Prediktivní analytika s PI Systemem

Vít Gruner

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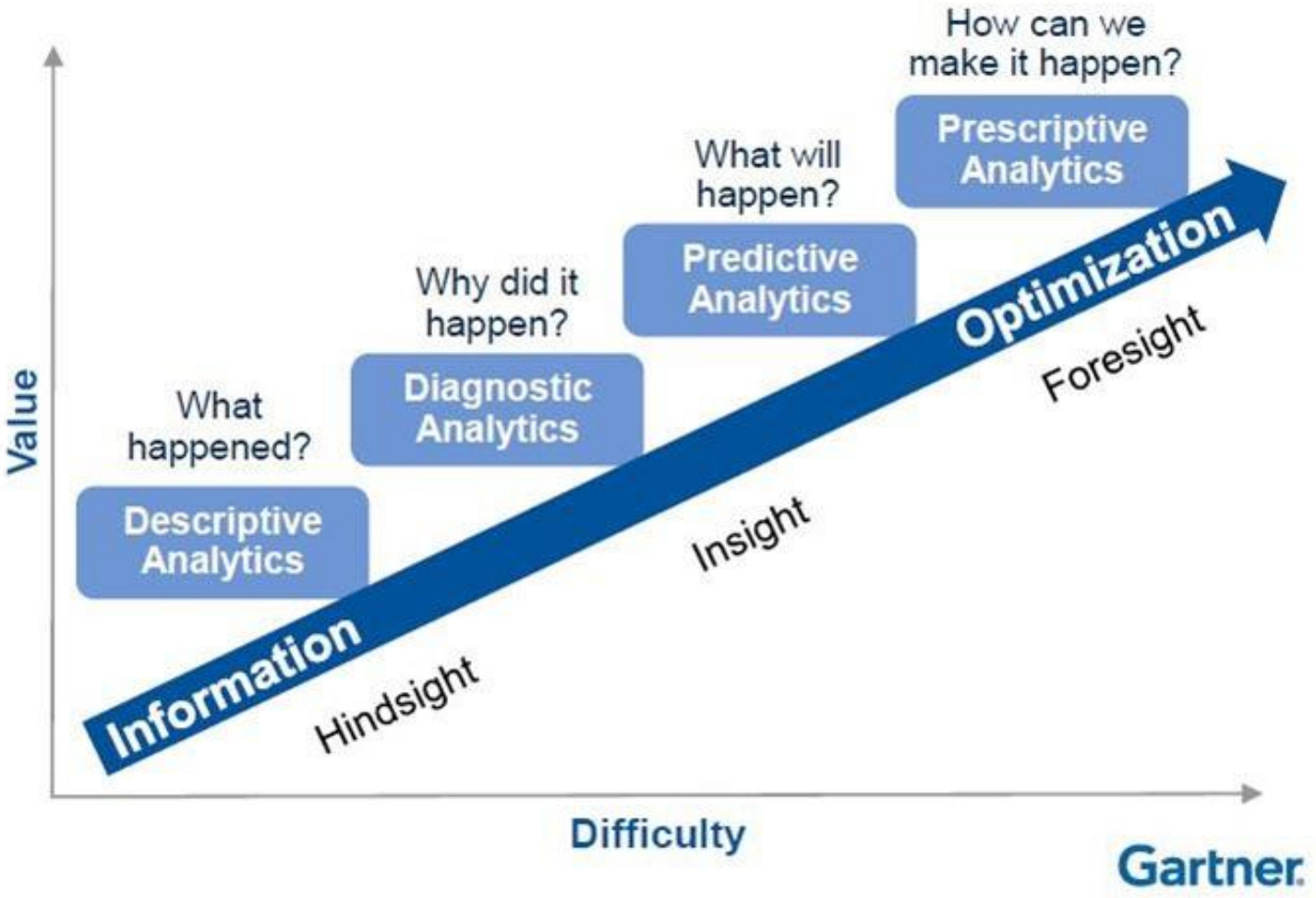
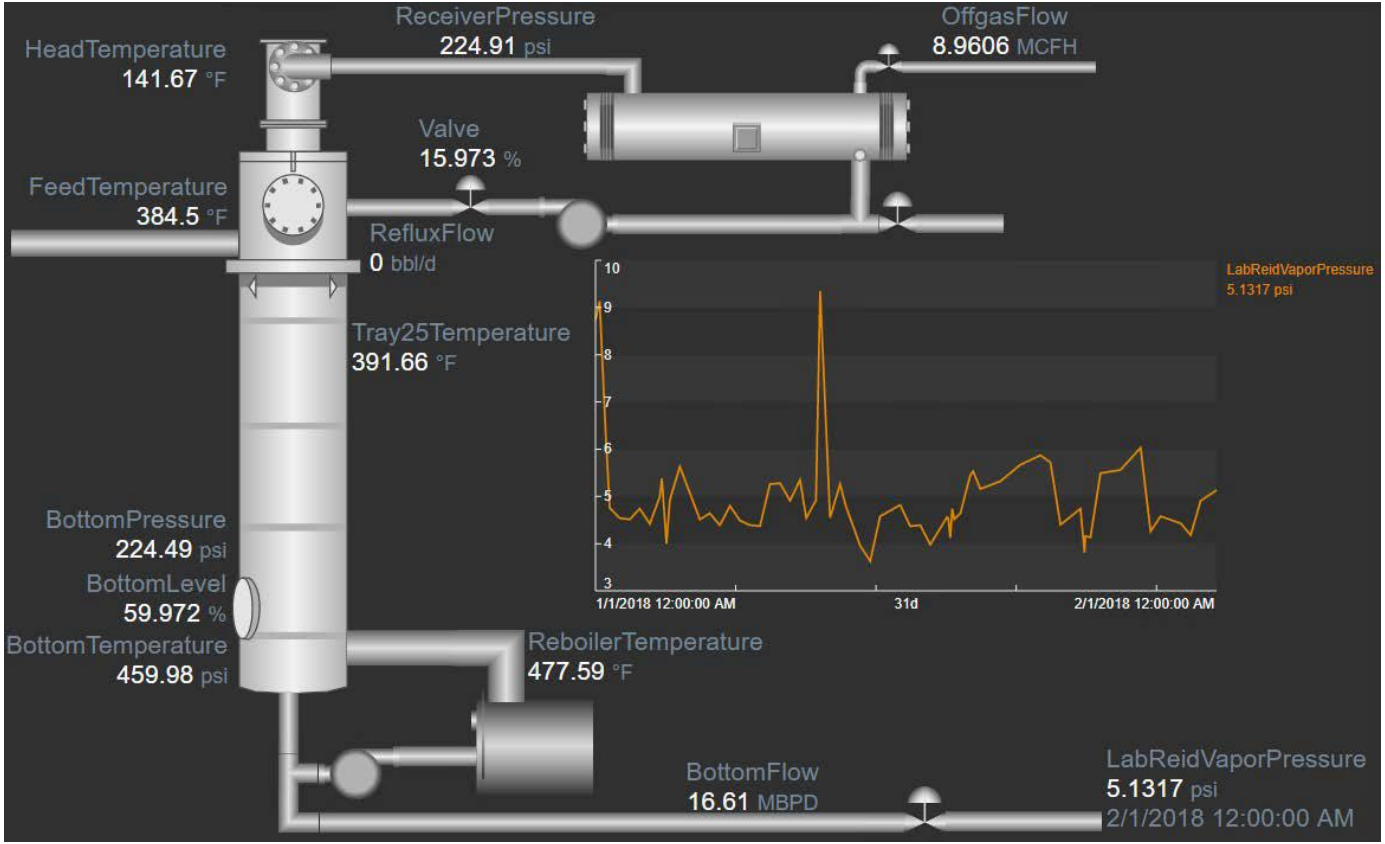
OSIsoft.



Problem Statement: Refinery Stabilization Column



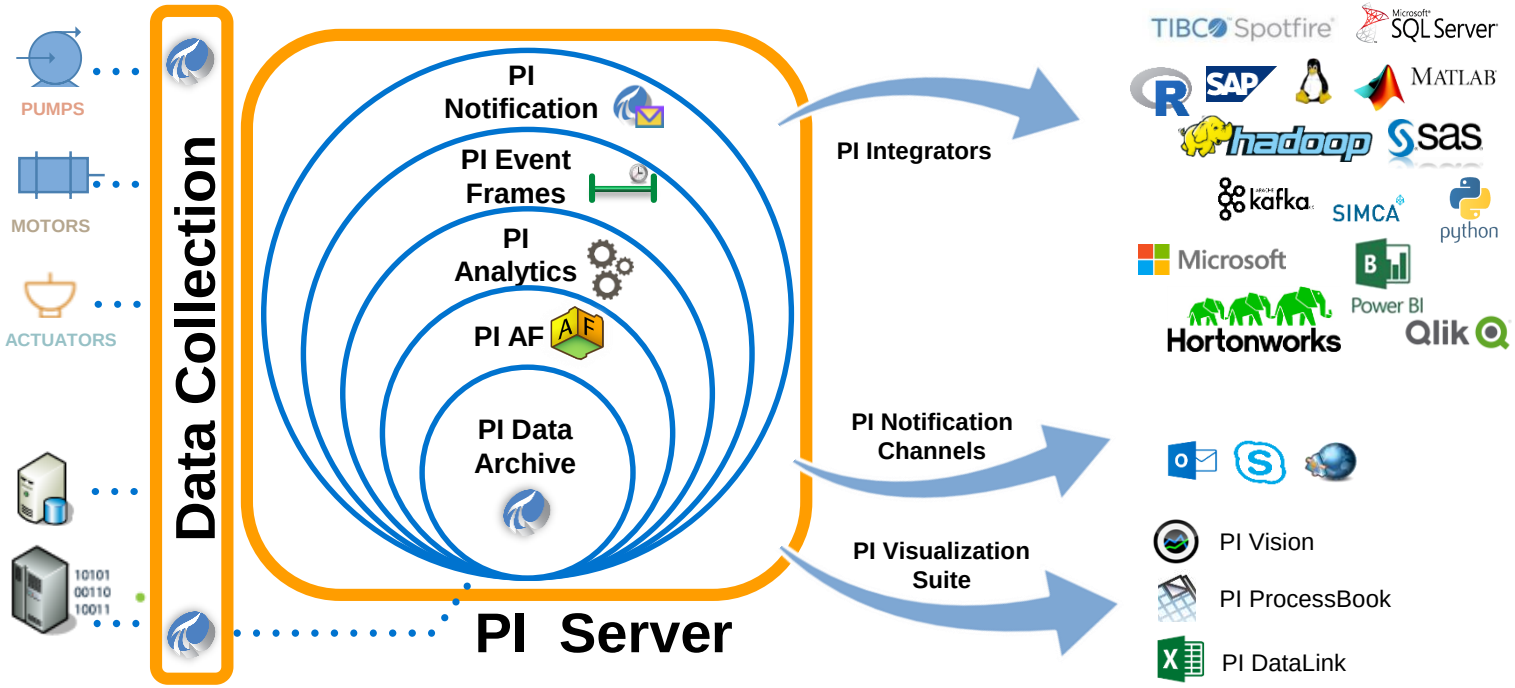
Problem Statement: Refinery Stabilization Column

- The product has to be stabilized by controlling its Reid Vapor Pressure (RVP)
- The stabilizer columns does not have on-line RVP analyzer
  - manual samples (taken twice a day) are analyzed by the laboratory
- More than 12 on-line measurements are collected each 6 minutes

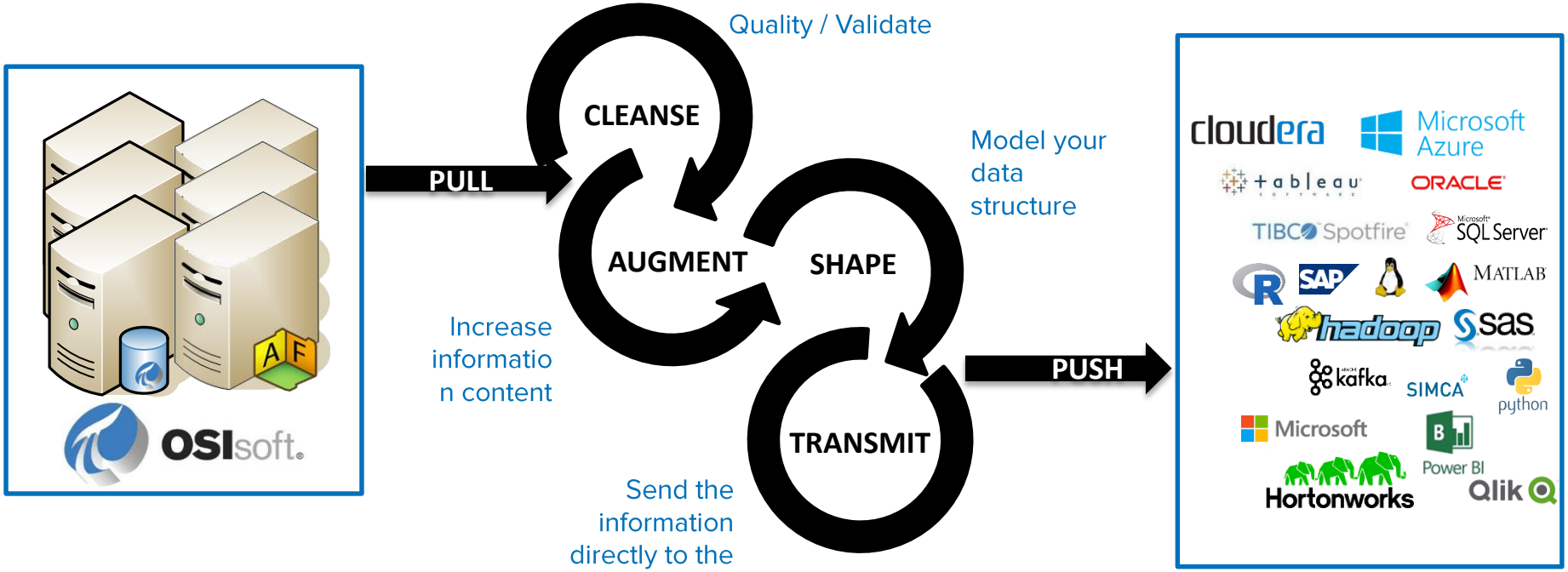
The goal:

- Use the process data collected in the PI System along with the laboratory measurements to generate a model predicting the RVP

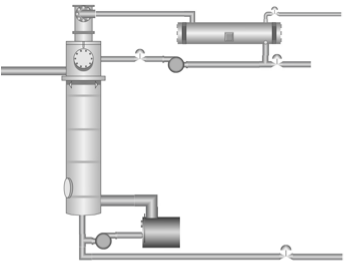
The PI System Infrastructure



PI Integrators



Refinery Stabilization Column – PI Architecture



Data Collection

PI Notification

PI Event Frames

PI Analytics

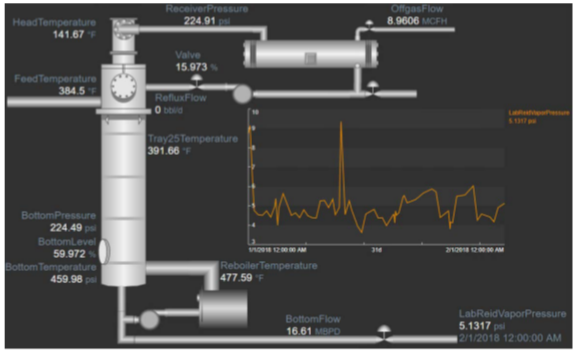
PI AF

PI Data Archive

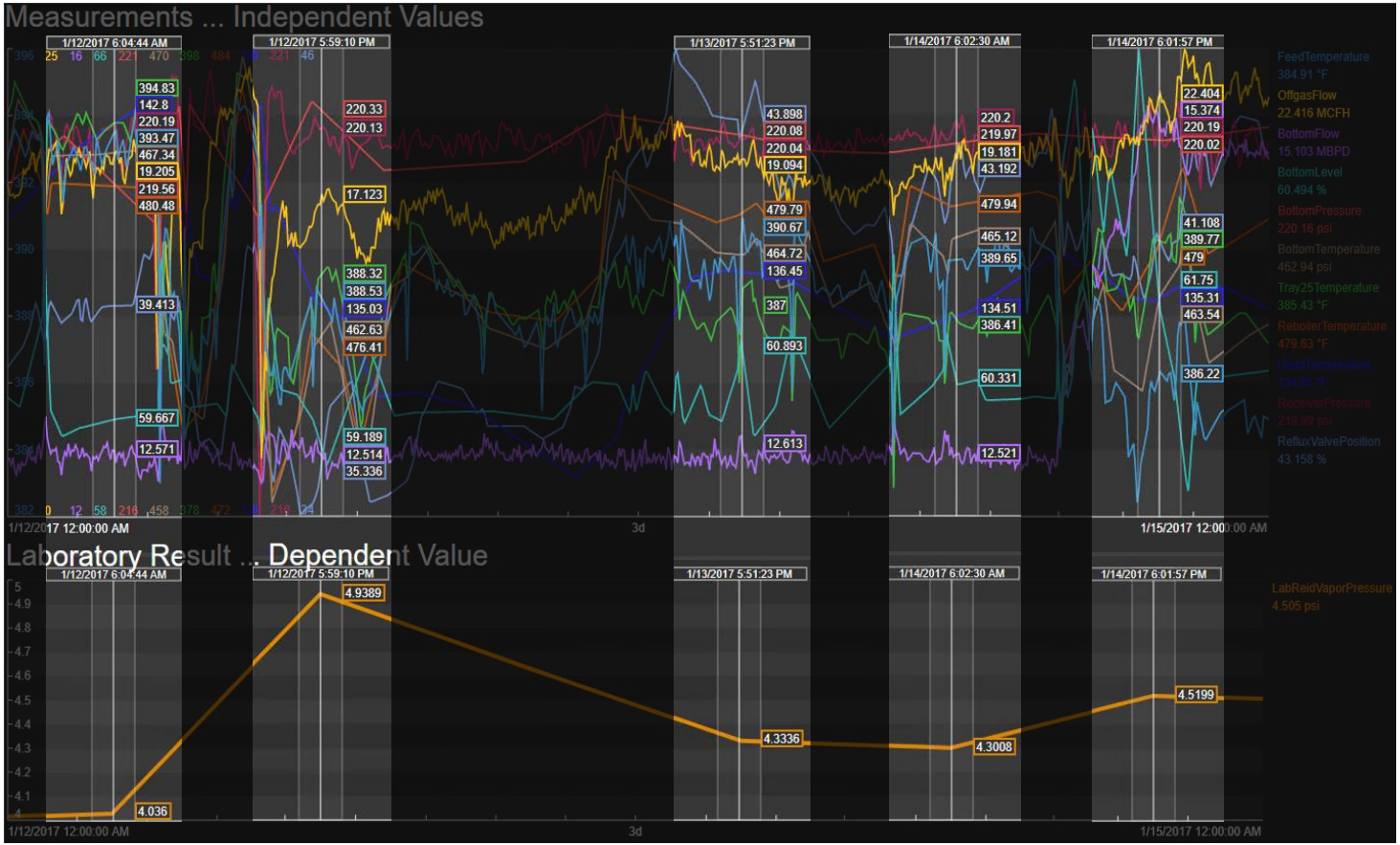
PI Server

PI Visualization Suite

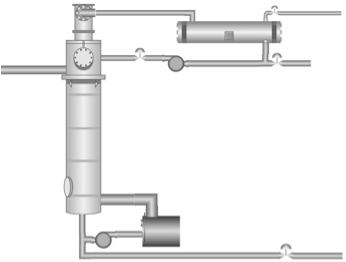
PI Vision



Machine Learning Model = Multivariate Function



Refinery Stabilization Column Predictive ML Models



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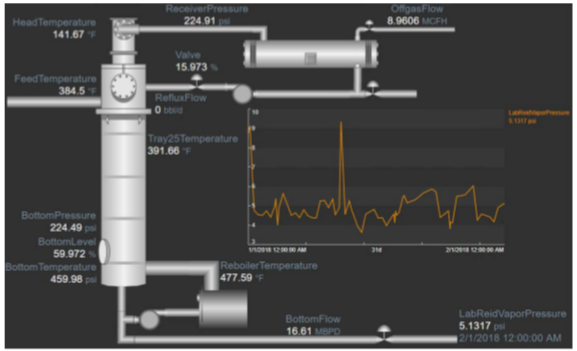
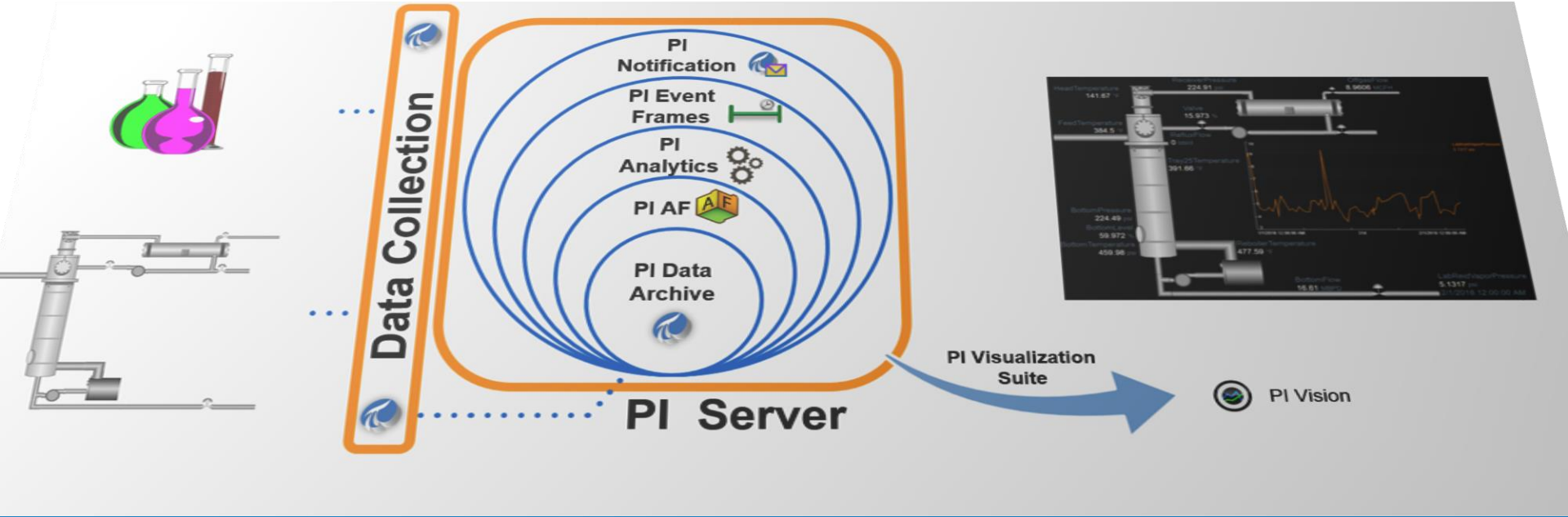
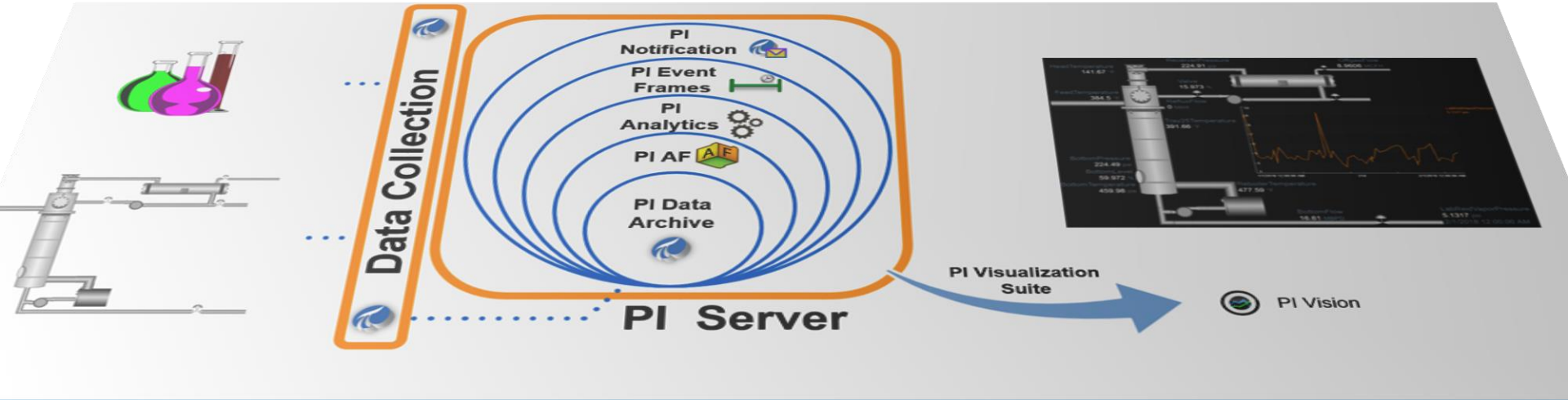


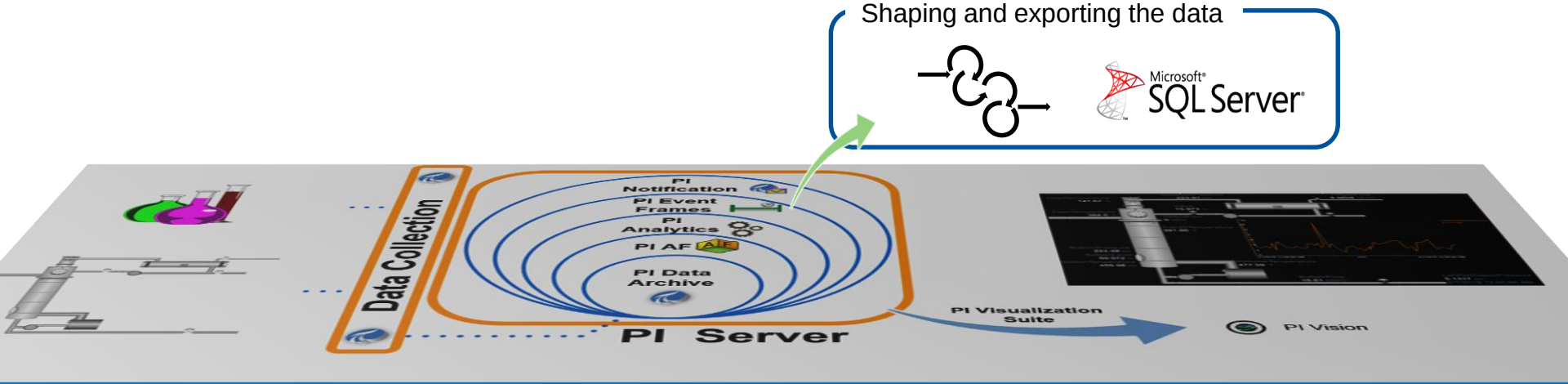
Refinery Stabilization Column Predictive ML Models



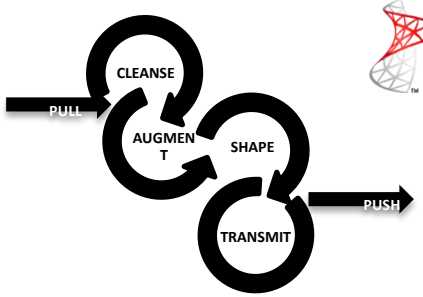
Refinery Stabilization Column Predictive ML Models



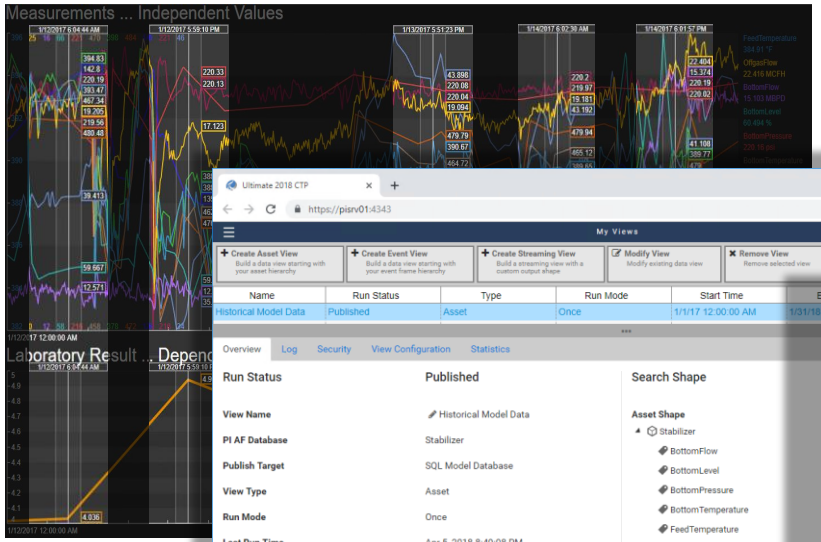
Refinery Stabilization Column Predictive ML Models



Shaping and exporting the data



Microsoft® SQL Server®



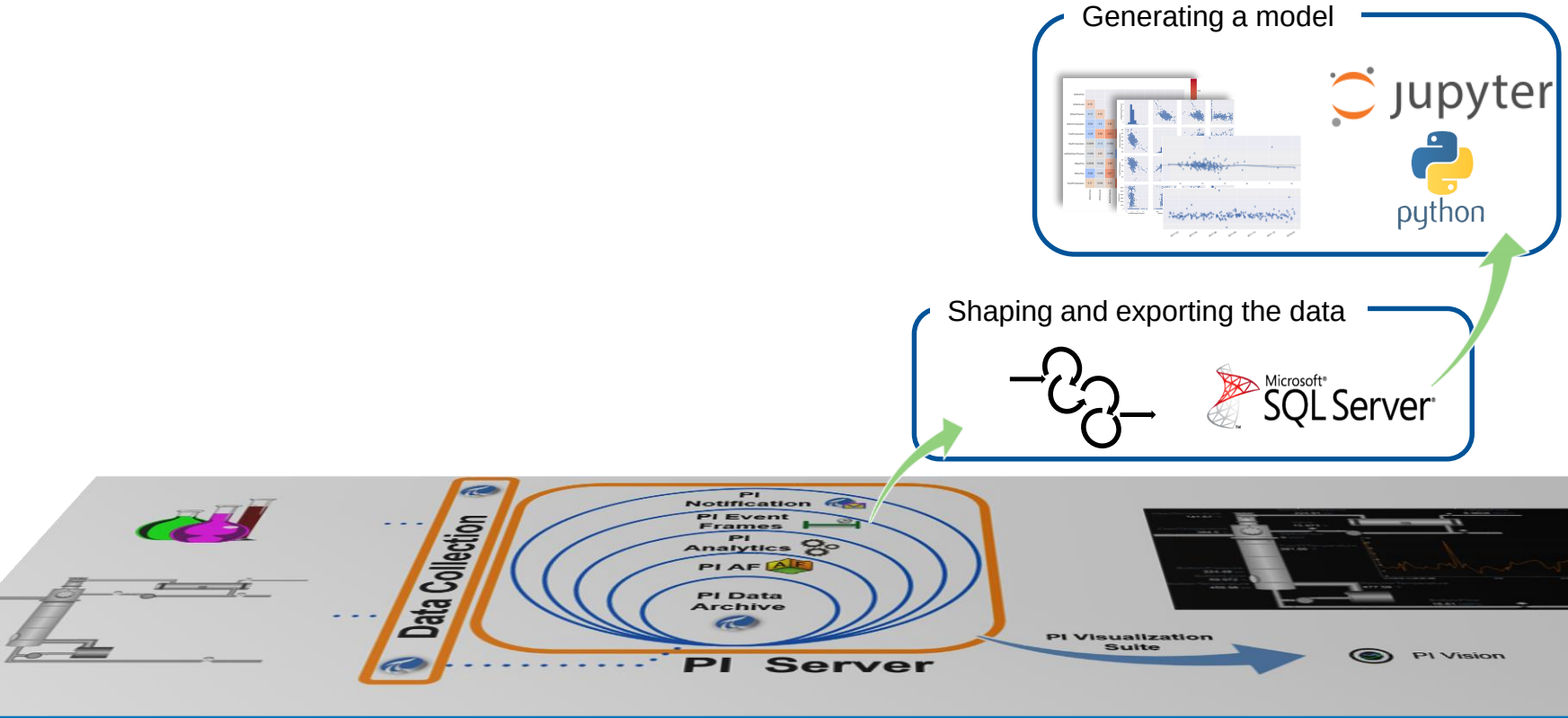

```
SELECT TOP 1000 [Id]
      ,[Stabilizer]
      ,[TimeStamp]
      ,[BottomFlow]
      ,[BottomLevel]
      ,[BottomPressure]
      ,[BottomTemperature]
      ,[FeedTemperature]
      ,[HeadTemperature]
      ,[OffgasFlow]
      ,[ReboilerTemperature]
      ,[ReceiverPressure]
      ,[RefluxFlow]
      ,[RefluxValvePosition]
      ,[Tray25Temperature]
      ,[LabReidVaporPressure]
      ,[PIIntTSTicks]
      ,[PIIntShapeID]
  FROM [ModelData].[dbo].[Historical Model Data]
```

100 % ▾

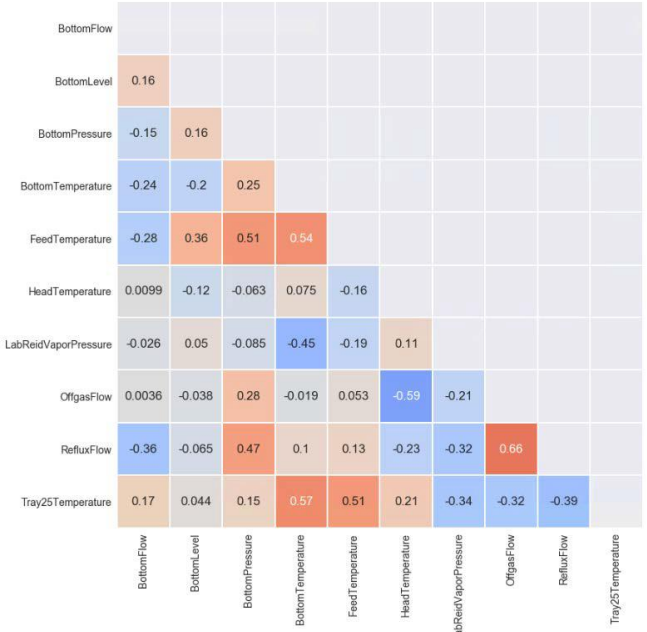
Results | Messages

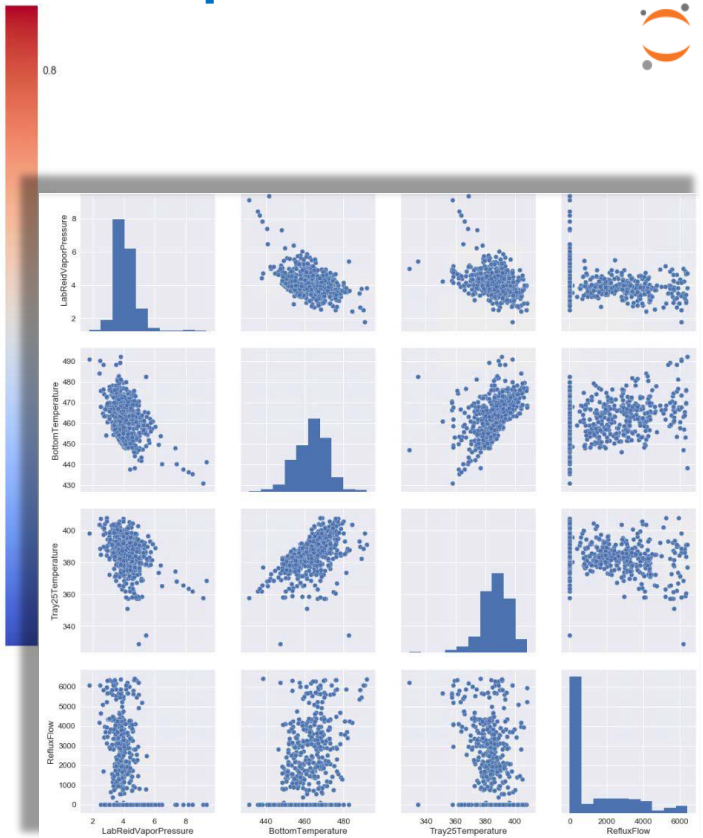
	Id	Stabilizer	TimeStamp	BottomFlow	BottomLevel	BottomPressure	BottomTemperature	FeedTemperature	HeadTemperature	OffgasFlow	ReboilerTemperature	ReceiverPressure
1	1	Stabilizer	2017-01-01 00:00:00.000	15.842270851135	59.196228027344	219.337173461914	474.98486328125	391.834045410156	273.827606201171	0	489.051330566406	220.084854125976
2	2	Stabilizer	2017-01-01 05:00:00.000	15.885624885559	59.916400909424	219.303970336914	473.329071044921	390.567321777343	278.574523925781	0	488.744567871093	219.991622924804
3	3	Stabilizer	2017-01-01 17:00:00.000	15.974317550659	60.005424499512	219.375656127929	476.650268554687	395.234008789062	285.700134277343	0	491.168548583984	220.089187622070
4	4	Stabilizer	2017-01-02 05:00:00.000	15.956583976746	60.170280456543	219.24119567871	473.580413818359	390.820220947265	304.855102539062	0	488.891845703125	220.061889648437
5	5	Stabilizer	2017-01-02 17:00:00.000	16.099704742432	60.614753723145	219.322891235351	477.060485839843	392.138671875	309.9111328125	0	491.012756347656	220.051177978515
6	6	Stabilizer	2017-01-03 05:00:00.000	16.084686275297	60.213829040527	219.376861572265	472.732940673828	388.80078125	308.165283203125	0	487.556884765625	220.022308349609
7	7	Stabilizer	2017-01-03 17:00:00.000	18.021993637085	59.679718017578	219.384857177734	468.795471191406	385.704498291015	337.381866455078	0	486.283538818359	219.95703125
8	8	Stabilizer	2017-01-04 05:00:00.000	17.819311141968	59.81600189209	219.308288574218	470.496032714843	385.128021240234	293.908905029296	0	488.33950805664	219.978088378906
9	9	Stabilizer	2017-01-04 17:00:00.000	18.046827316284	60.434307098389	220.0929602539	471.326843261718	386.597534179687	135.924972534179	15.770408630371	489.874267578125	219.831878662109
10	10	Stabilizer	2017-01-05 05:00:00.000	17.828824996948	59.848300933838	222.097885131835	470.463653564453	386.406951904296	149.846054077148	28.346687316895	489.171112060546	221.638473510742
11	11	Stabilizer	2017-01-05 17:00:00.000	18.001346588135	59.724563598633	220.756240844726	469.090118408203	385.562371826171	141.367645263671	26.619531631469	489.484771728515	220.731796264648
12	12	Stabilizer	2017-01-06 05:00:00.000	17.930227279663	59.714340209960	220.509017944335	469.944671630859	384.742736816406	135.592086791992	26.178880691528	491.318115234375	220.340022460937
13	13	Stabilizer	2017-01-06 17:00:00.000	18.015043258667	60.018531799316	220.488983154296	472.224884033203	387.214324951171	139.747817993164	25.742961883544	493.324859619140	219.599609375
14	14	Stabilizer	2017-01-07 05:00:00.000	17.901599884033	60.599925994873	220.731796264648	470.341064453125	385.073730468750	133.522094726562	23.684286117554	491.268829345703	219.652481079101

Refinery Stabilization Column Predictive ML Models



Generating a model – Data Preparation





Generating a Linear Regression Model

Model Training

```
from sklearn.linear_model import LinearRegression
linReg = LinearRegression()

linReg.fit(X_train, y_train)
```

	LinReg
const	21.643687
BottomFlow	-0.040710
BottomLevel	-0.032544
BottomPressure	0.030519
BottomTemperature	-0.018783
FeedTemperature	0.014180
HeadTemperature	0.004406
OffgasFlow	0.019082
RefluxFlow	-0.000348
Tray25Temperature	-0.048495

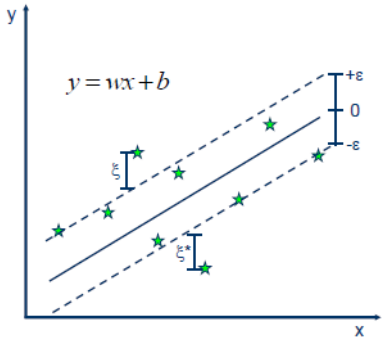
LinReg Model:

RVP = 21.64 +
-0.041*BottomFlow +
-0.033*BottomLevel +
0.031*BottomPressure +
...

Generating a Support Vector Regression Model

Support Vector Regression

Image Source



Fit as many instances as possible on the street (wx+b

- Minimize:

$$\frac{1}{2}\|w\|^2 + C\sum_{i=1}^{N}(\xi_i + \xi_i^*)$$

- Constraints:

$$y_i - wx_i - b \le \varepsilon + \xi_i$$

$$wx_i + b - y_i \le \varepsilon + \xi_i^*$$

$$\xi_i, \xi_i^* \ge 0$$

Modeling

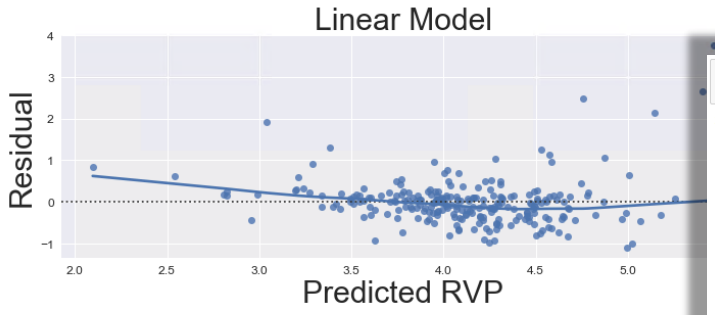
```
from sklearn.svm import SVR
svrModel = SVR(kernel='rbf')
svrModel.fit(X_train, y_train)
```

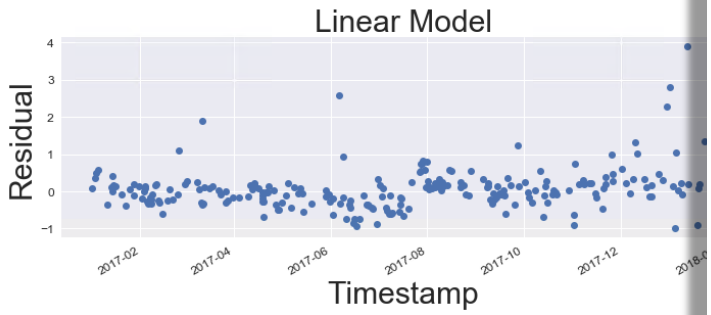
```
SVR(C=1.0, cache_size=200, coef0=0.0, degree=3, epsilon=0.1, gamma='auto',
  kernel='rbf', max_iter=-1, shrinking=True, tol=0.001, verbose=False)
```

Model Verification

```
evaluateModel(X_test, y_test, linReg, 'Linear')
```

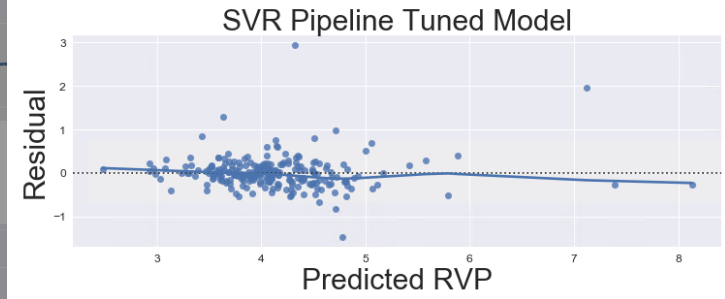
```
Linear Model RMSE = 0.5648484654589196
```

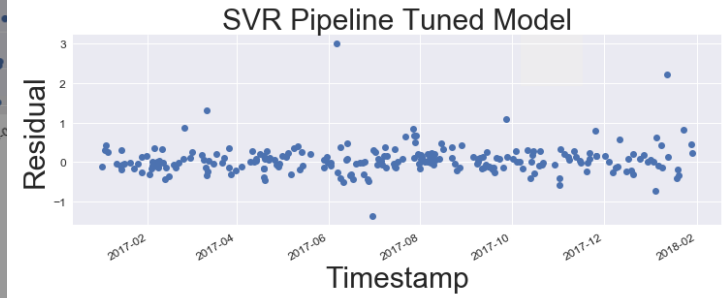




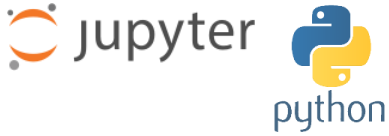

```
svrPipelineTuned = svrPipelineCV.best_estimator_
evaluateModel(X_test, y_test, svrPipelineTuned, 'SVR Pipeline Tuned')
```

```
SVR Pipeline Tuned Model RMSE = 0.3770256681670012
```





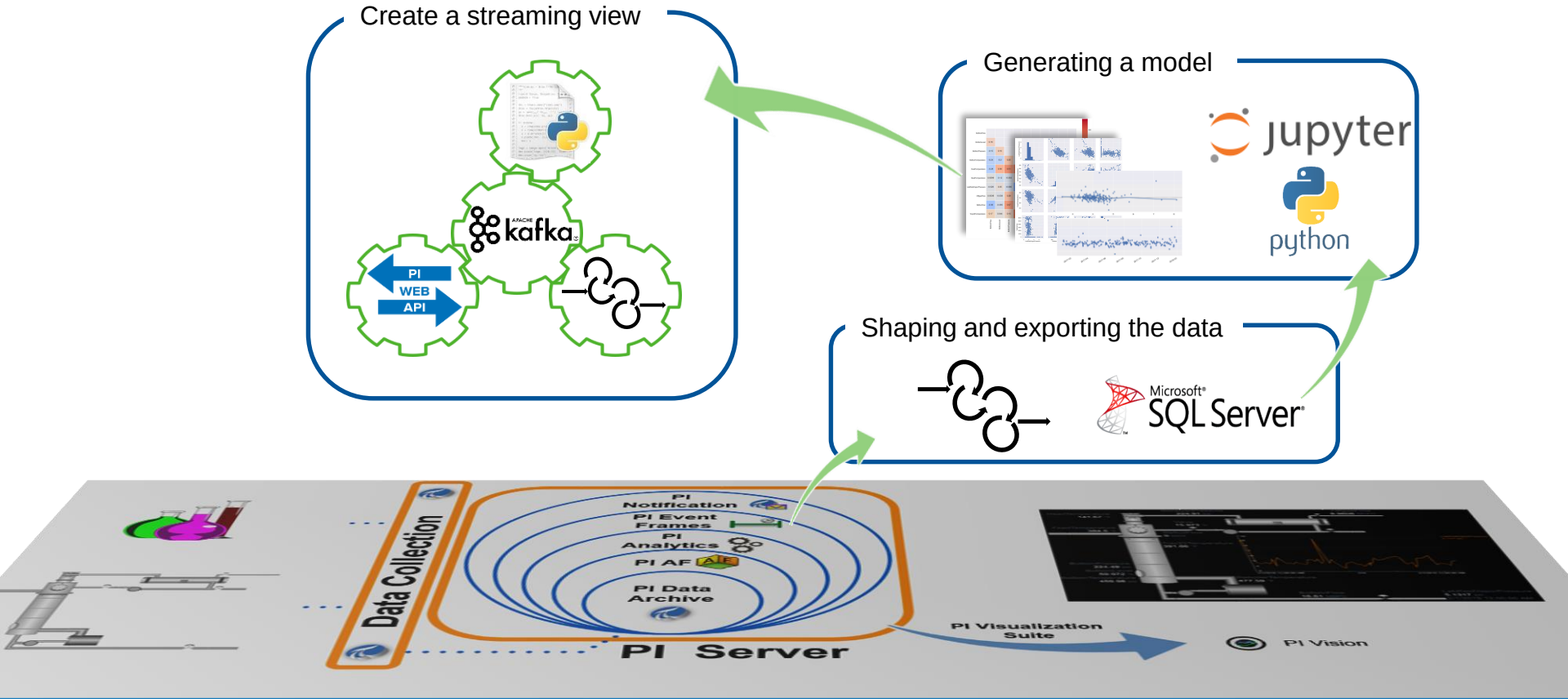
Create a Streaming View



Streaming

```
from requests.packages import urllib3
urllib3.disable_warnings()
import requests
from requests_kerberos import HTTPKerberosAuth, OPTIONAL
import base64

def writeValuesToPI(time, linReg_prediction, svr_prediction):

    timeISO8601 = time[:19] + 'Z'


    elementPath = 'PISRV01\Stabilizer\Houston\Stabilizer'
    linPredPath = 'PISRV01\Stabilizer\Houston\Stabilizer|LinReg_RVP'
    svrPredPath = 'PISRV01\Stabilizer\Houston\Stabilizer|SVR_RVP'


    elementWebId = 'P1Em' + base64.b64encode(elementPath.encode()).decode('ascii')
    svrPredWebId = 'P1AbE' + base64.b64encode(svrPredPath.encode()).decode('ascii')
    linPredWebId = 'P1AbE' + base64.b64encode(linPredPath.encode()).decode('ascii')

    url = f'https://pisrv01/piwebapi/streamsets/{elementWebId}/value?webIDType=PathOnly'

    body = [
      {
        "WebId": svrPredWebId,
        "Value": {
          "Timestamp": timeISO8601,
          "Value": svr_prediction
        }
      },
      {
        "WebId": linPredWebId,
        "Value": {
          "Timestamp": timeISO8601,
          "Value": linReg_prediction
        }
      }
    ]

    r = requests.post(
        url,
        str(body),
        auth=HTTPKerberosAuth(mutual_authentication=OPTIONAL),
        verify=False
    )

    print(f'PI Web API Response Status: {r.status_code}')
```

Refinery Stabilization Column Predictive ML Models



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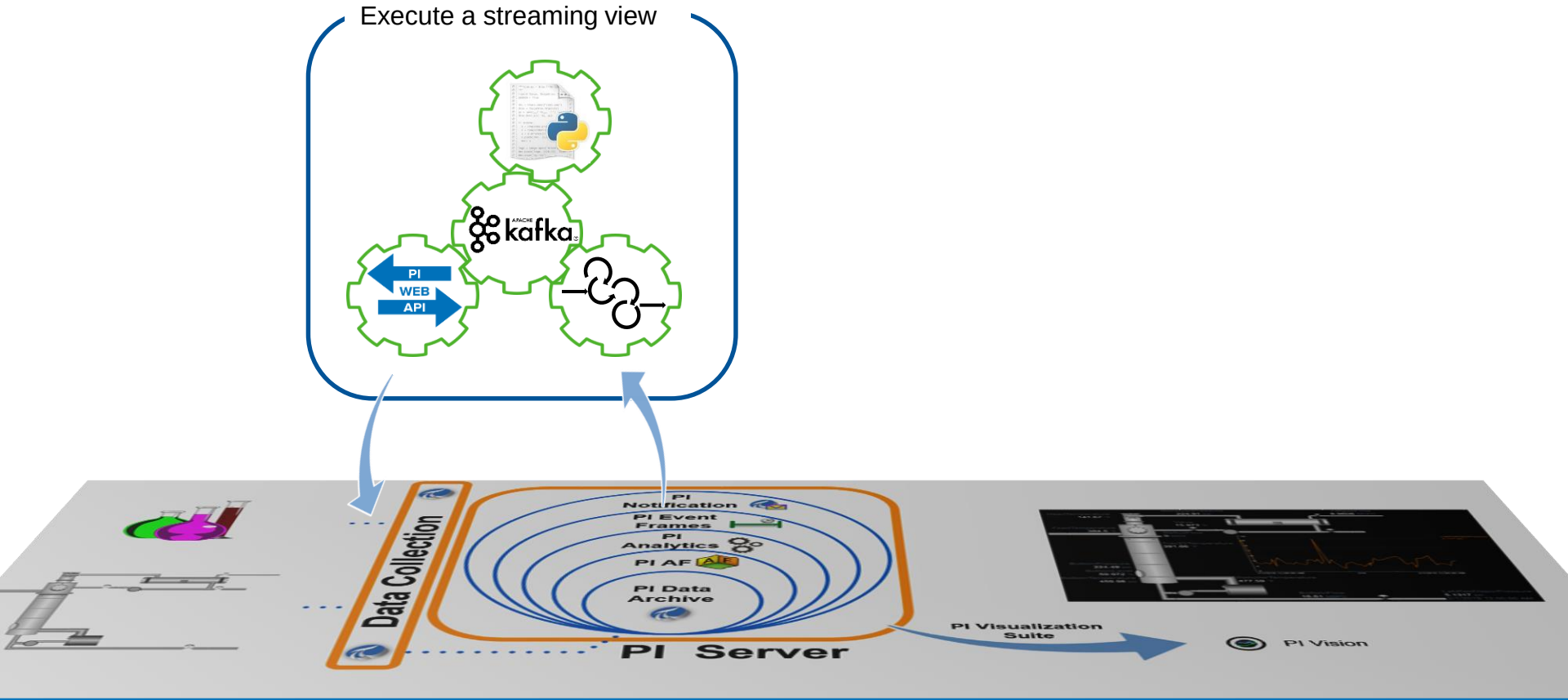

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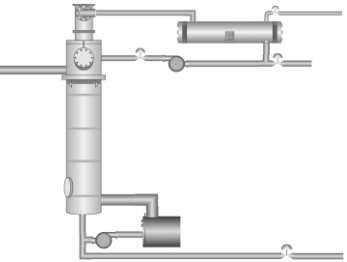

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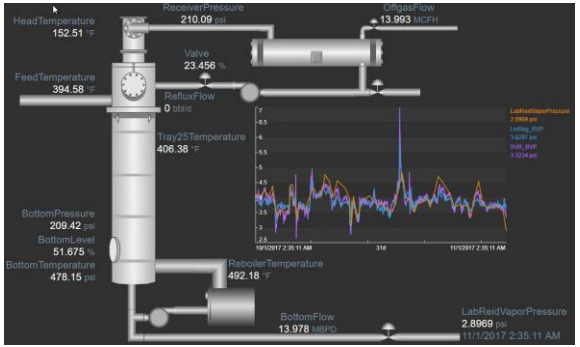
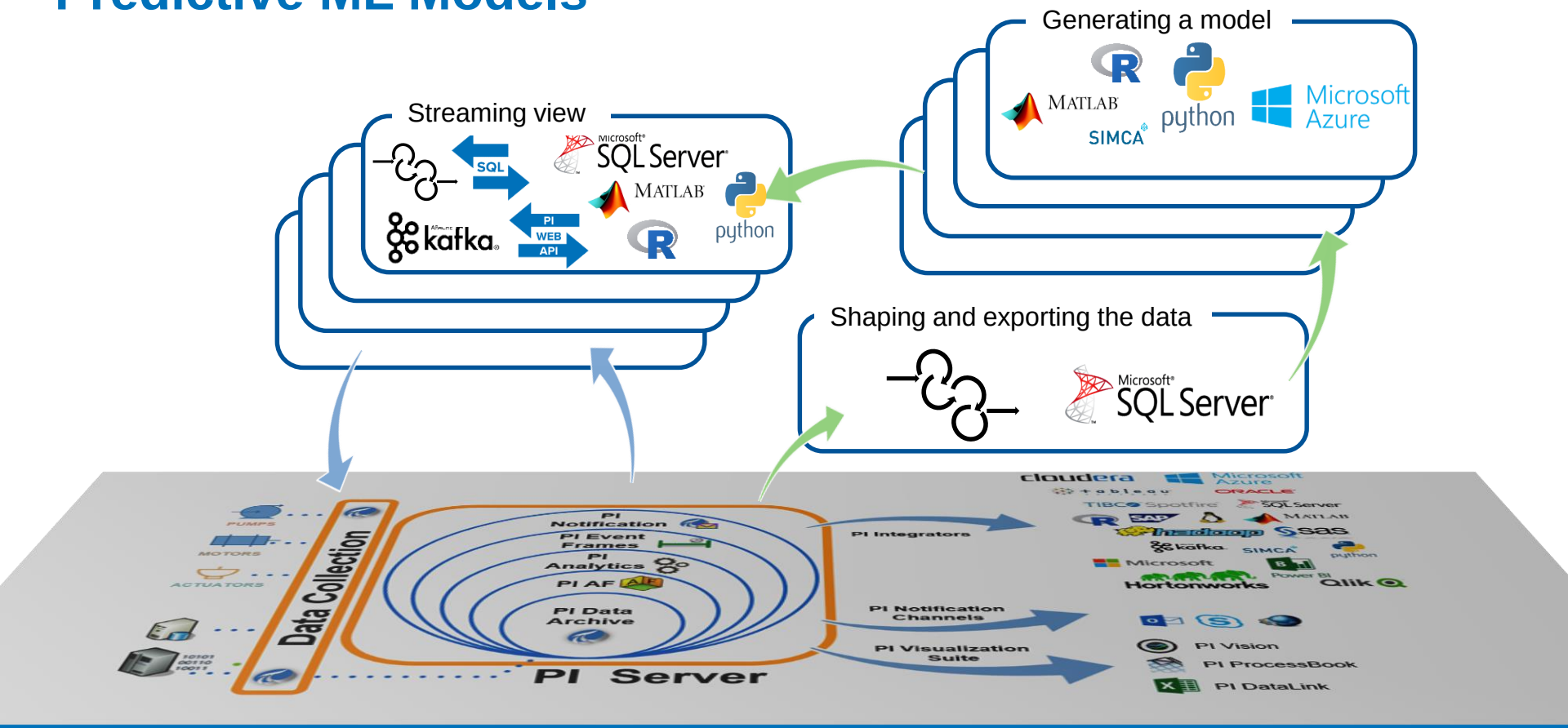
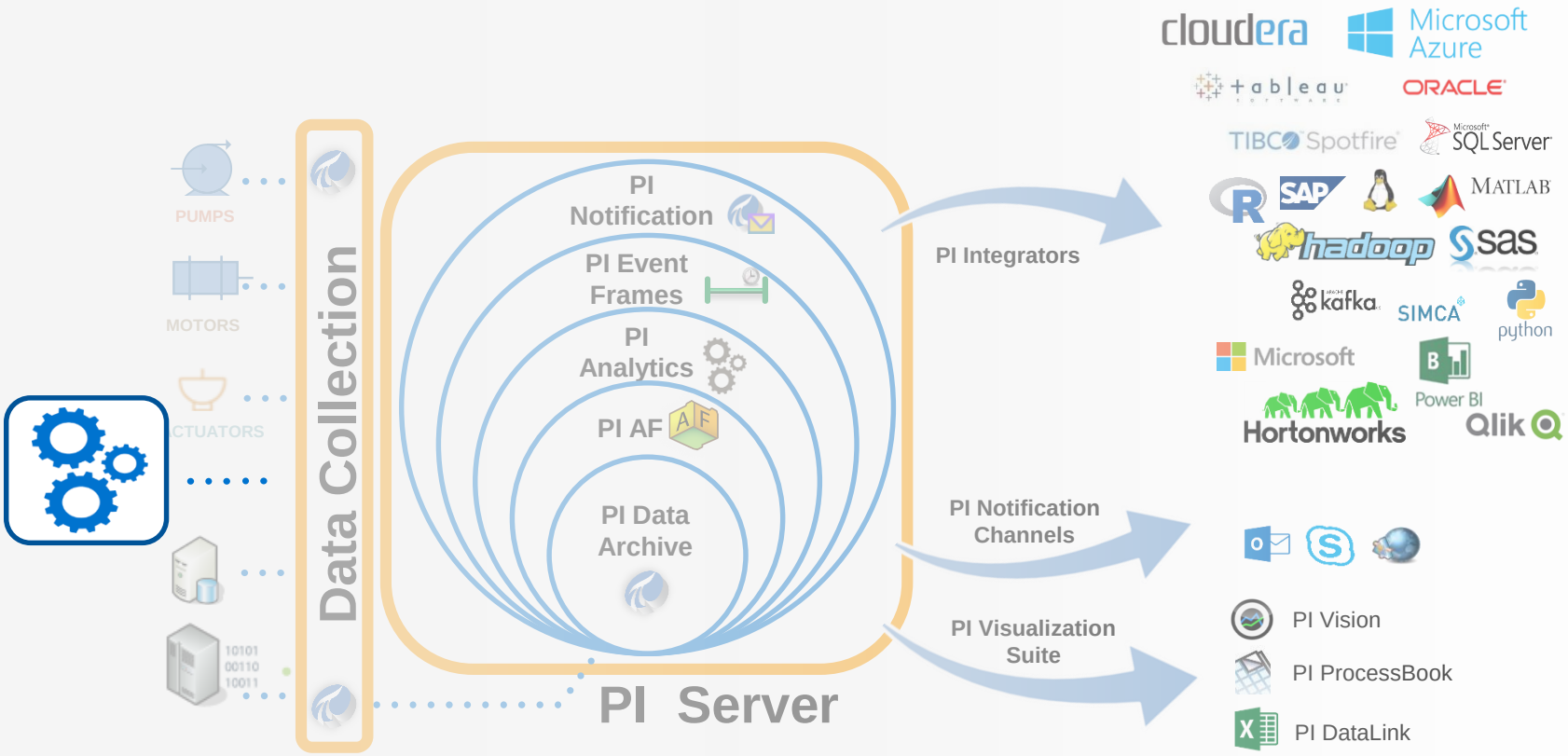


Predictive ML Models



ML Models in PI System Infrastructure



Examples

Deschutes Brewery - Brewing Beer the Smart Way
(https://www.osisoft.com/Presentations/Brewing-Beer-the-Smart-Way/)

Boehringer Ingelheim - A Case Study in Biopharmaceutical Data Analytics
(https://www.osisoft.com/Presentations/A-Case-Study-in-Biopharmaceutical-Data-Analytics--Using-Asset-Framework-and-Event-Frames-for-MVDA/)

Vitens N.V. - Data Science with R and the PI System
(https://www.osisoft.com/Presentations/Data-Science-with-R-and-the-PI-System/)

Using MATLAB with PI System for Analysis and Process Monitoring
(https://www.mathworks.com/videos/using-matlab-with-pi-system-for-analysis-and-process-monitoring-81859.html)

Challenges

- Pharma, food & beverage - prediction of fermentation performance
- Chemistry - prediction of reaction outcomes
- Metallurgy - liquid metal composition
- All industries – condition based maintenance (degradation curve prediction)
- …

Thank You