# Welcome! We will begin shortly

## Mentored Learning Session

**Beyond the Numbers**

### Learning Outcomes

- Explore pressing problems of different timelines and their solutions
- Appreciate the evolution of inferential and computational paradigms over the years
- Understand the impact of early data science methods on development of newer advanced technologies
- Gain insights on diverse applications of data science

**Guidelines**

Listen only mode

Ask questions at the interest of the larger audience


Questions in the Q&A Box

**Thank you**

Kindly utilize the chat box for **subject-relevant questions only** to maximize your learnings from the session.
Your **questions** are being managed by the academic team, and they will be **answered**

# Summarizing the week's learnings

- Early civilizations made use of decisions to solve critical problems that impacted the growth and sustenance of the community
- Data Science involves the amalgamation of two paradigms - the inferential and computational paradigms
- The Inferential paradigm focuses on the statistical methods for analysis, while computational paradigm focuses on computational methods and algorithms
- Data Science has evolved from simple probabilistic models and primary computers in the early 1950s to highly advanced inference methods and computing in 2020s
- The developments in inferential and computational paradigms act as catalysts that propel further advancements in these categories, as the evolution continues

# 1940s to Late 1960s

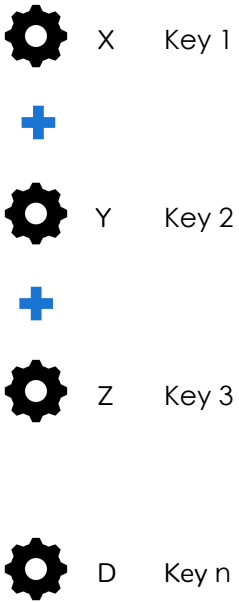
# Breaking the Lorenz Cipher

# Breaking the Lorenz Cipher

**Lorenz Cipher** - German **Encryption system** used in World War II

HELLO

Input message




A key is assigned to each rotor at the start, which encrypts the input and transmits to receiver

MYRXT

Output message

As the message is typed, the rotors move, encrypting each character with a different character

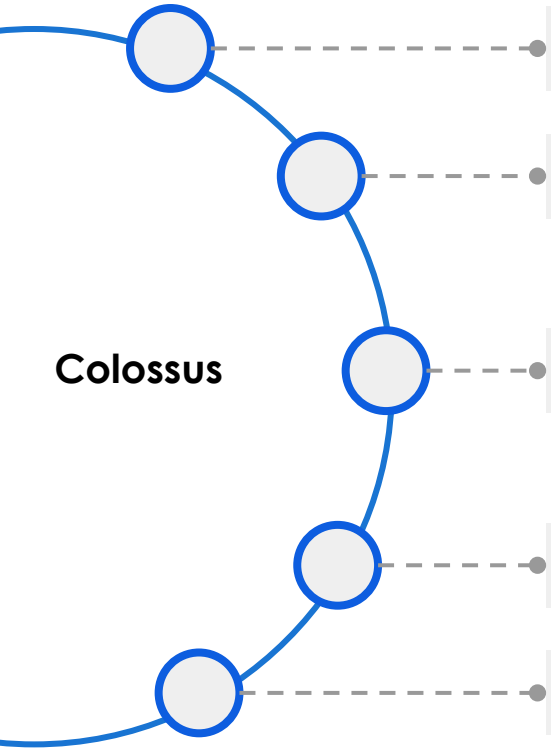
# Breaking the Lorenz Cipher

## What were the problems?

| | |
|---|---|
| **Complexity** | The Lorenz system comprises of gear wheels that rotate at high speeds making the decryption process difficult |
| **Length of Messages** | As the length of the input message increases, more characters need to be analysed for decryption |
| **Lack of input knowledge** | No part of the input message is known to decrypter beforehand, making it difficult to decrypt |
| **Manual Decryption** | Decryptors have to manually identify patterns in cipher, making it error prone and time consuming |
| **Limited computational power** | Decrypting the message involved high computational power, to identify keys used and the patterns in the message |

# Breaking the Lorenz Cipher

## How was it solved?




**Brute Force attack**

Trying every possible combination of settings until the correct one was found

**Chi-Squared Test**

Difference between the frequency distribution of the letters in the ciphertext and the expected frequency distribution

**Boolean algebra**

Binary codes representing the ciphertext and the possible key values were compared to determine if they produced the correct plaintext

**Statistical Analysis**

Analyzing the distribution of letters, words, and phrases in the ciphertext to identify recurring patterns

**Machine Learning**

"Learned" from its previous attempts and adjusted its settings accordingly.

# Breaking the Lorenz Cipher

## What was its impact?

| | |
|---|---|
| **Allied victory** | Enabled intercepting and decrypting German high-level military communications |
| **Modern cryptography** | Development of the first public-key cryptography methods |
| **Versatility of computers** | Provided an early example of the power and versatility of electronic computers |

# 1970s to Late 1980s
# Global Forecast System

# Global Forecast System

## What were the problems?

- Inaccurate forecasts
- Lack of Global coverage
- Slow Data Processing
- Poor Data Quality

- Difficulty in predicting natural disasters
- Inadequate warnings
- Inefficient disaster management

# Global Forecast System

## What is the Global Forecast System?

**Global Forecast System**

- Developed by **National Oceanic and Atmospheric Administration** in **1985**
- Produces medium level weather forecasts upto **16 days in advance**
- Uses a combination of **statistical** and **computational methods**
- Creates a **3-Dimensional** representation of **atmosphere** based on data from different sources
- Provides **detailed forecasts** on various weather parameters like **temperature, precipitation, humidity**

The Global Forecast System brought about a shift in weather prediction, from reliance on atmospheric science to mathematical simulation of atmospheric conditions for forecasting

# Global Forecast System

## What are the Data Science techniques involved?

| | |
|---|---|
| **Numerical Weather Prediction** | Mathematical models and physical equations that simulate atmosphere |
| **Data Assimilation** | Combines data from weather balloons, ocean buoys, satellite data with NWP for accurate representation of atmosphere |
| **Ensemble Forecasting** | Multiple forecasts by slightly changing input parameters - accounts for uncertainty |
| **High Performance computing** | Supercomputers capable of performing trillions of computations per second |

# Global Forecast System

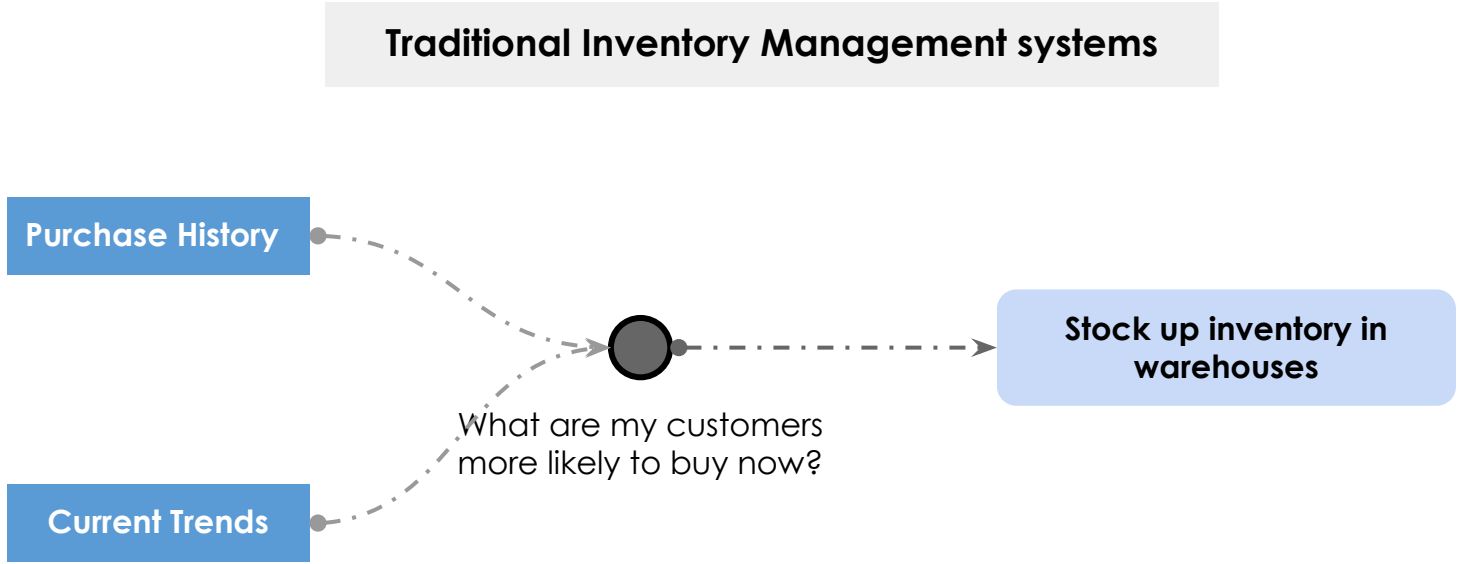
## What was its impact?

- Highly accurate and reliable forecasts
- Better planning and disaster management
- Reduced damage to resources

# 1990s to Late 2000s
# Amazon’s Anticipatory Shipping

# Anticipatory Shipping

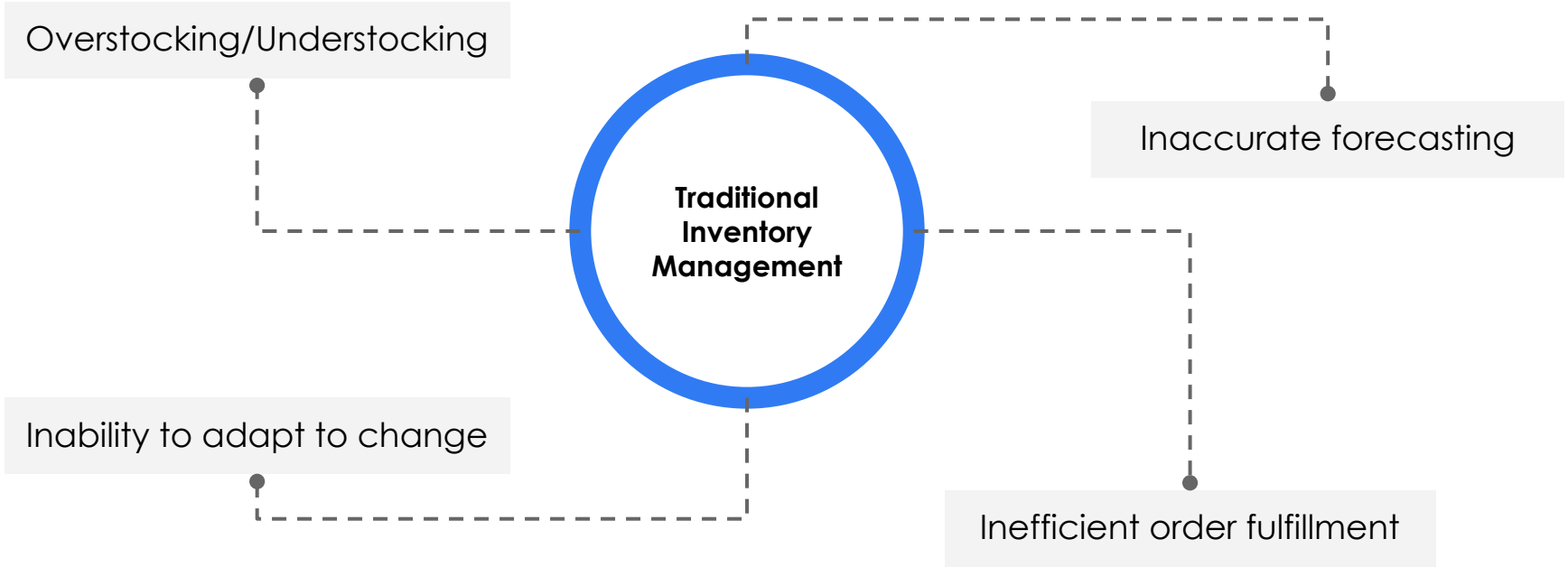
## What were the problems?




Traditional inventory management systems restocked on products only after inventory dropped to a certain threshold - after a customer buys a product

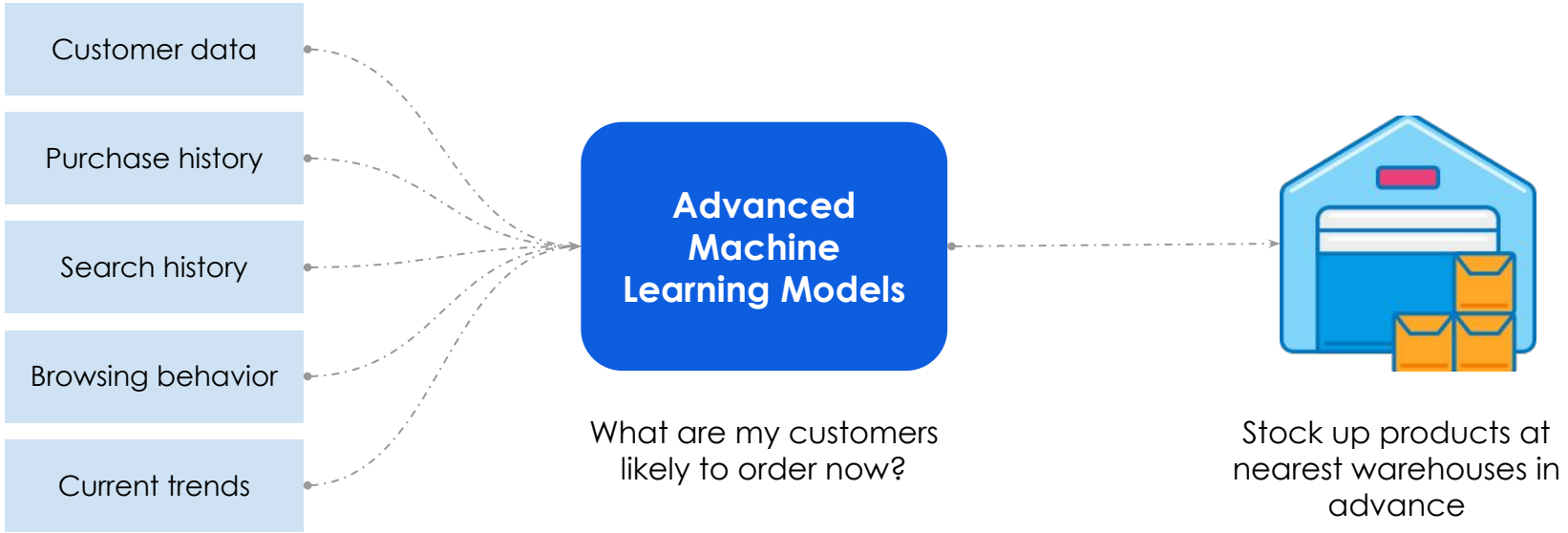
# Anticipatory Shipping

## What were the problems?



# Anticipatory Shipping

## What was the solution?



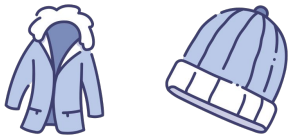

Amazon's Anticipatory shipping system used vast data to predict products most likely to be bought, and made them available at the nearest warehouses for faster delivery

# Anticipatory Shipping

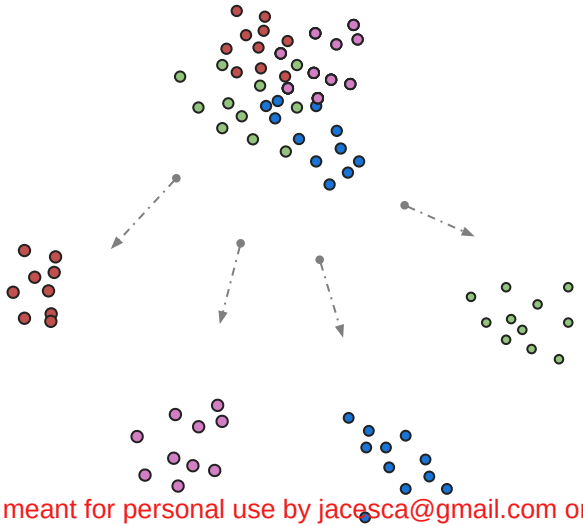
## What were the data science techniques used?

| Collaborative Filtering | Clustering | Decision Trees |
|---|---|---|

X buys

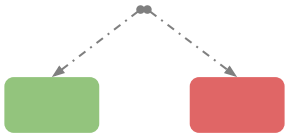


The website recommends



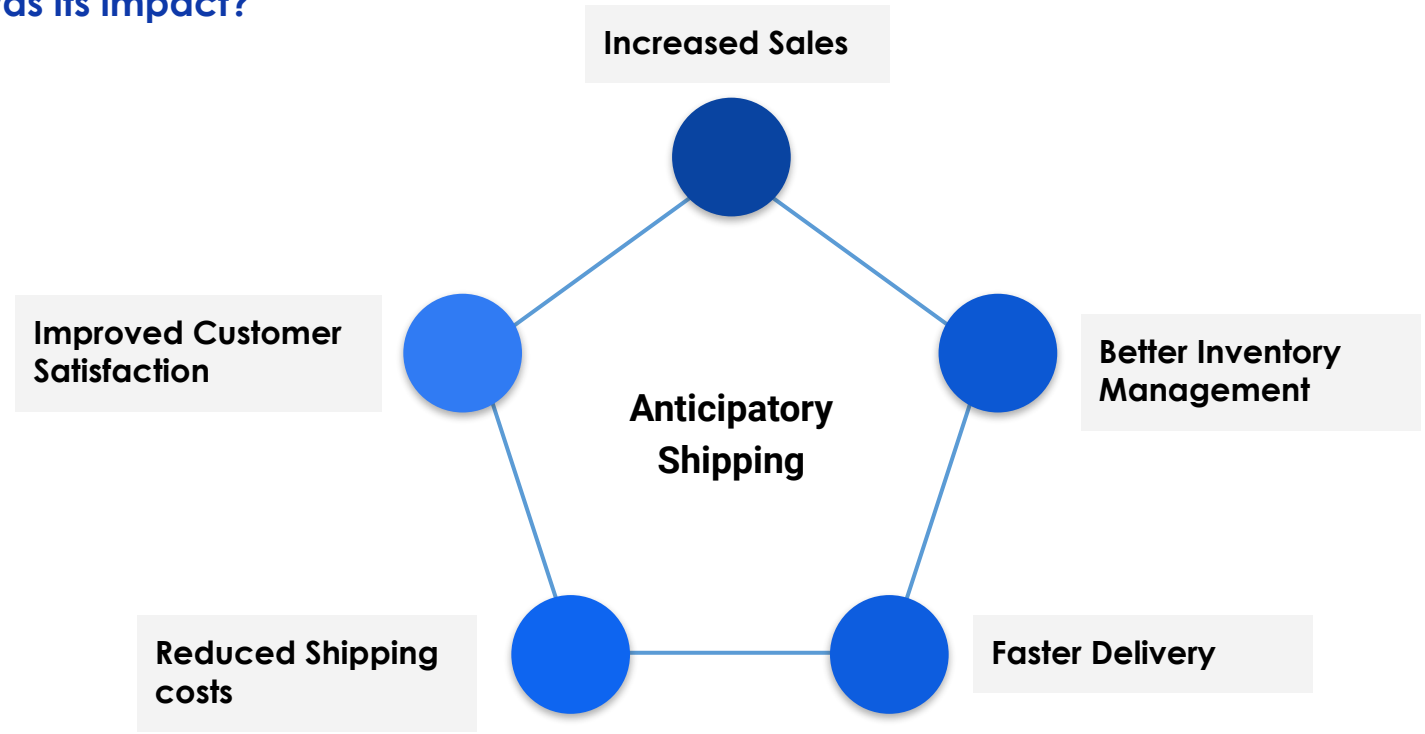
Based on X's purchase patterns

Will they buy these products



# Anticipatory Shipping

## What was its impact?



## 2010s to 2020+

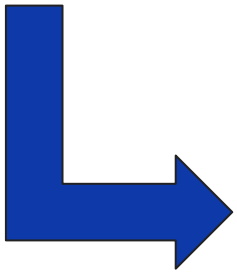
# Aircraft Predictive Maintenance

# Predictive Maintenance

## What were the problems?

**Reactive Maintenance Model**

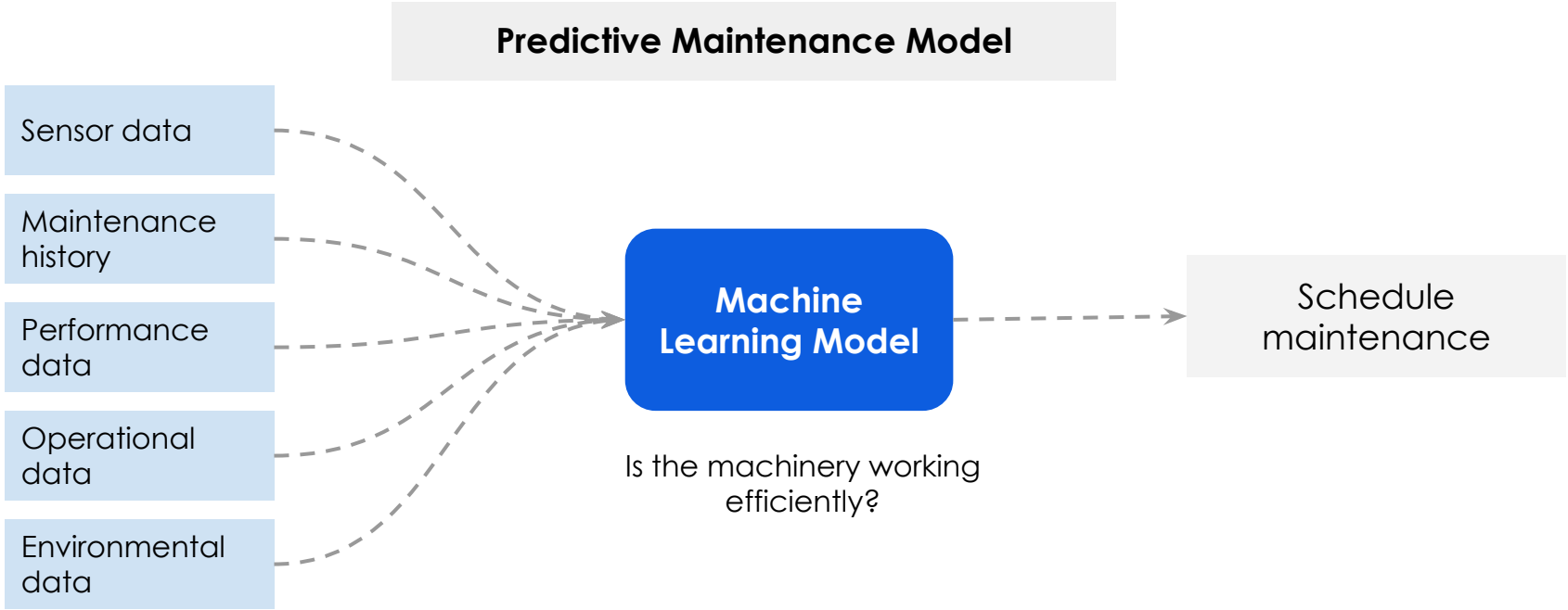
Equipment would be serviced/ replaced only after failure



- Unplanned downtime
- Over-servicing of machinery
- Decreased productivity
- Increased costs

# Predictive Maintenance

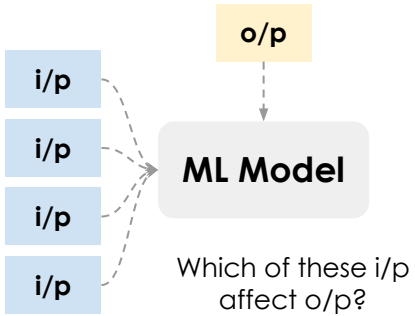
## What was the solution?



# Predictive Maintenance

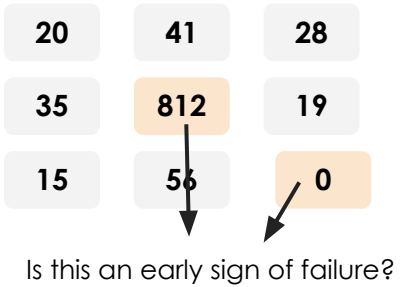
## What are the Data Science techniques involved?

### Regression Analysis




**Monitor variables that are most correlated with failure regularly**

### Anomaly Detection



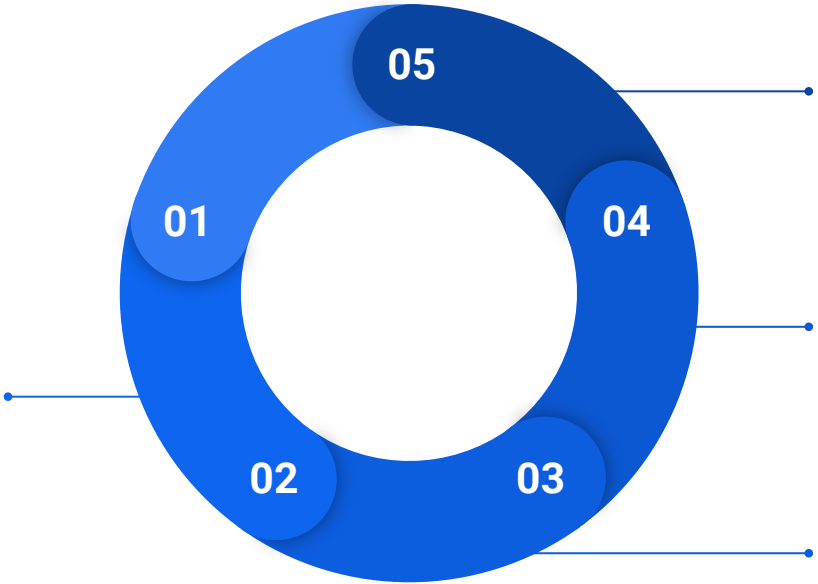

**Identify data points that differ significantly from normal values**

# Predictive Maintenance

## What was its impact?

Improve equipment performance.

Optimize maintenance schedule.




Proactively schedule maintenance and repairs

Reduce downtime and maintenance costs

Improves equipment safety and reliability

# Summary

- Data Science has been instrumental in solving critical problems of different eras, which in turn transformed humanity by leaps and bounds
- Colossus displayed the combined power of influential and computational paradigms in breaking the Lorenz code, thereby helping Allies win the WW2
- Global Forecast System laid the foundations for accurate forecasting, through notable data science techniques that helped in effective disaster management
- Anticipatory Shipping, by using powerful Machine Learning and statistical algorithms, helped break the dependency on traditional inventory management and revolutionize online shopping
- Predictive Maintenance transformed the aviation industry, by accurate and efficient identification of anomalies, which in turn helped reduce accidents and ensure better performance of machinery

Great Learning

# Happy Learning !