Reference Architecture:

Achieving Predictive Maintenance with Dell, SAP, and IFM

How IoT-enabled predictive maintenance (PdM) predicts failures, extends machine life and helps you gain RoA

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August 2016

Revisions

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Executive summary

A cure for downtime, a boost for profits

In manufacturing, transportation, energy, or any asset-intensive field, downtime and shrinking MTBF (mean time between failures) are the enemies, topped only by outright system failure. All three greatly increase overhead. And so does crisis maintenance. One large U.S. automotive manufacturer reported that for its maintenance staff of 15,000 to 18,000, "85 percent to 90 percent [of their maintenance work] is crisis work."[1] A 19:1 ratio of planned to unplanned maintenance is commonly considered to be world-class by manufacturers. But this ratio raises the question: even if the plant is operating at 19:1 is all that planned maintenance really necessary? In equipment-heavy fields, operations traditionally works to prevent machine failures and predict equipment replacement or maintenance to keep costs down. Accurate prediction is the key, but it's also the toughest part of the job. Today, replacing reactive maintenance with predictive maintenance (PdM) is a way to reduce the cost and disruption of planned maintenance without increasing the unplanned downtime and the phenomenal cost of operations shutdowns. Although the majority of the data for predictive maintenance originates from operations technology, IT can help with predictive maintenance as well by providing predictive analytics and business data. In the simplest terms, the purpose of predictive maintenance systems is to shift maintenance practices from reactive and preventative to predictive in order to reduce unnecessary planned maintenance, unexpected downtime and lost productivity.

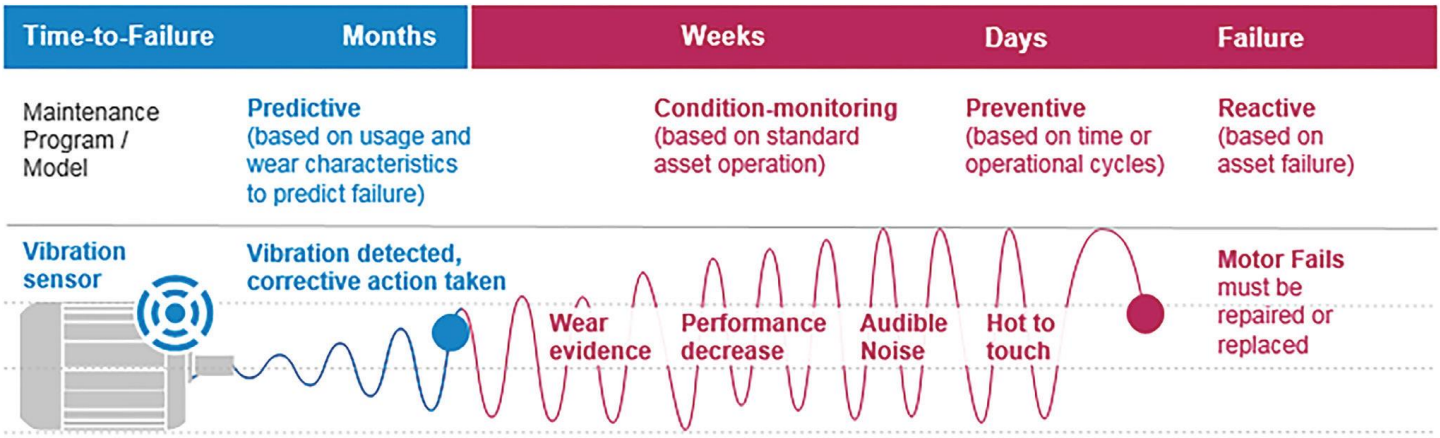
What is predictive maintenance?

Predictive maintenance (PdM) is the analysis of equipment sensor data to predict equipment failures and increase uptime while minimizing costs. Any industry that operates machinery — including manufacturing, transportation, energy, building automation, and many others — can benefit from predictive analytics enabled by sensor-generated data. The value of predictive maintenance over other maintenance models is that PdM empowers maintenance and operations decision-makers to "see" when an asset will need intervention well in advance of its failure. PdM provides the highest possible asset visibility by collecting and analyzing various types of data. Here are some of its capabilities:

- Identifying key predictors and determining the likelihood of outcomes
- Optimizing decision-making by systematically analyzing measurable real-time and historical data
- Planning, budgeting and scheduling maintenance repairs and replacements
- Ensuring proper spare parts inventory

Comparing maintenance methods

The following example illustrates the amount of advanced notice of a probable failure each of the four commonly-used maintenance models can provide. PdM enables you to save time and money by detecting the failure based on data sources with enough lead time to schedule maintenance without undue disruption, while also avoiding damage to the machine.



1 Introduction

Sensors have proliferated the shop floor for decades but in most cases have only been used for command and control — a huge opportunity for analytics and insight is being missed. This sensor data has been limited to only operations teams and, rarely, if ever combined with IT data. Predictive Maintenance is predicated on the principle of bridging the gap between IT and OT. However, there are a couple of considerations when looking at how to get started with Predictive Maintenance. It can be very easy to get sucked into all the equipment that could be rigged up with sensors and start collecting data. In this sense, IoT and Predictive Maintenance have followed a similar path to Big Data – collect as much as you can with the hopes that it will someday be useful. We recommend starting the investigation from a business perspective instead. Investigate equipment types of largest maintenance expense, biggest impact to overall downtime and most sensor data availability. Trying to focus on these parameters can help companies find opportunities that will yield short-term gains while establishing a foundation for long-term benefits.

Once the best place to start is identified, understanding how to get the data from OT and IT systems is required and in some cases additional sensors will also be necessary. In many instances the best place to start is with historian systems that may already be collecting and storing sensor data. Combining this historical data with IT data can be a quick win in the Predictive Maintenance space. However, in lots of cases additional sensor data will be required. In these situations, many customers are concerned about making sure they are using the "right" standards and thus projects are stalled in a fruitless search for a standard. The IoT industry is several years from having definitive standards but IoT Gateways, like those supplied by Dell eliminate the concern of developing to the wrong protocol. These gateways are specifically designed to be a universal translator between the operations world and the IT world. In some instances, new sensors will need to be installed in order to make sure that the right data is collected. In this case customers will need to find the right sensor from the right provider and get the whole stack to work together.

The complexity of building a system ranging from sensor hardware to analytics software has been a major barrier to IoT adoption. This hurdle has been recognized at each level of the stack. Dell, SAP, and ifm have all faced this challenge as well as the realization that none of us could cover the whole stack on our own. This collaboration is a proposal for building a complete architecture for Predictive Maintenance from best-in-class providers that all interoperate.

1.1 Objective

The Internet of Things offers companies the ability to aggregate existing data sources, gain visibility into new data, and identify patterns through analytics to make better business decisions.

According to a recent survey report conducted by the Aberdeen Group, "best-in-class" companies are increasingly utilizing IoT to implement predictive maintenance models that address their top operational challenges in order to improve their use of assets. Some advanced solutions even include automated work orders in coordination with ERP systems. Results show that such predictive maintenance practices:

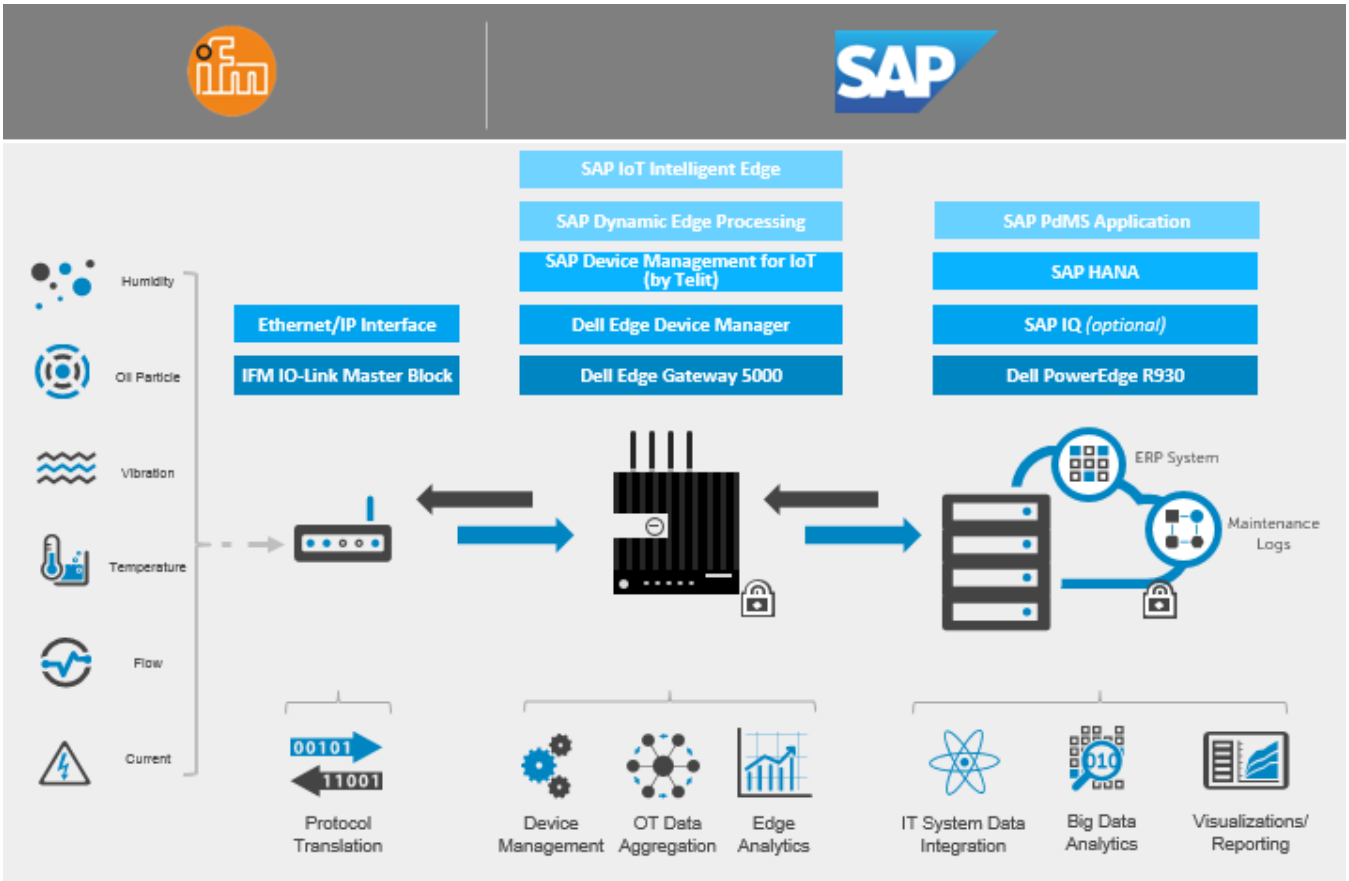
- **Reduce unplanned downtime to 3.5%** – The amount of unscheduled downtime against total availability
- **Improve Overall Equipment Effectiveness (OEE) to 89%** – Availability x Performance x Quality = OEE
- **Reduce maintenance costs by 13% YoY** – Total maintenance costs including time and personnel
- **Increase return on assets (RoA) by 24%** – Profit earned from equipment

1.2 Audience

This document is intended for both Information Technology and Operations Technology audiences in asset intensive industries such as manufacturing, transportation, energy, and others. It is ideal for audiences exploring how IoT-enabled predictive maintenance could be effectively deployed in their environment. Readers who have some familiarity with concepts including IoT, device protocols, streaming analytics, and predictive analytics will gain a deeper understanding of how these concepts can come together to increase maintenance efficiencies in your business.

2 Solution Overview

To provide a blueprint for you to build your PdM deployment around, Dell has developed a flexible architecture centered on the Edge Gateway 5000® with partners including SAP and ifm for a complete solution. Device instrumentation is provided by ifm with a variety of ideal sensors to gather machine operation data. The sensor data is translated to Ethernet/IP traffic by the ifm IO-Link master block and then passed on to the **Dell Edge Gateway 5000** which enables you to collect, analyze, relay, and act on the real-time data. Dell Edge Device Manager (EDM) allows you to deploy, group, and securely manage connected gateways regardless of their physical location. The SAP edge stack including SAP Intelligent Edge, SAP Dynamic Edge Processing and SAP Device Management for IoT (by Telit) manages device connectivity, local storage and analytics, data stream analytics and synchronization with the backend system. This ensures that perishable data is acted on immediately by generating alerts, and also makes certain that only meaningful data is sent to the cloud to minimize consumption of expensive network bandwidth. The ideal backend for your PdM deployment is the Dell PowerEdge R930 HANA appliance running on premise or in your cloud with the SAP Predictive Maintenance and Service (PdMS) application stack. This enables you to integrate structured and unstructured IT system data into your models, and run big data analytics to identify even more granular patterns to predict failures earlier. SAP HANA also provides integration into your Enterprise Asset Management system for reporting, generating alerts, and automating maintenance dispatching



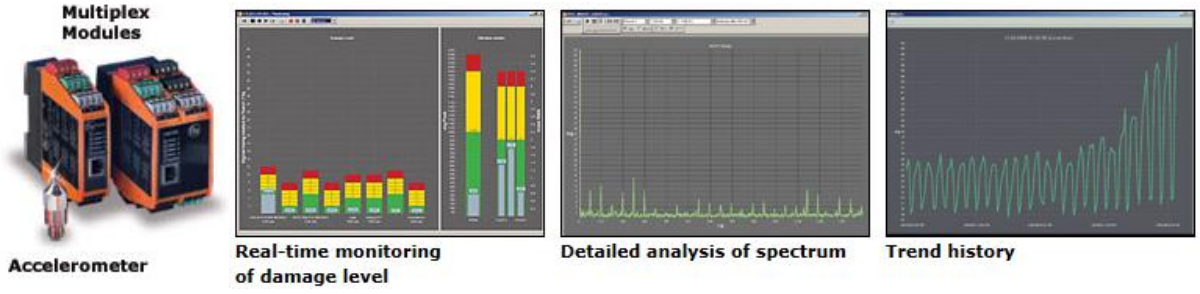
2.1 Edge Description

After choosing your PdM use case applications, identify which data sources are needed for implementation. Some existing data will only need to be integrated (data from existing MES and ERP systems and machines that simply need to be connected to the Internet), whereas other systems will need to be instrumented to capture data. In these cases, it may be necessary to add new devices, such as sensors that clamp over the wiring in an electrical panel or mount on a machine to measure vibration from a specific mechanism. The key to successful implementation of a predictive maintenance program is utilizing the proper sensors to determine machine condition. Sensor selection starts with an understanding of a machine's potential failure modes and the warning signs associated with these modes. Typical warning signs on equipment with rotating parts include unbalance, bearing damage, cavitation (pumps), increased machine vibration levels, increased temperature of machine components, loss or reduction of lubrication flow, and loss or reduction of cooling water flow. Each warning sign can be monitored with the appropriate sensor technology. When new instrumentation is required here are a few sensors to consider including in your plan.

Vibration Sensors

Vibration sensors monitor the acceleration present during machine operation, and are the best starting point when developing a predictive maintenance strategy. Sensors should be mounted to a rigid portion of the machine (frame for example) and as close to the object being measured (bearing, shaft, etc.) to insure proper vibration signal transfer. Basic vibration sensors detect an overall increase in machine vibration indicating a potential machine issue. More sophisticated sensors use FFT (Fast Fourier Transform) signal processing to look at sensor signals in the frequency domain in order to detect issues with specific machine components like rolling element bearings or fan blades. Vibration sensors provide the best leading indicator information of machine condition.

ifm's multiplex vibration monitor provides specific vibration analysis on components inside a machine such as rolling element bearings, rotational unbalances and gear drives. The system consists of a cabinet-mount diagnostic module and multiple compact accelerometers that are mounted permanently on the equipment. The system's internal microprocessor tracks up to 20 different machine components. Programming of the monitor is straight forward using the "wizard" guided configuration software. ifm's **UW0001** Vibration Starter Kit has everything you need to get started.



Temperature

Temperature sensors monitor critical machine components or auxiliary systems to detect changes in machine condition. For direct measurement applications, RTD's (Resistive Temperature Detectors) and thermocouples are used. For indirect measurement applications, non-contact infrared sensors are used. Typical applications are bearing temperature, lubrication temperature, and cooling water temperature.

ifm's compact **TN series** temperature sensor combines evaluation electronics, digital display, sensing probe and process fitting, for a completely sealed and calibrated system ready to install in your application. A simple pushbutton menu allows the sensor to be programmed to fit your application setpoints. These sensors are designed with a two color (red/green) integrated digital display indicating if process values are in an acceptable range or if limits have been exceeded.

Oil Particle

Oil particle sensors monitor the level of particle contamination present in lubrication systems. An increase in particle count can indicate potential wear issues in gear boxes. Oil particle sensors are inline devices that should be mounted after critical machine components in the lubrication loop.

ifm's **LDP100** inline particle monitor monitors the degree of cleanliness or the level of contamination in oils. The integrated data memory allows data recording over a longer period. The LCD display indicates the cleanliness level. The particle monitor operates according to the light extinction principle. The changes to light intensity of a laser beam caused by particles in the medium flowing through the measurement cell are detected by a photo detector.

Flow

Flow sensors monitor the flow rate of lubrication or cooling water flow. Reduction or loss of flow rate can lead to future machine issues. Flow sensors are mounted in the lubrication or cooling line, and the sensing principle used (thermal, magnetic inductive, ultrasonic, etc.) is dependent on the media type, flow rate, and line size required.

ifm's **SV series** vortex flow meter is designed to simultaneously monitor flow rate and detect fluid temperature of circulating water in industrial applications. Encased in a compact robust housing for harsh environments, the meter utilizes the vortex flow principle. The vortex flow technology enables a simple sensor design that can be easily manufactured at a very low cost. The meter provides a high contrast TFT LCD digital display that can be customized to best suit the application.

Current

Current sensors monitor the current draw of machine components. A typical application is monitoring the current draw of a motor. Increased current draw over time can indicate wear/issues with the motor. These sensors are clamped around the electrical cable feeding the motor.

Humidity

Humidity or moisture sensors monitor the water content in hydraulic and lubrication oils. Excess moisture can lead to corrosion and other machine issues. These sensors are typically mounted in the lubrication or hydraulic tank.

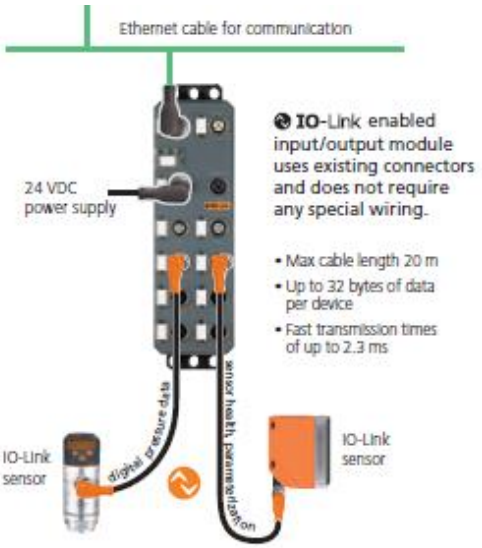
ifm's **LDH100** sensor measures the relative moisture in the oil in the range of 0...100 % by means of a capacitive measuring element. Besides the relative moisture the sensor also provides the medium temperature as an analog signal.

Other Sensors

The sensor types discussed above are the most common devices used in machine predictive maintenance, but many other sensors are available for machine specific applications. A variety of position sensors (inductive, photoelectric, capacitive, and magnetic) are available for machine position or product detection. Other process sensors like pressure and level are also available.

Accessing Sensor Data through IO-Link

Industry 4.0 is based on making our factories smarter, so our machines can gather valuable data, then communicate and utilize that data in real time. This communication enables enhanced production capabilities while being able to immediately access and analyze data that was not previously available. The foundation of Industry 4.0 is utilizing real time data from the plant floor. Once collected, this data can be analyzed, formulated and shared to make every aspect of Industry 4.0 a reality. Sensors on the machines collect vast amounts of data but, until now, the data has been essentially trapped, with no pathway to control or data collection systems. IO-Link can access this trapped data through existing wiring.

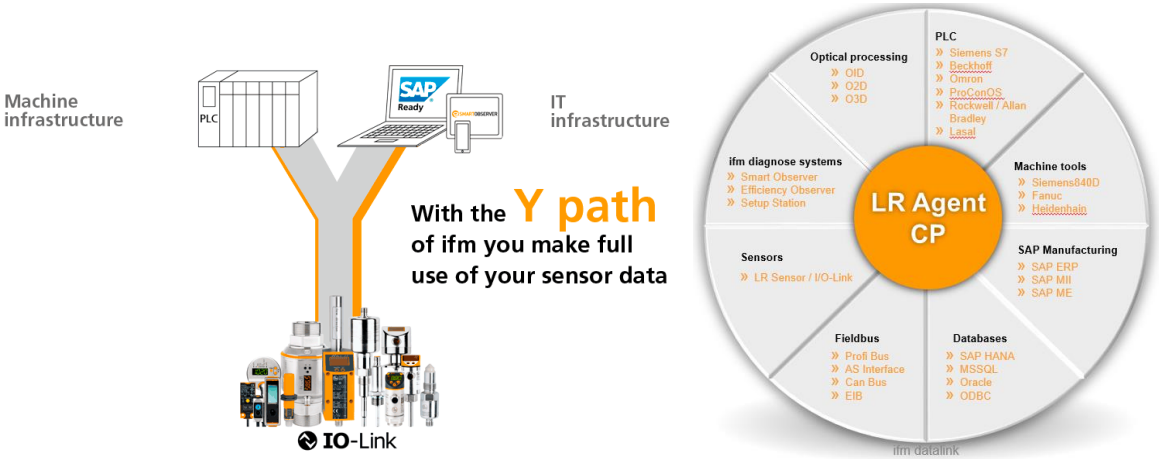


IO-Link unlocks the data in sensors

IO-Link is a new, manufacturer-independent point-to-point connection for sensors and actuators. It can be used to transmit sensor data digitally. Using an IO-Link master block, predictive maintenance sensor data is easily transferred to a wide variety of SAP solutions via Ethernet.

LINERECORDER Agent

ifm's LINERECORDER Agent software allows for simple mapping of sensor data to SAP PCo or HANA via the SAP IoT adapter.



LINERECORDER SMART OBSERVER

ifm's LINERECORDER SMART OBSERVER software is used for condition monitoring of systems. Machine condition is displayed locally, and sensor data can be stored in the Edge Gateway for further pre-processing.

LINERECORDER SMART OBSERVER

2.2 Fog Description

Dell Edge Gateways connect your field sensors, devices and manufacturing systems to the internet. Ruggedized, fan-less, with industrial-grade form factors and DIN-rail or wall mounts, our gateways are expandable and purpose-built for long life and 24/7 use, reliable at -30°C to 70°C. The Dell Edge Gateway 5000 enables you to collect, analyze, relay, and act on real-time data from machine sensors and generate accurate, dynamic predictions. Perform analytics on aggregate data at the edge, and then send only

summarized results over the network. Decentralized data analytics also allows local systems to maintain normal operations when the connection to the cloud is temporarily lost.

- Connect your systems, sensors and devices securely to the internet
- Accept diverse I/O — wired or wireless—natively, and integrate industry protocols, like BACnet, Modbus, CANbus, ZigBee…
- Aggregate, normalize, analyze and send only prime data to the back-end for storage and trend analysis
- Supports Trusted Platform Module (TPM) v1.2 to securely store artifacts (including passwords, certificates, or encryption keys) used to authenticate the gateway.
- Exchange data with the cloud, data center, other devices — providing analytics in the "fog"
- React in real time, even when the network is down or latent
- Offer hardware-level security and BIOS lockdown of I/O ports, with intrusion alerts on the IP65 enclosure
- For environments with poor connectivity or limited network capacity, gateways can process, store, and forward filtered data, as well as provide offline capability to maintain operations.

Edge Device Manager (EDM) for Dell Edge Gateways allows managers to deploy, group, and securely manage connected gateways regardless of their physical location.

EDM provides the quickest path to productivity with no management software to install on premise or maintain and automatic access to the latest functionality from the cloud. The powerful push notification framework coupled with OS and application imaging functionality allows EDM to deploy and manage OS images, updates, applications to devices seamlessly.

- With EDM you get:
    - GUI-driven configurations and exceptions handling
    - Simplified device registration and grouping
    - Advanced insights into your Edge Gateway and embedded PCs
    - All from a browser

Key considerations

- When thinking about data sources, consider the nature of your organization's environment. In the case of equipment located outdoors or in non-temperature controlled locations, the sensors and gateways you install must be able to natively withstand extreme temperatures in the -30°C to 70°C (-22°F to 158°F) range.
- Consider selecting gateways with more computing power than you initially need to support new applications you'll likely find in the future. Investing in computing headroom now will be much less expensive than paying for a truck roll to upgrade a gateway's capacity at a later date.

Table 1 Dell Edge Gateway 5000 configuration

Component	Description
Operating system	Windows 10 Enterprise 2015 LTSB
Processor	Intel® Atom™ CPU E3827 @ 1.74GHz
Installed Memory	8GB
Hard Drive	32GB Solid State Hard Drive M.2 SATA
Application	Java 8 Update 91, Smart Observer 1.3.3.58, Microsoft SQL Server Compact Edition, Dell Command Monitor Dell Edge Device Manager SAP applications (listed below)
Server	PowerEdge R930, 2x Intel® Xeon® E7-4809 v3 2.0GHz
Installed Memory	32x 32GB RDIMM
Storage	16x 1TB 7.2K RPM Near-Line SAS 12Gbps 2.5in Hot-plug Hard Drive

SAP IoT Intelligent Edge provides a set of software components that can be installed on the Dell Edge Gateway 5000 to manage device connectivity and management, local storage and analytics, data stream analytics and synchronization with the backend system.

The following bundle of products are recommended for collecting, storing and processing data at the edge including:

- SAP Plant Connectivity (PCo) – connects to many databases and sensor protocols on the shop floor such as:
  - OPC, OPCDA, OPCHDA, OPC A&E, and OPC UA
  - OLEDB and ODBC
  - Proficy, OSIsoft PI and IP21 Historians
  - Citect SCADA systems
  - File monitors and web sockets
- Streaming Lite - provides the ability to implement complex event processing on the edge including:
  - Consolidating input from multiple sensors or sources
  - Aggregating, enriching and filtering raw data
  - Generating actions or alerts on the edge without requiring a round trip to a central server
  - Streaming value added event data to a central Smart Data Streaming server for additional event processing and recording
- SQL Anywhere – provides a small footprint embedded database gathers and stores sensor data from devices

SAP Partner Edge Products

- Dynamic Edge Processing – brings critical business data from ERP and other business suite applications from the core to the edge for real-time decisions based on a fusion of business and sensor data even if connectivity to the core is not currently available.
- HANA IoT Connector by OSIsoft – provides a direct connection between OSIsoft Pi historians and SAP backend Predictive Maintenance and Service applications
    - Accesses the rich data sets generated by control and automation systems and smart devices
    - Merges operations data from OSIsoft with business data from SAP and third-parties
    - Combines time-series data with transactional business data
    - Enables enhanced business analytics and delivers applicable business insights
    - Supports most national and industry best-practice doctrines for security
- SAP Device Management for IoT by Telit –designed to easily capture, process and forward data from production machines to the device management platform or another SAP system. Telit deviceWISE supports all popular PLCs from Siemens, Mitsubishi, Rockwell, Omron and most widely used production equipment, and is compatible with virtually any database, message queuing and application server system available, including IBM, SAP, ORACLE and Microsoft.

2.3 Cloud/Backend Description

The Dell PowerEdge R930 is the compute platform for SAP HANA scale-up and scale-out platforms. Sensor data from Dell Edge Gateway 5000 is forwarded to SAP HANA for real-time analytics and predictive maintenance. Deployment of SAP HANA may be on premise or cloud based. Dell's SAP HANA certified platforms (as shown below) support scale-up environments for memory size up-to 4TB RAM or scale-out for memory size up-to 32TB RAM – in an appliance delivery model or Tailored Data Center model (build your own).

Dell designed the Dell PowerEdge R930 with the ability to scale to accommodate mixed workloads while maximizing the performance of your applications and managing server lifecycles. The latest generations of Dell PowerEdge servers are pre-configured to run SAP HANA. Dell PowerEdge servers provide efficient growth and scalability without a rip-and-replace. Dell technologies built into the Dell PowerEdge R930—like the Dell™ OpenManage™ system-management portfolio and the integrated Dell™ Remote Access Controller (iDRAC) with Lifecycle Controller—automate and simplify many lifecycle-management tasks.

Benefits of SAP HANA running on the Dell PowerEdge R930:

Significant performance improvements for standard enhanced mixed loads running on the Dell PowerEdge R930 compared to previous-generation Dell PowerEdge rack servers—a world record of 26 percent for four-socket servers.

Up to 100 percent more bandwidth for critical applications, compared to the previous-generation servers, because the Dell PowerEdge R930 can seamlessly interface with your storage devices through its RAID controller. That's up to 24 hard-disk drives (HDDs) or eight solid-state drives (SSDs).

- More automation and better management, so application-deployment times can be reduced up to 99 percent.
- Dell PowerEdge R930 rack servers support up to 96 dual in-line memory modules (DIMMs) of DDR4 memory which helps data centers to quickly analyze more data in real-time—all of which is funneled through SAP HANA and into sharper insights that help you make smarter, faster decisions.
- Dell supports delivery of SAP HANA platforms as an appliance or build-your-own (SAP's Tailored Data Center model). The advantages of the platform delivered as an appliance implies a pre-configured, optimized, pre-certified solution with delivery service included.

Table 2 Dell PowerEdge 930 configuration

Analytics/BW	128-384GB	512GB	768GB	1.0TB	1.5TB	2.0TB
Server	Dell PowerEdge R930 (w/Intel E7v4 cpu)					
Processor	2x or 4x Intel E7-8880v4 or E7-8890v4			4x Intel E7-8880v4 or E7-8890v4		
Memory DIMM Size	8 or 32GB RDIMMs	16 or 32GB RDIMMs	16 or 32GB RDIMMs	32GB RDIMMs	32GB RDIMMs	32GB RDIMMs or 64GB LRDIMMs
Storage: OS + SAP + LOGS	5x800GB or 1.2TB SAS SSD + 1 hot spare (RAID 5 configuration)					
DATA	3-11x800G or 3-7x1.6TB SAS SSD + 1 hot spares (RAID 5 configuration)					
OS	SUSE Enterprise Linux (SLES) for SAP HANA / Red Hat Enterprise Linux (RHEL) for SAP HANA					
File System	XFS for DATA & LOG volumes					

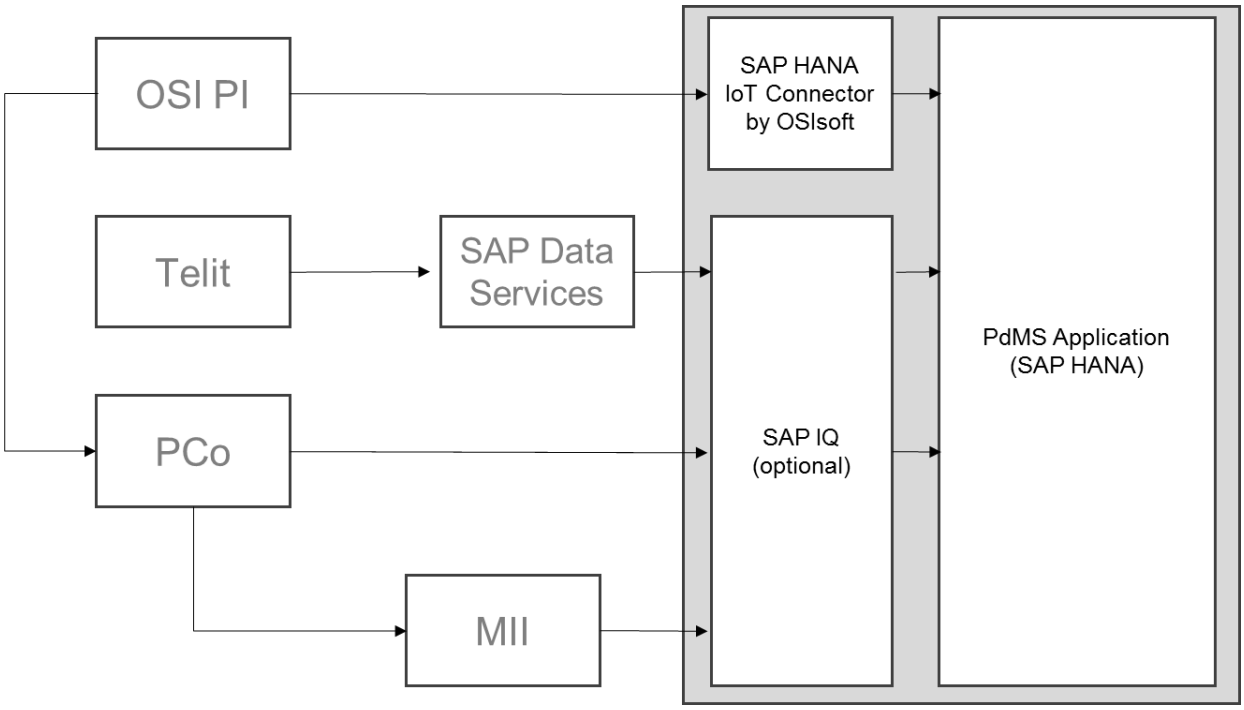
Explore more details on recommended Dell PowerEdge R930 HANA Appliance configurations here

SAP HANA and Predictive Maintenance and Service Application (PdMS) combines both operational and IT data to perform analysis on the combined data set. Although some data processing can be accomplished at the edge, for more advanced analytics data analysis needs to be done at the core where more storage and compute power are available. SAP Predictive Maintenance and Service is an application that runs on top of SAP HANA and the following components are required from SAP:

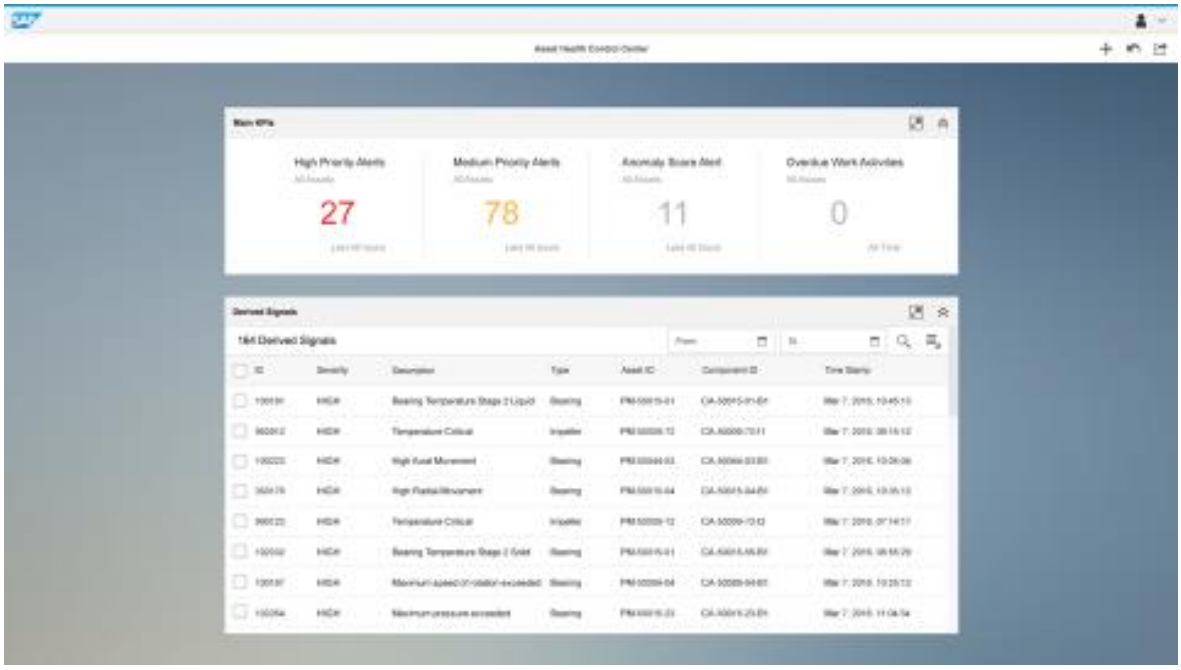
- SAP Predictive Maintenance and Service, On-Premise Edition
- SAP HANA Platform or Enterprise Edition

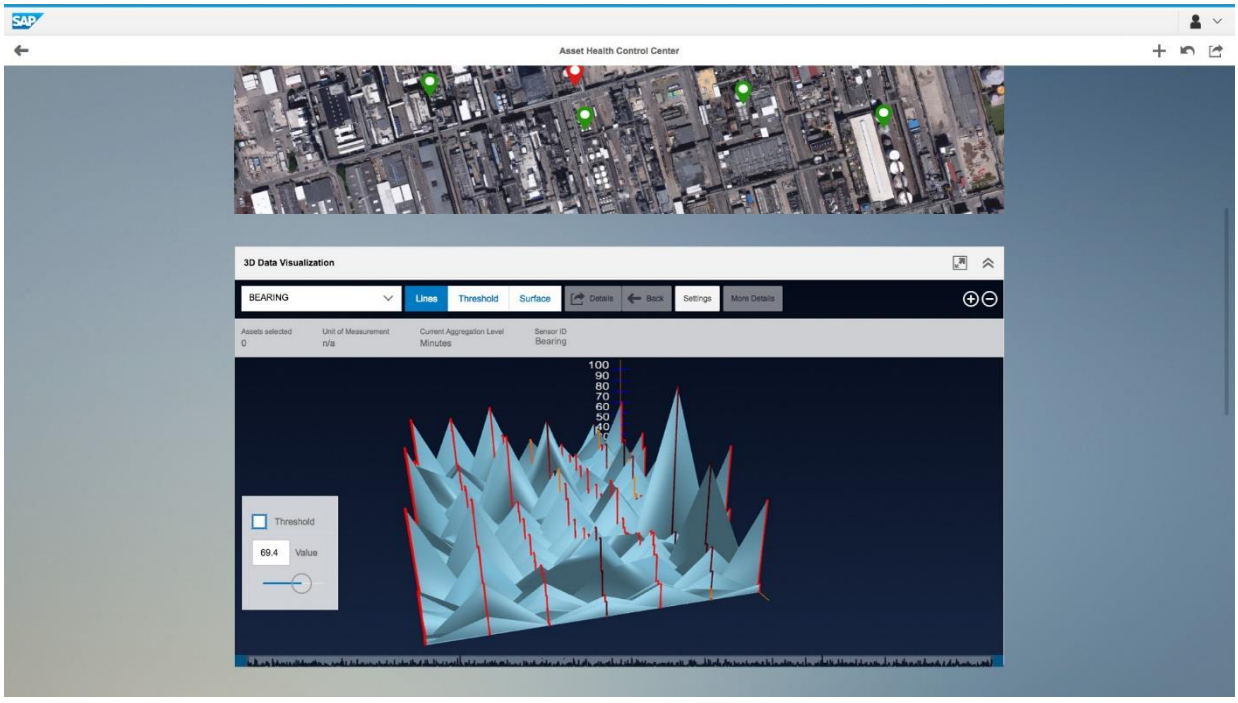
These optional components may be useful in many situations to get more value from your Predictive Maintenance installation:

- SAP IQ or OSIsoft Pi – either of these databases can serve as warm data stores to persist sensor data not currently needed within SAP HANA. This can help reduce the total cost of ownership as well as increase performance for large amounts of data
- R in SAP HANA studio – is a method for developing customized data science algorithms for individualized analysis.



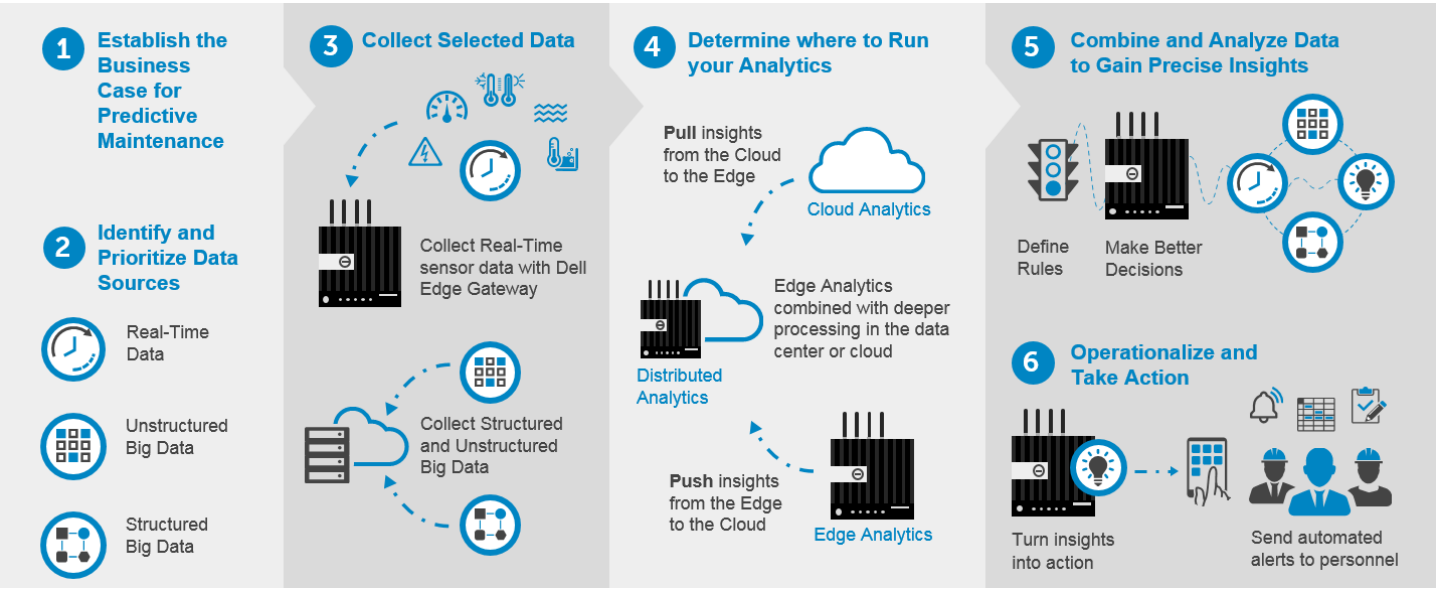
SAP Predictive Maintenance and Service Screens





3 Best Practice Recommendations

Dell recommends that you follow these 6 best practice steps to plan your PdM implementation:



Explore more details on these recommended best practice steps in the [Dell Solution Brief for Predictive Maintenance]

Additional best Practices to consider:

- **Start with Vibration Analysis:** Vibration sensors are the best starting point for deploying a real time predictive maintenance program. Start with a critical, bottleneck machine, install vibration sensors to monitor the critical components of the machine, and begin collecting data to understand machine condition. Other sensors can be added later as the root cause of the critical failure modes are uncovered.
- **Unlock data sources already available through the machine:** Machines already utilize a lot of sensors for control of the machine itself. Using the existing data from these sensors along with new sensor data (vibration sensors for example) will provide a lot of information regarding machine condition. Sensor data can be pulled directly from the PLC. If the sensors are IO-Link compatible, the sensor data can also be passed directly to an Edge Gateway.
- **IT OT convergence:** Consider the relationships between organizations such as IT, operations, finance, and your project team. Is your IT and operational technology (OT) infrastructure converged, giving your operations equipment access to the core IT network and making it easier to link your systems together? We believe it is always better to partner with both IT and OT organizations from the start.
- **Architect starting with what you have:** Move from pilot to production quickly and cost-effectively by leveraging existing investments, without being forced to rip-and replace, and by integrating open, future-ready infrastructure solutions.
- **Wired vs. wireless sensors considerations:** Another consideration is whether to use wired or wireless sensors to collect data from your various energy sources, a decision that is typically

influenced by a number of factors. For example, are you working with a large manufacturing plant, distributed field assets, or an oil rig? Are the various energy consumers close together, spread out, indoors, or outdoors? Can you easily pull cables to sensors at major energy consumption points? Hard-wired connections provide reliable connectivity, but pulling cables can be cost prohibitive in both retrofits and new installations, or even impossible in some facilities. In such cases, wireless sensors can be attractive alternatives. Can you get a wired power source to each sensor, or do they need to be self-powered (e.g., battery, solar)? What locations are in relatively close proximity to sensors, and therefore are more suitable for data aggregation? These are important factors when deciding between wired and wireless sensor solutions.

- **Cloud vs. on premise considerations:** The backend server in this reference architecture may be setup in a cloud or on premise. Benefits of an on premise setup include ownership and control of IT resources and faster performance for local users, this should be balanced by the cost for resources to support the infrastructure; cooling, electricity, and physical security costs and unused capacity when equipment is purchased for peak demand. Setup in a cloud environment, on the other hand, offers predictable monthly expenses, ease in scaling up or down based on demand, maintenance and overheads are the responsibility of the service provider. This should be balanced with less control and access to systems as compared to on premise environment, and performance is reliant on quality of internet connections in customer locations.
- **Standard vs. extended algorithm access:** In many cases the standard algorithms included in the SAP Predictive Maintenance and Service application are sufficient but for situations where they are not the application can be extended. Three generally applicable data science algorithms are available within the application out-of-the-box: Anomaly detection, Principal Component Analysis and Weibull Remaining Useful Life. These are purposely meant to cover cases where little or no additional information beyond the sensor data itself is known. They assume that the majority of the time a machine is running normally and deviations from that may indicate an issue. If additional information is available using customized data science algorithms can provide even better results.
- **Security considerations:** Data security is priority number one. At a minimum, protect business-critical and personal information using data encryption and tunneling. Intelligent gateways offer hardware-level security with a Trusted Platform Module (TPM), Secure Boot, and BIOS-level password and port lockdown for minimizing unauthorized access to the system. For more discussion about securing your energy management solution check out this Dell security white paper.

4 Conclusion

Dell research shows that getting and accelerating access to the right data is the key to faster analytics and improved corporate decision-making — both big factors in the organization's success. Sensors alone do not transform operations, and data points without connectivity do not transform business activity. It takes experience to put together a solution that embraces all of the preceding best practices for predictive maintenance. It was with these best practices in mind that Dell, SAP, and ifm collaborated on an IoT enabled solution to bring predictive maintenance quickly to life in an operations environment.

Benefits:

This reference architecture for predictive maintenance provides the highest possible visibility of each asset by collecting and analyzing various types of data. The Dell, SAP, and ifm IoT solution:

- Identifies key predictors and determines the likelihood of outcomes
- Optimizes decision-making by systematically applying measurable real-time and historical data
- Speeds up deployments because the solution is pre-tested, helping you get to ROI faster
- Uses standardized infrastructure providing choice and flexibility to meet your business needs
- Scales for deployment and support worldwide

A Additional resources

Dell PdM solution brief

Cookbook: Dell platforms for SAP HANA

Dell.com/HANA

Dell.com/IoT

SAP Predictive Maintenance and Service, On-Premise Edition Enterprise Architecture Explorer

SAP Predictive Maintenance and Service, On-Premise Edition Deployment Guide

SAP HANA Cloud Platform IoT Services

SAP Device Management for IoT by Telit

ifm Overview of IO-Link

ifm Y-Path – from sensor to SAP

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