Predictive maintenance: How data can increase production

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MAINTENANCE MADE EASY WITH THE HELP OF DATA
Predictive maintenance involves gathering targeted data for analysis, the results of which will help anticipate potential failures before they occur. Companies opt for this type of maintenance to avoid predictable incidents and repair equipment, assembly lines, or machinery with minimum impact on their operations.

“Having to repair a faulty product is disastrous for a manufacturer’s brand image. But shutting down machinery for random preemptive checks can also be extremely costly when you consider the production downtime. Predictive maintenance tools allow industrial companies to predict maintenance needs just in time, thus ensuring that neither breakdowns nor maintenance will slow down production,” explains Pierre-Jacques Evrard, solutions consultant with software provider TIBCO Software.

PREDICTING BETTER THAN SHUTTING DOWN TO CHECK
Evrard is convinced that timely action will become a competitive lever for equipment manufacturers before too long. He is careful to distinguish between this new predictive maintenance approach and preventive maintenance, which is already commonly used in industry. The latter involves performing a higher number of preemptive checks to prevent incidents that might not actually occur.

“An equipment manufacturer will typically submit a preventive maintenance plan to their customers. This will be a service contract setting out a fixed maintenance schedule from the date of delivery. But this will not take accurate account of contextual data, in particular the manner in which the machinery will actually be used. You could say that this type of maintenance is too cautious: it requires too many production shutdowns resulting in unnecessary extra costs,” he claims.
A predictive maintenance solution on the other hand uses real-time data to create a progressive maintenance plan with both financial and operational benefits. Evrard notes that predictive maintenance concepts have already secured deals over conventional competitor maintenance schedules in the aircraft and helicopter manufacturing business. He mentions in particular the case of rescue aircraft, whose missions can rarely be forecasted, and which are more likely to break down as the result of salt corrosion or strong winds than the number of weeks spent in flying service. Evrard reckons that, depending on the contract, dedicated service providers could likewise replace their preventive maintenance plan with a predictive maintenance offering.

**ANTICIPATION CREATES A BETTER USER EXPERIENCE**

According to Evrard, predictive maintenance is set to really boom with the growing commercialization of electric vehicles.

“For this type of vehicle,” he maintains, “the usual preventive inspection after clocking up a certain number of kilometers no longer makes sense. Battery wear is the most important thing to check in this case. But battery wear depends largely on driver behavior, which varies by age, whether they live in an urban or rural area, and even their habits.” For instance, drivers who regularly recharge their battery after short drives, increase the likelihood of their automobile not being able to cover longer distances.

To avoid disappointed customers defecting to the competition, a number of manufacturers have been asking customers to visit their dealer more often to check whether their battery needs to be replaced. But this recommendation unfairly penalizes good drivers.

“With predictive maintenance, the manufacturer can identify the driver’s behavior beforehand and ask them to come by the dealership only when this becomes necessary. This approach could even open up new business opportunities while showing the customer that the manufacturer is looking out for them without being intrusive,” adds the solutions consultant from TIBCO Software.

**FEWER MAINTENANCE VISITS**

Machine operators in particular will find that predictive maintenance quickly helps to reduce downtime.

“When you have a process that requires 200 steps—like semiconductor wafer manufacturing—you cannot afford to inspect every bit of equipment because it would take too much time and significantly slow down your production line. But not checking equipment settings or relying on random tests to save time would jeopardize the reliability of the final product. In this case, predictive maintenance saves both time and inspection effort by specifying what needs to be examined and when,” affirms Evrard.

In fact, TIBCO Software has installed a sampling system for a semiconductor manufacturer that collects real-time data on events related to each item of equipment. A software engine learns the sequence of events and, in particular, the sequence that could lead to a problematic situation. As soon as it detects this pattern emerging, it triggers an alarm to let the maintenance teams know that this specific piece of equipment needs to be checked.

“One year later, this manufacturer had recorded a 66% drop in inspections, which ultimately allowed it to produce more wafers with the same standard of quality,” reveals Evrard.

A predictive maintenance solution can cut overall maintenance costs by 20 to 30%. This takes into account the cost of the software and offsets it against the costs of all actions and resulting downtime avoided.
10% FEWER OUTAGES BRING AN ANNUAL SAVING OF USD 1.4 MILLION

In the United States, an oil platform operator has introduced predictive maintenance to reduce pump downtime.

“The need to perform regular maintenance on several thousand electro-submersible pumps (ESPs) previously cost this operator almost $40,000 USD per day in lost production. Simply by reducing the number of repair incidents by 10%, the operator managed to save $1.4 million USD per year,” declares Sadaq Boutrif, senior technical leader at TIBCO Software.

In this particular case, the operator works with pumps that experience frequent breakdowns and are buried over 800 meters down. Their hope was to predict breakdowns so that they could slow down the pumps and give themselves enough time to fix them; or, if that were not possible, stop the pump to repair it before it causes a chain reaction of outages, which would further lengthen the repair process. In response to an RFP, TIBCO Software demonstrated the ability of TIBCO Spotfire® to analyze a large number of historical data variables (temperature, pressure, etc.) within a few hours. The analysis can produce a behavioral model capable of predicting breakdowns before they occur with more than 95% accuracy:

- Operating conditions
- Optimum detection point
- Time
- Failure
- Cost / downtime

The TIBCO StreamBase® streaming analytics engine then executes this model on the measurement data streamed in real time from the pumps.

“Our comprehensive, integrated platform compresses time to solution down to just a few weeks; in other words, from model development to runtime. It is this agility that makes predictive maintenance so effective,” adds Boutrif.

As it is based on operational measurements, predictive maintenance means that maintenance activities are much more efficient and are only carried out where necessary. As such, it eliminates the costs and constraints typically encountered in preventive maintenance scenarios.

THE FOUR SUCCESS FACTORS OF PREDICTIVE MAINTENANCE

Predictive maintenance is not a new development, it is just the digital aspect that is shaking up old habits.

“Chemical or acoustic analysis of production equipment has already been around for a while. But now we can use sensors and digitally process their readings. The processing of this information has not yet been standardized though,” points out Reda Kadri, digital enterprise architectures specialist at Capgemini. He advises organizations with an interest in predictive maintenance software to look at four key considerations: the maintenance contract, the service provider tasked with piloting the solution, the consistency of the services, and user training.
REINVENTING MAINTENANCE CONTRACTS
Kadri underlines the difficulty of introducing predictive maintenance software when procuring equipment that only comes with periodic maintenance contracts. He claims that digital predictive maintenance raises questions that require clear answers, such as:

- Would this kind of system not be too intrusive?
- Is there a way to ensure that the transferred data will remain confidential?
- How will the sensors impact production operations?

Aside from these considerations, the first hurdle that needs to be overcome, even before discussing the possible savings, is the need for a complete reinvention of maintenance contracts.

THE EQUIPMENT MANUFACTURER IS NOT THE BEST PARTNER FOR PREDICTIVE MAINTENANCE
In the same vein, the digital architecture specialist from Capgemini highlights an issue of trust: the equipment manufacturer cannot take on the role of service provider and also supply the predictive maintenance solution. It goes without saying that an organization may—understandably—doubt the objectivity of its supplier when it calls to say that it has detected a risk of failure, and that to avoid it, the organization would need to buy replacement parts.

“This is like the scenario when you visit a mechanic who tells you that he has discovered a problem with the carburetor, the brakes, or whatever, and assures you that you should replace the part if you don’t want to break down in the middle of nowhere. You cannot help but feel that he may be trying to cheat you by giving you information that he alone can verify,” says Kadri. He maintains that it is better to stick to a normal maintenance arrangement with the equipment provider—based on an inspection schedule agreed at the outset—rather than risk a partnership of mistrust.

He strongly recommends that organizations team up with a specialist service provider if they want to derive the maximum benefit from predictive maintenance.

STARTING A CULTURAL REVOLUTION
The biggest challenge to overcome, according to Kadri, is getting everyone within the organization on the same page. A predictive maintenance solution is based on the assumption that every department agrees on how it should be used, which is often not necessarily the case. There are plenty of situations where anticipating failures with on-site data would be of huge assistance, but where the dividing lines between the various departments involved prove to be too inflexible.

To make predictive maintenance an integral part of projects undertaken by organizations, he advises working on a proof-of-concept (POC) first. This means starting by integrating the solution into small R&D projects with an independent team responsible for each project.

“The concept will creep into the corporate culture by spreading virally. All it takes is for one small team to be convinced, and before long all the other departments will have heard good things about predictive maintenance,” explains Kadri.

TRAINING INTERNAL TEAMS
Another obstacle is providing digital technology training for the organization’s personnel.

“Specific expertise is required in order to use predictive maintenance. It involves inputting data into a statistical model to find iterations. The problem is that there are too few people in industry who are familiar with big data,” observes Kadri.

He reckons that the candidates best suited to dive into predictive maintenance are financial services companies and any organization with a digital-based activity. Everyone else will either have to provide big data training for their staff or hire people who already have some basic knowledge.
Kadri acknowledges that this is an obstacle, but he is adamant that it is worth overcoming. “We have observed in the past that it has not been cost-effective to rely on internal competencies. Remote maintenance, with the telecommunication systems that go along with it, has put off more than one industrial company and their teams composed largely of engineers. But after a certain length of time, it was clear that those who had made the effort to build the right team ended up with much better financial results than the others,” he attests.

He maintains that bad incidents are a trigger for deciding whether to adopt a predictive maintenance solution. It’s often when an organization understands the risks of those incidents happening again that they have a better understanding of the value that an on-site maintenance system would have for their business. On a more general level, he foresees the trend heading towards real-time quality control, and expects to see wide-scale adoption of predictive maintenance in three to five years’ time.

**KICK-START WITH A POC**

The best way to start a predictive maintenance project is with a POC based on a specific use case. During a six to 15-week timeframe, a small dedicated team (often from a technical function) would be tasked with designing the technical solution, getting it kick-started, and learning how to use it. Then, to put their lab work into practice, thought must be given to project management. This should involve the administrative and financial department, functional units, and safety personnel (to whom the maintenance technicians are answerable). It is not good practice for IT to lead a predictive maintenance project by itself because a cross-disciplinary, collaborative approach is essential to broad success.

“In railroad transport, for example, the priority after an emergency brake procedure is not to analyze the data to discover how exactly the track had been damaged. It is enough to know that it happened! The priority is to prevent the next train from derailing,” says Kadri.

The next stages to emerge from the project will be a change management plan (training), a methodology (process specification), and a new organizational structure (defining roles and responsibilities). When the solution is in place for a given use case, the organization will gradually gain expertise in predictive maintenance. Then, after a while, it will restructure itself to bring the rest of its maintenance processes into line.

To derive the maximum benefit from predictive maintenance, the organization must seek to lock down its maintenance contracts, get a specialized service provider on board, encourage cross-functional collaboration, and train its teams.

**SELECTING THE RIGHT TOOLS TO AVOID INCIDENTS**

Predictive maintenance is the ability to capture operational and environmental data as soon as possible and feed it into the latest analytics tools so that big data specialists can create statistical models. On-site source data will usually come from the Internet of Things (IoT), equipment fitted with sensors that produce digital readings combined with a communication system to transfer this information.

“The ability to relay the data to the analytics system in real time is the first step in the move to industrialize predictive maintenance,” adds Evrard. He reckons that companies are usually keen to monitor their equipment and integrate the large volumes of data sourced from the IoT, so this first step is generally not an obstacle.
USING ANALYTICS TO AVOID BREAKDOWNS

According to Evrard, organizations already have plenty of experience in collecting operational data and storing it in a data lake using technologies like Hadoop, for example. Too often, however, they still tend to analyze their information using traditional business intelligence (BI) tools. These tools are not in the best position to create a predictive model, because they are content with measuring the aggregated data without truly analyzing it.

“When we support organizations during their predictive maintenance projects, the first step is to deploy the analytical functionalities in order firstly to discover and secondly visualize what is hidden in the data,” explains Sadaq Boutrif, senior technical leader at TIBCO Software.

“We can say that if a certain combination of circumstances re-occurs, there will be a 90% chance of it resulting in the same failure. The operator then tries to avoid a re-occurrence by using the software to test alternative scenarios for deploying the equipment,” says Boutrif. In industry, the prime objective is to avoid downtime as much as possible, even if this means adopting a temporary “downgraded” mode for this purpose.

Just from an IT perspective, Boutrif notes that most organizations tend to use a cloud-based analytics tool. These ready-to-run online services, which the customer doesn’t even need to install, combine the benefits of cloud-based analytics with pay-as-you-go pricing. This means that payment for using this solution is only required for the time spent by operators detecting faults. This model is not suitable for every scenario, however, especially where large volumes of data are involved and where confidentiality is paramount.

APPLYING THE MODEL IN REAL TIME

It is not enough simply to analyze previously recorded behavior, however.

“Organizations often use an analytics tool to find faults in their production line, and then ask their equipment provider to fix the machines in accordance with the fault-avoidance usage model. This is not the ideal course of action, however, because the faulty equipment might not have been the sole cause of the failure,” emphasizes Boutrif.

He reckons it is much more efficient to run the behavioral model through another kind of software, known as a streaming analytics engine. This will continue to search for indications of a future incident in the environmental data transmitted in real time.

“Analytics involves working with static historical data in order to determine behavior. Streaming analytics technologies are different because they probe new data in real time and trigger actions to limit risks as soon as they see the model(s) that lead(s) to an incident occurring,” he explains. In this case, these solutions will automatically trigger one of two actions: either direct action on the equipment itself (decrease the power of the motor, switch to rescue equipment, etc.), or notification of the personnel in charge of operation.

REGULAR REBUILDING OF THE MODEL

As we have seen, a predictive model is based on varying volumes of historical data and suggests a relevant response in a given context. This environment will evolve, however, especially if the model proves successful: it seems clear that the more time that passes, the less efficient the models will become.

“Take component A in a system that also includes component B. If you design a predictive model to anticipate failures of component A, you will optimize the maintenance windows and alter the interaction that A may have with component B. It is clear that the behavior of component B will change and that its risk of failure will be altered,” remarks Boutrif.
TIBCO Software’s streaming analytics solution is called TIBCO StreamBase. This platform enables the real-time execution of statistical models (R, MATLAB, etc.) on data transferred directly by operational sensors. Unlike retroactive analytics tools, the cloud continues to play a minor role here. But the arrival of standardized and powerful IoT communication protocols like Message Queuing Telemetry Transport (MQTT) or Constrained Application Protocol (CoAP) will benefit the roll-out of cloud models in the future.

He therefore advises regular validation of the predictive model’s relevance using the analytics tool. This will serve to adapt predictive maintenance to the new behavior and, secondarily, evaluate the operational improvements of the previous model.

“Analytics needs to be applied regularly at the point when the model processed by the streaming analytics engine is no longer efficient and as soon as enough new data has been gathered to improve this model or create another one,” he concludes, pointing out that the interval between these two models, ranging from several weeks to several months, depends on the organization’s activity.

DATA SCIENTISTS: THE ARCHITECTS OF PREDICTIVE MAINTENANCE

Data scientists are the ones who actually execute predictive maintenance. Their job is to create statistical models by manipulating the analytics tool. According to Boutrif, their input is vital for the success of a predictive maintenance project.

“When putting together a predictive model, automatically isolating the important parameters upon analyzing the data is not guaranteed. You need to make progress by iterations and make assumptions, which is only possible with the data science expertise that comes with statistical training,” he explains.

He notes that data scientist profiles are still encountered all too rarely within organizations.

“I expect them to become more common in the next three years, and not just within dedicated structures (which we see today), but also alongside operational teams when a new generation of graduates emerges from courses with a more digital than mathematical focus,” he predicts.

Until then, he encourages organizations to compensate for the lack of these profiles by turning to specialized service providers.

“The service provider will typically be a company with expertise in the statistical analysis of data. More and more of them are entering the market and they are the ones recruiting all the data scientists,” he concludes.

It is worth noting, however, that responsibility for integrating the predictive model into the streaming analytics engine falls within the responsibility of IT management.

Predictive maintenance relies on sensors that transfer on-site data to an analytics tool to selectively model possible incidents, and to a streaming analytics engine that continually monitors the risk of incidents.