C3.ai

Enterprise AI for Predicting HVAC Chiller Failures

The building systems division of a Fortune 500 manufacturer provides equipment and services that enable customers to maintain comfortable conditions while optimizing building energy expenditures. The division required a reliability solution that would allow it to reduce downtime and costly, unscheduled maintenance for its commercial Heating, Venting & Cooling (HVAC) chiller systems.

The manufacturer deployed C3 AI® Reliability for 165 of its chillers to address these objectives. The customer selected C3 AI for its proven ability to rapidly integrate sensor data, normalize and cluster disparate readings, and run machine learning algorithms to identify deteriorating conditions before failures occur.

C3 AI Reliability analyzes sensor, maintenance, equipment, facility, and customer data across a portfolio of buildings and uses machine learning techniques to identify equipment operating outside of expected parameters. Based on these operating conditions, the application predicts the probability of equipment failure and enables operators to effectively plan maintenance work based on business priorities, including cost of downtime and customer satisfaction.

In 4 days, C3 AI and the customer loaded, normalized, and mapped 3 years of sensor data for all 165 chillers, created custom analytics on these data, and configured a machine learning algorithm to predict chiller failure events. C3 AI Reliability exceeded the identified accuracy and precision targets.

Project Objectives

- Load and cluster sensor data for use in a predictive model
- Train a machine learning model to predict chiller failure
- Demonstrate speed of development and deployment by completing project in < 1 week

Results

$178M
Annual benefit identified

4 Weeks
To project completion from receiving data to model delivery

73%
Model precision[1]

71%
Model recall[2]

1. True positives / Total predictions
2. True positives predicted / Total events

Challenge

Historically, the building systems conducted chiller maintenance reactively. This created several challenges, including business disruptions and downtime, costly emergency repairs, and reduced customer satisfaction. The manufacturer was in search of a solution that could enable the rapid integration of all relevant equipment and facility data sources and deploy machine learning algorithms to predict failure before it occurred. This would enable the group to align maintenance resources, precisely forecast equipment inventory, and reduce overall equipment downtime.

The state of the manufacturer's sensor data represented a significant challenge towards achieving this goal:

- First, the company did not have a comprehensive mapping of assets, sensors, and measurements (e.g., temperature, pressure, control signals) across its chiller fleet
- Second, sensor-chiller mappings were internally inconsistent across the chiller fleet (e.g., sensor 1 from chiller 1 and sensor 1 from chiller 2 did not measure the same metric)

Without these mappings, the company was unable to isolate signals in its sensor data
to indicate impending failures, which would have allowed it to align maintenance and spare-parts resources to remediate with minimal downtime.

The company maintained at least 3 years of data for each sensor, with data at 1-minute, 5-minute, and 15-minute intervals. Overwhelmed by the complexity and disorganization of these readings, the company had resorted to conducting costly, time-based and reactive maintenance for these high-value assets.

About the Customer

- Global equipment manufacturer and services company
- 100,000 employees
- $30 billion in revenue
- Building systems division provides equipment and services that enable buildings to efficiently maintain comfortable conditions

Project Highlights

- Configured C3 AI Reliability in 4 days
- Loaded 3 years of sensor data for 165 HVAC chillers (40-50 sensor feeds per chiller)
- Developed 163 analytics as inputs for failure prediction algorithm
- Trained and tuned a machine learning model to predict chiller failures with 73% precision and 71% recall

Approach

The manufacturer set an aggressive goal to test C3 AI's ability to deliver value rapidly, giving C3 AI one week from data delivery to demonstrate predictive failure model results.

C3 AI used 3 kinds of data to develop a failure prediction model:

- Chiller data from 7,500 sensors, arriving in varying time intervals
- Failure event information (e.g., time, location, and type of failure)
- Publicly available weather data

Over the course of one day, the C3 AI team integrated this data into the C3 AI Suite, using native functionality to normalize and interpolate misaligned time series data.

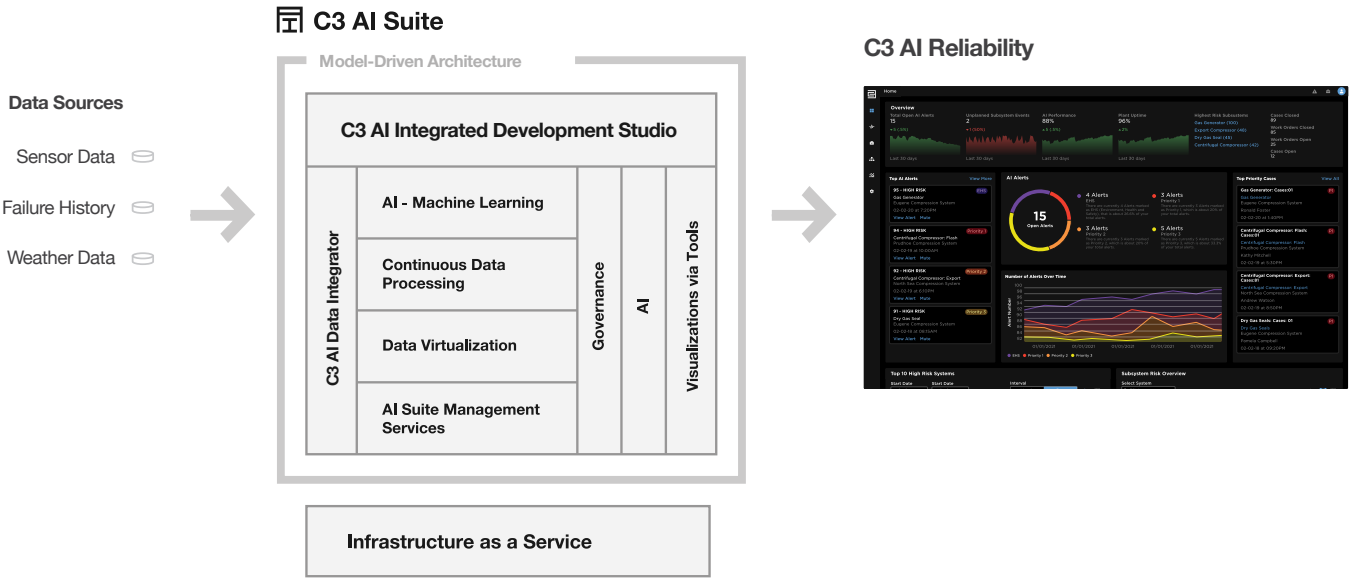
Next the team rapidly iterated on different statistical approaches to group sensors from across the fleet according to their behavior. This approach enabled the team to create over 700 features for a machine learning model without going through the process of hand-mapping sensors to building assets, a task which would have consumed weeks and which could not have been scaled up for the company's global fleet of chillers. On the C3 AI Suite, sensor correlation and feature generation took one day.

Next, C3 AI configured a machine learning model to predict chiller failure. The final model incorporated 163 features most associated with failure, including weather signals, pressure and temperature readings, and asset operating history. The model also incorporated a closed-loop system that enabled it to improve based on feedback from the field—meaning operators would benefit from increasingly-accurate predictions for their specific equipment operating environments.

Finally, C3 AI tested the algorithm's performance on operational data. The model achieved 73% precision and 71% recall, both of which exceeded the manufacturer's target ranges. With further tuning, model precision and recall will improve further.

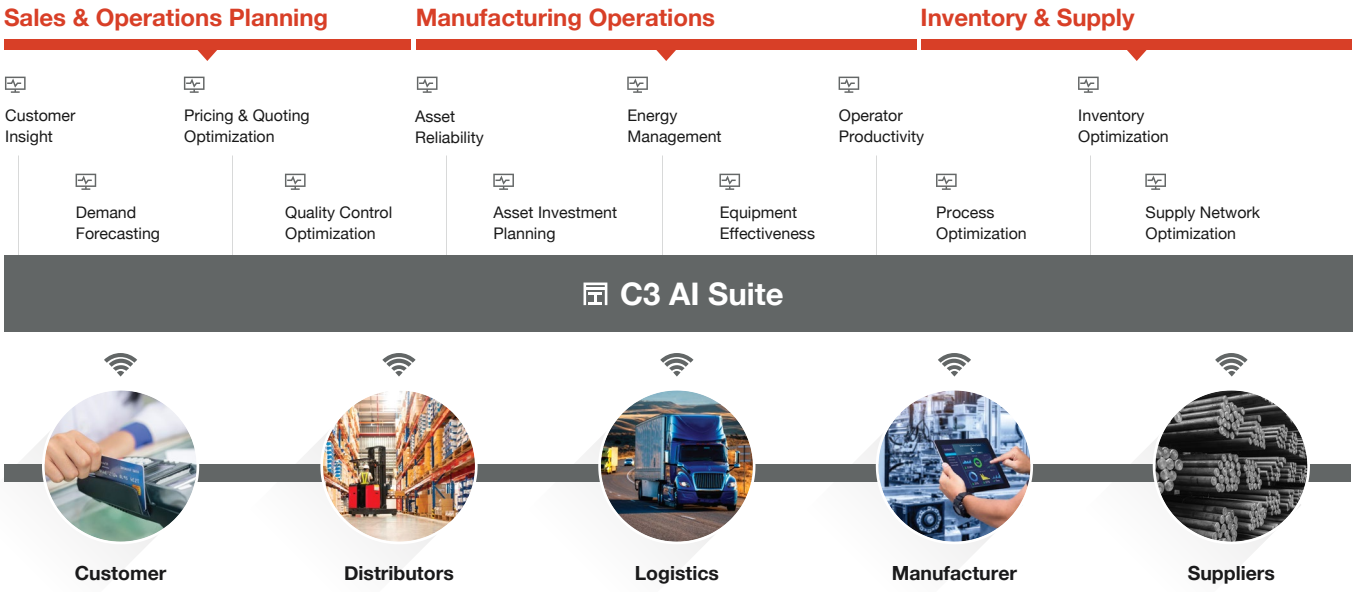
Additional features which can be deployed as part of C3 AI Reliability include:

1. Algorithms for free text analysis of maintenance and work order notes and comments. This enables C3 AI Reliability to correlate machine-predicted results with operator observations.
2. Unsupervised algorithms for anomaly detection. This enables C3 AI Reliability to detect performance aberrations even in previously unobserved operating conditions.



Enterprise AI for Manufacturing

The C3 AI Suite provides the necessary, comprehensive services to build enterprise-scale AI applications up to 40 times faster than alternative approaches. The C3 AI Suite uses all relevant data sources to rapidly generate predictive insights, enhance grid asset management and forecasting systems, boost energy efficiency initiatives, and enrich customer engagement. Many of the largest global utilities are already using the C3 AI Suite to drive their digital transformation efforts, generating hundreds of millions of dollars in economic value annually.



C3 AI manufacturing applications are built on the C3 AI Suite and use AI at scale to provide ever-smarter actionable insights for business-critical challenges. These applications include:

C3 AI Reliability

Increase operations and equipment uptime by anticipating equipment risks using a system of systems approach. Unsupervised deep-learning algorithms leverage the unified data to identify anomalies and recommend prescriptive actions. Actionable insights increase production, reduce unplanned downtime, and improve safety in operations.

C3 AI Inventory Optimization

Reduce inventory holding costs, improve cash flow and supply chain visibility, and increase the productivity of inventory analysts. C3 AI Inventory Optimization uses advanced machine learning to analyze variability in demand, supplier delivery times, quality issues, and product line disruptions to build real-time recommendations for users to optimize operations by confidence level and receive real-time notifications and root cause analysis.

C3 AI Production Schedule Optimization

Optimize planning and scheduling across manufacturing and distribution operations using advanced AI and machine learning. C3 AI Production Schedule Optimization generates dynamic manufacturing and distribution plans and optimal industrial schedules using a holistic view of customer demand, supply chain, manufacturing, and distribution.

C3 AI CRM for Manufacturing

Grow revenues, maximize customer lifetime value, prevent customer churn, and increase customer satisfaction. C3 AI CRM for Manufacturing unifies all available enterprise and extraprise data and uses advanced machine learning algorithms to prioritize leads, recommend new product offers, detect clients at risk of churn, and drive more accurate revenue and product forecasts.

C3 AI Process Optimization

Improve throughput and product quality by applying advanced machine learning to complex discrete, batch, or process manufacturing data in order to pinpoint process opportunities to identify defects early on and improve production yield.

C3 AI Energy Management

Reduce energy costs through real-time tracking, analytics, and optimization. C3 AI Energy Management uses machine learning techniques to enable accurate forecasting, benchmarking, demand response, and anomaly detection to lower costs, improve operations, and meet energy efficiency and sustainability goals.

Proven Results in 8-12 Weeks | **Visit c3.ai/get-started**