Transformer Failure Prediction: an AI Solution

ORGANIZATION

Our client is a Fortune 500 energy company serving 3 million customers across multiple states in the USA. They operate more than 24,000 megawatts of generating capacity and own approximately 122,500 circuit miles of distribution and transmission lines over a 91,000-square-mile service area. Their goal is to be a market leader by improving operational efficiency and customer satisfaction through AI solutions.

CHALLENGE

To enhance operational efficiencies and customer satisfaction, the client's Power Delivery business unit aimed to effectively predict distribution transformer failures using Advanced Metering Infrastructure (AMI) data. This predictive ability would allow for proactive transformer replacement, reducing customer power outages.

XTIVIA partnered with the client and provided expertise to implement a turnkey data and AI solution. The technical challenges encountered included:

- The need for AMI and master data to build a predictive AI product.
- Handling massive data volumes, with millions of AMI rows requiring a robust data engineering solution.
- Data being available in multiple formats and stored in various databases and file systems.
- Assets' master data, including transformers, meters, feeders, and network/region data, were housed in an Oracle Database.
- The challenge of provisioning AMI data in real-time due to its sheer volume.
- Modeling massive AMI data for transformer failure prediction.

AI SOLUTION

The client's business team sought a cloud-based AI solution that could rapidly innovate and provide the best service by connecting multiple data sources to create a predictive product for transformer failures. This solution would help reduce power outages by enabling proactive maintenance and replacement of transformers.

XTIVIA provided expertise in data engineering and data science to design and develop an AI product. This product used an analytics development methodology to measure voltage on customer meters and develop an algorithm that detects voltage spikes above the transformer's nominal range. Early detection of these spikes allowed for targeted replacement or maintenance of transformers.

Theory Behind the Model:

- Voltage spikes above the transformer's nominal range can indicate potential failure.
- Such spikes could result from winding failures within the transformer.
- Early identification of these spikes enables targeted maintenance or replacement.

PRODUCT DEVELOPMENT APPROACH

Step 1: Data Collection and Aggregation

- Collect, aggregate, and load AMI data to a data lake from the Meter Data Management System.
- Load asset mapping data to the data lake.
- Clean, prepare, and manipulate data as needed to train the model.

Step 2: Threshold Detection & Model Training

- Identify the right voltage spikes and their duration using multiple test datasets to train models.
- Review model results with the product team and refine thresholds for overvoltage identification.

Step 3: MVP Launch

- Soft launch the MVP using Excel report output and distribute to the business.
- Review and refine results with the product team and prepare a roadmap for full product development and launch.

Step 4: AI Product Deployment

- Deploy the AI product.
- Automate detection of meters with spikes above identified thresholds (e.g., 6% continuous for 24 hours, 20% continuous for 6 hours).
- Identify transformers based on meter-transformer relationships from asset mapping data.

Step 5: Model Output

- Create a Power BI dashboard with identified meters and transformers, including a map view of the data.
- List affected transformers based on overvoltage and continuous spikes, showing spike durations.

Step 6: Action

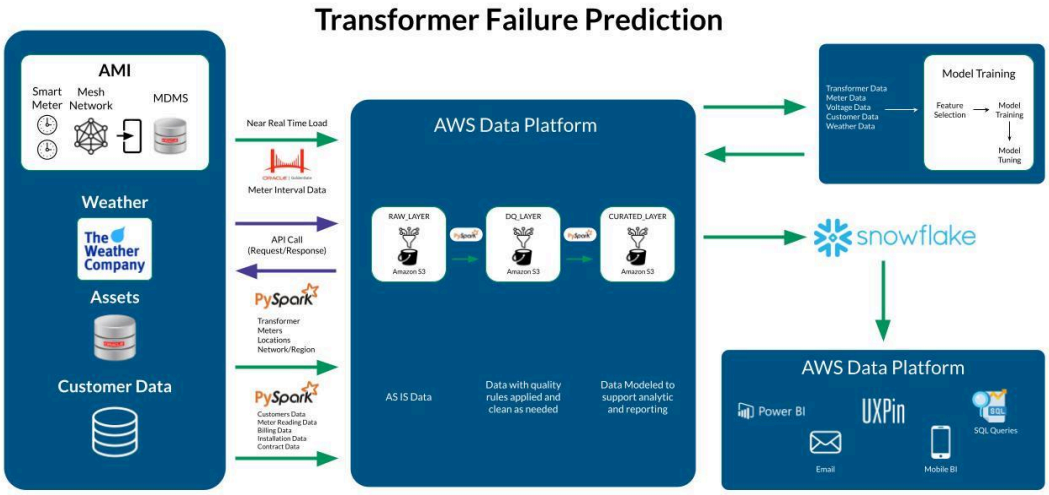
- The network team verifies and prioritizes the list for field inspections of identified assets (meters and transformers).
- Plan for transformer replacement as needed.

Step 7: Product Soft Launch and Full Dashboard Deployment

Step 8: Rollout

- Roll out the product for multiple networks, different transformer types, and downstream & upstream assets using a similar methodology.

ARCHITECTURE & DATA FLOW



BUSINESS RESULT

Through our client's project, XTIVIA found new ways to make AI products more effective and collaborative. The implementation of transformer failure prediction yielded significant improvements in both customer satisfaction and operational efficiency for the client.

Customer Satisfaction:

- **Reduced Customer Outage Minutes:** The AI product's ability to predict transformer failures before they occur led to a notable reduction in outage duration. On average, the project reduced outages by 90 minutes per customer. When scaled across the entire system, this equated to avoiding hundreds of thousands of outage minutes annually, significantly enhancing customer satisfaction.
- **Prevention of Equipment Damage:** By identifying and addressing continuous over/under voltage conditions, the AI product prevented potential damage to customer equipment. This proactive approach helped in reducing customer claims related to equipment failures, thus enhancing customer trust and satisfaction.
- **Improved Outage Notifications:** The accurate mapping of assets enabled better and more precise outage notifications to customers. This improvement in communication allowed customers to better prepare for potential outages, further enhancing their overall experience.

Operational Efficiency:

- **Proactive Maintenance:** The AI product facilitated the early identification of transformers at risk of failure, enabling the utility to undertake proactive maintenance. This approach reduced the frequency of unexpected transformer failures and extended the lifespan of the assets.
- **Effective Crew Utilization:** By prioritizing the replacement and maintenance of high-risk transformers, the AI product optimized crew deployment. This efficient use of resources ensured that maintenance activities were targeted where they were most needed, reducing downtime and operational costs.

- **Training Opportunities:** The insights gained from the AI product highlighted areas where crew training could be improved. This led to the identification of training gaps and opportunities, enhancing the overall skill set of the maintenance teams and ensuring better installation and maintenance of assets.
- **Correct Mapping Errors:** The implementation of the AI product also helped in identifying and rectifying mapping errors within the utility's asset database. This led to more accurate asset management and improved the reliability of outage notifications.

Scalability and Extensibility:

- The AI product was designed to be scalable and extensible, aligning with the client's AI vision and future demands. This means the solution can be expanded to cover multiple networks, different transformer types, and downstream & upstream assets, providing long-term value and adaptability to the client's evolving needs.

Key Metrics Achieved:

- **Reduction in Outage Minutes:** The average reduction in outage duration per customer was 90 minutes.
- **Annual Avoided Outage Minutes:** Scaling the solution system-wide could yield hundreds of thousands of avoided outage minutes annually.
- **Enhanced Asset Management:** Proactive identification and maintenance of at-risk transformers reduced the likelihood of unexpected failures, enhancing overall asset management.

Through this project, XTIVIA not only helped the client achieve their goal of reducing transformer failure rates and enhancing customer satisfaction but also demonstrated the value of leveraging AI and data engineering solutions to solve complex operational challenges. The success of this initiative highlights our ability to help clients implement impactful, data-driven solutions that drive tangible business results.

KEYWORDS
AI Product, Data Engineering, Data Science
SOFTWARE
Oracle, SAP CCS, Amazon S3, PySpark, Athena, Snowflake, Power-BI
HARDWARE/PLATFORM
AWS
ADDITIONAL KEYWORDS
Transformer Failure Prediction, Advanced Metering Infrastructure (AMI), Predictive Maintenance, Utility AI Solutions, Smart Grid Analytics, Power Outage Reduction, Proactive Asset Management, Voltage Spike Detection, Predictive Analytics, Energy Sector AI Applications, Cloud-based AI Solutions, Data-Driven Maintenance, Operational Efficiency in Utilities, Customer Satisfaction in Energy Sector, AI in Power Delivery

ABOUT XTIVIA

At XTIVIA, we've been providing IT solutions and consulting services for over 30 years. We offer a wide range of services, including technology assessments, IT service and asset management, software development, data analytics, cloud migration, DevSecOps, ERP, and enterprise content management. Our team of experts is dedicated to each discipline, ensuring that our clients receive the best possible service. We've partnered with industry leaders such as Atlassian, IBM, Microsoft, Oracle, and more to bring our clients the latest solutions. Through strategic acquisitions, we've acquired talented people who are experts in their industries, passionate about what they do and committed to providing exceptional service to our clients. Whether you need to improve your IT infrastructure or implement new

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