# CAPSTONE PROJECT

# PREDICTIVE MAINTENANCE OF INDUSTRIAL MACHINERY

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# OUTLINE

- Problem Statement
- Proposed System/Solution
- System Development Approach
- Algorithm & Deployment
- Result (Output Image)
- Conclusion
- Future Scope
- References

# PROBLEM STATEMENT

Develop a predictive maintenance model for a fleet of industrial machines to anticipate failures before they occur. This project will involve analysing sensor data from machinery to identify patterns that precede a failure. The goal is to create a classification model that can predict the type of failure (e.g., tool wear, heat dissipation, power failure) based on real-time operational data. This will enable proactive maintenance, reducing downtime and operational costs.

# PROPOSED SOLUTION

- **Objective:** Anticipate industrial machinery failures using ML.
- **Components:**
  - **Data Collection:** Gather historical sensor data (temperature, speed, torque, tool wear) from Kaggle dataset.
  - **Data Preprocessing:** Clean data; engineer features for failure indicators.
  - **ML Model Development:** Implement classification model (e.g., Random Forest) to predict failure types.
  - **Deployment (on IBM Cloud):** Deploy model on IBM Cloud Lite services; create alerts for predictions.
  - **Evaluation:** Assess model performance using metrics (Accuracy, Precision, Recall, F1-Score).

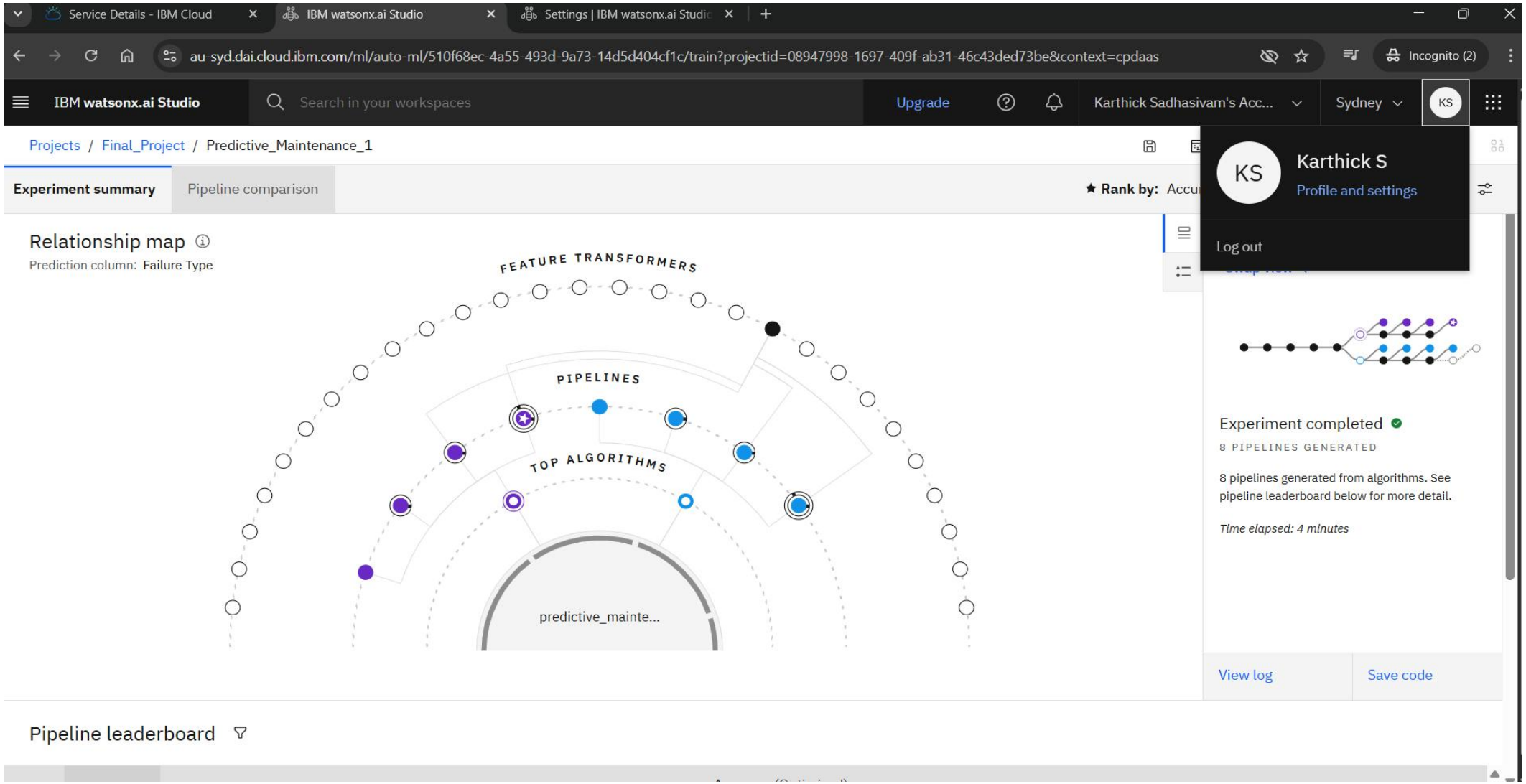
# SYSTEM APPROACH

- **Data Source:** Kaggle Predictive Maintenance Dataset (predictive_maintenance.csv).
- **Development Environment:** Python with pandas, numpy, matplotlib, seaborn, scikit-learn.
- **Cloud Platform (IBM Cloud Lite Services):**
  - **IBM Watson Studio:** For data prep, model development, and deployment.
  - **IBM Cloud Object Storage (COS):** For data and model storage.
  - **IBM Watson Machine Learning:** For model deployment and management.
  - **IBM Cloud Foundry / Code Engine:** For application logic/API endpoints.

# ALGORITHM & DEPLOYMENT

- **Algorithm Selection:**
  - **Chosen**: Random Forest or Gradient Boosting Classifier.
  - **Justification:** Robust, handles complex sensor data, good interpretability, less prone to overfitting.
- **Data Input:** Sensor features (Air temperature, Process temperature, Rotational speed, Torque, Tool wear) and Type.
  - **Target:** Failure Type.
- **Preprocessing:** Scaling numerical features, one-hot encoding categorical features.
- **Training:** Split data, train model, hyperparameter tune, cross-validation.
- **Prediction:** Model takes real-time preprocessed sensor data, outputs predicted failure type and probabilities.
- **Deployment (IBM Cloud):**
  - Model saved and deployed as web service via IBM Watson Machine Learning.
  - Application (e.g., Flask) on IBM Cloud Foundry to interact with deployed model for alerts/dashboard.

# RESULT

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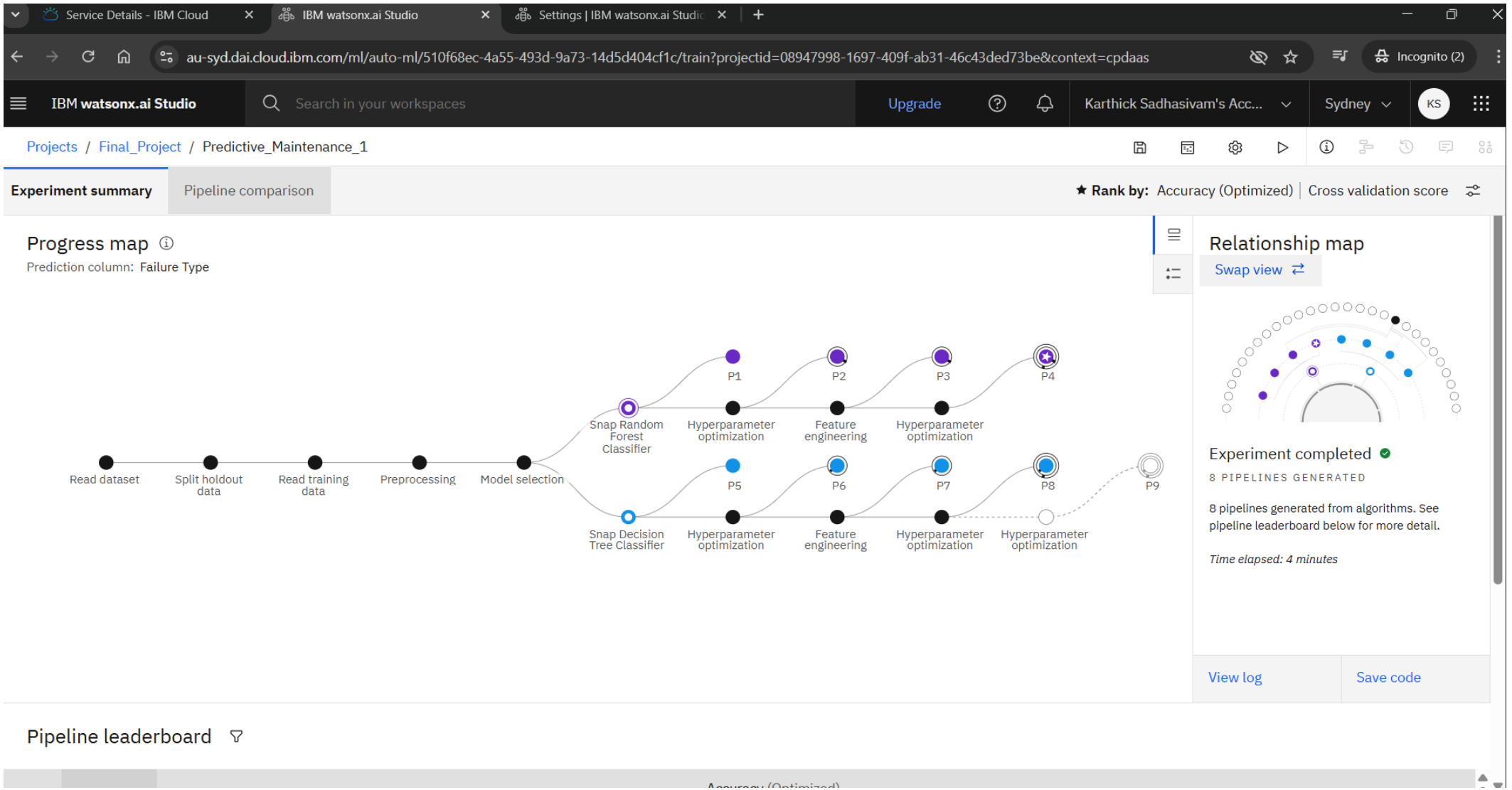
# RESULT



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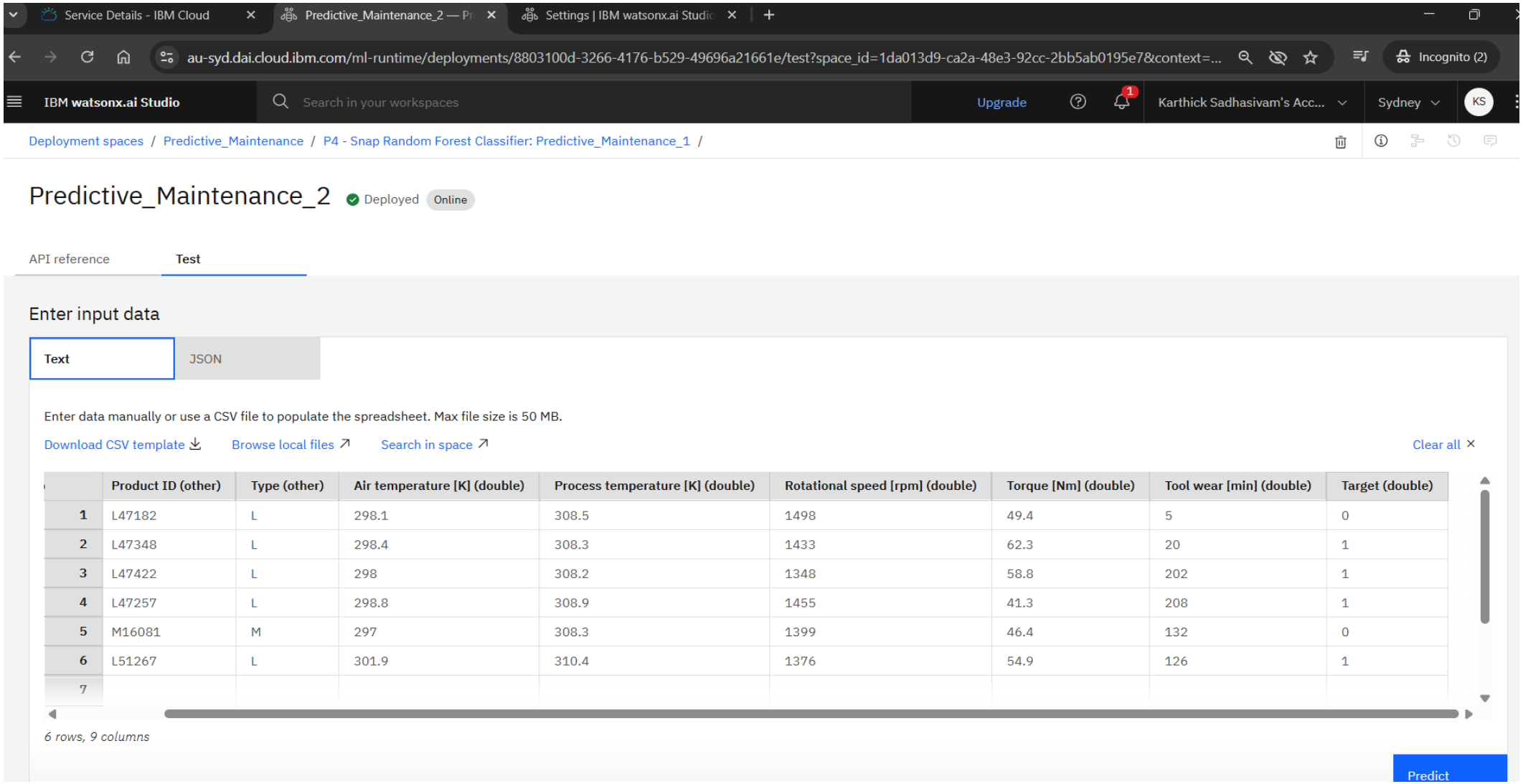
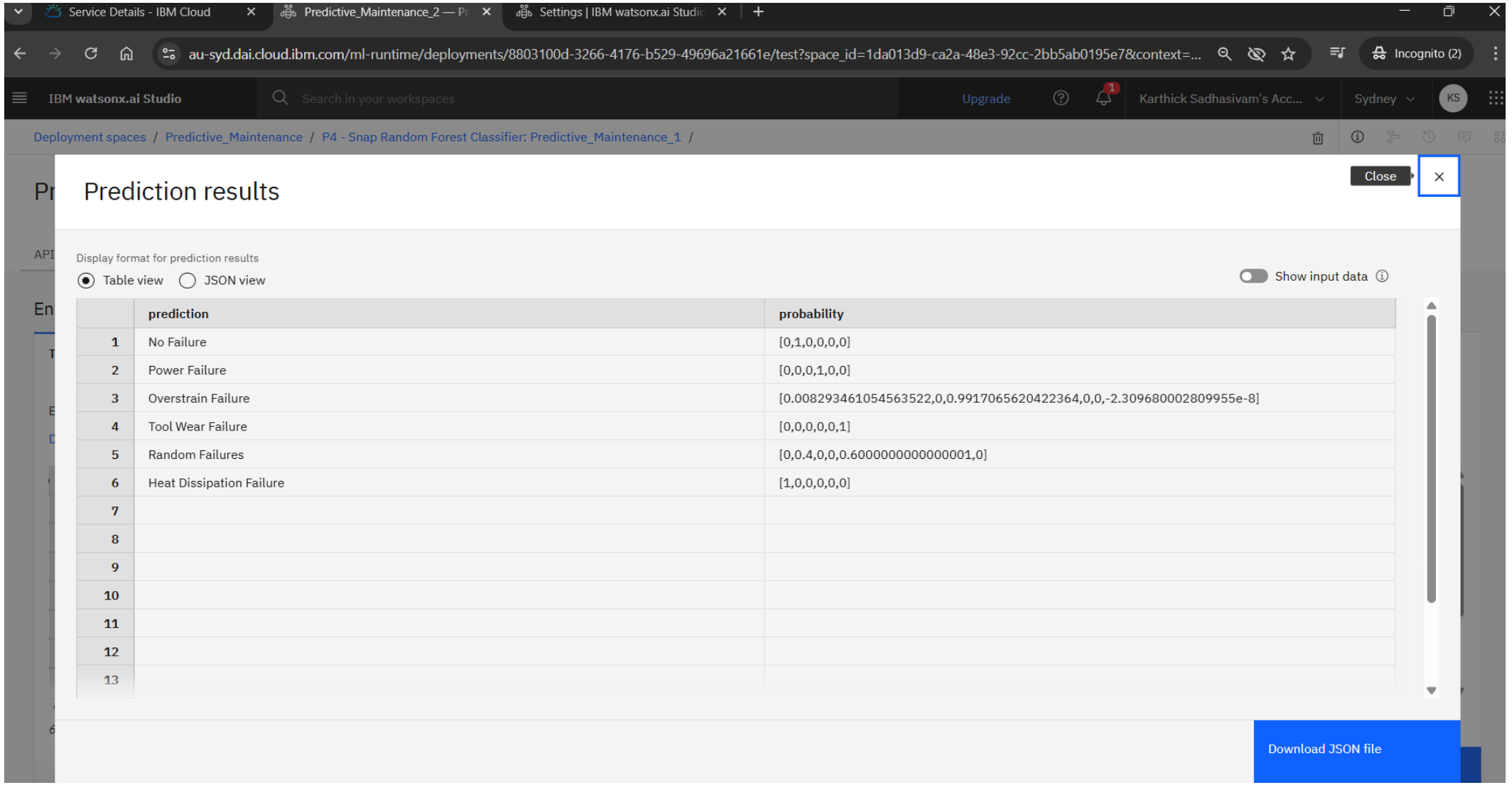



| | Product ID (other) | Type (other) | Air temperature [K] (double) | Process temperature [K] (double) | Rotational speed [rpm] (double) | Torque [Nm] (double) | Tool wear [min] (double) | Target (double) |
|---|---|---|---|---|---|---|---|---|
| 1 | L47182 | L | 298.1 | 308.5 | 1498 | 49.4 | 5 | 0 |
| 2 | L47348 | L | 298.4 | 308.3 | 1433 | 62.3 | 20 | 1 |
| 3 | L47422 | L | 298 | 308.2 | 1348 | 58.8 | 202 | 1 |
| 4 | L47257 | L | 298.8 | 308.9 | 1455 | 41.3 | 208 | 1 |
| 5 | M16081 | M | 297 | 308.3 | 1399 | 46.4 | 132 | 0 |
| 6 | L51267 | L | 301.9 | 310.4 | 1376 | 54.9 | 126 | 1 |
| 7 | | | | | | | | |

# RESULT




| | prediction | probability |
|---|---|---|
| 1 | No Failure | [0,1,0,0,0,0] |
| 2 | Power Failure | [0,0,0,1,0,0] |
| 3 | Overstrain Failure | [0.008293461054563522,0,0.9917065620422364,0,0,-2.309680002809955e-8] |
| 4 | Tool Wear Failure | [0,0,0,0,0,1] |
| 5 | Random Failures | [0,0.4,0,0,0.6000000000000001,0] |
| 6 | Heat Dissipation Failure | [1,0,0,0,0,0] |
| 7 | | |
| 8 | | |
| 9 | | |
| 10 | | |
| 11 | | |
| 12 | | |
| 13 | | |

# CONCLUSION

- **Summary:** Developed and deployed a predictive maintenance model on IBM Cloud, successfully anticipating machinery failures from sensor data.
- **Effectiveness:**
  - Reduced Downtime & Operational Costs.
  - Improved Efficiency & Enhanced Safety.
- **Challenges:** Data quality, class imbalance, real-time inference optimization, IBM Cloud integration.
- **Improvements:** Incorporate more data, explore deep learning, develop advanced UI.

# FUTURE SCOPE

- **IoT Integration:** Direct integration with IoT sensors for real-time data streaming.
- **Multi-Machine Fleet Management:** Expand to large, heterogeneous fleets, potentially using edge computing.
- **Prescriptive Maintenance:** Recommend specific actions and optimal scheduling.
- **Reinforcement Learning:** Optimize maintenance schedules dynamically.
- **Anomaly Detection:** Identify novel failure modes.
- **Scalability & Robustness:** Optimize for enterprise-level deployment.
- **Enterprise System Integration:** Seamlessly integrate with ERP/CMMS.

# REFERENCES


- Kaggle Dataset: Shivam Bansal. (2021). Predictive Maintenance Dataset. Kaggle. https://www.kaggle.com/datasets/shivamb/machine-predictive-maintenance-classification
- Documentation for scikit-learn, pandas, numpy.
- IBM Cloud documentation (Watson Studio, COS, Watson Machine Learning).

# IBM CERTIFICATIONS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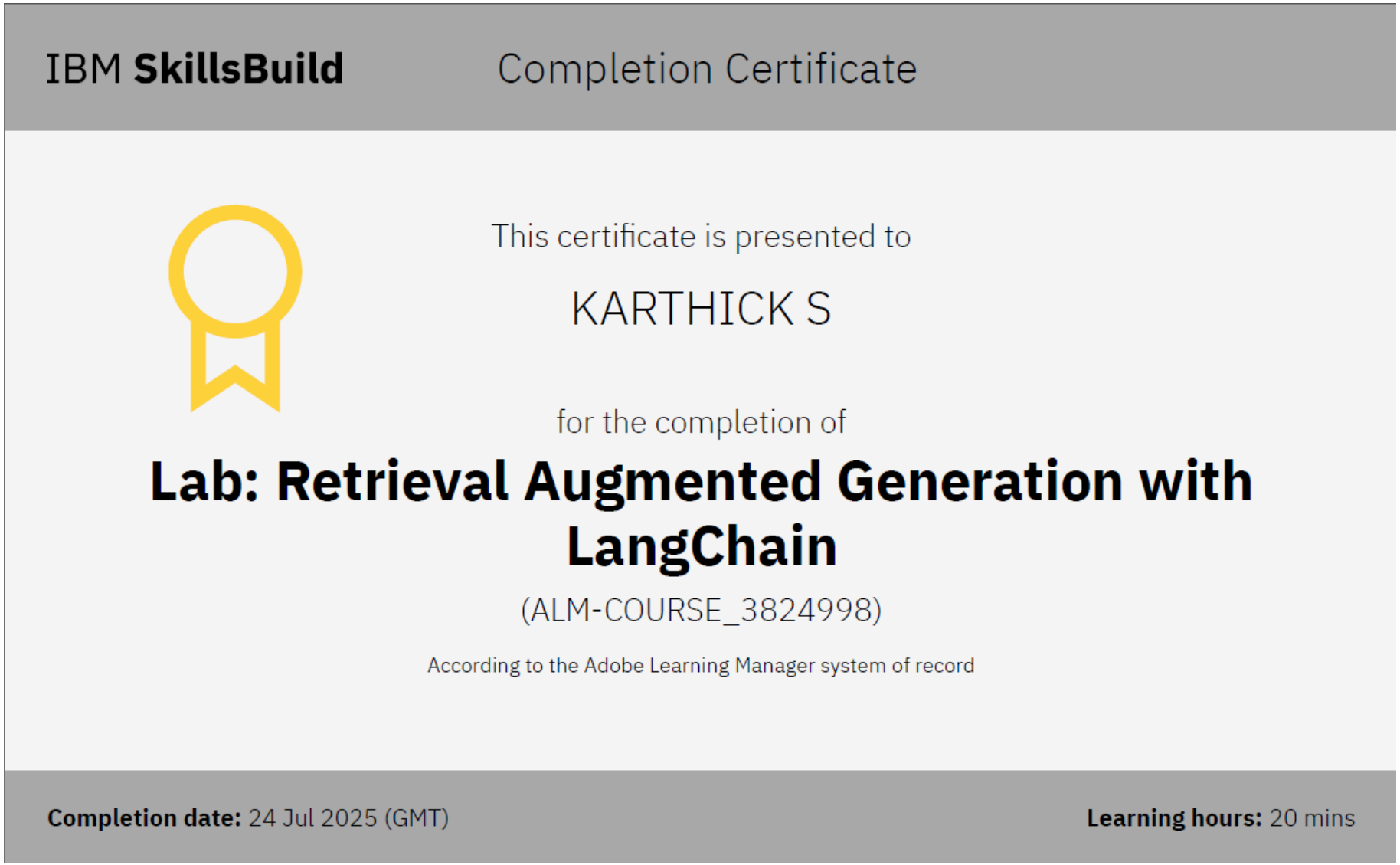

IBM **SkillsBuild** Completion Certificate

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According to the Adobe Learning Manager system of record

**Completion date:** 24 Jul 2025 (GMT)

**Learning hours:** 20 mins

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# THANK YOU

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