IBM Prescriptive Maintenance on Cloud



User Guide

Version 1 Release 0

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Note

Before using this information and the product it supports, read the information in “Notices” on page 31.

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Chapter 1. Product overview

IBM® Prescriptive Maintenance on Cloud focuses on the needs of the reliability engineer to identify and manage asset reliability risks that could adversely affect plant or business operations. It applies machine learning and analytics to operational data generated by critical assets to gain a better understanding of asset performance and then operationalize these analyses for continuous process improvement regarding maintenance practices and resources.

Welcome to Prescriptive Maintenance on Cloud

IBM Prescriptive Maintenance on Cloud looks for patterns in how an equipment asset is used and the environment in which it is operating. It then correlates this information with any known failures in the equipment. These correlations are used to evaluate new data about the equipment asset, resulting in predictive scores that indicate the relative health of the equipment and the likelihood of future failures.

The ability to determine when maintenance should be performed on equipment assets leads to the following business benefits:

- You can estimate and extend the life of your assets.
- You can increase the return on your assets.
- You can optimize your maintenance, inventory, and resource schedules.

Prescriptive Maintenance on Cloud goes beyond both preventive and regularly scheduled maintenance to ensure asset performance, thereby enabling maximized value at every step of a process. Using Prescriptive Maintenance on Cloud, you can perform the following tasks:

- Predict the failure of an instrumented asset so that you can prevent costly unexpected downtime.
- Make adjustments to maintenance schedules and tasks to reduce repair costs and minimize downtime.
- Determine the most effective maintenance cycles.
- Identify the root cause of asset failure faster so that you can take corrective actions.

Instrumented assets generate data such as device ID, timestamp, temperature, and status code.

Examples of instrumented assets are manufacturing equipment, mining equipment, drilling equipment, farming equipment, security equipment, cars, trucks, trains, helicopters, engines, cranes, oil platforms, and wind turbines.

Data from instrumented assets and data from other sources such as maintenance records, maintenance logs, inspection reports, repair invoices and warranty claims can be collected and used in models that predict when an asset is likely to fail.

Prescriptive Maintenance on Cloud helps an organization optimize its maintenance program by developing a set of recommendations to carry out when specific changes in asset health are identified. These recommendations can be based upon analysis of historical maintenance records, best practices and procedures provided by subject matter experts, original equipment manufacturer recommendations, as

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well as analysis of correlations that indicate potential problems or pending asset failure. The goal of developing these optimized decisions or recommendations is to further improve maintenance practices. When an anomaly in asset performance is identified specific recommendations can be made to maintenance personnel in order to affect the most efficient remedy of the problem. In the case of a manufacturing organization which provides service or warranty support for products that are used by hundreds or thousands of customers, the ability to monitor asset performance in the field and proactively initiate a service call, in comparison to waiting for the client to initiate a repair request or warranty claim, can significantly transform the way the manufacturer provides service. With a better understanding of asset usage and performance in the field manufacturer may wish to modify its warranty program based upon asset usage or warranty costs. Additionally greater insight into asset usage and performance can help the manufacturer to optimize the parts inventory and locations so as to reduce the volume of inventory and identify locations to facilitate proactive customer service.

For example, an automobile assembly plant is a system that combines thousands of pieces of equipment with interlocking pieces. It is critical that such a system is able to work efficiently and produce safe, high quality products. Prescriptive Maintenance on Cloud looks for patterns in the usage and environmental information for equipment that correlate with failures that take place. These patterns are used to create predictive models to score incoming new data in order to predict the likelihood of failure. Scores that are generated from this information give an indication of the health of the piece of equipment. In addition, key performance indicators (KPIs) are collected, which are used for reporting. KPIs help to identify assets that do not conform to normal patterns of behavior. The plant employees can use dashboards and reports to monitor and track the lifecycle of each piece of equipment.

How is data backed up and restored?

IBM Open Platform redundancy is used to protect customer data in a big data environment. In addition, Tivoli® Storage Manager is used to back up data in the production environment, which includes Linux files and databases. Linux files include customer uploaded files and middleware/application configuration/log files. Databases include DB2® databases in an IBM Predictive Maintenance and Quality SaaS environment.

The following table shows the backup schedule for various aspects of the solution.

Table 1. Backup schedule for solution data

Data	Backup type	Frequency	Time (Central Time)	Retention period
Files	Full	Bi-weekly	00:00 - 03:00 on the 1st and 16th day of each month	5 weeks
Files	Incremental	Twice daily	00:00 - 03:00 and 12:00 - 15:00	14 days
Databases	Full	Monthly	00:00 - 03:00 on the 1st day of each month	3 months
Databases	Full	Weekly	00:00 - 03:00 on Mondays	5 weeks
Databases	Incremental	Daily	0:00 - 03:00	14 days

During the backup window, the solution is accessible but access performance is impacted.

In the event of a system failure that causes data damage or loss, IBM will help to restore the data to the recovery time points, according to its backup policy.

What's new

The What's new section contains a list of new, changed, and deprecated configuration features for this release. It also contains a cumulative list of similar information for previous releases. You can use these lists to plan your application deployment strategies and the training requirements for your users.

New features in the current release

The following features are added or upgraded in the current release:

- The Factory Reset option enables you to to reset the product. Selecting this option deletes all data and configuration settings, returning the product to its original state.

New features in the previous release

The following features were added or upgraded in the previous release:

- The manufacture date field MF_DATE from entity property files is now used for training. Two new fields, age_entity and age_entity_cusum, are automatically generated and populated with data. The age_entity field contains the age of the asset in days based on its manufacturing date. The age_entity_cusom field contains the CUSUM (cumulative sum) of asset age. If you do not want to use the manufacture date in training, you can disable it by using the metaInput JSON object in the translation file.
- The root-mean-square error (RMSE) value now shows in your notifications.
- You now have more control of your data to customize the training and scoring processes.
- When you hover over an asset card, you can view more information about that asset card.

Accessibility features

Accessibility features help users who have a physical disability, such as restricted mobility or limited vision, to use information technology products.

For information about the commitment that IBM has to accessibility, see the IBM Accessibility Center (www.ibm.com/able).

HTML documentation has accessibility features. PDF documents are supplemental and, as such, include no added accessibility features.

Chapter 2. Using the product

You can use Prescriptive Maintenance on Cloud to upload data. With the data, you can view and analyze the maintenance requirements of equipment assets. You can also organize and track your equipment assets.

Logging on

Log on to access Prescriptive Maintenance on Cloud.

About this task

Provide your IBM ID to your local administrator. Your administrator is responsible for ensuring that you have the security access level that is appropriate to your role in your organization. Your administrator will also supply you with the web address URL for accessing the solution portal.

Procedure

1. Enter the URL into the address field of the browser.

   Note: The fully qualified domain name is required in the URL, for example, `https://web_hostname/ibm/pm/` where web_hostname is the host name of the web server. If you use the IP address instead of the registered fully qualified domain name, some windows do not open correctly.
2. At the IBM ID log in page, enter your IBM ID and password. The Prescriptive Maintenance on Cloud home page appears.

What to do next

On first use, you see a Welcome screen in which you can do the following things:

- Get a tour of the main elements of the software.
- View a tutorial video.
- View the documentation.
- Download sample data.
- Load sample data.

After first use, you can click the **User** icon to access these functions.

Each time you close your browser window, you must enter your IBM ID and password to log in again.

Downloading the tutorial and sample data

Prescriptive Maintenance on Cloud includes a tutorial and sample data.

About this task

The topic shows how to download the tutorial and sample data.

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Procedure

1. Click the **User** icon and click **Tutorial download** to download the mp4 file for the steps for a process engineer.
2. Click **Sample data download** to download the sample data that is used for the tutorial.

Using data files

On the home page, you can upload entity property files and event files. You can preview, download, and delete uploaded files.

Entity property files

Entity property files describe asset detail information and associate an asset with an asset type.

The following table describes key columns in the entity property file.

Table 2. Key columns in the entity property file

Column name	Description
NEXT_PM	The next planned maintenance date for an asset. The margin value is the predicted failure date minus NEXT_PM.
MF_DATE	The manufacture date of an asset.
WELL_MAINTAIN	Determines whether an asset is well maintained: • A well maintained asset's margin value is greater than 0 and less than WELL_MAINTAIN. • An over-maintained asset's margin value is greater than WELL_MAINTAIN. • An under-maintained asset's margin value is less than 0.

Important:

- The file must not contain repeated column names.
- The file must contain an asset_id column. The asset_id column cannot contain empty or null values.
- Values in the ASSET_TYPE column cannot contain spaces.
- The MF_DATE column must use one of the following date formats consistently within each file:
  - yyyy-MM-dd hh:mm:ss
  - dd/MM/yyyy HH:mm:ss
  - yyyy/MM/dd H:mm:ss
  - yyyy/M/d H:mm:ss
  - d/M/yyyy H:mm:ss
  - dd.MM.yyyy HH:mm:ss
  - MM-dd-yyyy HH:mm:ss tt, where tt = AM or PM

Event files

Event files record failure events and asset operating data. Event data must be in a continuous time series that is recorded at a second, minute, hourly, or daily level. The product does not support longer-interval time series such as weekly or monthly.

Important:

- The file must not contain repeated column names.
- The file must contain an asset_id column. The asset_id column cannot contain empty or null values.
- The file must record failure events.
- The failurEvent, maintenancEvent, and repairEvent columns must be of type flag.
- The file must contain a timestamp column.
- `is_fail` is a keyword for a failure event field in an event file. If you use `is_fail` as a column name for another field, the column will be renamed as `is_fail_renamed`. In the analysis results, the failure event field will be renamed as `is_fail`.
- The nextMaintenance and manufacturedDate columns must use one of the following date formats consistently within each file:
  - yyyy-MM-dd hh:mm:ss
  - dd/MM/yyyy HH:mm:ss
  - yyyy/MM/dd H:mm:ss
  - yyyy/M/d H:mm:ss
  - d/M/yyyy H:mm:ss
  - dd.MM.yyyy HH:mm:ss
  - MM-dd-yyyy HH:mm:ss tt, where tt = AM or PM

Translation file

You can use the translation file to map columns in your data files.

Uploaded files are automatically parsed to determine whether they are entity property files or event files. Columns in uploaded files are automatically read to determine the type of data they contain. If you want to customize the way data in uploaded files is handled, you can edit the translation file.

The translation file contains the following JSON objects:

entityPropertyFile
: Used to map columns in entity property files.

dataFile
: Used to map columns in event files.

metaInput
: Used to enable or disable fields in entity property files.

exclusion
: Used to exclude fields in event files.

In the `entityPropertyFile` JSON object, `assetType` is the asset type, `nextMaintenance` is the next maintenance date, and `manufactureDate` is the manufactured date.

In the `dataFile` JSON object, `failureEvent` is the failure event flag, `maintenanceEvent` is the maintenance event flag, and `repairReplaceEvent` is the repair or replace event flag.

In the following example of the `metaInput` JSON object, `IBM` is the asset type, and `disable` indicates that the non-required data fields for the IBM asset type from the entity property file are disabled.

```
"metaInput":
{
     "IBM":"disable"
}
```

In the following example of the `exclusion` JSON object, `IBM` is the asset type, and `index` and `f4` are the fields to be excluded.

```
"exclusion":
{
     "IBM":"index,f4"
}
```

Uploading data files and previewing the data

On the home page, you can upload event files and entity property files. You can upload the files one at a time.

About this task

The system parses each file to identify the file type.

Procedure

1. Select **My Data** > **Files** > **Browse for file**, select the file, and select **Open**.
2. In the Progress pane, view the status of the upload.
3. In the Uploaded Files section, view the files.
4. To view the uploaded file variable type and dimension information, hover over the tags in each file card.
5. To preview the data in the file, click **Preview**. The first 10 rows of the data are shown.

Downloading data files

On the home page, you can download a data file that has been uploaded.

Procedure

1. Select **My Data** > **Connections** > **Files**.
2. In the Uploaded Files section, view the files.
3. From the list of files, click the menu button of the file and click **Download**.

Deleting data files

On the home page, you can delete a data file that has been uploaded.

About this task

When you delete a file, the operation does not delete the associated events in the database, but only deletes the file from the system.

Procedure

1. Select **My Data** > **Connections** > **Files**.
2. In the Uploaded Files section, view the files.
3. From the list of files, click the menu button of the file and click **Delete**.

Configuring training settings

You can configure the training settings by configuring the data handling rules and model settings. To access these settings, select the settings icon.

Resampling and data handling rules

You can configure the resampling rule and data handling rules that are used by the product.

Resampling rule

Resampling rules affect the way data is aggregated. Two options are available for resampling data:

None No resampling technique is performed on the original data set.

Downsampling
Data is downsampled. Downsampling rebalances the distribution between failure events and non-failure events to increase the proportion of failure events.

Data handling rules

Data handling rules specify the aggregation rule and missing value rule for each event field. You can define data handling rules for individual fields. The options for aggregation rule and missing value rule depend on the type of field.

The following table describes the types of aggregation rules.

Table 3. Aggregation rules

Aggregation rule	Description
T_IF_ANY_T	True if any true. If one or more true values exist, then true is used.
F_IF_ANY_F	False if any false. If one or more false values exist, then false is used.
mode	The value that occurs most frequently is used.
first	The value that occurs first is used.
last	The value that occurs last is used.
sum	The sum of all values is used.
mean	The average of all values is used.
max	The maximum value is used.
min	The minimum value is used.
count	The number of events in the time period is used.

The following table describes the types of missing value rules.

Table 4. Missing value rules

Missing value rule	Description
false	If the event does not have this value, false is used.
ffill	The last available value is used.
bfill	The first available value is used.
mean	The average is used.
min	The minimum value is used.
max	The maximum value is used.
interpolate	A linear interpolation is used.

Configuring model settings

You configure your model settings to train your model. You can choose to automatically or manually configure the model settings. If you manually configure the setting, you have more control of the values.

About this task

When you upload your data, an initial training is automatically completed by using the following parameters:

- Number of Trees: 3
- Maximum Depth of Tree: 3
- Learning Rate: 0.3

For the Gradient Boosting Decision Tree (GBDT) regression model type, the following parameters are available:

- Number of Trees, range [2, 100], default 10
- Maximum Depth of Tree, range [2, 10], default 4
- Loss Function, default **`leastSquaresError`**, **`logLoss`**, and **`leastAbsoluteError`**
- Learning Rate, range [0.01, 0.3], default 0.1

During training, the settings icon and **Retrain** button are disabled.

Procedure

1. On the **Model Settings** tab, select the analysis interval to define how you want the data set to be aggregated before training. The default option for the analysis interval is daily or you can select weekly, monthly, yearly, or the raw option where no aggregation is done during training.
2. In the Define Model Settings box, do one of the following options:
   a. Add the parameter values.
   b. Select **Automatically define model parameters** to have the values be automatically defined. If you select **Automatically define model parameters**, the training speed is slow.
3. Optional: Select **Automatically Retrain on Apply** for the system to automatically start a training that is based on the new values.
4. Select **Apply**.

Analysis results

You can select an asset type and then see the analyses for all equipment assets of that type.

On the asset panel, click the asset type menu and select an asset type.

Equipment assets are grouped by the following categories:

All Assets
All equipment assets, or all equipment assets of the selected type.

Over Maintained
Scheduled maintenance is long before the predicted failure of the asset.

Well Maintained
Scheduled maintenance is close to the predicted failure of the asset.

Under Maintained
Scheduled maintenance is long after the predicted failure of the asset.

Needs Data
More data is required to perform an analysis for the asset.

Each equipment asset appears on a separate card that provides important indicators of asset health:

Top Driver
The variable that is most likely to cause asset failure.

Margin
The number of days' difference between the next scheduled maintenance and the next predicted failure of the asset.

Attention: Negative margin means that the asset is predicted to fail before the next scheduled maintenance.

Graph The graph gives a concise visual reference of asset health:

- The gray horizontal bar indicates the total top driver count before the next predicted failure of the asset.
- The dark portion of the horizontal bar indicates the current top driver count.

  Attention: If the entire horizontal bar is dark, then the asset is already past its next predicted failure.
- The vertical bar indicates the current average top driver count for this asset type.
- The arrow at the end of the horizontal bar indicates if the current top driver count is more than twice the average top driver count for this asset type.

You can sort the cards based on Margin, or filter the cards based on Top Driver or Asset Property Type.

Click a card to open a window that shows more analysis results for the asset, including the following details:

- The number of days until the next scheduled maintenance date.

- All drivers (that is, variables that contribute to asset failure). A driver whose name ends with _LTD is derived from an existing field by accumulating between failure events.
- The maintenance history of the asset.
- A histogram of all drivers or a particular driver.

Tip: Specify a time scale to view a particular period of time.

Notification

You can receive system notifications in Prescriptive Maintenance on Cloud.

The notification icon shows the number of notifications that you have received and show in chronological order.

The notification types are:

File uploaded
A system notification indicates the user has completed uploading a file.

File deleted
A system notification indicates the user has deleted a file.

Analysis complete
A system notification indicates an analysis of an asset is complete.

Asset added
A system notification shows that assets were added to the system.

Errors found
Shows errors and the cause of each error. Errors may be caused by failures during file upload, failures during analysis of an asset, or other reasons.

Resetting the product

You can use the Factory Reset feature to reset the product. Selecting this option deletes all data and configuration settings, returning the product to its original state.

About this task

To reset the product, complete the following steps.

Procedure

1. Log in to the product.
2. Click the user icon.
3. Select the **Factory Reset** option.
4. Click **Continue**. Data deletion begins.

Results

When the factory reset operation is complete, the message "Successfully deleted user data" is displayed.

Chapter 3. Integrating with other products

You can integrate Prescriptive Maintenance on Cloud with other products to import and analyze maintenance data from those products.

Integration with Watson IoT Platform

Prescriptive Maintenance on Cloud integrates with IBM Watson® IoT Platform to make predictions about asset failure based on the current state of the asset.

Configure your organization in Watson™ IoT Platform

Before integrating Prescriptive Maintenance on Cloud with Watson IoT Platform, you must configure your organization in the platform. This guide does not explain how to create device types and device IDs.

You must add ASSET_ID in the **Metadata** field of a device ID. This metadata is used to determine with which asset ID this device associated. For example,

```
{
"ASSET_ID": "JK84-JAS-144"
}
```

Next, send data to devices. Prescriptive Maintenance on Cloud supports receiving simple JSON data only. See the following example. The timestamp and asset ID are added automatically when generating files:

```
{
"is_fail":"true",
"temperature_flag":"true",
"event_count":"3"
}
```

Add Integration

Before integrating with Watson IoT Platform, you need to create an integration in Prescriptive Maintenance on Cloud. You must enter the organization ID, API key, and authentication token to connect to Watson IoT Platform. After connecting to an organization, you can select the devices from which to receive data.

In Prescriptive Maintenance on Cloud, in the **IoT** tab, click **Add Integration**. Enter the organization ID, API key, and authentication token to connect to an organization. You can create only one integration for each organization.

Once connected to the organization, select the devices from which you want to receive data. Select **Add all data from all devices**, or click **Select Devices/Types/Events** to select specific devices.

Set **Analysis Interval** to Daily. The analysis interval is how often Prescriptive Maintenance on Cloud triggers IoT data analysis. Only the Daily interval is supported.

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Analyze IoT data

After an integration with Watson IoT Platform is created, Prescriptive Maintenance on Cloud receives data from that integration and starts analyzing daily, at midnight.

You can disconnect from the integration by clicking **Disconnect**. Prescriptive Maintenance on Cloud stops receiving data from that integration. You can reconnect to integration by clicking **Connect**.

You can pause analysis data from an integration by clicking **Pause Analysis**. Prescriptive Maintenance on Cloud stops analyzing data from that integration. You can continue analysis by clicking **Continue Analysis**. During a pause, Prescriptive Maintenance on Cloud can still receive data from that integration.

Integration with Maximo Asset Management

Prescriptive Maintenance on Cloud uses historical maintenance and metric data to make predictions about asset failure based on the current state of the asset. IBM Maximo® Asset Management is an application that supports device maintenance. It can be the source of some or all of the asset data that is needed by Prescriptive Maintenance on Cloud.

Overview

Asset data from Maximo Asset Management may be provided to PM either as a file (csv) or through a http interface. The csv format may be most convenient for a large historical data set while the http interface is convenient for ongoing updates.

Maximo Asset Management provides the capability to define and filter the data for export to PM. In general, the exported data fields correspond to the columns of a csv file for upload to PM. Thus they include timestamp, asset id, failure, maintenance, and metric data.

Maximo Asset Management integration capabilities are defined using several components. Object Structures define the data fields. Publish Channels can determine when the data is exported and can filter which data to include. End Points determine the export method (ex. File or HTTP). And External Systems combine a Publish Channel with an End Point.

Work Orders

Maximo Asset Management work orders can be an import source of maintenance data for the PM application. This includes asset failure, asset repair or replace, and routine maintenance. The following is a description of a set of Maximo Asset Management external system artifacts that allow export of this work order data to Prescriptive Maintenance on Cloud.

Object Structure – PMEX_WORKORDER

The PMEX_WORKORDER Object Structure includes the following fields of WORKORDER. The extended fields (PMEX_) are added as non-persistent attributes of WORKORDER.

- ASSETNUM
- SITEID

- WORKTYPE
- FAILDATE
- FAILURECODE
- STATUS
- STATUSDATE
- PMEX_TIMESTAMP
- PMEX_ASSET_ID
- PMEX_IS_FAIL
- PMEX_IS_MAINTENANCE
- PMEX_IS_REP_REPLACE
- WELL_MAINTAIN

Prescriptive Maintenance on Cloud needs the values of timestamp, asset_id, is_fail, is_maintenance, is_rep_replace. By default, Prescriptive Maintenance on Cloud will infer these values. Asset_id is the combination of ASSETNUM+SITEID. If there is a FAILURECODE then is_fail is TRUE and the timestamp is FAILDATE (otherwise timestamp is STATUSDATE). If the WORKTYPE is CM or EM then is_rep_replace is TRUE and otherwise if it is PM then is_maintenance is TRUE.

This default mapping can be overridden by using a publish channel to explicitly set the value of any of the fields beginning with PMEX_.

Meters

Maximo Asset Management meters can provide metric data that the PM application uses to train and score asset failure models.

Object Structure – PMEX_METER

The PMEX_METER Object Structure includes the following fields of ASSETMETER. The extended fields (PMEX_) are added as non-persistent attributes of ASSETMETER.

- SITEID
- METERNAME
- LASTREADING
- LASTREADINGDATE
- PMEX_TIMESTAMP
- PMEX_ASSET_ID
- PMEX_METRIC_NAME
- PMEX_METRIC_VALUE

Prescriptive Maintenance on Cloud uses Maximo Asset Management meters as metrics. It needs the values of timestamp and asset_id. It also needs the metric name and value. By default, Prescriptive Maintenance on Cloud will infer these values. Asset_id is the combination of ASSETNUM+SITEID. Timestamp is LASTREADINGDATE. The metric name is the METERNAME and the metric value is LASTREADING.

As with the work order, this default mapping can be overridden by using a publish channel to explicitly set the value of any of the fields beginning with PMEX_.

Endpoints

The object structures for Prescriptive Maintenance on Cloud can be exported using an HTTP or Flat File (csv) endpoint. A Flat File endpoint may be more appropriate for a large amount of historical data while an HTTP endpoint is ideal for automatically exporting new data.

The HTTP endpoint must be configured with the URL, username, and password for Prescriptive Maintenance on Cloud. It must also include the header “content-type application/xml” and the http method “POST”.

Summary

Maximo Asset Management is an application with powerful capabilities to support asset maintenance. Historical data in Maximo Asset Management can be used to train and score predictive models in Prescriptive Maintenance on Cloud. The resulting "days to failure" prediction in Prescriptive Maintenance can provide a valuable insight to help optimize asset maintenance and thus provide efficient and productive asset use.

Chapter 4. Application programming interface

The application programming interface enables you to perform actions such as posting entity and event data, uploading a file, and retrieving a result.

Post entity data from Maximo Asset Management

Posts entity data from IBM Maximo Asset Management.

URL

/ibm/pm/service/apiWrapper

Method

The request type POST

URL parameters

apiName="Maximo"

Username=*IBM_ID*

type=property

Sample body

```
<?xml version="1.0" encoding="UTF-8"?>
<PublishMXPM_PM xmlns="http://www.ibm.com/maximo"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
creationDateTime="2017-03-14T13:37:20-04:00" transLanguage="EN"
baseLanguage="EN" messageID="3456160.1489513040315874425"
maximoVersion="7 6 $build$ V7608-46" event="1">
  <MXPM_PMSet>
    <ASSET action="Add">
      <ASSETNUM>80901</ASSETNUM>
      <PMEX_ASSET_ID> 80901vBEDFORD </PMEX_ASSET_ID>
      <PMEX_ASSET_TYPE> AIRCRAFTBRAKES</PMEX_ASSET_TYPE>
      <PMEX_MANUFACTURE_DATE>2016-03-01T00:00:00-05:00</PMEX_MANUFACTURE_DATE>
      <PMEX_NEXT_MAINTENANCE>2017-03-01T00:00:00-05:00</PMEX_NEXT_MAINTENANCE>
      <SITEID>BEDFORD</SITEID>
      <WELL_MAINTAINED>14</WELL_MAINTAINED>
    </ASSET>
  </MXPM_PMSet>
</PublishMXPM_PM>
```

Headers for IBM ID authorization

Content-Type: text/html

Authorization: Basic *authorization_string*

Headers for API key authorization

Content-Type: text/html

APIKEY: *API_Key*

Success response

200 OK {}

Sample call

```
https://server_url/ibm/pm/service/apiWrapper?apiName=maximo
&Username=user_name&type=property
```

Notes This REST API call supports both API key and IBM ID for authentication.

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To generate the authorization_string for an IBM ID, base64 encode the user name and password separated by a colon, for example: `Authorization: Basic base64_encode(`*`IBM_ID`* `':'` *`IBM_ID_password`*`)`

Post event data from Maximo Asset Management

Posts event data from IBM Maximo Asset Management.

URL

/ibm/pm/service/apiWrapper

Method

The request type POST

URL parameters

apiName="Maximo"

Username=*IBM_ID*

type=data

Sample body

```
<?xml version="1.0" encoding="UTF-8"?>
<PublishPMEX_WO_ANDMETER
xmlns="http://www.ibm.com/maximo"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
creationDateTime="2016-10-18T12:11:29-04:00"
transLanguage="EN" baseLanguage="EN" messageID="3114181.1476807089991377382"
maximoVersion="7 6 20151202-1713 V7603-143" event="1">
  <PMEX_WO_ANDMETERSet>
    <WORKORDER action="Replace">
      <ASSETNUM>811</ASSETNUM>
      <FAILDATE xsi:nil="true" />
      <PMEX_ASSET_ID>811vBEDFORD</PMEX_ASSET_ID>
      <PMEX_IS_FAIL>TRUE</PMEX_IS_FAIL>
      <PMEX_IS_MAINTENANCE>TRUE</PMEX_IS_MAINTENANCE>
      <PMEX_IS_REP_REPLACE>FALSE</PMEX_IS_REP_REPLACE>
      <PMEX_TIMESTAMP>2016-12-05T12:11:25-04:00</PMEX_TIMESTAMP>
      <SITEID>BEDFORD</SITEID>
      <STATUS changed="1" maxvalue="COMP">COMP</STATUS>
      <STATUSDATE changed="1">2016-12-05T12:11:25-04:00</STATUSDATE>
      <WONUM>6011</WONUM>
      <WORKTYPE>PM</WORKTYPE>
      <PMEX_METER_READINGS>
          <meterdata>
            <metername>TEMP</metername>
            <meterreading>200</meterreading>
        </meterdata>
        <meterdata>
            <metername>PRESSURE</metername>
            <meterreading>2.0</meterreading>
        </meterdata>
        <meterdata>
            <metername>VIBRATION</metername>
            <meterreading></meterreading>
        </meterdata>
      </PMEX_METER_READINGS>
      <PMEX_OPTIONAL_FIELDS>
          <optionalfield>
              <fieldname>OptionalField1</fieldname>
              <fieldvalue>TestValue</fieldvalue>
          </optionalfield>
          <optionalfield>
              <fieldname>OptionalField2</fieldname>
              <fieldvalue>TestValue</fieldvalue>
```

```
            </optionalfield>
          </PMEX_OPTIONAL_FIELDS>
        </WORKORDER>
      </PMEX_WO_ANDMETERSet>
    </PublishPMEX_WO_ANDMETER>
```

Headers for IBM ID authorization

Content-Type: text/html

Authorization: Basic *authorization_string*

Headers for API key authorization

Content-Type: text/html

APIKEY: *API_Key*

Success response

200 OK {}

Sample call

`https://`*`server_url`*`/ibm/pm/service/apiWrapper?apiName=maximo&Username=`*`user_name`*`&type=data`

Notes This REST API call supports both API key and IBM ID for authentication. To generate the authorization_string for an IBM ID, base64 encode the user name and password separated by a colon, for example: `Authorization: Basic base64_encode(`*`IBM_ID`*` ':' `*`IBM_ID_password`*`)`

Post entity data in JSON format

Posts entity data in JSON format.

URL

/ibm/pm/service/apiWrapper

Method

The request type POST

URL parameters

apiName="json"

Username=*IBM_ID*

type=property

Sample body

```
[
 {
  "ASSET_TYPE": " Aircraft ",
  "ASSET_ID": "810vBEDFORD ",
  "NEXT_PM": "2016-08-16 00:00:00",
  "MF_DATE": "2015-05-01 00:00:00",
  "LOCATION": "BEDFORD",
  "MF": "IBM-US",
  "WELL_MAINTAIN": 10,
  "MACHINE_LEVEL": 1
 }
]
```

Headers for IBM ID authorization

Content-Type: application/json

Authorization: Basic *authorization_string*

Headers for API key authorization

Content-Type: application/json

APIKEY: *API_Key*

Success response

200 OK {}

Sample call

`https://server_url/ibm/pm/service/apiWrapper?apiName=json&Username=user_name&type=property`

Notes This REST API call supports both API key and IBM ID for authentication. To generate the authorization_string for an IBM ID, base64 encode the user name and password separated by a colon, for example: `Authorization: Basic base64_encode(IBM_ID ':' IBM_ID_password)`

Post event data in JSON format

Posts event data in JSON format.

URL

/ibm/pm/service/apiWrapper

Method

The request type POST

URL parameters

apiName="json"

Username=*IBM_ID*

type=data

Sample body

```
[
 {
  "ASSET_ID": "810vBEDFORD ",
  "Timestamp": "2016-11-18 00:00:00",
  "IS_FAIL":"TRUE",
  "IS_MAINTENANCE": "FALSE",
  "IS_REP_REPLACE": "TRUE",
  "Speed": 15.383333,
  "Win_Angle": 180.665922,
  "Wind_Grade": "Soft",
  "Power_Grade": "Large"
 }
]
```

Headers for IBM ID authorization

Content-Type: application/json

Authorization: Basic *authorization_string*

Headers for API key authorization

Content-Type: application/json

APIKEY: *API_Key*

Success response

200 OK {}

Sample call

```
https://server_url/ibm/pm/service/apiWrapper?apiName=json
&Username=user_name&type=data
```

Notes This REST API call supports both API key and IBM ID for authentication. To generate the authorization_string for an IBM ID, base64 encode the user name and password separated by a colon, for example: `Authorization: Basic base64_encode(IBM_ID ':' IBM_ID_password)`

Upload a file

Enables users to upload a file.

URL /ibm/pm/service/apiWrapper

Method
The request type POST

Headers for IBM ID authentication
Authorization: Basic *authorization_string*

Headers for API key authentication
APIKEY: *API_Key*

URL parameters

apiName=file_upload

Username=*IBM_ID*

Success response
200 OK or "result":["error_message":"File upload failed"]

Sample CURL call with IBM ID authentication

```
curl –k -X post --user IBM_ID:IBM_ID_password --connect-timeout 600
-F file=@c:\inputdata_4_1M_part.csv "https://server_url/ibm/pm/
service/apiWrapper?apiName=file_upload&Username=user_name"
```

Sample CURL call with API key authentication

```
curl –k -X post -H "APIKEY:API_Key" --connect-timeout 600 -F
file=@c:\inputdata_4_1M_part.csv "server_url/ibm/pm/service/
apiWrapper?apiName=file_upload&Username=user_name"
```

Notes This REST API call supports both API key and IBM ID for authentication. To generate the authorization_string for an IBM ID, base64 encode the user name and password separated by a colon, for example: `Authorization: Basic base64_encode(IBM_ID ':' IBM_ID_password)`

Download data

Downloads the analysis result data for one asset.

URL

/ibm/pm/service/apiWrapper

Method
The request type POST

Headers for IBM ID authentication
Authorization: Basic *authorization_string*

Headers for API key authentication
APIKEY: *API_Key*

Data parameters

```
{
 "apiName":"file_download",
 "Assetid":"JK84-JAS-142",
 "Username":"user_name",
 "Assettype":"myAssetType",
 "FutureOnly":"true" or "false" (default is false)
}
```

Success response

200 OK

Returns data as part of the response.

Sample HTTP calls

To download the file for a specific asset:

```
https://server_url/ibm/pm/service/apiWrapper?apiName=file_download
&Assetid=my_asset_ID&Username=user_name
```

To download the file for a specific asset type (all assets included):

```
https://server_url/ibm/pm/service/apiWrapper?apiName=file_download
&Assettype=my_asset_type&Username=user_name
```

To download the file with predictions for a specific AssetID:

```
https://server_url/ibm/pm/service/apiWrapper?apiName=file_download
&Assetid=my_asset_ID&Username=user_name&FutureOnly=true
```

To download the file with predictions for a specific AssetType:

```
https://server_url/ibm/pm/service/apiWrapper?apiName=file_download
&Assettype=AIRCRAFTBRAKES&Username=user_name&FutureOnly=true
```

Sample CURL calls with IBM ID authentication

To download the file for a specific asset:

```
curl -X post -u IBM_ID:IBM_ID_password -o filename.csv -v
"https://server_url/ibm/pm/service/apiWrapper?apiName=file_download
&Assetid=JK84-JAS-141&Username=user_name"
```

To download the file for a specific asset type (all assets included):

```
curl -X post -u IBM_ID:IBM_ID_password -o filename.csv -v
"https://server_url/ibm/pm/service/apiWrapper?apiName=file_download
&Assettype=my_asset_type&Username=user_name"
```

To download the file with predictions for a specific AssetID:

```
curl -X post -u IBM_ID:IBM_ID_password -o filename.csv -v
"https://server_url/ibm/pm/service/apiWrapper?apiName=file_download
&Assetid=my_assetID&Username=user_name&FutureOnly=true"
```

To download the file with predictions for a specific AssetType:

```
curl -X post -u IBM_ID:IBM_ID_password -o filename.csv -v
"https://server_url/ibm/pm/service/apiWrapper?apiName=file_download
&Assettype=AIRCRAFTBRAKES&Username=user_name&FutureOnly=true"
```

Sample CURL calls with API key authentication

To download the file for a specific asset:

```
curl -X post -H "APIKEY:API_Key" -o filename.csv -v
"https://server_url/ibm/pm/service/apiWrapper?apiName=file_download
&Assetid=JK84-JAS-141&Username=user_name"
```

To download the file for a specific asset type (all assets included):

```
curl -X post -H "APIKEY:API_Key" -o filename.csv -v
"https://server_url/ibm/pm/service/apiWrapper?apiName=file_download
&Assettype=my_asset_type&Username=user_name"
```

To download the file with predictions for a specific AssetID:

```
curl -X post -H "APIKEY:API_Key" -o filename.csv -v
"https://server_url/ibm/pm/service/apiWrapper?apiName=file_download
&Assetid=my_assetID&Username=user_name&FutureOnly=true"
```

To download the file with predictions for a specific AssetType:

```
curl -X post -H "APIKEY:API_Key" -o filename.csv -v
"https://server_url/ibm/pm/service/apiWrapper?apiName=file_download
&Assettype=AIRCRAFTBRAKES&Username=user_name&FutureOnly=true"
```

Notes This REST API call supports both API key and IBM ID for authentication. To generate the authorization_string for an IBM ID, base64 encode the user name and password separated by a colon, for example: `Authorization: Basic base64_encode(IBM_ID ':' IBM_ID_password)`

Retrieve analysis results

Gets analysis result data in JSON format for a specific asset type or asset ID.

URL

/ibm/pm/service/apiWrapper

Method

The request type POST

Headers for IBM ID authentication

Authorization: Basic *authorization_string*

Headers for API key authentication

APIKEY: *API_Key*

Success response

200 OK

Returns JSON data that contains analyzed results.

Sample HTTP calls

To retrieve analysis results for a specific asset:

```
https://server_url/ibm/pm/service/apiWrapper?apiName=analysisResult
&Assetid=my_asset_ID&Username=user_name
```

To retrieve analysis results for a specific asset type, all assets included:

```
https://server_url/ibm/pm/service/apiWrapper?apiName=analysisResult
&Assettype=my_asset_Type&Username=user_name
```

Sample CURL calls with IBM ID authentication

To retrieve analysis results for a specific asset:

```
curl -X post -u IBM_ID:IBM_ID_password --connect-timeout 600
"https://server_url/ibm/pm/service/apiWrapper?apiName=analysisResult
&Assetid=my_asset_ID&Username=user_name" --insecure
```

To retrieve analysis results for a specific asset type, all assets included:

```
curl -X post -u IBM_ID:IBM_ID_password --connect-timeout 600
"https://server_url/ibm/pm/service/apiWrapper?apiName=analysisResult
&Assettype=my_asset_type&Username=user_name" --insecure
```

Sample CURL calls with API key authentication

To retrieve analysis results for a specific asset:

```
curl -X post -H "APIKEY:API_Key" --connect-timeout 600
"https://server_url/ibm/pm/service/apiWrapper?apiName=analysisResult
&Assetid=my_asset_ID&Username=user_name" --insecure
```

To retrieve analysis results for a specific asset type, all assets included:

```
curl -X post -H "APIKEY:API_Key" --connect-timeout 600
"https://server_url/ibm/pm/service/apiWrapper?apiName=analysisResult
&Assettype=my_asset_type&Username=user_name" --insecure
```

Notes This REST API call supports both API key and IBM ID for authentication. To generate the authorization_string for an IBM ID, base64 encode the user name and password separated by a colon, for example: `Authorization: Basic base64_encode(IBM_ID ':' IBM_ID_password)`

Chapter 5. Troubleshooting

This section contains troubleshooting information for Prescriptive Maintenance on Cloud.

The following table shows possible error messages and corrective actions:

Table 5. Prescriptive Maintenance on Cloud error codes, messages, explanations, and corrective actions

Error code	Error message	Explanation	Action
PM-W-0003	The file X uploaded successfully	File uploaded successfully to the data lake and finished parser.	
PM-W-0004	The file X was deleted	The file deleted successfully from the data lake and Hbase.	
PM-W-0005	The File X upload failed	Exception happened during file upload to the data lake.	Check that the file contains the correct timestamp column and other required fields. Event files require failure event, timestamp, and asset id fields. Entity property files require asset type, asset id.
PM-W-0021	There is no asset_id column in the file X	ASSET_ID is a required column in Prescriptive Maintenance data. But file parser can not find it from uploaded file.	Add ASSET_ID column in the file which report this error and upload it again.
PM-W-0022	There is no timestamp column in the file X	Timestamp is a required column in Prescriptive Maintenance data. But file parser can not find it from x file.	Add timestamp column in x file and upload it again.
PM-W-0023	There are repeated column names in the file X	File parser found duplicated column names in x file.	Remove or rename duplicated column name in x file, and upload it again.
PM-W-0024	The type of failurEvent, maintenancEvent or repairReplaceEvent column in the file X is not correct	File parser use translation file to parse x file and find failureEvent, maintenanceEvent or repairReplaceEvent didn't contain flag value (True/False).	Edit translation file map correct flag value fields to these specified columns. Or edit x file to make these columns contain flag value (True/False).

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Table 5. Prescriptive Maintenance on Cloud error codes, messages, explanations, and corrective actions (continued)

Error code	Error message	Explanation	Action
PM-W-0025	The type of nextMaintenance or manufacturedDate column in the file X is not correct	File parser use translation file to parser the data find nextMaintenance or manufacturedDate didn't contain timestamp value.	Edit translation file map correct timestamp fields to these specified columns. Or edit data to make these columns contain correct timestamp data(True/False)
PM-W-0026	There is no asset_type column in the file. Choose a column as the asset_type	File parser find user upload file is a entity property file. But this file didn't contain ASSET_TYPE column.	Add one more column ASSET_TYPE in this file or use translation file to map one column to asset_type.
PM-W-0027	None of the assets in the file X have an asset type. Upload an entity property file and manually trigger the analysis	User didn’t upload entity property file related with asset_id in event data.	Upload entity property file contain asset_type information for asset_id in event data.
PM-W-0030	Successfully disconnected from the IBM Watson IoT Platform	Disconnected from IoT platform.	
PM-W-0031	You haven't connected to this organization	User disconnect from a unconnected IoT organization.	Refresh UI and disconnect option disappear.
PM-W-0032	You already connected to this organization	User try to connect to IoT organization which has already been connected to.	Refresh UI and connect option disappear.
PM-W-0033	Successfully connected to the IBM Watson IoT Platform	User connected to IoT platform.	
PM-W-0034	You must create a connection to this organization before attempting to connect	User try to connect to an IoT platform which connection definition haven’t been created yet.	Create a IoT connection in IoT UI and then connect to it.
PM-W-0035	Successfully deleted connection	User delete one IoT connection.	
PM-W-0036	An error occurred when deleting an IoT connection	An exception happen when delete IoT connection.	Disconnect to IoT platform first then delete this connection again.
PM-W-0039	An error occurred while analyzing file X	A timeout error occurred when analyzing file x	Rerun analyzing by click retrain button on UI.

Table 5. Prescriptive Maintenance on Cloud error codes, messages, explanations, and corrective actions (continued)

Error code	Error message	Explanation	Action
PM-W-0040	File X upload failed with file parser	Error happen when system cannot parse File x	Check file format matches with translation file and upload it again.
PM-W-0041	You already added integration to organization X	User try to add a new integration connection which already existed.	User can edit old one to make the change. IoT platform on support one connection from a client.
PM-W-0043	An error occurred when saving the translation file	User uses invalid JSON file as translation file.	Check translation file is in correct JSON format.
PM-W-0044	The API Key or Authentication Token is wrong	Failed to authenticate with IoT platform with input API key and authentication token.	Check API key and Authentication token input correctly.
PM-W-0045	You must disconnect from IoT platform before saving this integration	User try to save integration while it connected.	Disconnect from IoT platform and then edit the connection.
PM-W-0046	There is no dataFile object in the translation file	User may delete dataFile object in translation file	dataFile object is required in translation file. User need to add it back or fix incorrect spelling.
PM-W-0047	There is no entityPropertyFile object in the translation file	User may delete entityPropertyFile object in translation file	entityPropertyFile object is required in translation file. User need to add it back or fix incorrect spelling.
PM-W-0048	The dataFile object is not a valid json object	After user edit translation file dataFile object is not a valid JSON object.	User need to fix the format of dataFile object in translation file before save it or replace it.
PM-W-0049	The entityPropertyFile object is not a valid json object	After user edit translation file entityPropertyFile object is not a valid JSON object.	User need to fix the format of entityPropertyFile object in translation file before save it or replace it.
PM-W-0050	You must provide failureEvent, maintenanceEvent and repairReplaceEvent in the dataFile object	After user edit translation file failureEvent, MaintenanceEvent or repairReplaceEvent can not be found in dataFile object.	User need to add failureEvent, MaintenanceEvent and repairReplaceEvent in dataFile object.

Table 5. Prescriptive Maintenance on Cloud error codes, messages, explanations, and corrective actions (continued)

Error code	Error message	Explanation	Action
PM-W-0051	You must provide assetType, nextMaintainance, manufacturedDate and wellMaintainThreshold in the entityPropertyFile object	After user edit translation file assetType, nextMaintainance, manufacturedDate or wellMaintainThreshold can not be found in entityPropertyFile object.	User need to add assetType, nextMaintainance, manufacturedDate and wellMaintainThreshold in dataFile object.
PM-W-0052	We found "key":"value" pairs in the translation file that duplicate column titles in the file X. "key" must use a different name than column titles	User use a column name in file x as Key in translation file.	Change either column name in file x or Key in translation file.
PM-W-0053	X rows contain an empty asset id in the uploaded file Y	Asset id is null in File Y	Provide a value for Asset id in File Y, and upload it again.
PM-W-0055	No asset type was found for X assets in event file Y	System didn't found asset type related to x number of assets in file Y.	Upload an entity property file contain relation between asset and its asset type.
PM-W-0056	The schema in file X does not match the previous model, so we cannot score the model. You must manually train a new model	Auto scoring process found uploaded file x columns didn't match previous trained model.	Edit file x to make columns consistent with previous model, or click retrain button to retrain a new model.
PM-W-0057	There is no failure event in file X	Prescriptive maintenance analysis require failure event in event file, but file x doesn't have it. File x will automatically delete from system.	Add failure event in file x then upload it again.
PM-W-0058	The event data for asset type X is not sufficient to build a model	To build analytic model it required at least 10 record. But data for asset type x doesn't have enough data.	Upload more data for asset type x and click retrain button to analysis it.
PM-W-0059	The model is not accurate for asset type X	Analytic model is built, but the model accuracy is very low.	Upload more historical event data and click retrain to analysis.
PM-W-0060	Event data for asset type X cannot fit a model	Asset type x can't build a model with current event data	Upload more historical event data and click retrain to analysis.

Table 5. Prescriptive Maintenance on Cloud error codes, messages, explanations, and corrective actions (continued)

Error code	Error message	Explanation	Action
PM-W-0061	The model built successfully, but the entity property file did not contain the next planned maintenance date. Margin cannot be calculated.	Entity property for this model doesn't contained next planned maintenance date. Model score cannot complete without that date.	Upload new entity property file contained next planned maintenance date. And click retain to analysis.
PM-W-0062	The asset type X was analyzed successfully	Asset type x has finished analysis successful.	
PM-W-0063	The asset type X was scored successfully	Asset type x has finished score successful.	
PM-W-0064	The asset type X analysis failed	Asset type x fail to analysis.	Click retrain to analyze. If problem still exist contact support, and provide event data and entity property data for further troubleshooting.
PM-W-0065	The asset type X scoring failed	Asset type x fail to score.	Make sure data schema is consistent with previous build model. And click retrain button. If problem still exist contact support, and provide event data and entity property data for further troubleshooting.
PM-W-0066	The uploaded file X is not a valid json file	User uploaded file x is doesn't contained correct JSON format	Check file x and fix incorrect format.
PM-W-0067	The asset id X scoring failed	Asset id x score failed	Make sure the asset contains event data and that the data schema is consistent with the previous build model. Click the retrain button. If problem still exists, contact support and provide event data and entity property data for further troubleshooting.
PM-W-0068	The asset id X scoring successfully	Asset id x score successfully	

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