# IOT – Fault Prediction Use Case

## Instructions

Danaher manufactures many types of devices, ranging from high definition microscopes to industrial printers to high performance filtration systems. As with all mechanical devices, on occasion these devices can fail. It is in the customer’s interest (and thus also Danaher’s interest) to minimize the occurrence and impact of these failures. In certain cases, data science methods can be used to predict when these failures might occur. Please consider the situation described below and describe in detail how you would approach the data science aspect of this problem. Consider questions like:

* What will be the data science process you would propose?
* What data science methods are most likely to be successful?
* How would you leverage the data?
* What challenges do you expect, and how would you solve them?
* What else should be considered?

Please submit your thoughts to the recruiter prior to the next round of interviews. You may submit questions via email. Note that the presentation that is part of the interview process is separate from this and should not be used to discuss your thoughts about this IoT problem.

## Problem description

A Danaher OpCo has about 1,000 connected devices that are located at customer sites. A fault on these devices can cause the device to be down for two or more hours. Faults occur, on average, about once a month per device. The objective is to predict faults far enough in advance such that action can be taken to avoid the fault. Typically, this is about 24 hours.

These connected devices stream two types of data back to the OpCo:

1. Synchronous sensor data – this data captures the value of about 50 sensors in the devices at regular time intervals (e.g. once per minute). Examples of values measured include voltages, currents, temperatures, rpms, and pressures. All records are timestamped.
2. Asynchronous event data – this is a log of events that occur on the device. Events logged include such things as: device or device subsystem started or shut down, user logins, system parameter changes, and system warnings and faults. The event records are time stamped and sent as they occur. There are several hundred event types.

On average, several years of data are available for each device.

* What will be the data science process you would propose?

Identify the business goal of the project. All business problems to be addressed which have to be streamlined. What is the goal to be achieved? How it is going to be achieved? Discuss in detail the technical feasibility and the resources available.

Feasibility study of the project, how data is to be collected, the rate at which data is to be collected ? Storage of the data? Inter connectivity issues as data has to be sent across the network using TCP/IP. How to deal with failures? How to prevent failures if any failures have occurred in the past. Identify sensors likely to fail. Fool fault proof has to be set up

Set and record a set of points that need to be followed to achieve the business goals.

This is done by following the best practices.

Studying of failures from other similar projects.

Identifying the bottlenecks.

A report has to be prepared to all stakeholders and should be agreed upon.

Setup the technical stack, ranging from data collection, data cleaning & data processing.

Adopting the right framework.

Building the right model.

Project should be data centric.

Propose the technical stack

Kafka – Storage of data , scalability , high availability and fault tolerant

Spark – Preprocess data at speed , scalability , high availability and fault tolerant

Data cleaning- Identify corrupted data

Pipeline- Build a pipeline that consist the above and keep monitoring

EDA – Analysis of data for better insights. Plot the data matplotlib, seaborn etc.

Models – Tested ML and Deep learning models. Build a baseline model. Build different models with best practices. Keep experimenting with more models.

Metrics – Compare the results of various metrics accuracy, recall, precision .MSE, RMSE, silhouette coefficients, Dunn’s Index, reconstruction loss etc

MLOPS- Build an automatic platform for regular ML experiments, versioning, monitoring and deployment. Integrate with Devops if application is part of a larger application.

Keep monitoring.

* What data science methods are most likely to be successful?

statistical and mathematical approaches for accurately extracting quantifiable data are most likely to be successful. technical and algorithmic approaches that facilitate working with large data sets, using advanced analytics techniques and methodologies that tackle data analysis from a scientific perspective; and engineering tools and methods that can help [wrangle large amounts of data](https://searchenterpriseai.techtarget.com/feature/Data-preparation-for-machine-learning-still-requires-humans) into the formats needed to derive high-quality insights.

Relationship of data

Data science techniques such as classification , regression & clustering all has to be considered.

Classification – classify whether a IOT device will fail or not based on historical data

Regression – Predict the highest voltages, currents, temperatures, rpms, and pressures , this can help in arriving at a base number and the variances all variables can be subjected to. This way any value falling outside these ranges is the first level alert that can save from failure.

* How would you leverage the data?

Data ingestion, data storage, data cleaning, data preprocessing, data understanding are the main points to leverage the data.

All the above steps have to be performed on a daily basis, recorded and identified how many corrupted data is expected on a daily , hourly, minutely basis this can be achieved in the cleaning process.

Outliers should be detected sooner than earlier this is a red alert on something has gone wrong.

Data comparison from historical data and current data. This can be achieved by plotting various density graphs, cluster graphs, pairwise graph etc.

* What challenges do you expect, and how would you solve them?

Challenges would come mostly from two sources. Reliability of the sensors functionality.

And connectivity issues due to network related problems. As network is sometimes unreliable.

Sensors malfunctioning is a recurrent problem. Perform a hypothesis testing on the sampling of devices.

Ensure high performance network connectivity. TCP/IP has to be used as against UDP. Reliability is more or faster delivery is priority has to be observed.

* What else should be considered?

Scalability issues, high availability, fault tolerant system.

**Why do IoT Projects Fail?**

by [Robin Duke-Woolley](https://www.sierrawireless.com/iot-blog/#/?a=robin duke-woolley), Founder and CEO, Beecham Research Ltd

May 05, 2020

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The IoT provides companies with the opportunity to gather data from a wide variety of assets and then transmit it, via the Internet, to cloud-based or other IT systems. Companies can then use this data to reduce the assets’ downtime, streamline their business processes, offer new services that increase their revenues, and otherwise transform their businesses.   
  
However, despite the promise of the IoT, and the success of many IoT projects, there have also been a large number of IoT project failures. These failures have led many companies to ask themselves what they got wrong with their IoT projects, and what they can do differently in the future to ensure their IoT projects are successful.  
  
To help address these questions my firm, Beecham Research, recently published a new report titled [“Why IoT Projects Fail.”](https://www.whyiotprojectsfail.com/)  
  
As one of the results from the online survey we conducted for this report demonstrates -- 58% of the respondents to the survey stated that their IoT project was either mostly unsuccessful, or wholly unsuccessful, with a further 30% stating their projects were ‘mostly’ successful but not entirely so -- the question of why IoT projects fail is of great importance to the large and growing number of companies who want to adopt IoT. It is also very relevant to the IoT companies who are providing these IoT adopters with the [embedded modules](https://www.sierrawireless.com/products-and-solutions/embedded-solutions/gnss-positioning-modules/), [IoT gateways](https://www.sierrawireless.com/products-and-solutions/routers-gateways/), [smart connectivity services](https://www.sierrawireless.com/products-and-solutions/sims-connectivity-and-cloud-services/), [edge-to-cloud solutions](https://www.sierrawireless.com/octave/) and the other solutions they need to bring these projects to fruition.  
  
In the report we reviewed a wide variety of IoT industry sources and surveys to see what they had discovered regarding the reasons for IoT project failures. We also interviewed and surveyed IoT adopters, IoT solution providers and other IoT experts to understand their perspective on why many IoT projects do not live up to expectations, and why those projects that do succeed, do so.  
  
What we found is that there are four high level reasons why IoT projects fail, with a series of lower level reasons:

* Business aims for the project are not thought out
* Company organizational issues arise
* Unforeseen technological problems emerge
* Customer and vendor problems come up

**IoT Project Business Aims Not Thought Out**

Unclear business objectives were a major reason for IoT project failure. This confusion resulted in IoT adopters not understanding what the project needed to accomplish from a technical perspective, in order to meet the company’s business objectives. In addition, our research found that many IoT adopters wanted to be seen as embracing IoT technological developments for the sake of keeping up with market trends, and failed to understand all the complexities involved in actually building and commercializing an IoT application.   
  
Following the launch of an IoT project, many companies also had no clear roadmap for how to evolve, scale, or otherwise move the project forward over time. In fact, we found that in many cases projects were running for several years before management recognized the project was not delivering significant benefits to the company and should be cancelled or revised.   
  
One key takeaway from our research on how first-time IoT adopters can avoid these and other problems? They should start small, with early tests to ensure that the project will realize the business objectives envisioned for it.

**Company Organizational issues**

In a wide number of cases it is not technical challenges (which can usually be solved given sufficient time and money) which lead to IoT project failure, but rather business and organizational related issues.

For example, different business units within a company might have different perspectives on an IoT project, inhibiting the project’s progress. In particular, with complex projects involving many different business departments or other units, resistance to change by one of the units can lead to the project’s failure. Many first-time IoT adopters also experienced difficulties when they tried to integrate new IoT practices with their older-established, legacy business practices.

What all these issues point to is that IoT adopters need to foster close collaboration between all the technical, managerial, partner, and other groups working on their IoT project if they hope for it to succeed.

**Unforeseen Technological Problems**

Technological problems that were not identified at the start of an IoT project is another one of the main reasons why many IoT projects fail. In particular, our research showed that IoT adopters often fail to appreciate the complexity of the connectivity part of an IoT application. For example, in an online survey we conducted of 25,000 IoT adopters/buyers managed by the [IoT M2M Council (IMC)](https://www.iotm2mcouncil.org/" \t "_blank) virtually all respondents identified connectivity issues – coverage, reliability, bandwidth, latency – as significant technical challenges.  
  
One of the reasons for this is that first-time IoT adopters that are accustomed to setting up wireless networks at their offices or other facilities, tend to believe IoT application connectivity is a simple matter of plug and play, not understanding that wireless devices were not designed with IoT in mind and that “wireless IoT” can be complex and needs proper planning. For example, scalability with these devices can be a problem as IoT adopters find they need different technologies to expand their IoT application from say 100 sensors, to hundreds of thousands of sensors. Additionally, IoT adopters may find that some connectivity technologies do not provide the wireless coverage they need to connect to edge devices located in remote rural areas, deep inside buildings, or underground. If they assume they will be able to do so and roll their project out anyway, when they encounter this problem it can and indeed has led to project failures. Some examples of this happening are highlighted in our report.

The lack of one universal worldwide network also causes issues, with IoT adopters finding they need to forge agreements with multiple mobile network operators (MNOs) around the world to achieve full coverage. One solution that some IoT adopters are using to address this particular challenge is to work with a connectivity provider who can provide them with worldwide coverage. These types of IoT-focused connectivity providers can deliver global coverage thanks to their agreements with multiple MNOs, and their ability to provide customers with an embedded SIM (eSIM) that can connect customers’ edge devices to all the networks they have agreements with.

**Customer and Vendor Problems**

A variety of problems with customers and vendors can lead to IoT project failure. Some IoT solution providers have unrealistically raised IoT adopter expectations, or over-hyped the capabilities of their products. Meanwhile, it can be difficult for IoT adopters to secure informed guidance on how to align their IoT project with their business objectives, or find help in determining the real-world feasibility and expected return on investment of their IoT projects.  
  
Another key problem identified in the published surveys we reviewed, as well as our own research with live interviewees and online respondents, is that insufficient IoT skills are a key contributor to IoT project failure. For example, 96 percent of respondents in our online survey cited sufficient expertise as being significant or very significant to project success. If they want their IoT projects to be successful, IoT adopters need to find a way to either acquire these IoT skills, or find IoT solutions that allow them to avoid the need to acquire these skills themselves.

**With the IoT Start Small, Then Learn, Evolve, and Expand**

While the problems above have led to many IoT project failures, it is important to keep in mind that the IoT is still relatively young, with many IoT adopters still considering themselves to be at the ‘innovation stage’ of their IoT-driven digital transformation.   
  
In addition, the IoT adopters we interviewed directly have a good idea of what business and technical challenges they must overcome if they want their IoT projects to succeed moving forward. They think that, by utilizing the lessons learned from their own and others’ IoT experiences, they can successfully deploy IoT applications that allow them to improve operational efficiencies, reduce costs, launch new business models, and improve their asset utilization.

Overall, and as emphasized in our report, the IoT has enormous business potential and in many cases is being implemented successfully. What this report indicates is that IoT solutions are complex with potentially lots of “moving parts.” As such, they need to be set up and managed carefully and with flexibility in mind. Also, they primarily affect operations activities and therefore should be field tested quickly and aggressively.

IoT is still in its early days. By learning from past experiences, this report aims to contribute knowledge in the hope that future surveys can point to higher levels of IoT project success.

**Related blogs:**

* [Leveraging the IoT to Deliver Innovative In-store Video Experiences](https://www.sierrawireless.com/iot-blog/iot-in-store-video-experiences/)
* [Smart Connectivity Delivers Flowbird Business-Critical IoT Connectivity](https://www.sierrawireless.com/iot-blog/smart-parking-solutions/)
* [What Impact Will 5G Have on Mobile Applications?](https://www.sierrawireless.com/iot-blog/5g-mobile-applications/)

<https://github.com/zhoushengisnoob/DeepClustering>

<https://github.com/HIK-LAB/Unsupervised-Image-Classification/blob/main/main.py>

<https://github.com/khangich/machine-learning-interview/blob/master/appliedml.md>

<https://github.com/DreamOfTheRedChamber/behavior-questions-answers#a-story-for-each-bullet-point-on-resume>

<https://github.com/yukimasano/self-label>

https://github.com/wvangansbeke/Unsupervised-Classification

https://github.com/ZhiyuanDang/NNM

https://github.com/yxgeee/SpCL