
model.add(MaxPooling1D(max_sequence_length - filter_size))
model.add(Flatten())
model.add(Dense(no_filters, activation='tanh'))
model.add(Dense(len(labels[0]), activation='softmax'))

optim=optimizers.Adam(lr=0.1, )
model.compile(loss='categorical_crossentropy',
              optimizer=optim,
              metrics=['acc'])
model.summary()
```

Model evaluation: Sentiment-specific word embeddings (SSWE) improves classification of sentiments



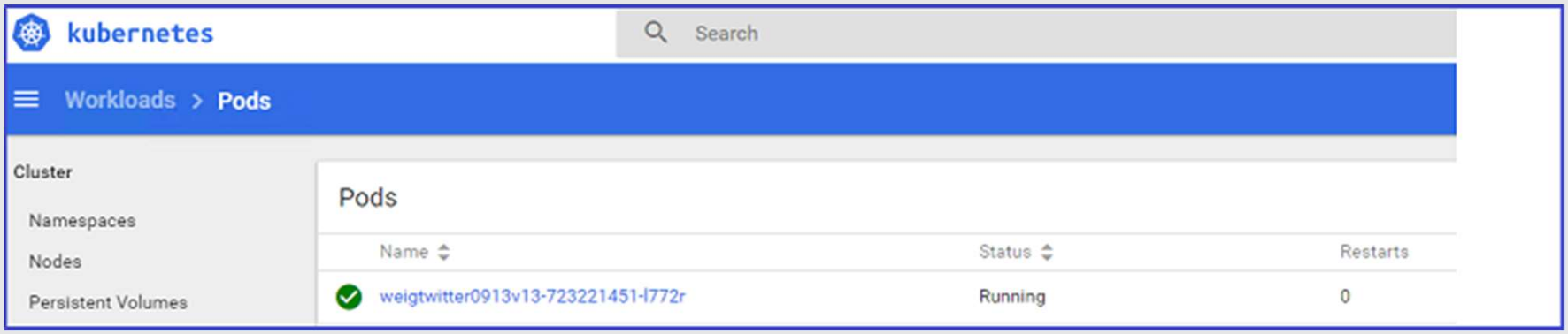
https://docs.microsoft.com/en-us/azure/machine-learning/team-data-science-process/predict-twitter-sentiment

http://www.aclweb.org/anthology/P14-1146

Model deployment

- The operationalization environment provisions Docker and Kubernetes in the cluster to manage the web-service deployment

```
az ml service create realtime --model-file (model file name) -f (scoring
script name) -n (your-new-acctname) -s (web service schema json file) -r
(compute environment, python or PySpark, etc) -d (dependency files)
```



Named entity recognition (NER)

https://github.com/Azure/MachineLearningSamples-BiomedicalEntityExtraction

Use case introduction: Biomedical named entity recognition using LSTMs

- Identify entities drugs, chemicals & diseases from medical abstracts (PubMed) or medical documents such as electronic health records (EHRs)

- Objective & question
  - Train a scalable model for NER using word vectors and DL architecture
  - Can we improve NER identification accuracy using domain-specific (biomedical) datasets for word embedding, rather than a generic dataset (e.g. Google news articles)?

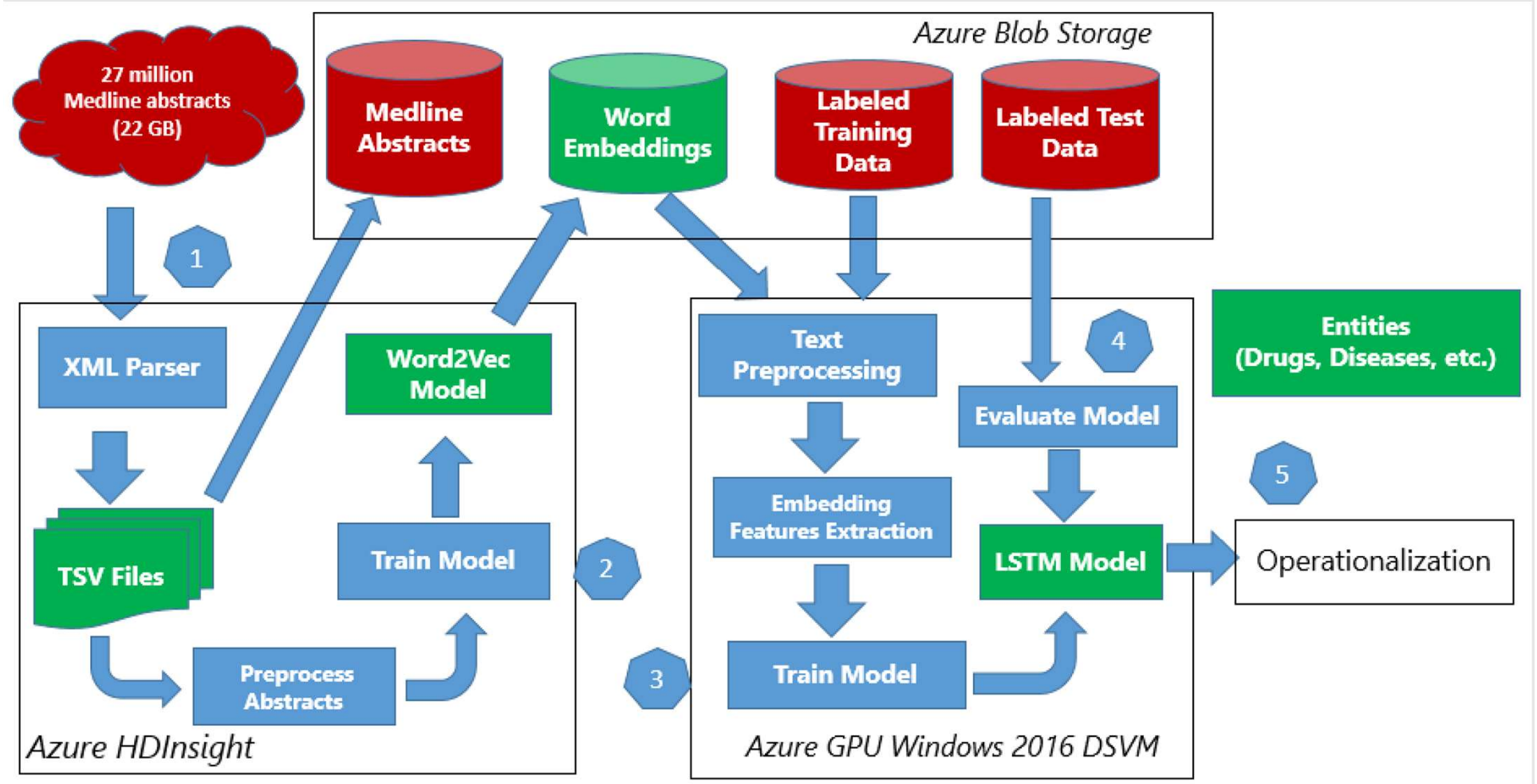
- Datasets
  - Word embeddings: Entire set of PubMed abstracts, ~30 MIL
  - Drugs and disease labeled data-set
  - Biological entities (protein, DNA, RNA etc.)

Labeled entity data-sets

```
Famotidine-associated   B-Chemical
delirium        B-Disease
.       O

A       O
series  O
of      O
six     O
cases   O
.       O

Famotidine      B-Chemical
is      O
a       O
histamine       O
H2-receptor     O
antagonist      O
used    O
in      O
inpatient       O
settings        O
for     O
prevention      O
of      O
stress  O
ulcers  B-Disease
and     O
is      O
showing O
increasing      O
popularity      O
because O
of      O
its     O
low     O
cost    O
.       O
```

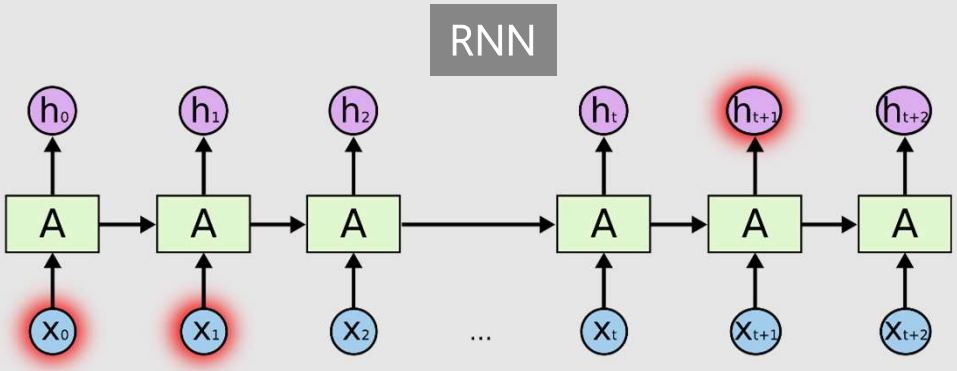
- Training: Typically labeled data containing
  - 500-2,000 abstracts
  - 8,000-20,000 sentences
- Test: Typically labeled data
  - 200-400 abstracts
  - 600-4,000 sentences

Architecture: Data pipeline and experimental setup



Word2Vec & Bi-directional LSTM architecture

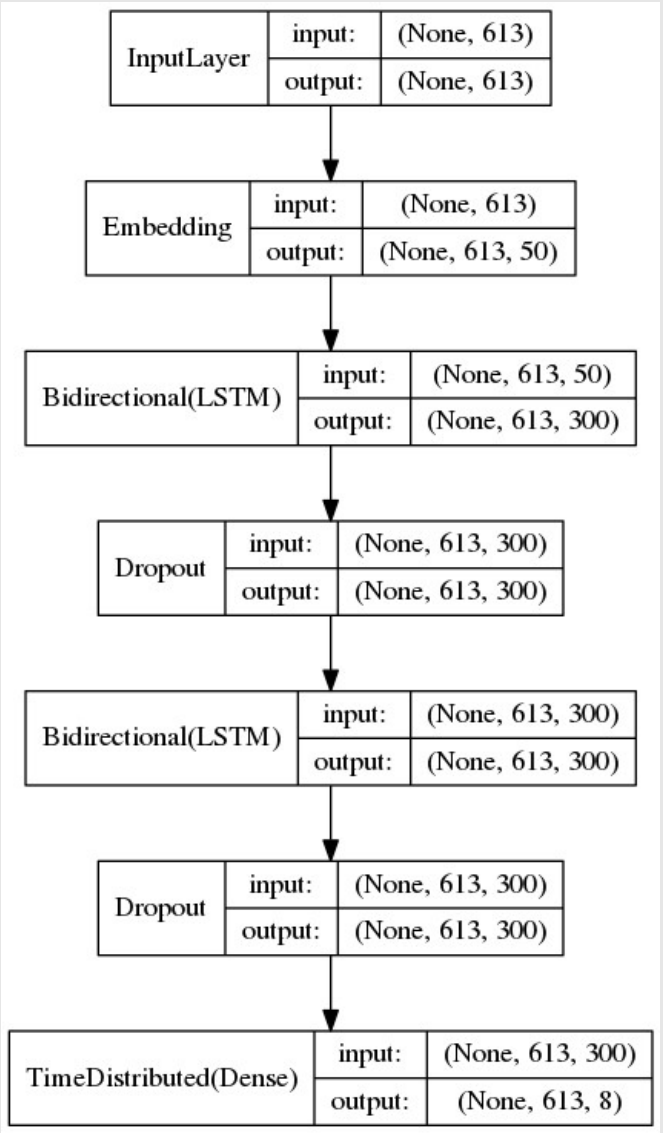
- Word2Vec training:
  - Spark MLlib implementation
  - Azure HDInsight Spark cluster
  - 11 nodes
- LSTM training:
  - GPU – DSVM (data science VM)



LSTM - Long Short Term Memory networks - special kind of RNN, capable of learning long-term dependencies (details not shown)

http://colah.github.io/posts/2015-08-Understanding-LSTMs/

Bi-directional LSTM for NER

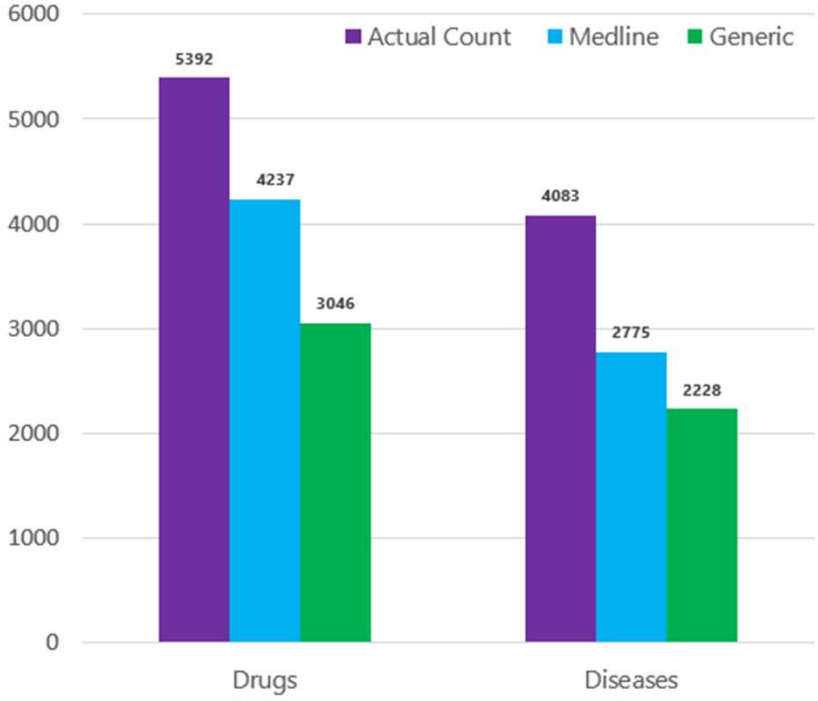


Bi-directional LSTM for NER - code

```
self.model = Sequential()
self.model.add(Embedding(self.wordvecs.shape[0], self.wordvecs.shape[1], \
                         input_length = train_X.shape[1], \
                         weights = [self.wordvecs], trainable = False))

for i in range(0, num_layers):
    if network_type == 'unidirectional':
        # uni-directional LSTM
        self.model.add(LSTM(num_hidden_units, return_sequences = True))
    else:
        # bi-directional LSTM
        self.model.add(Bidirectional(LSTM(num_hidden_units, return_sequences = True)))

    self.model.add(Dropout(dropout))

self.model.add(TimeDistributed(Dense(train_Y.shape[2], activation='softmax')))

self.model.compile(loss='categorical_crossentropy', optimizer='adam')
print(self.model.summary())

self.model.fit(train_X, train_Y, epochs = num_epochs, batch_size = batch_size)
```

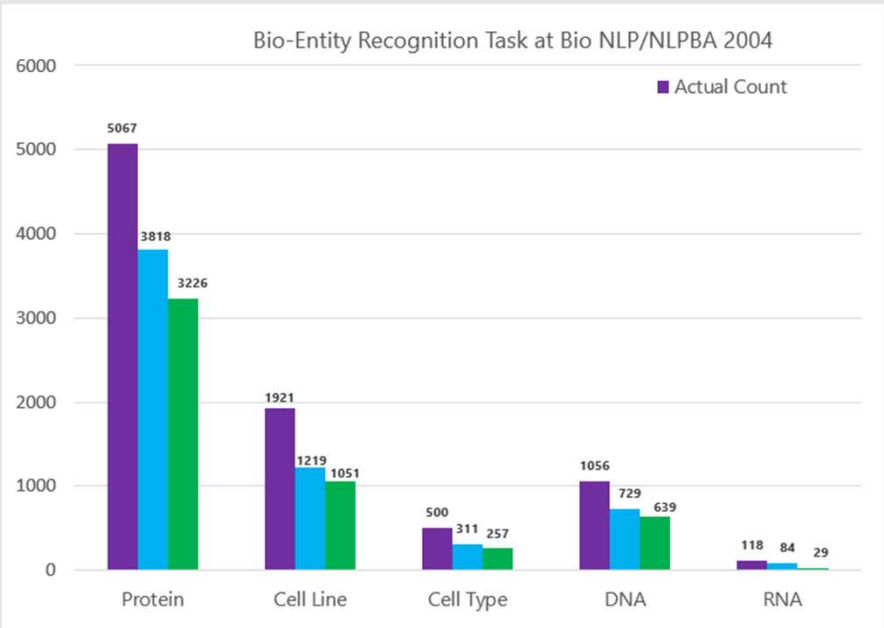
Biomedical NER model evaluation

Doman-specific embedding improve performance of NER identification



Embedding Dataset	Precision	Recall	F1 Score
MEDLINE	**0.73**	**0.74**	**0.74**
Google News	0.68	0.55	0.61

Semeval 2013 - Task 9.1 (Drug Recognition)



Embedding Dataset	Precision	Recall	F1 Score
MEDLINE	**0.65**	**0.71**	**0.68**
Google News	0.55	0.60	0.57

BioCreative V CDR task

Detection of entities – example with biomedical abstract from PubMed

Entity Extractor

Baricitinib, Methotrexate, or Baricitinib Plus Methotrexate in Patients with Early Rheumatoid Arthritis Who Had Received Limited or No Treatment with Disease-Modifying-Anti-Rheumatic-Drugs (DMARDs): Phase 3 Trial Results.
Keywords: Janus kinase (JAK), methotrexate (MTX) and rheumatoid arthritis (RA) and Clinical research.

In 2 completed phase 3 studies, baricitinib (bari) improved disease activity with a satisfactory safety profile in patients (pts) with moderately-to-severely active RA who were inadequate responders to either conventional synthetic1 or biologic2DMARDs. This abstract reports results from a phase 3 study of bari administered as monotherapy or in combination with methotrexate (MTX) to pts with early active RA who had limited or no prior treatment with DMARDs. MTX monotherapy was the active comparator.

Bcl-3 protein was also highly expressed in early burst-forming-unit-erythroid (BFU-E)-derived erythroid precursors (day 7) and decreased during maturation (days 10 and 14), suggesting that Bcl-3 is involved in normal erythroid proliferation. In these hematopoietic cells, Bcl-3 was hyperphosphorylated. GM-CSF and Epo modulated the subcellular localization of Bcl-3. Upon stimulation of TF-1 cells with GM-CSF or Epo , the nuclear translocation of Bcl-3 was dramatically enhanced . verexpression of Bcl-3 in TF-1 cells by transient transfection along with the NF-kappaB factors p50 or p52 resulted in significant induction of an human immunodeficiency virus-type 1 (HIV-1) kappaB-TATA-luceriferase reporter plasmid , demonstrating that Bcl-3 has a positive role in transactivation of kappaB-containing genes in erythroid cells. Stimulation with GM-CSF enhanced c-myb mRNA expression in these cells. Bcl-3 in nuclear extracts of TF-1 cells bound to a kappaB enhancer in the c-myb promoter together with NF-kappaB2/p52 and this binding activity was enhanced by GM-CSF stimulation. Furthermore, cotransfection of Bcl-3 with p52 or p50 in TF-1 cells resulted in significant activation of a c-myb kappaB-TATA-luceriferase reporter plasmid . Selective Serotonin Reuptake Inhibitors (SSRIs) : SSRIs (e.g. , fluoxetine , fluvoxamine , paroxetine , sertraline) have been rarely reported to cause weakness , hyperreflexia, and incoordination when coadministered with 5-HT1 agonists. If concomitant treatment with AXERT and an SSRI is clinically warranted, appropriate observation of the patient is advised.

See Results

Entity Extractor Output

See Results

Entity Extractor Output

Key: Disease, Drug or Chemical, DNA, RNA, Protein, Cell Line, Cell Type

Baricitinib , Methotrexate , or Baricitinib Plus Methotrexate in Patients with Early Rheumatoid Arthritis Who Had Received Limited or No Treatment with Disease-Modifying-Anti-Rheumatic-Drugs (DMARDs) : Phase 3 Trial Results .
Keywords : Janus kinase (JAK) , methotrexate (MTX) and rheumatoid arthritis (RA) and Clinical research .
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This abstract reports results from a phase 3 study of bari administered as monotherapy or in combination with methotrexate (MTX) to pts with early active RA who had limited or no prior treatment with DMARDs .
MTX monotherapy was the active comparator .

Summary

- TDSP (Team Data Science Process) provides a standardized process for development & deployment of AI services on Azure
- Resources are available to use TDSP and AML together, along with data platforms on Azure to develop and deploy AI solutions
- Common DL use cases are provided as examples in open GitHub repos, with suggestions and experiments on how to improve performance

Thank you!

https://aka.ms/tdsp
tdsp@microsoft.com

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