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Predicting Employee Attrition using XGBoost Machine Learning Approach

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***Abstract*—Considering the global competitive scenario, there is ocean of opportunities for skilled and talented persons in the world, and given a good chance, employees part from one organization to another. Employee turnover is regarded as the key issue for all organizations these days, because of its adverse effects on workplace productivity, and accomplishing organizational objectives on time. To overcome this problem, organizations are now taking support via machine learning techniques to predict the employee turnover. With high precision in prediction, organizations can take necessary actions at due course of time for retention or succession of employees. Most of the data comes from basic HR based database systems, which are not highly efficient in prediction and modeling and these models are not very accurate in data models and cannot assist the organizations to take successful decisions. The primary objective of this research paper is to predict employee attrition i.e. whether the employee is planning to leave or continue to work within the organization. In this paper, we propose a novel model for predicting Employee Attrition using Machine Learning based approach i.e. XGBoost which is highly robust. In order to validate the accuracy of the system proposed for Employee Attrition, the data set is acquired via online database and fetched to the system and highly stunning and precision results are shown by the system with regard to Employee turnover behavior.**

Keywords—Employee Attrition, Turnover, XGBoost, Machine Learning, Supervised Learning, Supervised Classification

I. Introduction

In recent times, all types of organizations are becoming very curious and cautious with regard to their market reputation and to gain a competitive edge over others to gain huge profits and attain all types of organizational objectives. Organizations focus on varied HR issues and practices. Organizations consider employees as the central resource for everything, so employees must be handled with utmost care. It is the primary responsibility of every organization to solve all sorts of employee issues and provide appropriate solutions and maintain cordial relations to boost strong work environment. The serious concern which affects the organization and even hampers productivity is Attrition. Attrition is regarded as a reduction in the employee's number via resignation, death, retirement or any other natural or normal means [1]. There was a time, when an employee joins the company, he/she has a thorough commitment towards workplace and doesn't leave the job for the whole life. But now the face of organizations has changed, especially the face of Information technology. The situation of organizations and work culture is completely different as if off now. Employees of these times are highly flexible as compared to old aged employees [21,22].

Employee attrition is also defined as the wastage rate or total turnover like situation of demand and supply mechanism. Employee attrition creates chronic problems in the organization, and it is realized by organizations in recent times. It also impacts the competitive strength of the company due to the ceaseless demand of proficient employees and globalization. With the emergence of next-generation IT companies, new start-up's, many of the employees have shown attrition because of acquiring new learning skills. In the eyes of management, attrition is highly expensive and challenging problem to determine concrete solutions. Today's organizations are refining and even re-defining various HR policies and practices, but to some extent, they are successful, but still the rate of attrition is moving up in every quarter or so. [2]

A. Attrition-Definition

According to Barron Business Dictionary, the word "Attrition" is defined as *"Normal and Uncontrollable reduction of a work force because of retirement, death, sickness and relocation"* [9].

According to Longman Dictionary of Contemporary English, Attrition happens "*when people leave a company or course of study and are not replaced* [10].

According to American Heritage Dictionary of English Language, "*Attrition is a gradual, natural reduction in membership or personnel, as through retirement, resignation or death"* [11].

According to Investopedia, "*Attrition in business can mean the reduction in staff and employees in a company through normal means such as retirement and resignation, the loss of customer or clients to old age or to growing out of a company's target demographic* [12].

B. Reasons for Attrition

The following points enlist the reasons for Employee Attrition:

- Unsuitable Behavior: Most of the studies have proved that unsuitable behavior creates adverse effect on productivity by forcing best employees to quit the organizations. Rude behavior, back biting, favourism are all the reasons of unsuitable behavior, forcing the employees to quit current organizations in search for better opportunities [23].
- Imbalance of Work-Life: Organizations have a target to get the work of three or more people performed by a single individual, creating an extreme work pressure on the person, which results in de-motivation, longer hours of work as well as weekends spoilage. This reason also lay strong roots for employee's attrition [24].
- Employee Misalignment: Sometimes, organizations hire people, less qualified and unsuitable for the job leading to non-synchronization of employees in work culture and goals achievement which ultimately leads to attrition [25].
- Lack of Decision-Making Ability: Employees sometimes feel highly insecure with regard to their ability to make or contribute in decision making. Organizations require employees to have ownership and empowerment. Empowered employees have complete independence to make suggestions and decisions. And if organizations don't boost empowerment which ultimately leads to job insecurity and results in attrition [26].
- Inadequate Professional Skills: Sometimes, promotion comes to those employees having less capability and even attaining high positions they cannot become effective leaders. So, ultimately, those sorts of employees cannot perform the job well and that impacts job efficiency, which results in forcing the employee to quit the job and this also increases attrition in the organization [27].
- Frozen Promotions and Salary Hikes: Over years of research, it is proved that promotion frozen and non-salary hikes also lay seeds of attrition. Sometimes organizations freeze salary increments and promotions and sometimes people find lack of growth professionally and financially, which forces the employees to look for opportunities and in turn attrition increases [28].

C. Organization of Paper

Section 2 highlights Literature Review/Related work. Section 3 embarks Research Methodology and highlights Model proposed with regard to Employee attrition. Section 4 highlights experimental design, analysis and the results of the study conducted. Section 5 concludes the paper with future scope.

II. Literature Review

The turnover of employee can be regarded as deface of intellectual capital of the organization. The Literature review revolves around the methodologies and techniques proposed for predicting attrition of employees by several researchers.

Cotton and Tuttle [4], proposed strongest indicators leading to employee attrition or voluntary retirement as age, tenure, pay, job satisfaction and future perceptions. Other similar researchers have added significant parameters to attrition like: Gender, Ethnicity, Education, Marital status, salary, professional skill enhancement, growth potential etc. [3].

With the increase in the turnover rate of employees, organizations face serious effects on attainting the pre-defined objectives. It even affects the ongoing work and existing employee's productivity. Hiring of new employees also wastes the useful financial resources of organization like training costs, hiring costs etc.

Ozolina-Ozola et al. [5] proposed that employee turnover and attribution is explained by employees' attitude towards job (by job satisfaction or organizational commitment or by both these attitudes). Employee turnover and attrition creates uncertainty among another workforce. The result of attrition and turnover has the emphasis of top management in nearly every organization. It indicates that the most costly and tough workforce objections facing organizations is turnover.

Hoffman et al. [6] utilized employee's survey responses regarding their manager to measure people management skills. The study concludes that, the managers with the good people management skills should get rewarded from the company, which would lead to the decrease in employee turnover. Ideally, better people managers should get perks and promotions, which would help with ensuring company's success. Also, consistent feedback regarding employees is required, which keeps the employees engaged and accountable towards their work. The study also analyzed that job which requires low skills (for e.g. Truckers, etc.) is much easier to perform as compared to the jobs which require highly skilled workers [29].

Ongori et al. [7] stated that organizations should pay employees depending on their performances, along with various incentives such as individual bonus, lump sum bonus, profits sharing and other benefits. So, if these are put in place they will decrease employee turnover. The research also proposed that the knowledge as well as company's ideas should be shared widely among the employees too, which gives employees the motivation for staying in their present

organization and become highly responsible for strong performances from the employees. Workforce optimization can also lead to the organization's success by getting work done and also establishing accountability. Good working conditions are also responsible for lower employee attrition rates. The study concluded that empowerment of employees would help with the company's success in retaining its employees [30].

O'Halloran et al. [8] explored how various performance related pay (PRP) schemes impact employee turnover. The study tested whether a profit sharing has an impact on turnover as compared to other forms of PRP. The study revealed that there exists a negative relationship between aggregate measures of PRP and turnover. Table 1 gives Comparison of different Models based on employee attrition.

TABLE 1: COMPARISON OF DIFFERENT MODELS BASED ON EMPLOYEE ATTRITION

FACTORS	AUTHORS	RESEARCH OUTCOME	YEAR
Flexible work arrangements	Goud	Trust, flexible arrangements employee engagement, retention leads to retention & job engagement	2014
Reward and Recognition	L.T. Silbert	Tangible Rewards and its outcomes on Organizational Support.	2005
Promotion and opportunity for Growth	L. Eyster, R Johnson and E. Toder	Strategies to employ & retention of previous employees.	2008
Training and development	Beynon et al.	Training provides employees loyalty and retention	2014
Leadership	Chung-Hsiung Fang, SueTing Chang, Guan-Li Chen	Applying Structural Equation Model to leadership style, satisfaction, Organization commitment model	2009
Pay and Compensation	Singh	Monetary strategies such as performance linked incentives, rewards, increment in salary helps retain employees	2013
	Ahsana (2013)	Compensation, career opportunity, supervisor support effects retention	2013
Organizational Support and Work life balance	Mignonac	Perceptions of disinterested support decrease employee voluntary turnover.	2013
Job Content	Bigdeli	Internal and external environmental factors, and motivational factors influence the employee's retention.	2013

III. RESEARCH METHODOLOGY

In this research paper, a novel model is proposed to analyze the employee attrition. All the variables are analyzed via some plots and inferences are drawn via exploratory analysis. After exploration some features are built based on the variables and the final decision is made to include/exclude some variables.

The Research Design [9] [10] undertaken for the study was predictive as well as descriptive. The typical data science pipeline, called "OSEMN" [11] is followed as demonstrated in figure 1

1. O: Obtaining the data is the first step in solving the problem.
2. S: Scrubbing or cleaning the data is the next approach. It includes data imputation of invalid or missing data and fixing column names.
3. E: Exploring the data will be the next right after and allow further insight of what our dataset contains. It also looks for any sort of weird or non-associated data.
4. M: Modelling the data provides predictive power on whether an employee will leave or not.
5. I: Interpreting the data to draw necessary conclusions.

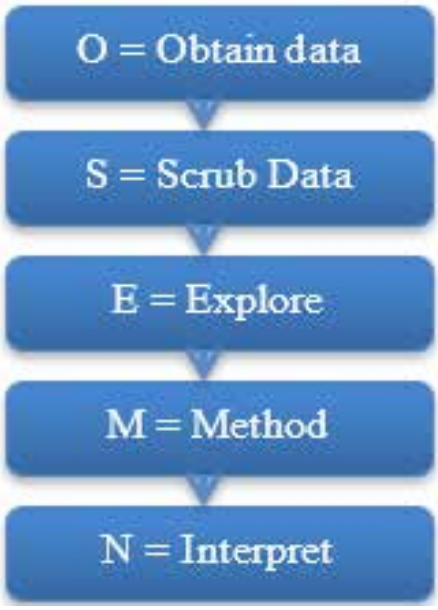


Fig. 1: OSEMN Research Design

The Research conducted considers "Supervised Learning" approach of machine learning. The research deals with two main parameters – active (No Attrition) and terminated (Attrition occurred).

The term 'Boosting' refers to a family of algorithms, which converts weak learner to strong learners. It includes generating accurate rules of prediction to problems by merging irregular and temperately imprecise rules-of-thumb. Boosting [12] refers to a meta algorithm the combines supervised learning to remove bias and converts weak learners to strong ones. A classifier is said to be a weak learner if it is less correlated with the factual classification, whereas a strong learner is a classifier that is subjectively well-correlated through the factual classification.

D. XGBOOST

XGBoost belongs to boosted tree algorithm and works on the principle of gradient boosting. As compared to others, practices a more regularized-model reinforcement to regulate overfitting and thus improvises performance. It is a fast method consisting of parallel tree construction and planned to be fault tolerant under the distributed setting. The classifier takes data in the form of DMatrix [13]. It is regarded as an internal data structure used by XGBoost for both memory efficiency and speed optimization.

XGBoost uses gradient boosting (GBM) framework at core. Yet, does better than GBM framework alone. It is used for supervised ML problems.

The following features were studied and incorporated during research:

1. Parallel Computing
2. Regularization: This is the major benefit of XGBoost [14]. GBM has no facility for regularization. Regularization is a method used to evade overfitting in linear and tree-based models.
3. Enabled Cross Validation: Measuring the performance of a prediction model on new datasets based on some set of methods.
4. Missing Values: XGBoost can handle lost values such that there already exists a trend in the model for the missing values.
5. Flexibility: It has defined support for objective functions designed by a user other than regression, classification etc.
6. Availability: It can be used with languages such as Python, Julia, R, Java, and Scala.
7. Save and Reload: XGBoost has the feature to avoid doing the computation again and again, thus saving the data model and saving time by reloading it in the future.
8. Tree Pruning [15]: It grows the tree to a maximum depth and then follow backward pruning till the loss function improvement is below a threshold, hence different from GBM [16].

IV. Results and Analysis

A. Experimental Design

1). Dataset Description

The dataset is acquired from IBM HR Data Analysis. (Source:https://www.ibm.com/communities/analytics/watson-analytics-blog/hr-employee-attrition/)

Table 1: Dataset Attributes with Description

Name	Description
Age	Numerical Value
Attrition	Employee Leaving The Company (0=No, 1=Yes)
Business Travel	(1=No Travel, 2=Travel Frequently, 3=Tavel Rarely)
Daily Rate	Numerical Value - Salary Level
Department	(1=Hr, 2=R&D, 3=Sales)
Distance From Home	Numerical Value - The Distance From Work To Home
Education	Numerical Value
Education Field	(1=Hr, 2=Life Sciences, 3=Marketing, 4=Medical Sciences, 5=Others, 6= Tehcnical)
Employee Count	Numerical Value
Employee Number	Numerical Value - Employee Id
Enviroment Satisfaction	Numerical Value - Satisfaction With The Enviroment

Gender	(1=Female, 2=Male)
Hourly Rate	Numerical Value - Hourly Salary
Job Involvement	Numerical Value - Job Involvement
Job Level	Numerical Value - Level Of Job
Job Role	(1=Hc Rep, 2=Hr, 3=Lab Technician, 4=Manager, 5= Managing Director, 6= Reasearch Director, 7= Research Scientist, 8=Sales Executieve, 9= Sales Representative)
Job Satisfaction	Numerical Value - Satisfaction With The Job
Marital Status	(1=Divorced, 2=Married, 3=Single)
Monthly Income	Numerical Value - Monthly Salary
Monthy Rate	Numerical Value - Monthy Rate
Numcompanies Worked	Numerical Value - No. Of Companies Worked At
Over 18	(1=Yes, 2=No)
Overtime	(1=No, 2=Yes)
Percent Salary Hike	Numerical Value - Percentage Increase In Salary
Performance Rating	Numerical Value - Erformance Rating
Relations Satisfaction	Numerical Value - Relations Satisfaction
Standard Hours	Numerical Value - Standard Hours
Stock Options Level	Numerical Value - Stock Options
Total Working Years	Numerical Value - Total Years Worked
Training Times Last Year	Numerical Value - Hours Spent Training
Work Life Balance	Numerical Value - Time Spent Bewtween Work And Outside
Years At Company	Numerical Value - Total Number Of Years At The Compnay
Years In Current Role	Numerical Value -Years In Current Role
Years Since Last Promotion	Numerical Value - Last Promotion
Years With Current Manager	Numerical Value - Years Spent With Current Manager

2). Data Preprocessing

In order to perform research, the dataset consists of lots of attributes which affect employee attrition directly or indirectly. As a matter of fact, we had to initially identify and prune the attributes into a dataset with reduced number of attributes that were relevant for the study.

In order to build our model, we trained the model on a training set and perform validations on the test set. We performed all our analysis on the training set and validated it on our testing set. We divided our dataset into training (75%) and testing (25%).

3). Feature Engineering

New features like Tenure per job, Years without change and compa Ratio is calculated on the basis of following assumptions:

1. Tenure per job: People who worked in many companies for small tenure have a higher chance of leaving that particular company as well to keep them going.
2. Years without Change: Changes in job or level or responsibility keeps the job more exciting and less monotonous. Using Promotion, Role and Job Change as a metric we created a variable to cover the different variants of change.
3. Compa Ratio: Compa Ratio [17] is the ratio of the actual pay of an Employee to the midpoint of a salary range. The salary range can be that of his/her department or organization or role. The benchmark numbers can be an organization's pay or Industry average.

To calculate our Compa Ratio at Department Level & Organization Level we used the Company pay information. People with Compa Ratio less than 1, usually feel underpaid and show more tendency to leave the Organization in search of a better pay.

4). Correlation of Attributes

The data that we have had a large number of attributes, but we have used some major attributes in finding out the turnover rate. We have found out many interesting relationships among these attributes that led us to our goal of finding the turnover rate and in which year the turnover rate touched its peak. In our data, we have shown a correlation between attributes such as how many years an employee spent in a company, how many years an employee spent in a company with current manager and how many years spent in the company since the last promotion. We have also shown the correlation between the level of job or service an employee is doing and monthly income of the employee. We have also considered the relation between the attributes like percent hike and the performance rating of an employee. We have also found out the correlation between attributes such as number of years spent by an employee under the current manager, the level of the job

and percentage of hike in salary. So, we have used a number of attributes and correlations among them to find out the turnover rate of a company in a certain period of time.

5). Binning

We needed to categorize the variables which can collect the impact making groups and make more sense as many of our variables are either continuous in nature or have lots of discrete values which peak at certain points. While doing these transformations, we ensure that we do the same for our Testing set also.

B. Analysis

The research study concluded that there are certain variables that influence the turnover rate of an organization. The variables highly influencing the attrition are enlisted as follows:

1. **Age:** Majority of employees that were around 30 years old had left their organization.

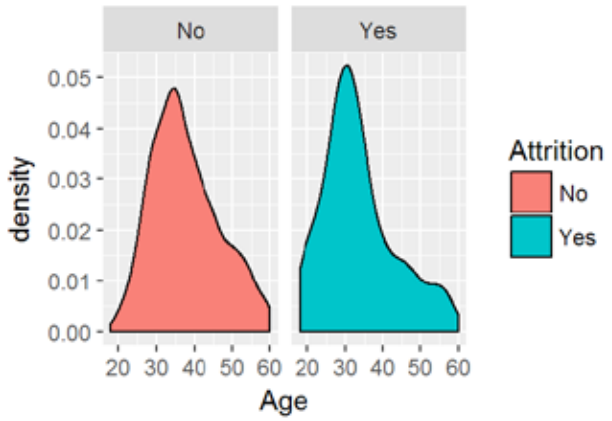


Fig. 2: Attrition W.R.T Age

2. **Gender:** In our study, we found out that a large number of attired individuals were male and it is because 61 percent of employees in the dataset were male.

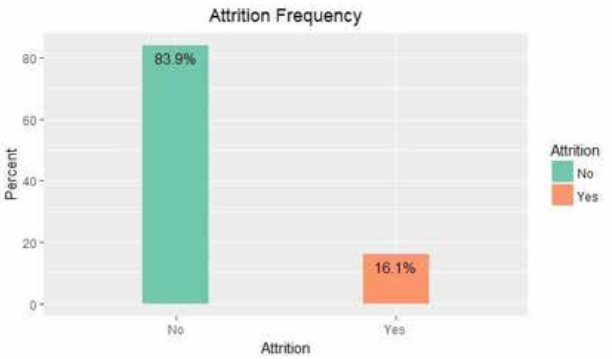


Fig. 3: Attrition Percentage in Data

3. **Distance from home:** A large number of the employees left the organization just because the office was close to their home. This is in contrast to the normal assumptions.

4. **Department:** There were less number of people attired from the HR department. The reason behind this is that there were the low proportion of HR employees in the organization

5. **Job Involvement:** The ratings were given as 'low', 'medium', 'high' and 'very high'. The study showed that the majority of employees who left the organization were either highly involved or low involved in their jobs.

6. **Job Satisfaction:** Looking at the job satisfaction, the higher levels of attrition were observed in lower job satisfaction levels.

Fig. 4: Attrition W.R.T Job Satisfaction

7. **Marital Status:** Attrition rates were higher if an employee was unmarried and lowest for the Divorced employees.

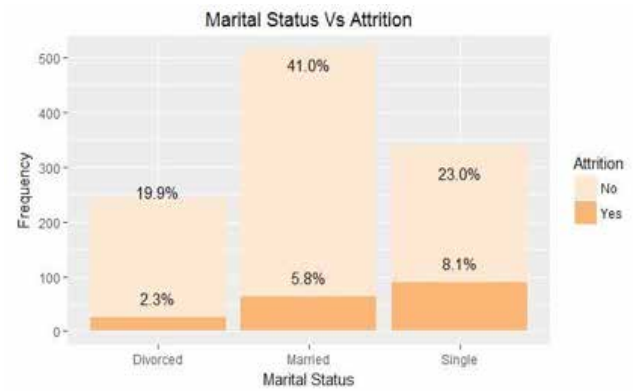


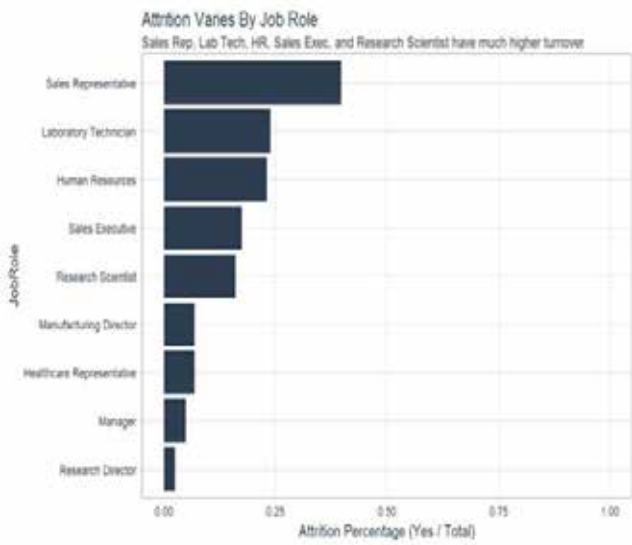
Fig. 5: Attrition W.R.T. Maritial Status

8. **Monthly Income:** Our study showed that if the monthly income of an employee is low, then their chances of leaving the company are high. It might be due to dissatisfaction with the income compared to the effort they are putting out.

9. **Years at company:** The study showed that large number of newcomers, left the organization which sidelined the recruitment efforts of the organization.

10. **Years in current role:** Majority of employees who worked for less than a year had left their organization. This might occur because they were offered a different role in a different company.
11. **Years since last promotion:** Majority of employees who were promoted recently, quit their jobs.
12. **Years with current Manager:** Attrition rate is higher when the current manager of an employee is replaced with the new ones.

Age	Attrition	BusinessTravel	DailyRate	Department	DistanceFromHome
41	Yes	Travel_Rarely	1102	Sales	1
49	No	Travel_Frequently	279	Research & Development	8
37	Yes	Travel_Rarely	1373	Research & Development	2
33	No	Travel_Frequently	1392	Research & Development	3
27	No	Travel_Rarely	591	Research & Development	2
32	No	Travel_Frequently	1005	Research & Development	2
59	No	Travel_Rarely	1324	Research & Development	3
30	No	Travel_Rarely	1358	Research & Development	24



After the implementation of the model, we concluded that a total of 14 factors influence the attrition rate more than any other factors. After using the baseline decision tree models that had maximum accuracy up to 83 percent, we decided to use a more advanced approach. For the same, we considered glmboost [18] and XGBoost [19] [20] techniques for our model. Our model, based on XGBoost worked the best for us with a decent specificity rate (> 50%) and a very low error rate (< 30 %). It had an improved accuracy over the baseline model which increased up to 89% as shown in Fig.6. The model was quite robust over its counterpart glmboost in terms of accuracy as well as error rate.

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction  No Yes
##        No  297  29
##        Yes  11  30
##
##                Accuracy : 0.891
##                  95% CI : (0.8546, 0.921)
##     No Information Rate : 0.8392
##     P-Value [Acc > NIR] : 0.003055
```

Fig. 6: Confusion Matrix and other Statistics

V. Conclusion

In this paper, a machine learning approach for predicting employee attrition is presented in this paper. The most significant drawback of existing organization's data models and database is that, they contain lots of redundant data and predicting something with precision is quite challenging. We implemented a precision model for predicting employee attrition using XGBoost based machine learning technique. XGBoost is regarded as a superior algorithm in terms of efficient memory utilization, high accuracy and low running times. It is simply highly robust and scalable technique to handle all sorts of noise from huge data sets and convert the data into a ready acceptable form for precision results. The model presented in this paper has very low rate less than 30% and the accuracy touches almost to 90%. Because of these reasons, XGBoost technique is recommended on top priority manner for employee turnover prediction to successfully enable the organization to take preventive action in due course of time.

A. Future Scope

In the near future, we like to implement the proposed model in real-world organizations to enable organizations to learn the employee turnover reasons. The research would go in the direction to make this model a "Predictive Mode" and solve various issues, i.e. Advanced ones not predicting- "Who is going to Leave?" but also "Why the Employees are doing turnover?". The model will become more accurate, scalable and ready to implement as such in top IT organizations HR departments.

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