Chapter-5

Allocation and Scheduling of Computational Power

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The task offloading & allocation and scheduling of computational power is going to go through the process of allocating and scheduling the computing resources that are shared among IoT devices. The many different categorization algorithms that are based on machine learning are now being investigated, and the most effective methods that are most suitable for fog computing are being identified. During testing, the impact that the proposed work would have on the latency issue that the existing system is experiencing will be evaluated. The implementation of a SMART FOG protocol-based approach to the creation of a fog environment that enables the sharing of computing resources with IoT devices is the major emphasis of this research work.

5.1 Task Offloading

Intelligent systems and smart applications that are self-sufficient, adaptable, and knowledge-based are currently being created. Among them are aerospace, healthcare, IoT, emergency and disaster management, and mobile apps, which are revolutionizing the computer industry. Applications with a high number of expanding devices have made the centralized cloud existing design unworkable. Despite the usage of 5G technology, delay-sensitive apps and the cloud cannot operate simultaneously owing to certain characteristics, such as latency, bandwidth, reaction time, etc., surpassing threshold levels. The use of middleware demonstrates that it is a more effective way to address these problems and yet adhere to the strict rules for job offloading. Middleware that uses fog computing is advised in this due to the services being offered at the network's edge, delay-sensitive applications can be efficiently used with this study article. Contrarily, fog nodes have a finite number of resources, which means they might not be able to handle all jobs, particularly those from computation-intensive applications. Moreover, fog is not a replacement for the cloud but rather an addition to it. Both technologies function similarly and provide services by job requirements, although fog computing is closer to the devices than the cloud is. The issue occurs when a decision must be made on what should be offloaded: data, particularly where to offload the computer or application in the cloud or the fog as well as how much to offload. When it comes to task-related characteristics like task size, duration, arrival rate, and needed resources, fog-cloud collaboration is stochastic.

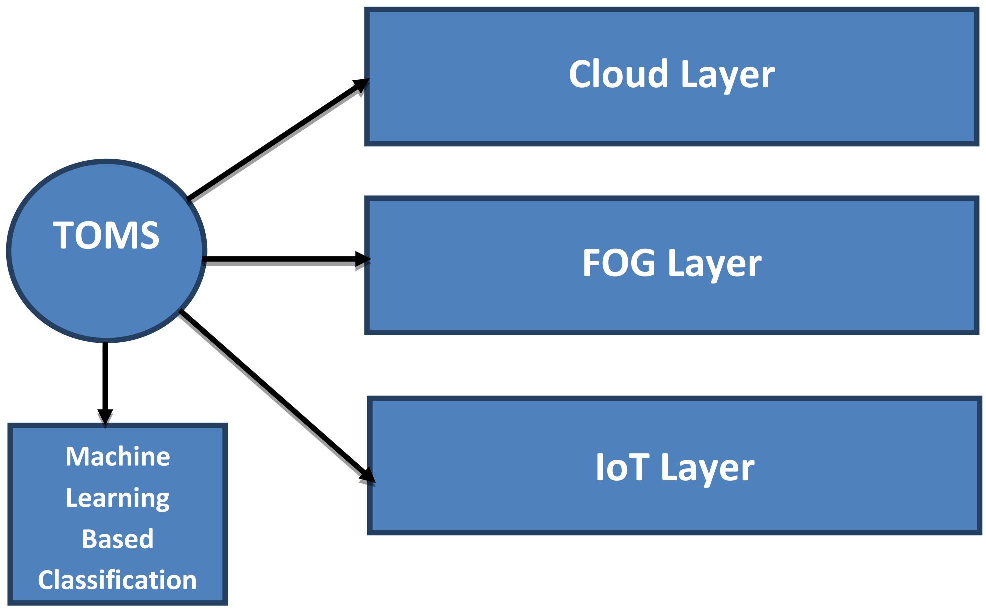

Figure 5.1: Proposed Task Offloading Management System (Li, 2019)

To better utilize the resources at the fog and cloud to improve QoS, dynamic task offloading becomes essential. Due to the complexity of this job-offloading policy creation, the research work addresses this issue and suggests an intelligent task-offloading model.

5.2 Task Offloading and Resource Management System

The Task Offloading & Resource Management System is a sophisticated framework designed to optimize task allocation and resource distribution within an IoT and fog computing environment. By leveraging real-time monitoring, machine learning-based analysis, and a policy repository for offloading criteria, the system intelligently determines when and where to offload computational tasks from IoT devices to fog nodes. Efficient resource management ensures that tasks are allocated to the most suitable nodes based on factors such as task urgency and available resources, leading to reduced latency and improved overall system performance. Through rigorous performance evaluation, the system ensures the reliability and effectiveness of the classification algorithms used for task allocation, contributing to seamless task distribution and optimal resource utilization throughout the network. The system consists of the following five main characteristics

The system consists of the following five main characteristics:

1. Task offloading criteria details: policy repository
2. Status of Fog layer: devices
3. Analysing the offloading and resource allocation using ML – approaches like various classification algorithms.
4. Using various performance measures to evaluate classification algorithms.
5. Suggest the best predictive construct.

The system comprises five main characteristics: a policy repository for task offloading criteria details, real-time monitoring of the fog layer status through devices, machine learning-based analysis using various classification algorithms to determine task offloading and resource allocation decisions, evaluation of classification algorithms using multiple performance measures, and the suggestion of the best predictive construct. These features together enable efficient task allocation, resource utilization, and decision-making in IoT and fog computing environments, optimizing system performance and improving overall efficiency.

Experimental Setup

The iFogSim simulator is being used for developing the Smart Fog environment. The dataset is being constructed recording the various values of attributes like No. of Fog system, Areas, Number of Cameras Per Area, Execution Time, ALD: motion_detector, object_detector, object_tracker, ALD: object_tracker, PTZ_CONTRO, CPU Delay: MOTION_VIDEO_STREAM, CPU Delay: DETECTED_OBJECT, CPU Delay: OBJECT_LOCATION, CPU Delay: CAMERA, Latency, Energy Consumed, Cost of execution, Total network usage, MIPS Million instructions per second, Number of processing elements, RAM, Priority, Previous Time etc.

Algorithm Executed

1) Load D

2) Pre-processing D

3) Train D, test D, split D

4) Classification modeling (IBK, K-Star, MLP, Logistic Regression, Bagging…)

i) Task offloading prediction

for i =0 to EOF ()

```
for j = 0 to (X. length-1)
calculate Z
return Z
p = f (z)
if (p == 1)
{
offloads to Fog
}
Else
{
offloads to Cloud
}
}
```

ii) Evaluation of predictive model using:

Accuracy ( )

Confusion matrix ( )

Average Execution Time ( )

iii) Comparative Analysis:

Comparative Eval (IBK, K-Star, MLP, Logistic Regression, Bagging…)

iv) Identify the most appropriate classifier or predictive model.

5) Implement the Constructed Predictive Model.

The suggested fog-cloud intelligent task offloading paradigm is evaluated and assessed using a simulated environment for machine learning Weka 3.8.4, a data science platform for data scientists, IT specialists, and business executives, has been used to carry out the simulation. A variety of machine learning techniques are used to train the model, with the recommended approach being LR, along with K-Nearest Neighbor, Nave Bayes, Decision Tree, Support Vector Machine, and MLP[1].

[1]Multiple Layer Perceptron

5.3 Comparative Analysis Based on Cross-Validation 10-Folds

Cross-validation – 10-fold: The 10-fold cross-validation provides a robust estimation of each classifier's generalization ability, as it tests the algorithms on different subsets of data, ensuring that the results are less sensitive to the specific data partitioning. For each fold, the classifiers are trained on nine folds and then tested on the remaining fold. This process is repeated ten times, with each fold serving as the testing set exactly once.

Table 5.1: Comparative Analysis of Classifiers Used for Task Offloading and Resource Allocation: 10-fold Cross Validation

Performance Measure	Logistic Regression	K-Star	IBK	J48	Bagging	MLP
Accuracy	0.82	0.53	0.55	0.75	0.69	0.91
Kappa Statistic	0.64	0.07	0.10	0.50	0.39	0.82
TP Rate	0.82	0.54	0.55	0.75	0.35	0.91
FP Rate	0.18	0.46	0.45	0.25	0.69	0.09
Precision	0.83	0.54	0.76	0.79	0.30	0.91
Recall	0.82	0.54	0.55	0.75	0.71	0.91
F-Measure	0.82	0.53	0.44	0.74	0.69	0.91
ROC Area	0.81	0.60	0.57	0.79	0.69	0.98
Mean Absolute Error	0.22	0.44	0.44	0.28	0.85	0.11
Execution Time Model Building	60ms	20ms	20ms	30ms	30ms	80ms

The performance metrics, such as accuracy, precision, recall, F1 score, and area under the receiver operating characteristic ROC curve, are calculated for each fold as shown in table 5.1.

Comparing the performance of the classifier based on Accuracy, Kappa statistics, TP rate, FP Rate, Precision, Recall, F-Measure, ROC Area, Mean Absolute Error, and Execution Time Model Building used for task offloading and resource allocation confirms that at configuration setting of cross-validation 10 folds in case of SMART FOG environment.

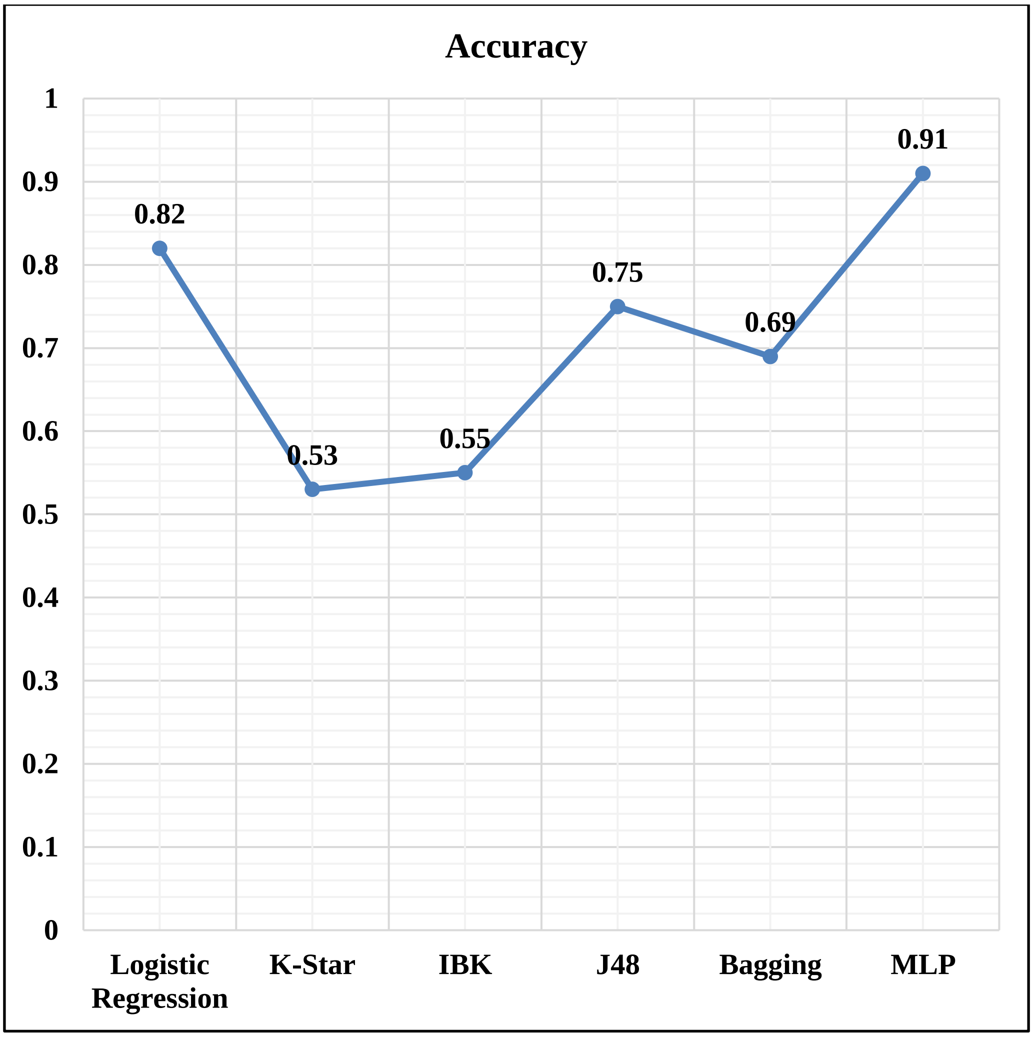

Figure 5.2: Accuracy Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-10 folds)

Figure 5.2, confirms that at configuration setting of cross-validation 10 folds the accuracy of MLP classifier with value 0.91 is found to be highest followed by Logistic Regression with value 0.82. The other classification algorithms had an accuracy of about 0.75 in case of J48 classifier, 0.69, 0.55, and 0.53 in case of Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure accuracy were found to be MLP and LR.

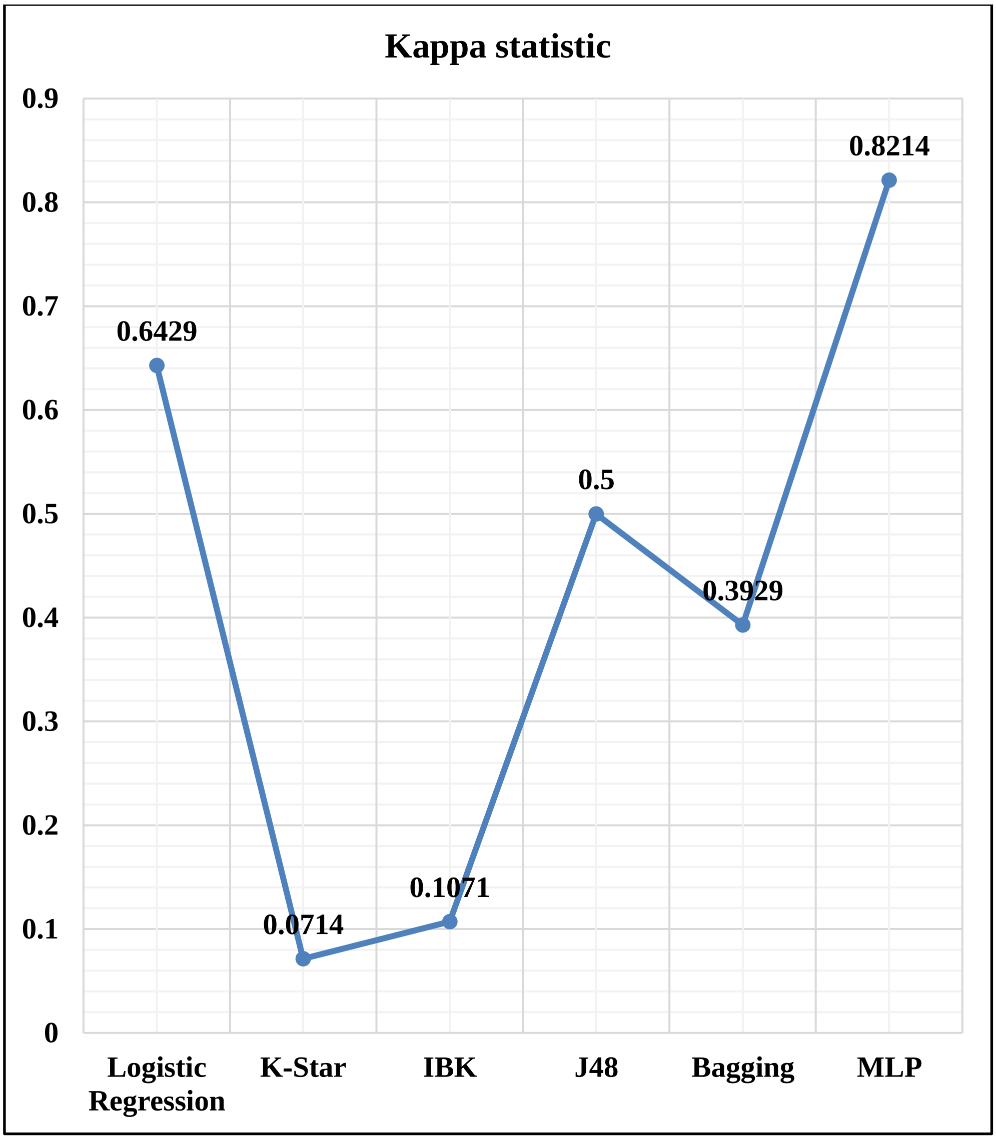

Figure 5.3: Kappa Statistic Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-10 folds)

Figure 5.3, shows the Comparison the performance of the classifier based on Kappa statistics used for task offloading and resource allocation in case of SMART FOG environment it can be interpreted that a higher Kappa statistics value of 0.82 in case of MLP and 0.64 in case of Logistic Regression suggests that they are the better classifiers as compared to other classification techniques.

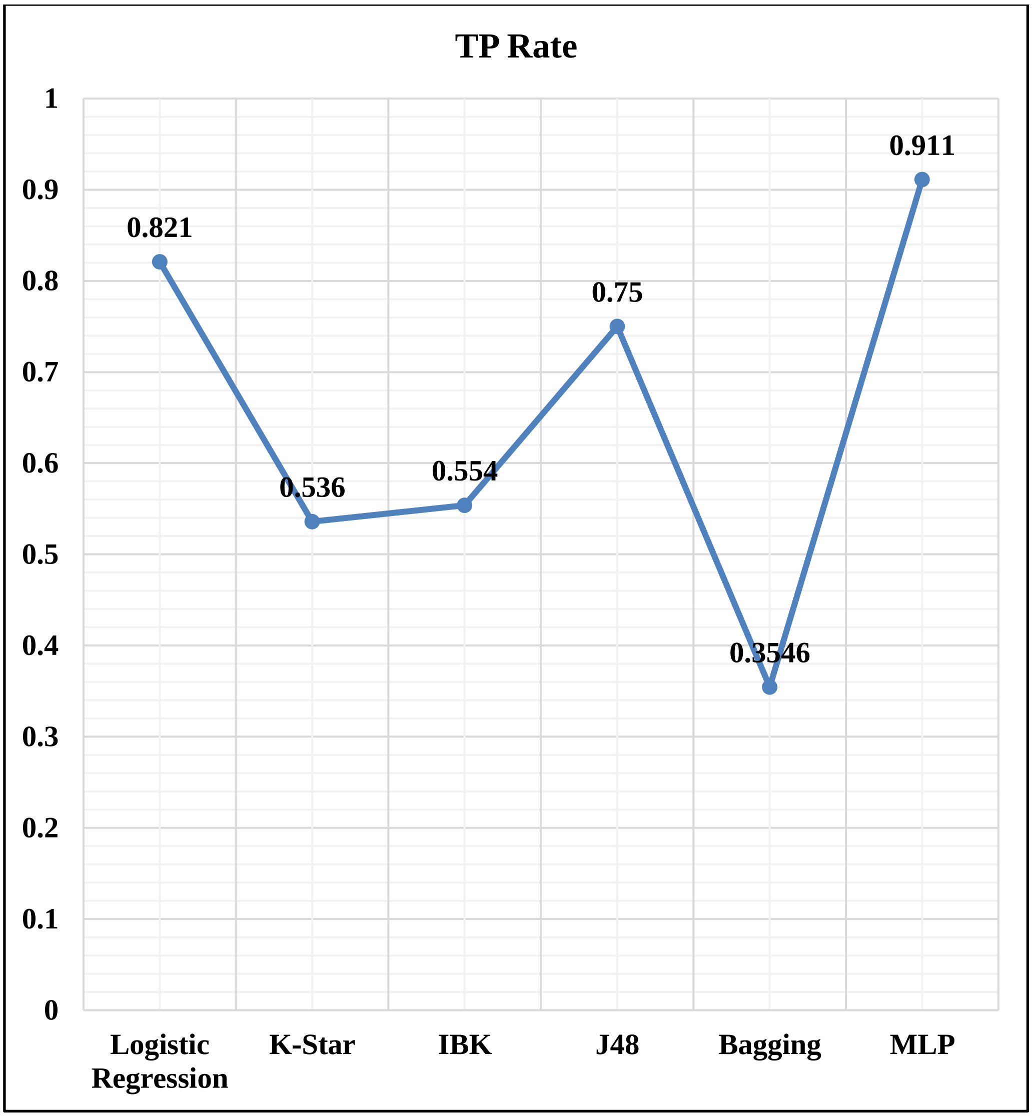

Figure 5.4: TP Rate Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-10 folds)

According to figure 5.4, it can be concluded that at the configuration setting of cross-validation, 10-fold the TP Rate of MLP classifier with value 0.91 is found to be highest followed by Logistic Regression with a value of 0.82. The other classification algorithms had to have TP Rate of about 0.75 in case of J48 classifier, 0.35, 0.55, and 0.54 in case of Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure TP rate were found to be MLP and LR.

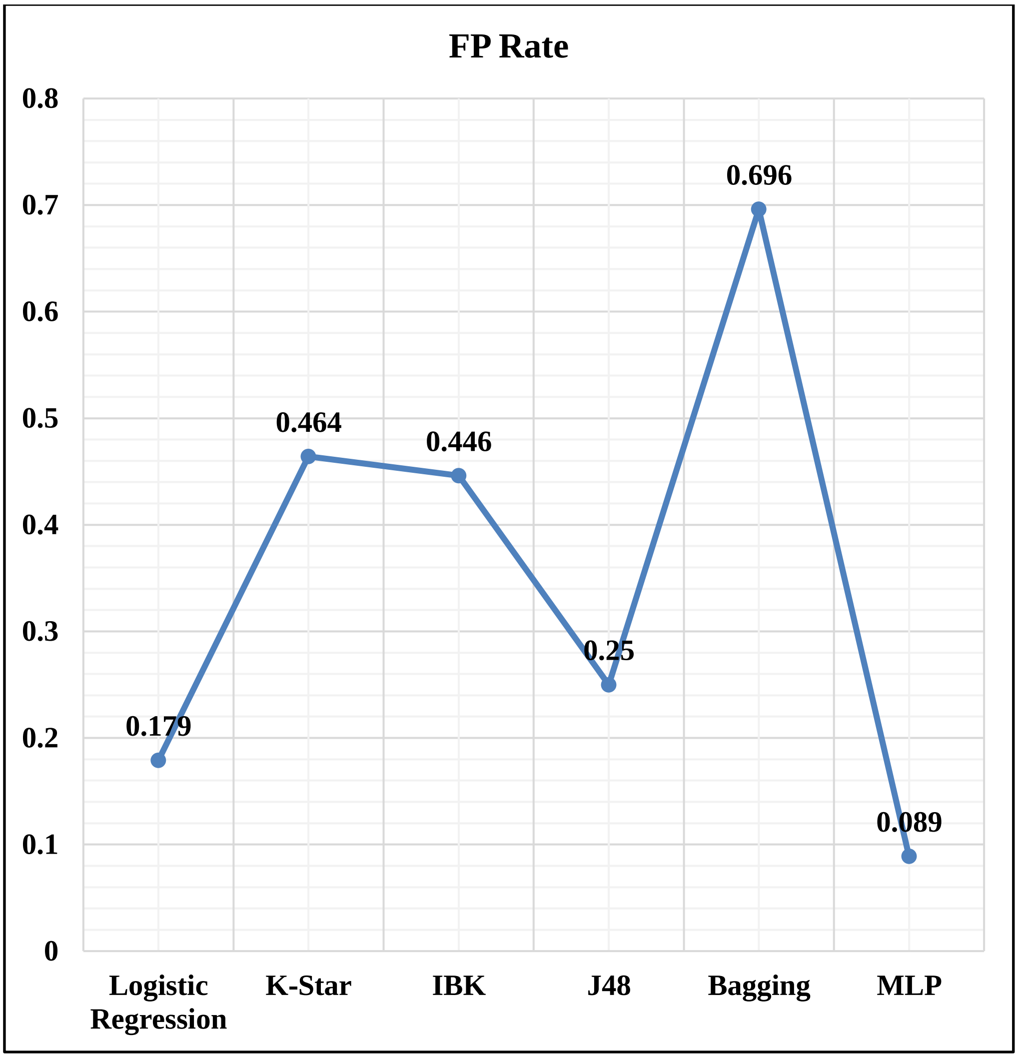

Figure 5.5: FP Rate Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-10 folds)

Figure 5.5, it can be concluded that at the configuration setting of cross-validation 10 folds the FP Rate of MLP classifier with value 0.09 is found to be lowest followed by Logistic Regression with value 0.18. The other classification algorithms had to have an FP Rate of about 0.25 in case of J48 classifier, 0.69, 0.45, and 0.46 in case of Bagging, IBK, and K-Star which were found to be quite higher. The most appropriate classifiers based on performance measure FP rate were found to be MLP and Logistic Regression having lesser FP rate values as compared to others.

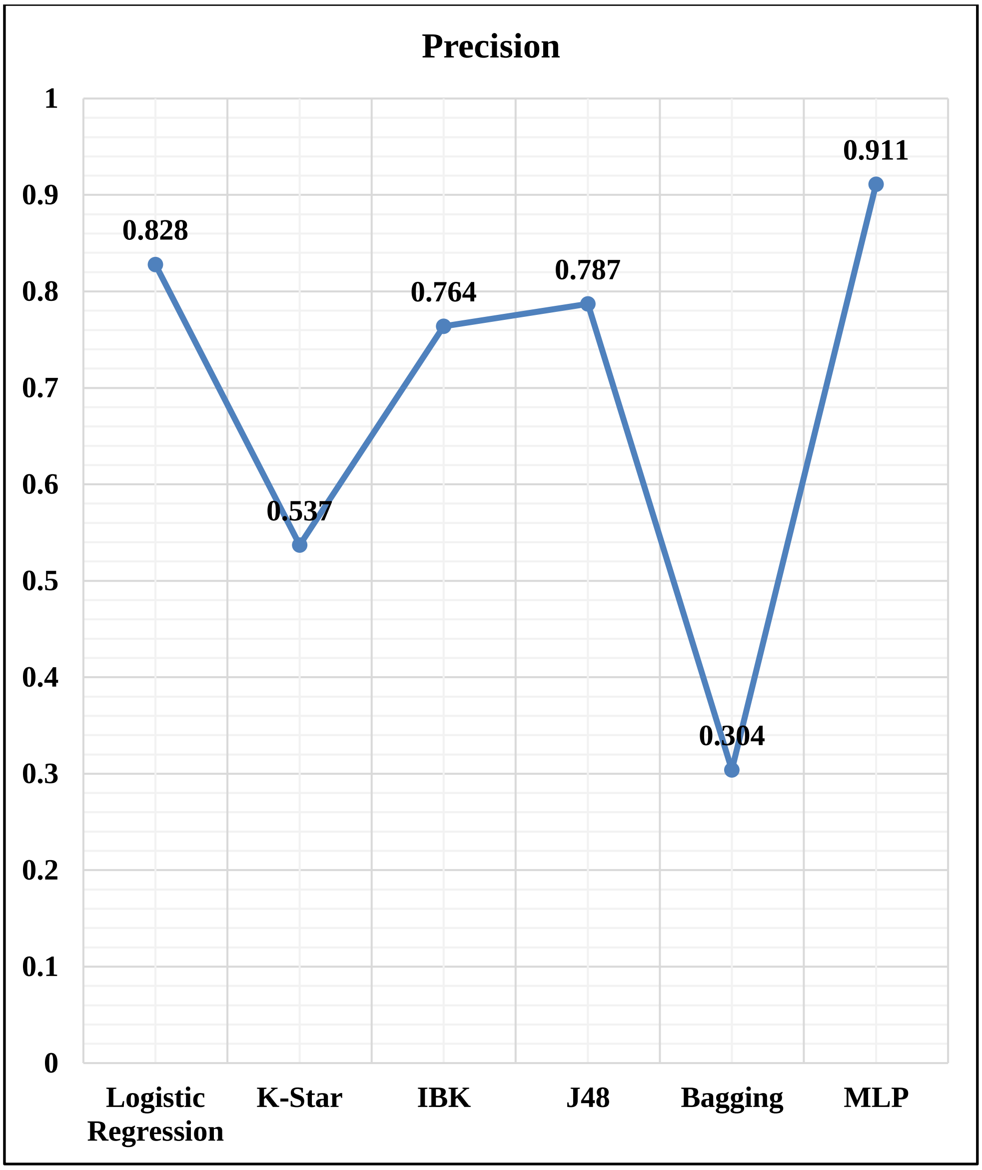

Figure 5.6: Precision Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-10 folds)

Figure 5.6, it can be concluded that at the configuration setting of cross-validation 10 folds the Precision of MLP classifier with value 0.91 is found to be highest followed by Logistic Regression with value 0.83. The other classification algorithms had to have a Precision of about 0.79 in case of J48 classifier, 0.30, 0.76, and 0.53 in case of Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure Precision were found to be MLP and LR.

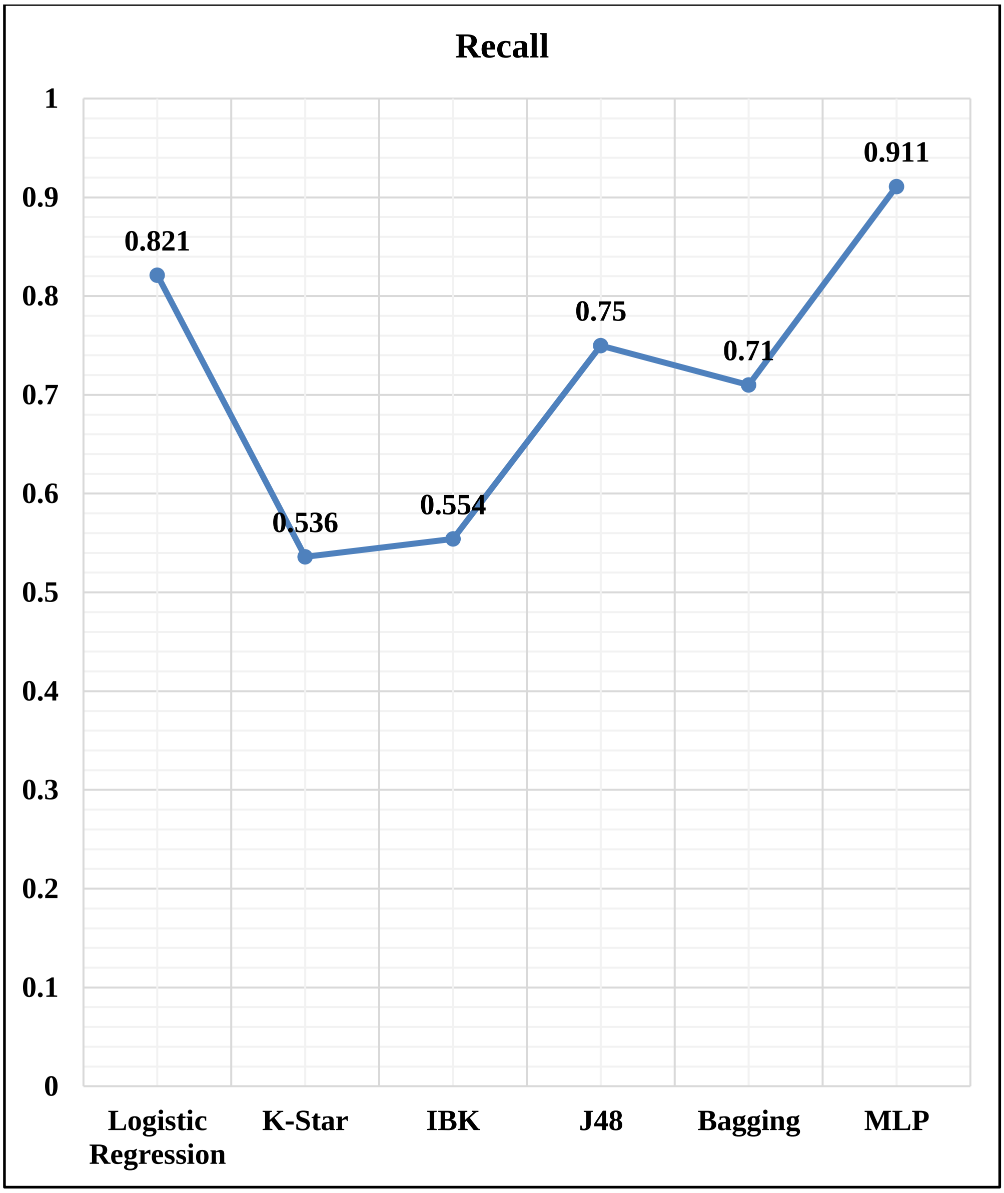

Figure 5.7: Recall Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-10 folds)

Results as shown in figure 5.7, confirm that at configuration setting of cross-validation 10 folds the Recall of MLP classifier with value 0.91 is found to be highest followed by Logistic Regression with value 0.82. The other classification algorithms had to have a Recall of about 0.75 in case of J48 classifier, 0.71, 0.55, and 0.53 in case of Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure Recall were found to be MLP and LR.

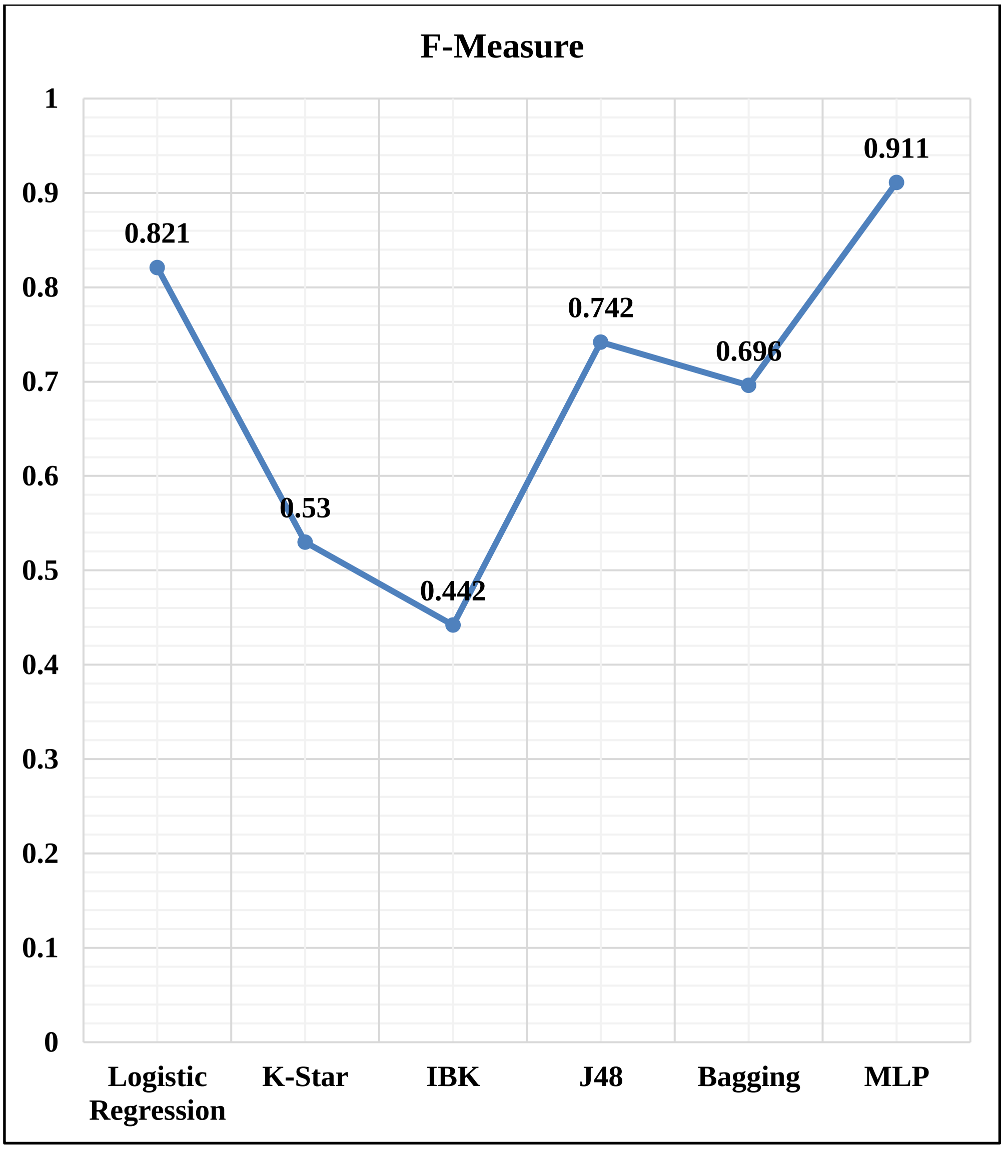

Figure 5.8: F-Measure Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-10 folds)

According the figure 5.8, it can be concluded that at the configuration setting of cross-validation, 10 folds the F-Measure of MLP classifier with value 0.91 is found to be highest followed by Logistic Regression with value 0.82. The other classification algorithms had to have an F-Measure of about 0.74 in case of J48 classifier, 0.69, 0.44, and 0.53 in case of Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure F-Measure were found to be MLP and LR.

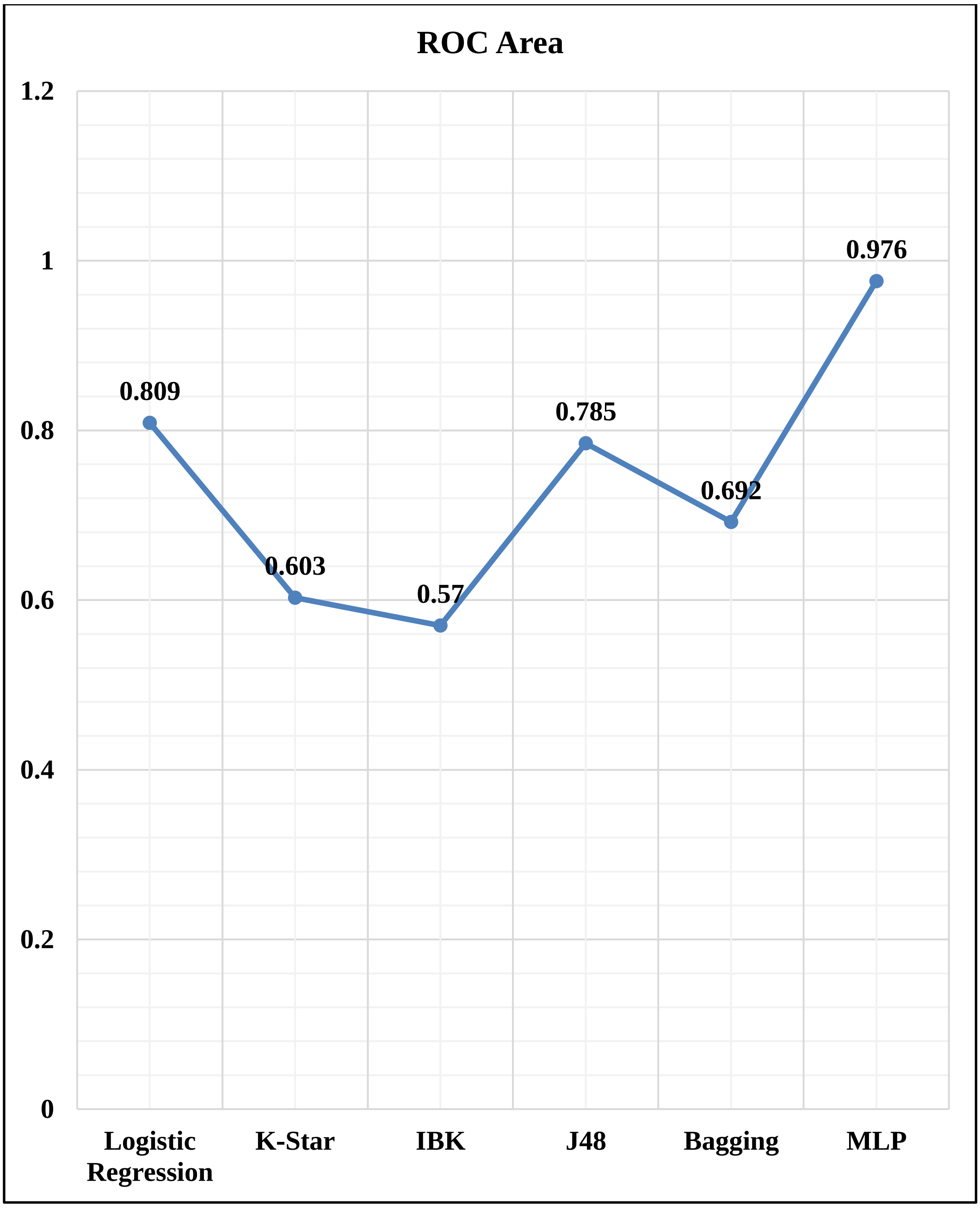

Figure 5.9: ROC Area Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-10 folds)

Figure 5.9, it can be concluded that at configuration setting of cross-validation 10 folds, the ROC Area of MLP classifier with value 0.97 is found to be highest followed by Logistic Regression with value 0.80. The other classification algorithms had to have a ROC Area of about 0.78 in case of J48 classifier, 0.69, 0.57, and 0.60 in case of Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure ROC Area were found to be MLP and LR.

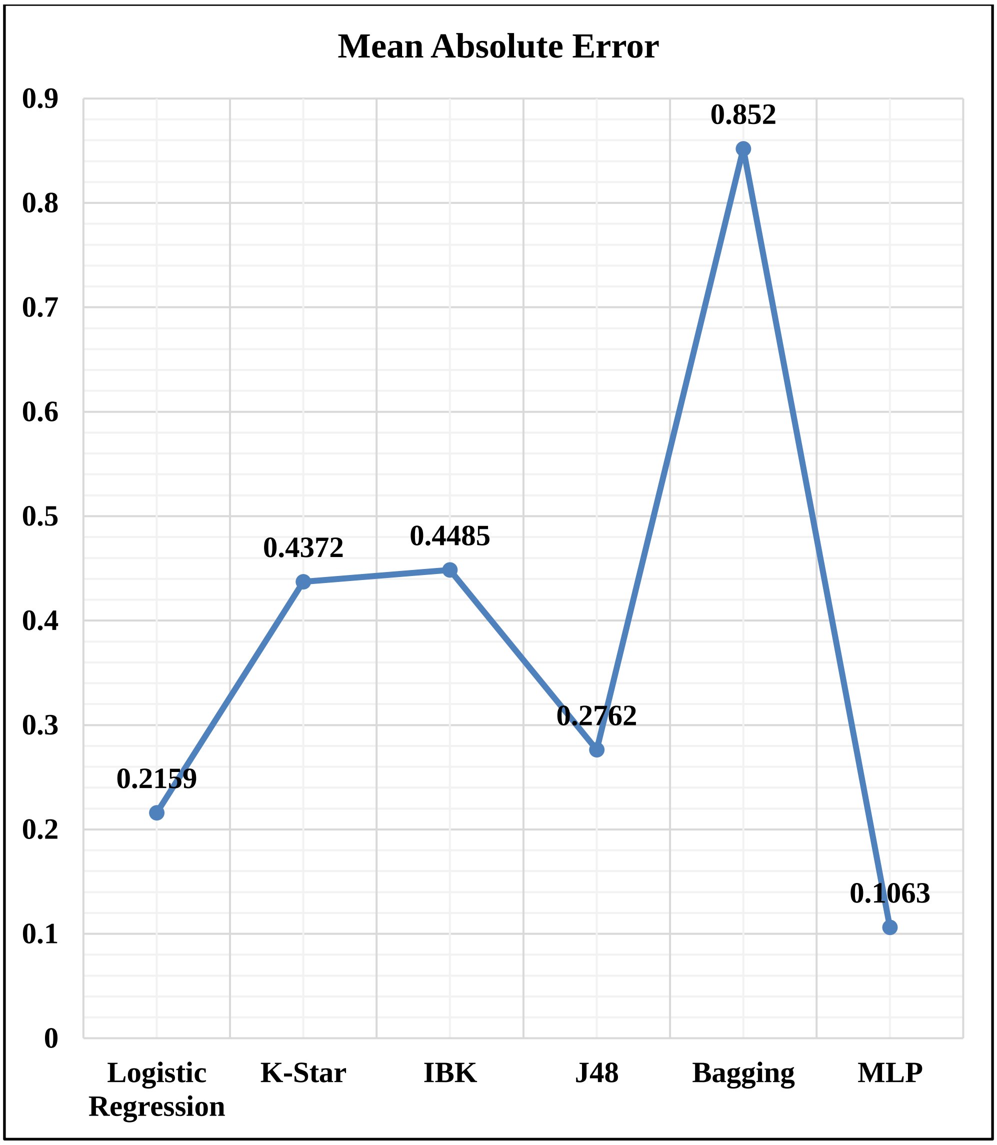

Figure 5.10: MAE Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-10 folds)

Figure 5.10, it can be concluded that at the configuration setting of cross-validation, 10 folds the mean absolute error value of MLP classifier with 0.10 is found to be lowest followed by Logistic Regression with value 0.21. The other classification algorithms had mean absolute error values of about 0.28 in case of J48 classifier, 0.85, 0.45, and 0.43 in case of Bagging, IBK, and K-Star were found to be quite high. The most appropriate classifiers based on performance measure mean absolute error value were found to be MLP and LR having lesser mean absolute error values as compared to others.

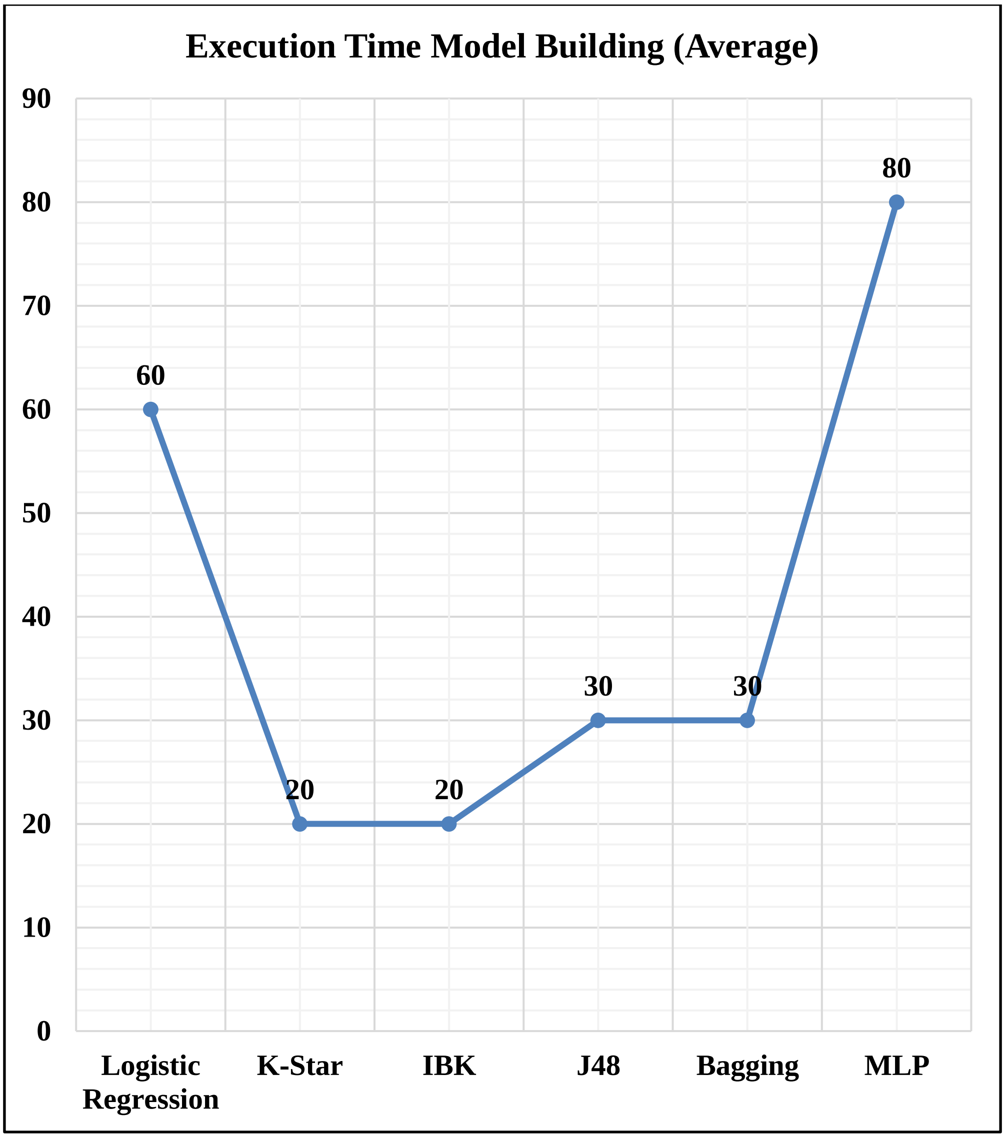

Figure 5.11: Average Execution Time for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-10 folds)

Figure 5.11, it can be concluded that at the configuration setting of cross-validation 10 folds the average execution time of model building of K-Star and IBK classifier is found to be 20 milliseconds which is quite less as compared with other classifiers. The other classification algorithms had to have an average execution time of model building of about 30ms in case of J48 classifier, 30, 60, and 80ms in case of Bagging, LR, and MLP. The most appropriate classifiers based on performance measure average execution time of model building were found to be K-Star and IBK.

5.4 Comparative Analysis Based on Cross-Validation 20 Folds

In the performance analysis of classification algorithms used for task offloading based on 20-fold cross-validation, the evaluation provides a comprehensive understanding of each algorithm's effectiveness in handling the task offloading problem. Cross-validation is a re-sampling technique that partitions the dataset into 20 subsets (folds), where each fold serves as both a training set and a testing set.

Table 5.2: Performance Analysis of Classification Algorithms Used for Task Offloading: 20fold Cross-validation

Performance Measure	Logistic Regression	K-Star	IBK	J48	Bagging	MLP
Accuracy	0.82	0.48	0.55	0.76	0.64	0.91
Kappa Statistic	0.64	-0.03	0.10	0.53	0.28	0.82
TP Rate	0.82	0.48	0.55	0.76	0.64	0.91
FP Rate	0.17	0.51	0.44	0.23	0.35	0.08
Precision	0.82	0.48	0.76	0.78	0.65	0.91
Recall	0.82	0.48	0.55	0.76	0.64	0.91
F-Measure	0.82	0.47	0.44	0.76	0.63	0.91
ROC Area	0.79	0.56	0.56	0.80	0.73	0.97
Mean Absolute Error	0.24	0.47	0.44	0.25	0.36	0.09
Execution Time Model Building	70ms	20ms	25ms	35ms	40ms	90ms

Table 5.2, shows that evaluation metrics, such as accuracy, precision, recall, F1 score, and area under the receiver operating characteristic ROC curve, are computed for each fold to assess the algorithm's performance consistently across different subsets of the data. The average performance metrics across all 20 folds provide a robust estimate of how well each algorithm generalizes to unseen data as shown in the figure below.

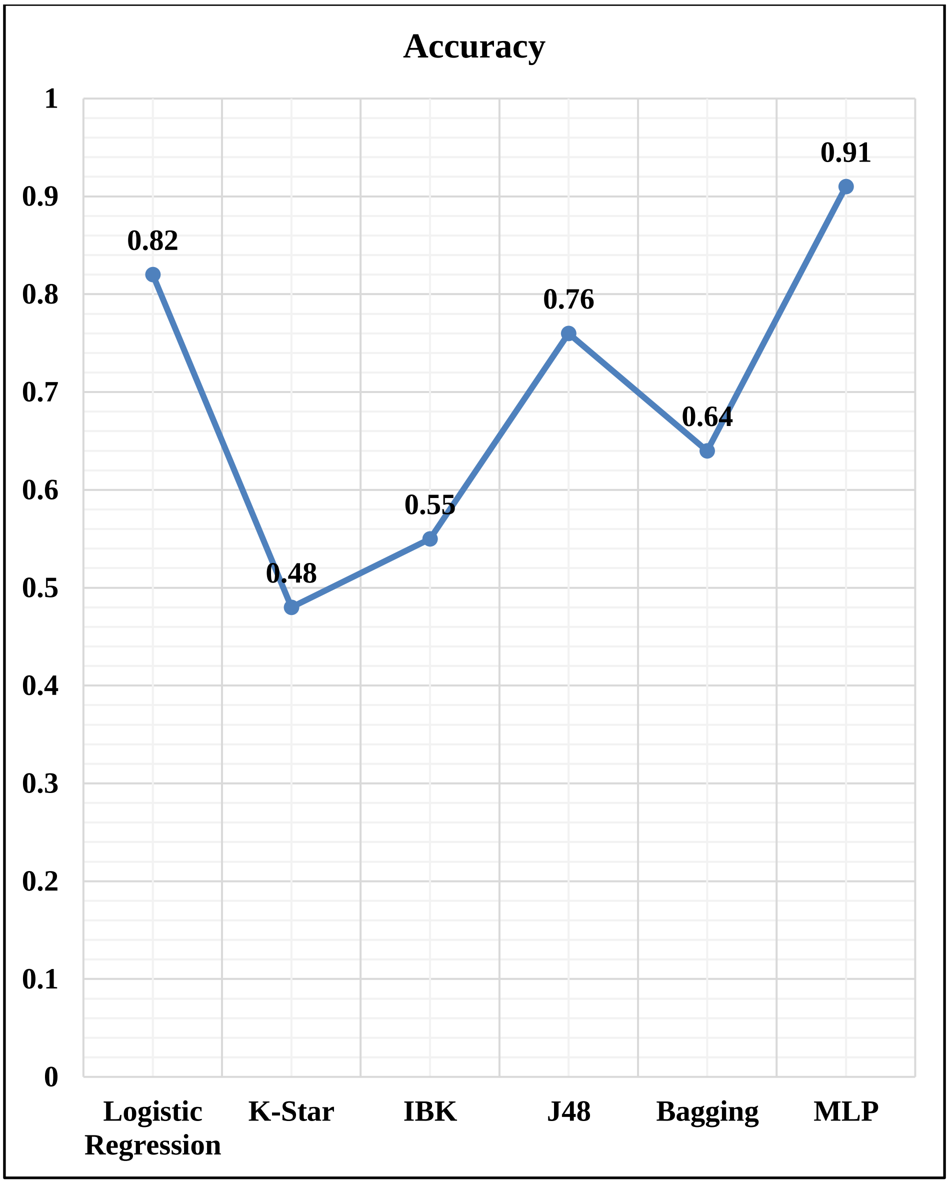

Figure 5.12: Accuracy Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-20 folds)

Figure 5.12, confirms that at the configuration setting of cross-validation, 20 folds the accuracy of MLP classifier with value 0.91 is found to be highest followed by Logistic Regression with value 0.82. The other classification algorithms had to have an accuracy of about 0.76 in case of J48 classifier, 0.64, 0.55, and 0.48 in case of Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure accuracy were found to be MLP and LR.

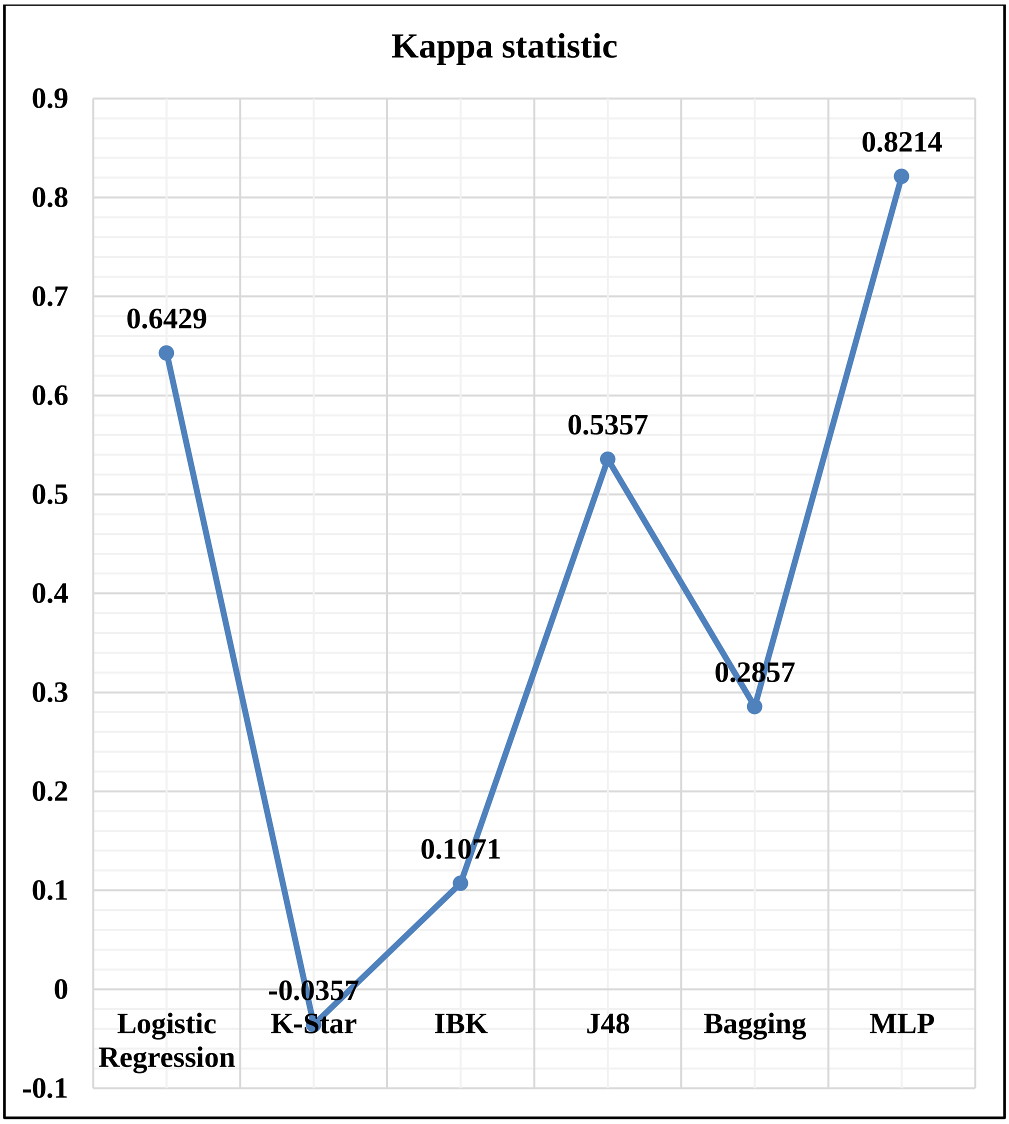

Figure 5.13: Kappa Statistics Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-20 folds)

Figure 5.13, it shows comparing the performance of classifiers based on Kappa statistics used for task offloading and resource allocation in case of SMART FOG environment it can be interpreted that a higher Kappa statistics value of 0.82 in case of MLP and 0.64 in case of Logistic Regression suggests that they are the better classifiers as compared to other classification techniques.

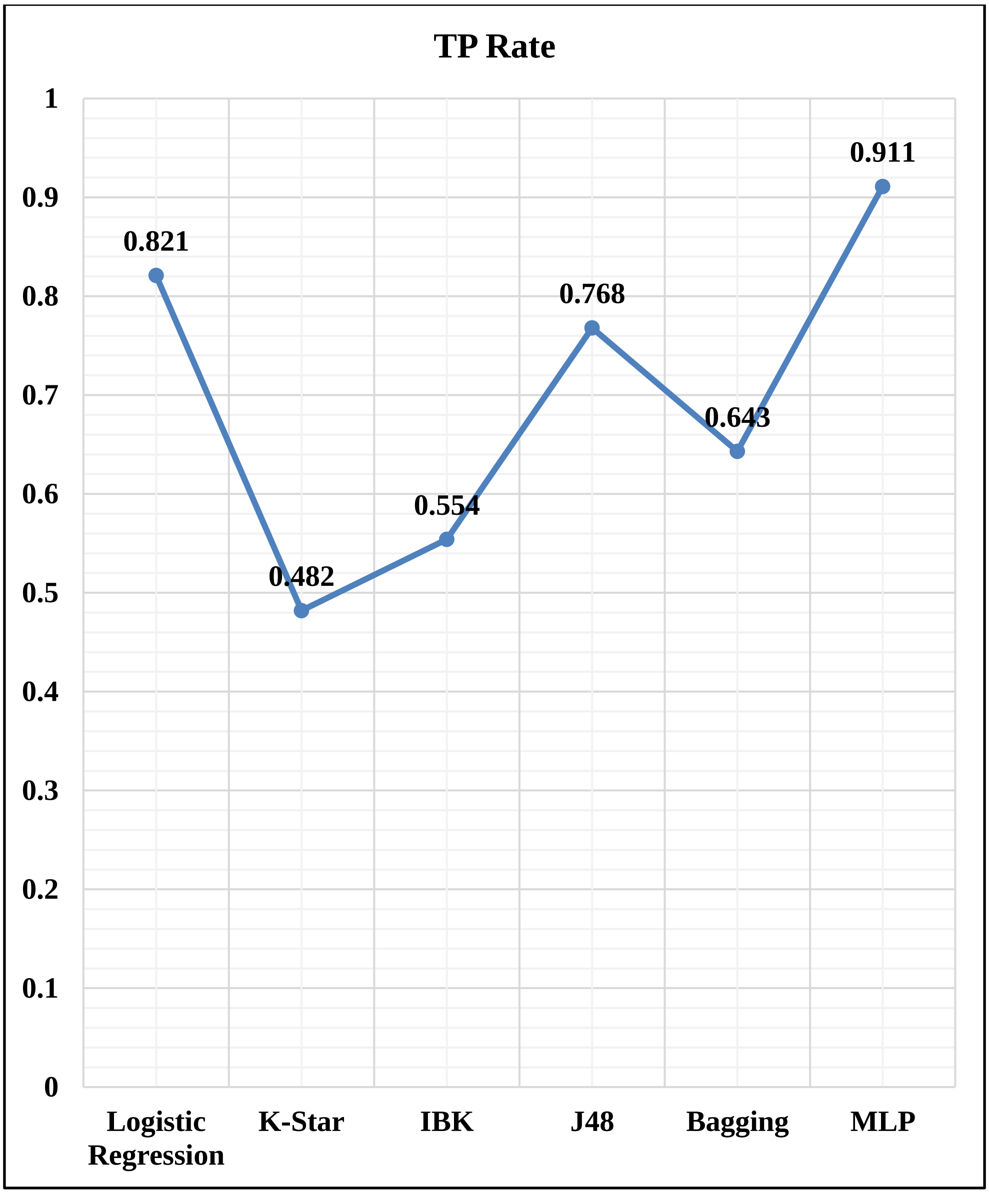

Figure 5.14: TP Rate Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-20 folds)

According to figure 5.14, it can be concluded that at configuration setting of cross-validation 20 folds the TP Rate of MLP classifier with value 0.91 is found to be highest followed by Logistic Regression with value 0.82. The other classification algorithms had to have a TP Rate of about 0.76 in the J48 classifier, 0.64, 0.55, and 0.48 in Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure TP rate were found to be MLP and LR.

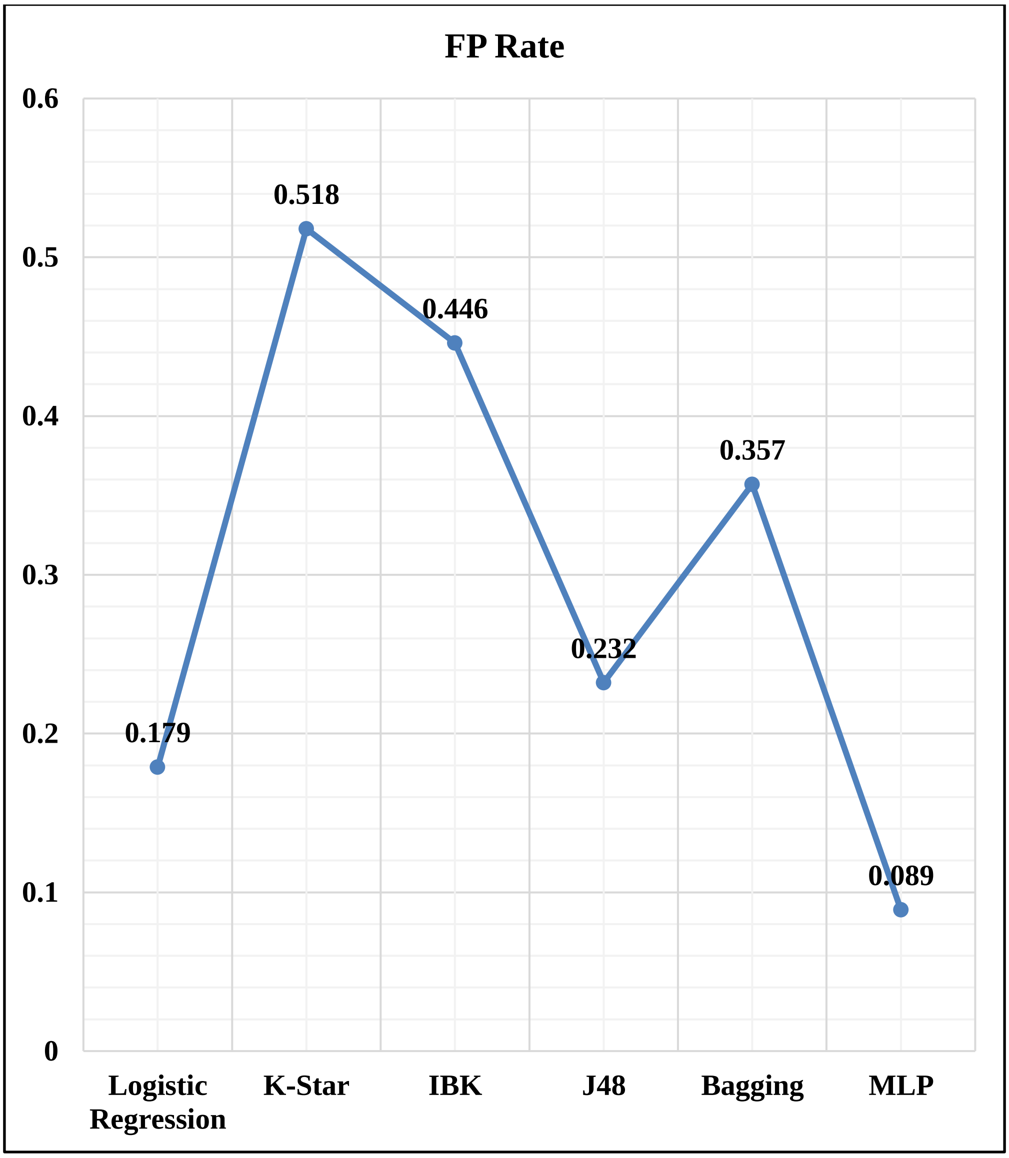

Figure 5.15: TP Rate Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-20 folds)

Figure 5.15, it can be concluded that at the configuration setting of cross-validation, 20 folds the FP Rate of MLP classifier with value 0.08 is found to be lowest followed by Logistic Regression with value 0.17. The other classification algorithms had to have an FP Rate of about 0.23 in case of J48 classifier, 0.35, 0.44, and 0.51 in case of Bagging, IBK, and K-Star which were found to be quite higher. The most appropriate classifiers based on performance measure FP rate were found to be MLP and LR having lesser FP rate values as compared to others.

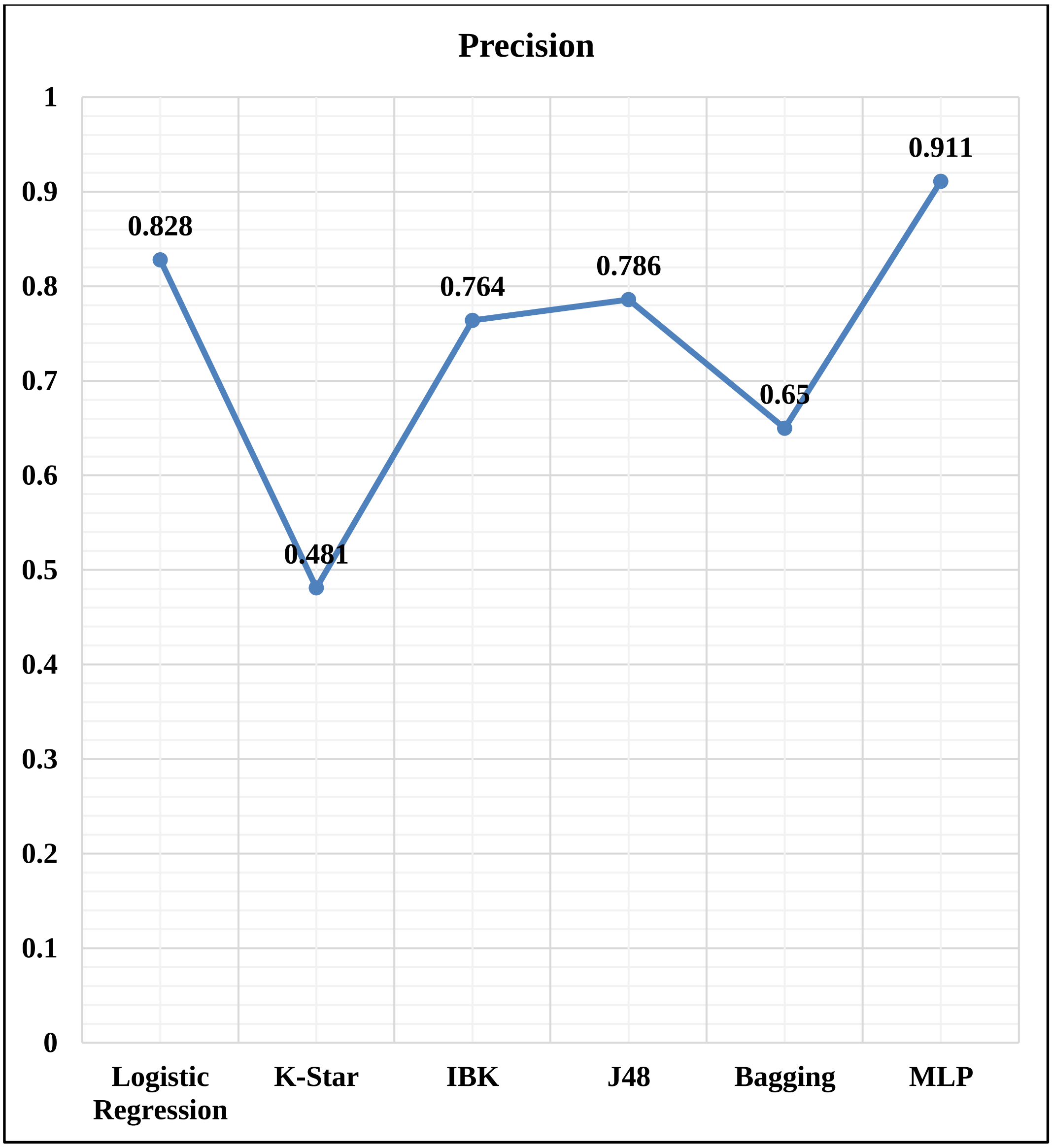

Figure 5.16: Precision Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-20 folds)

Figure 5.16, it can be concluded that at the configuration setting of cross-validation 20 folds the Precision of MLP classifier with value 0.91 is found to be the highest followed by Logistic Regression with value 0.82. The other classification algorithms had to have a Precision of about 0.78 in case of J48 classifier, 0.65, 0.76, and 0.48 in case of Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure Precision were found to be MLP and LR.

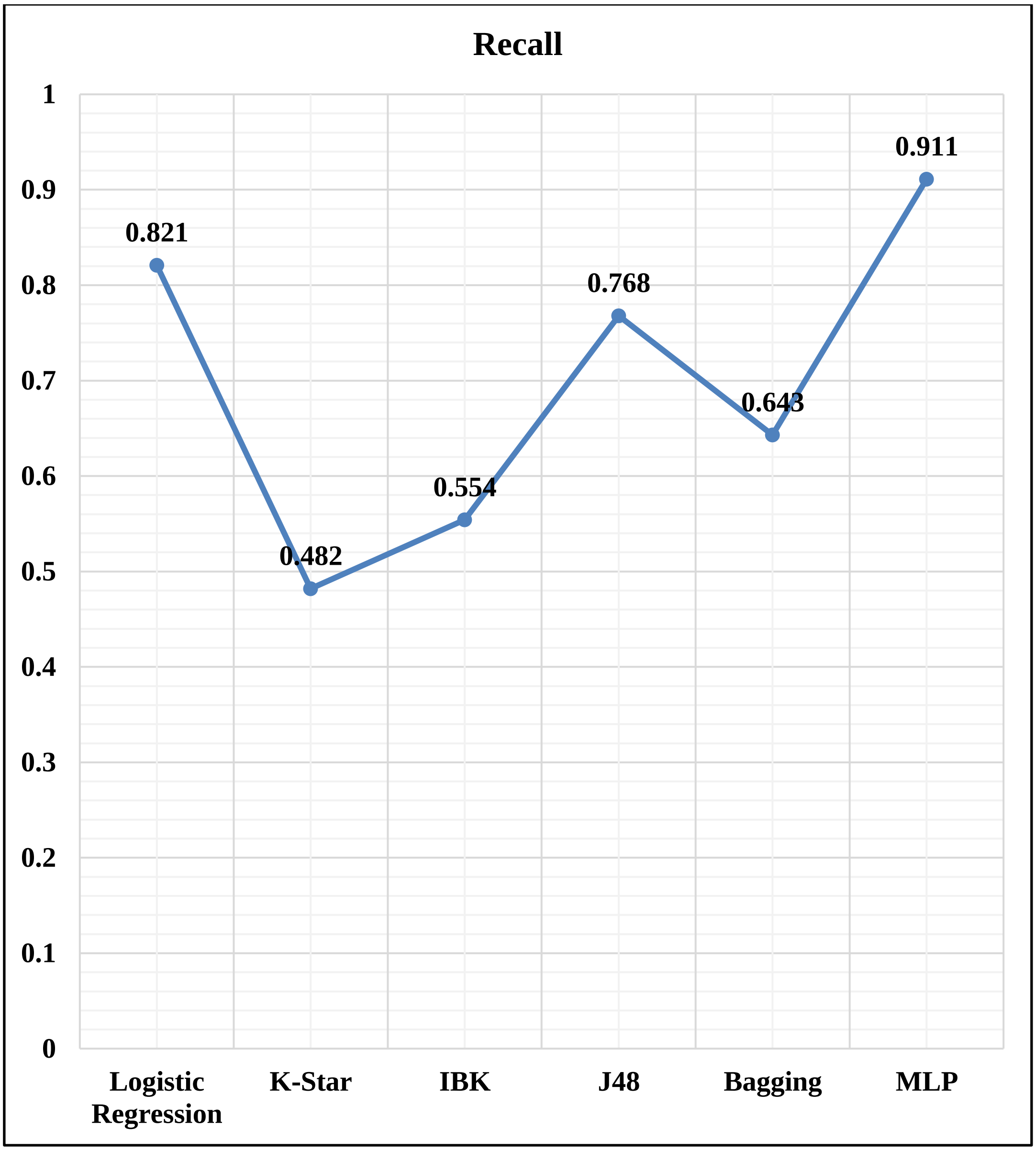

Figure 5.17: Recall Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-20 folds)

Results as shown in figure 5.17 confirm that at configuration setting of cross-validation 20 folds the Recall of MLP classifier with value 0.91 is found to be highest followed by Logistic Regression with value 0.821. The other classification algorithms had to have a Recall of about 0.76 in case of J48 classifier, 0.64, 0.55, and 0.48 in case of Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure Recall were found to be MLP and LR.

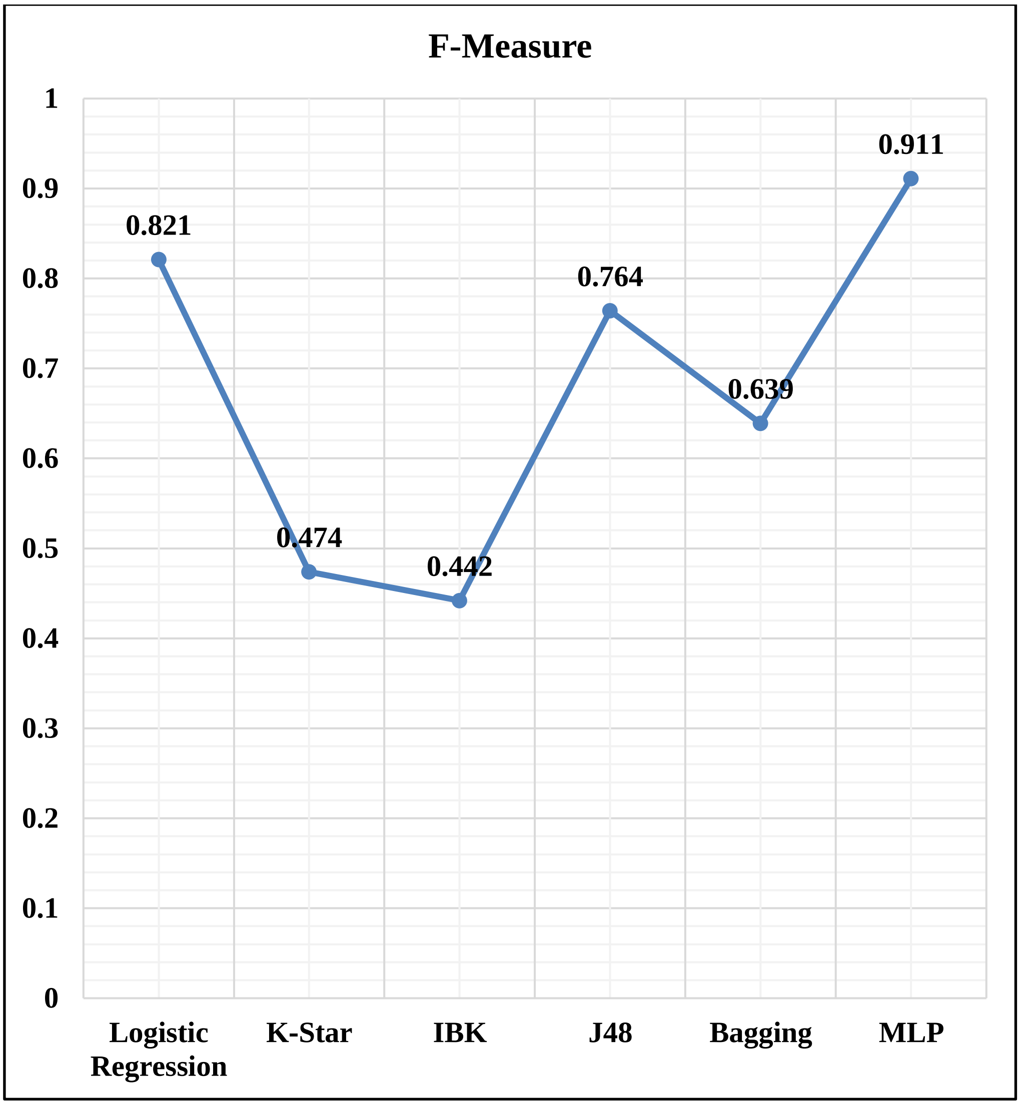

Figure 5.18: F-Measure Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-20 folds)

According to figure 5.18, it can be concluded that at the configuration setting of cross-validation 20 folds the F-Measure of MLP classifier with value 0.91 is found to be highest followed by Logistic Regression with value 0.82. The other classification algorithms had to have an F-Measure of about 0.76 in case of J48 classifier, 0.63, 0.44, and 0.47 in case of Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure F-Measure were found to be MLP and LR.

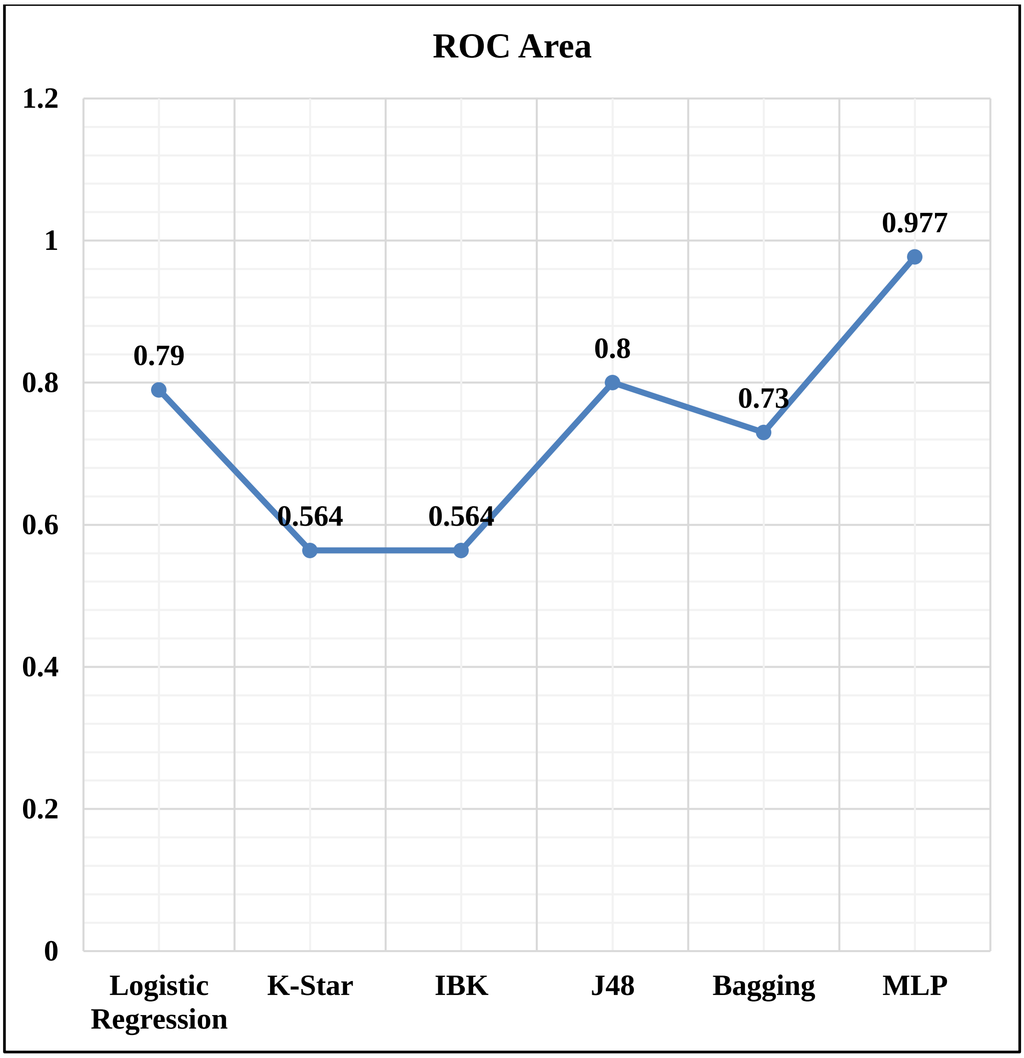

Figure 5.19: ROC Area Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-20 folds)

Figure 5.19, it can be concluded that at the configuration setting of cross-validation 20 folds, the ROC Area of MLP classifier with value 0.97 is found to be highest followed by Logistic Regression with value 0.79. The other classification algorithms have ROC Area of about 0.8 in case of J48 classifier, 0.73, 0.56, and 0.56 in case of Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure ROC Area were found to be MLP and LR.

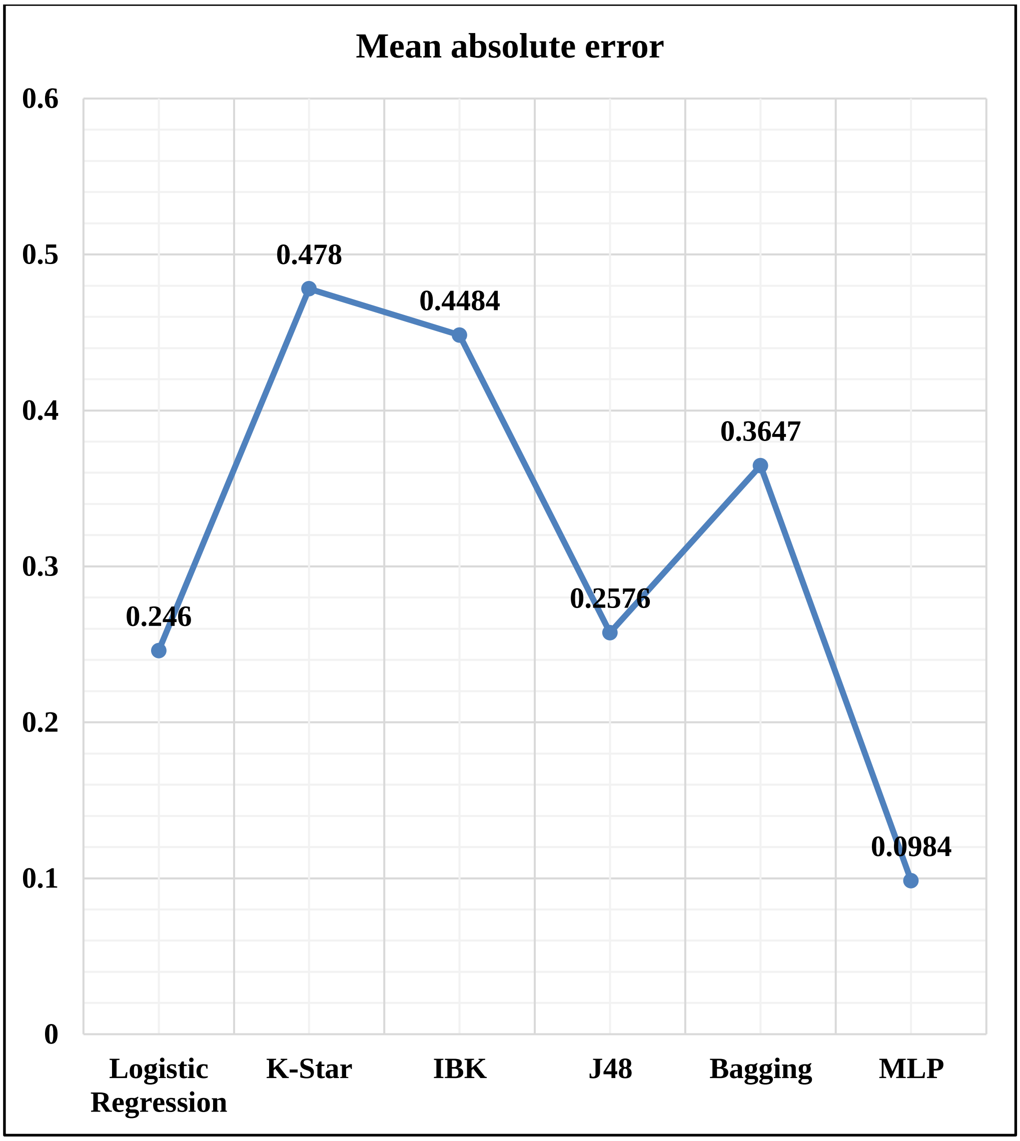

Figure 5.20: MAE Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-20 folds)

Figure 5.20, it can be concluded that at the configuration setting of cross-validation, 20 folds the mean absolute error value of MLP classifier with 0.09 is found to be the lowest followed by Logistic Regression with value 0.24. The other classification algorithms were having mean absolute error value of about 0.25 in case of J48 classifier, 0.36, 0.44, and 0.47 in case of Bagging, IBK, and K-Star were found to be quite high. The most appropriate classifiers based on performance measure mean absolute error value were found to be MLP and LR having lesser mean absolute error values as compared to others.

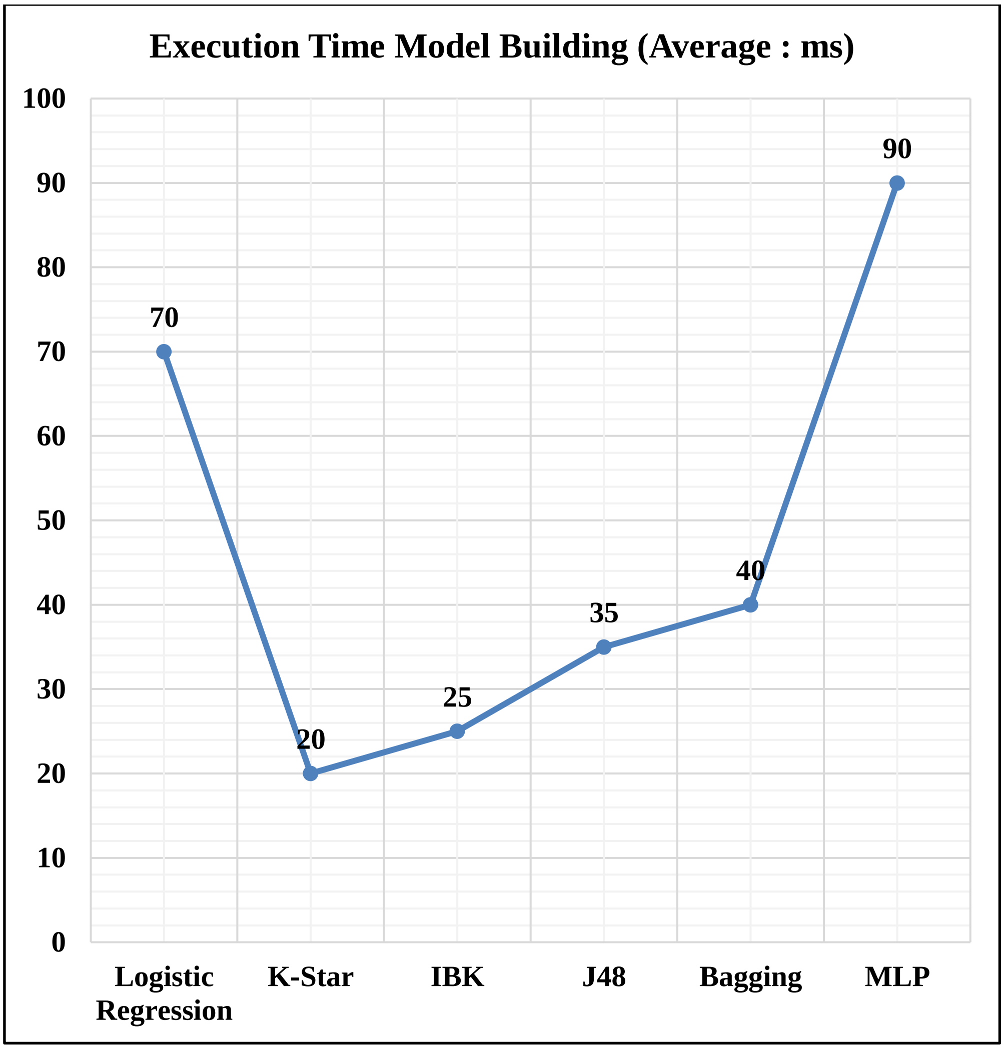

Figure 5.21: Average Execution Time for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Cross Validation-20 folds)

Figure 5.21, it can be concluded that at the configuration setting of cross-validation 20 folds, the average execution time of model building of K-Star and IBK classifier is found to be 20 and 25 milliseconds respectively which is quite less as compared with other classifiers. The other classification algorithms had to have an average execution time of model building of about 35ms in case of J48 classifier, 40, 70, and 90 ms in case of Bagging, Logistic Regression, and MLP. The most appropriate classifiers based on performance measure average execution time of model building were found to be K-Star and IBK.

5.5 Comparative Analysis Based on Split 33%

Classifier mode – Percentage Split Method – 33%: In the performance analysis of classification algorithms used for task offloading with the Percentage Split Method (also known as the Holdout Method) using a split ratio of 33%, the dataset is divided into a training set comprising 67% of the data and a testing set comprising 33% of the data. The training set is used to train the classification algorithm, and the testing set is used to evaluate its performance.

Table 5.3: Performance Analysis of Classification Algorithms Used for Task Offloading: Percentage Split Method – 33%

Performance Measure	Logistic Regression	K-Star	IBK	J48	Bagging	MLP
Accuracy	0.76	0.44	0.73	0.73	0.47	0.68
Kappa Statistic	0.52	-0.10	0.47	0.47	-0.05	0.36
TP Rate	0.76	0.44	0.73	0.73	0.47	0.68
FP Rate	0.23	0.55	0.26	0.26	0.52	0.31
Precision	0.83	0.44	0.74	0.78	0.47	0.72
Recall	0.76	0.44	0.73	0.73	0.47	0.68
F-Measure	0.74	0.43	0.73	0.72	0.47	0.67
ROC Area	0.86	0.57	0.73	0.73	0.45	0.77
Mean absolute error	0.23	0.44	0.28	0.26	0.51	0.30
Execution Time Model Building	30ms	35ms	30ms	35ms	30ms	60ms

Table 5.3, shows that by using a 33% split, a larger portion of the data is allocated to training, which allows the algorithm to learn patterns and relationships within the data. However, the testing set is still substantial enough to provide a good assessment of the algorithm's generalization and performance on unseen data. The results of the evaluation are shown below in the figure.

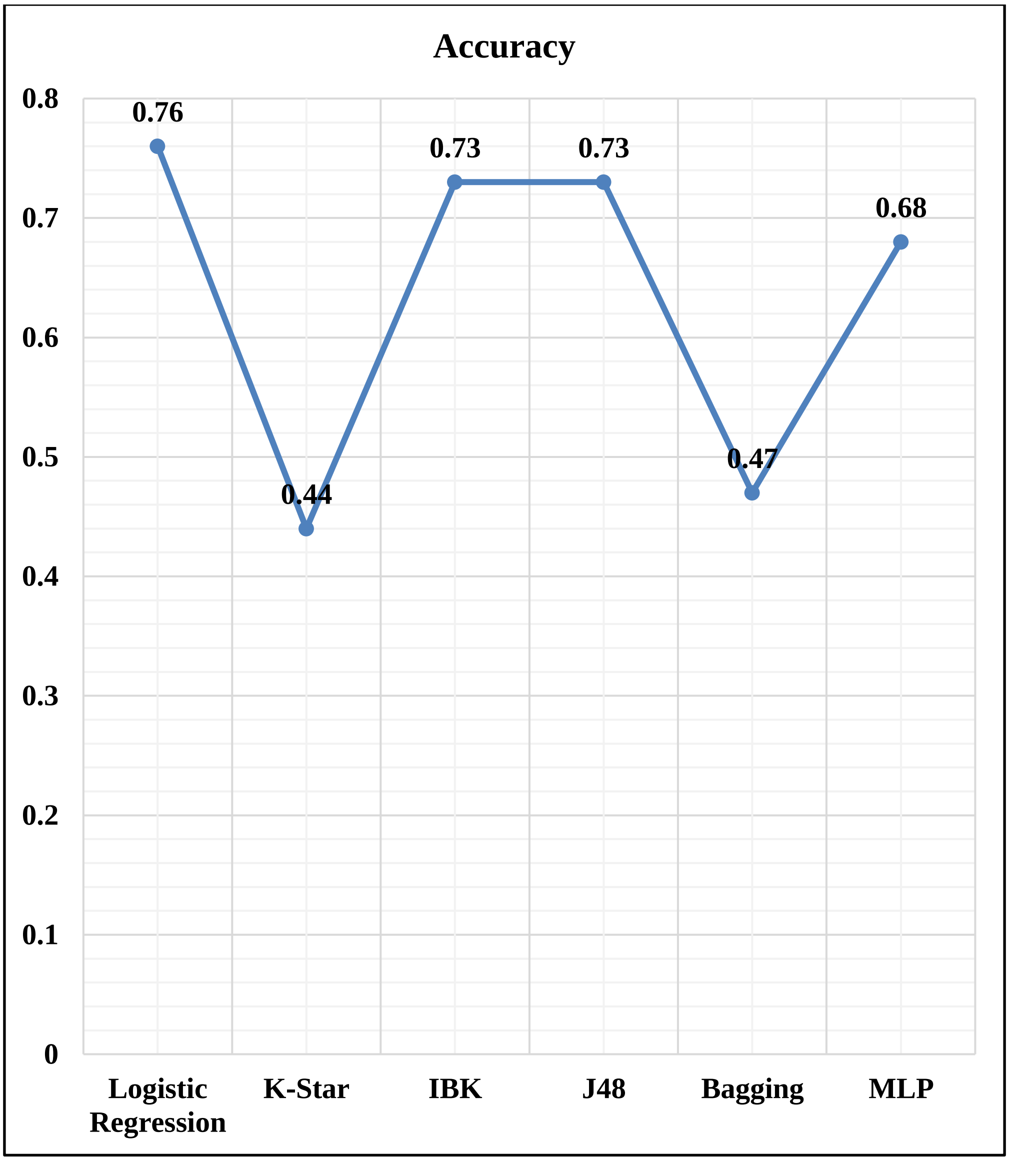

Figure 5.22: Accuracy Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Split-33%)

Figure 5.22, confirms that at the configuration setting of split 33% the accuracy of the Logistic Regression classifier with value 0.76 is found to be highest followed by IBK and J48 with values 0.73 respectively. The other classification algorithms had to have an accuracy of about 0.47 in case of Bagging classifier, 0.44 in case of K-Star. The most appropriate classifier based on performance measure accuracy was found to be Logistic Regression is 0.76 as compared with others.

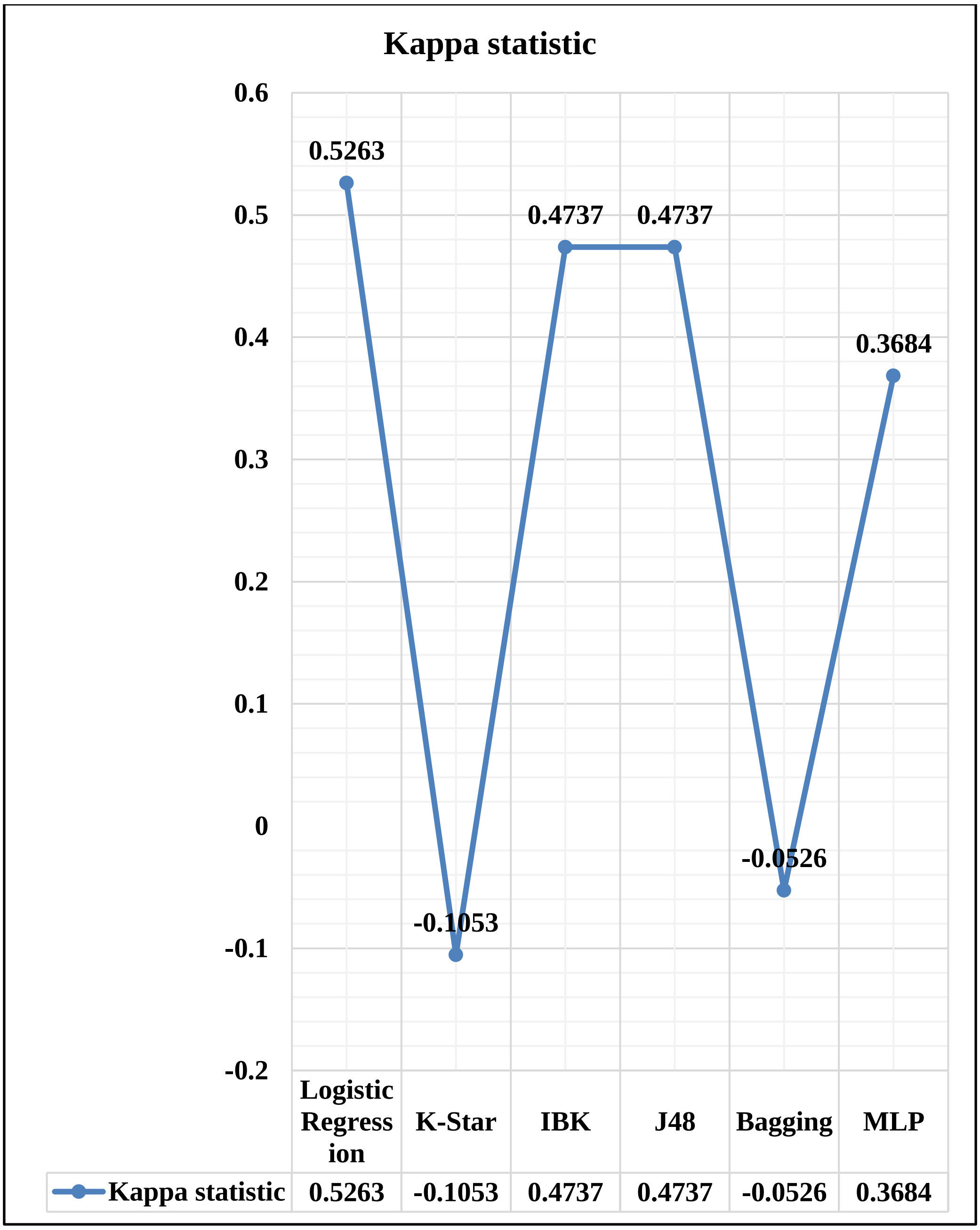

Figure 5.23: Kappa Statistics Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Split-33%)

Figure 5.23, shows that comparing the performance of classifiers used for task offloading and resource allocation in SMART FOG environment based on Kappa statistics it was found that Logistic Regression with value 0.52 was better as compared to other classifiers with Kappa statistics values 0.47, 0.47, 0.36, -0.05, and -0.10 for IBK, J48, MLP, Bagging, and K-Star respectively.

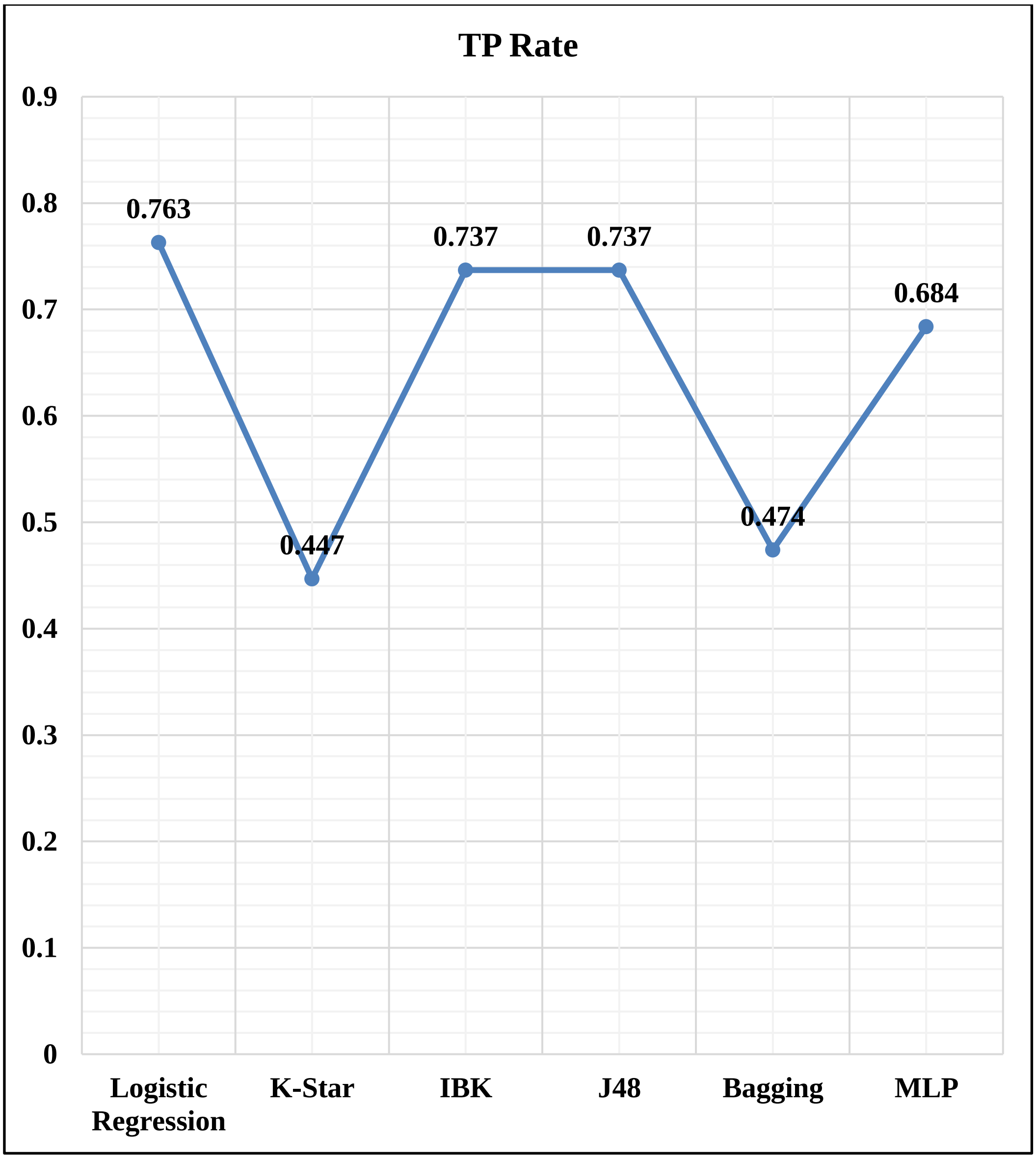

Figure 5.24: TP Rate Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Split-33%)

According to figure 5.24, it can be concluded that at configuration setting spilt 33%, the TP Rate of Logistic Regression classifier with value 0.76 is found to be highest followed by IBK and J48 with value 0.73. The other classification algorithms had to have a TP Rate of about 0.68 in case of MLP classifier, 0.47 and 0.44 for Bagging, and K-Star respectively. The most appropriate classifier based on performance measure TP rate was found to be Logistic Regression is 0.76.

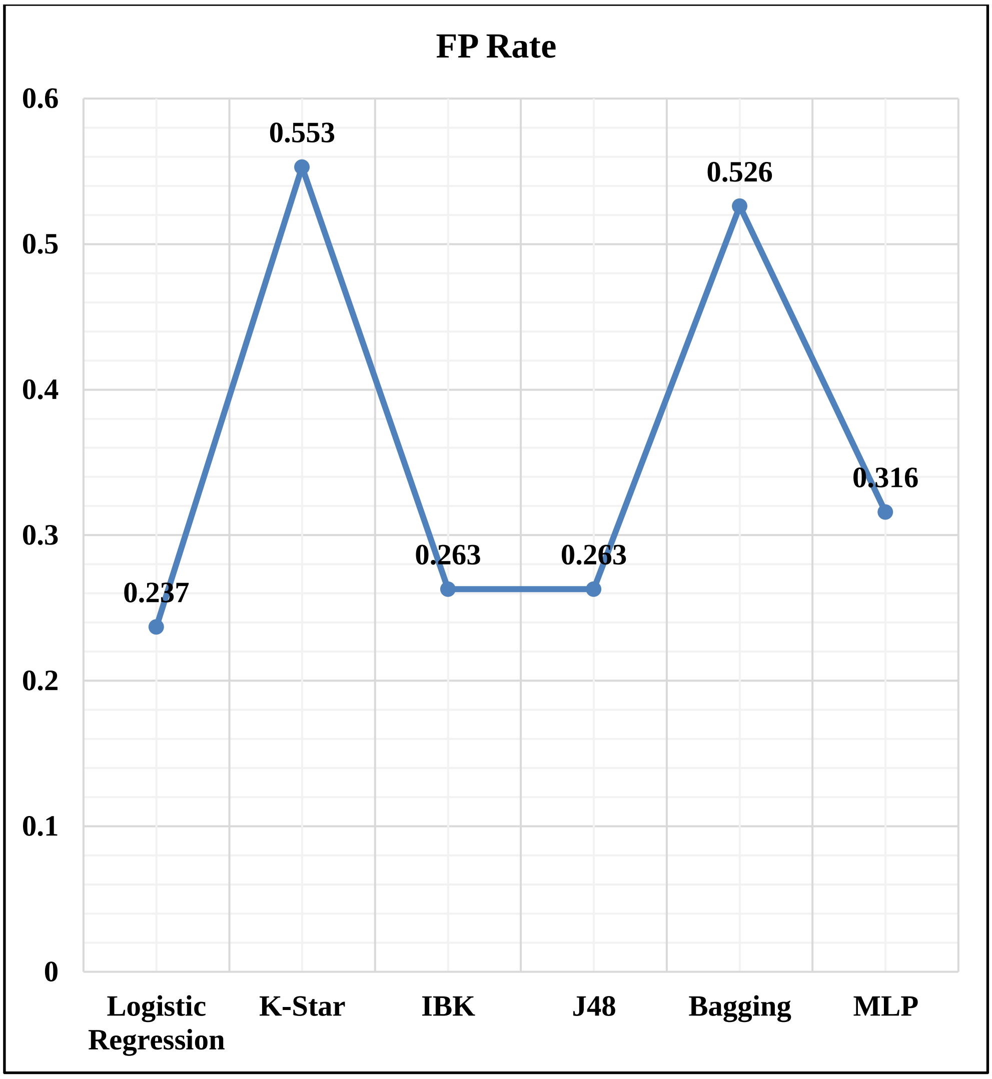

Figure 5.25: FP Rate Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Split-33%)

Figure 5.25, it can be concluded that at a configuration setting split 33%, the FP Rate of the Logistic Regression classifier with a value 0.23 is found to be the lowest followed by IBK and J48 with a value 0.26. The other classification algorithms had to have an FP Rate of about 0.31 in case of MLP classifier, 0.52, and 0.55 in case of Bagging and K-Star had to be quite high. The most appropriate classifiers based on performance measure FP rate were found to be Logistic Regression, IBK and J48 having lesser FP rate is 0.55 values as compared to others.

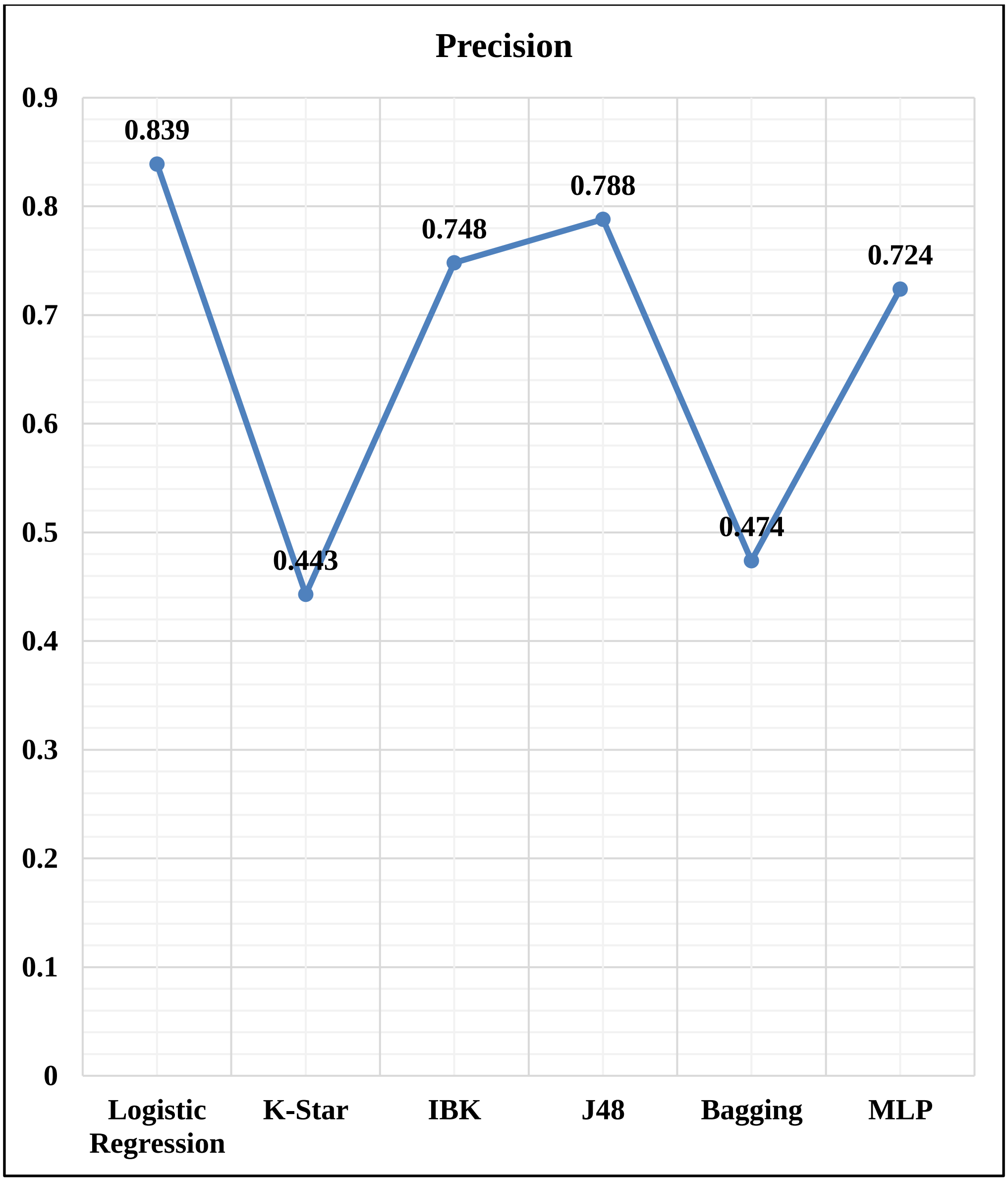

Figure 5.26: Precision Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Split-33%)

According to figure 5.26, it can be concluded that at the configuration setting spilt 33%, the Precision score of the Logistic Regression classifier with value 0.83 is found to be highest followed by IBK and J48 with value 0.74 and 0.78 respectively. The other classification algorithms had to have a Precision of about 0.72 in case of MLP classifier, 0.47 and 0.44 for Bagging, and K-Star respectively. The most appropriate classifier based on performance measure Precision was found to be Logistic Regression is 0.83.

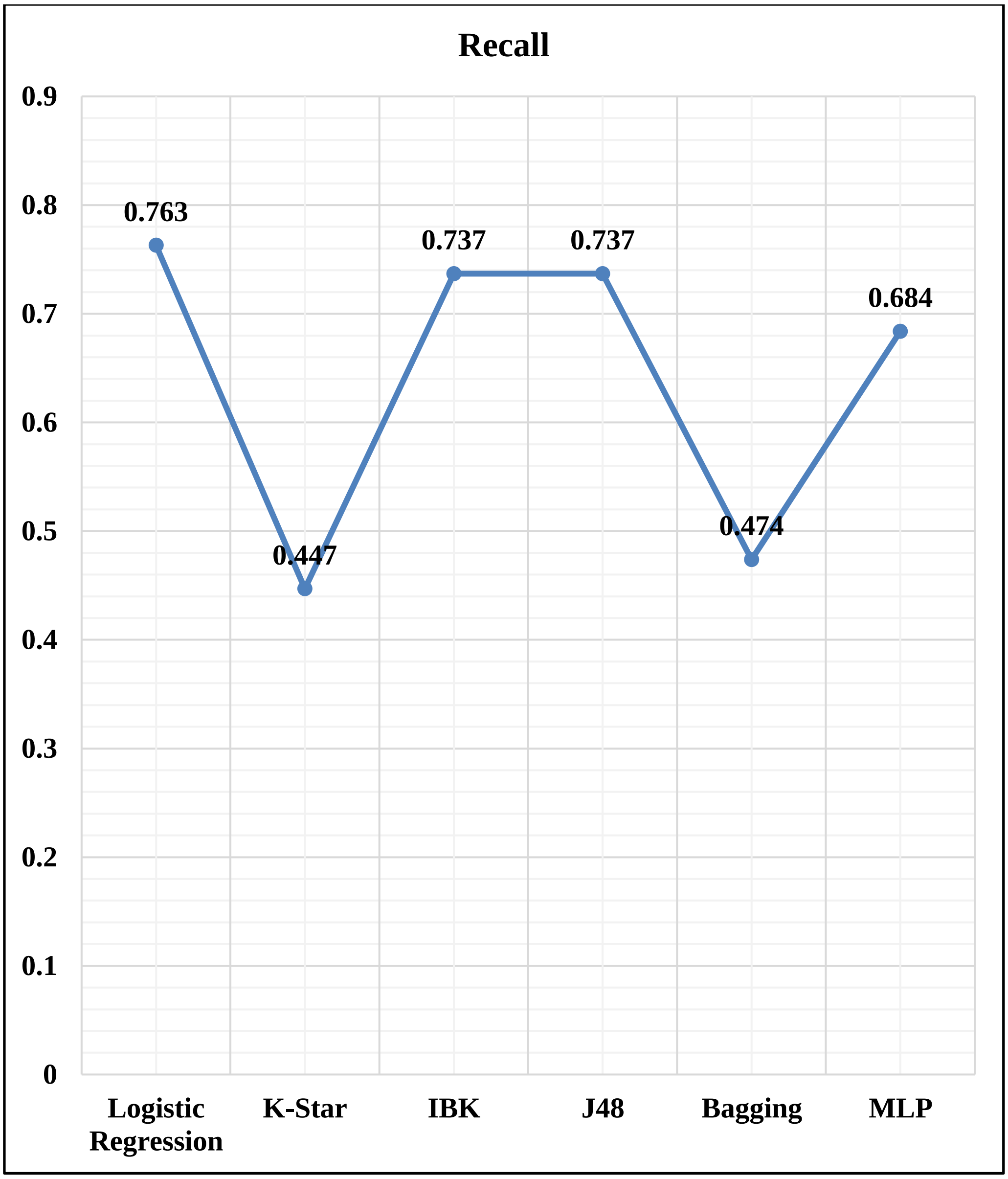

Figure 5.27: Recall Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Split-33%)

Figure 5.27, it can be concluded that at configuration setting spilt 33%, the Recall score of the Logistic Regression classifier with value 0.76 is found to be highest followed by IBK and J48 with value 0.73. The other classification algorithms had to have a Recall of about 0.68 in case of MLP classifier, 0.47 and 0.44 for Bagging, and K-Star respectively. The most appropriate classifier based on performance measure Recall was found to be LR is 0.76.

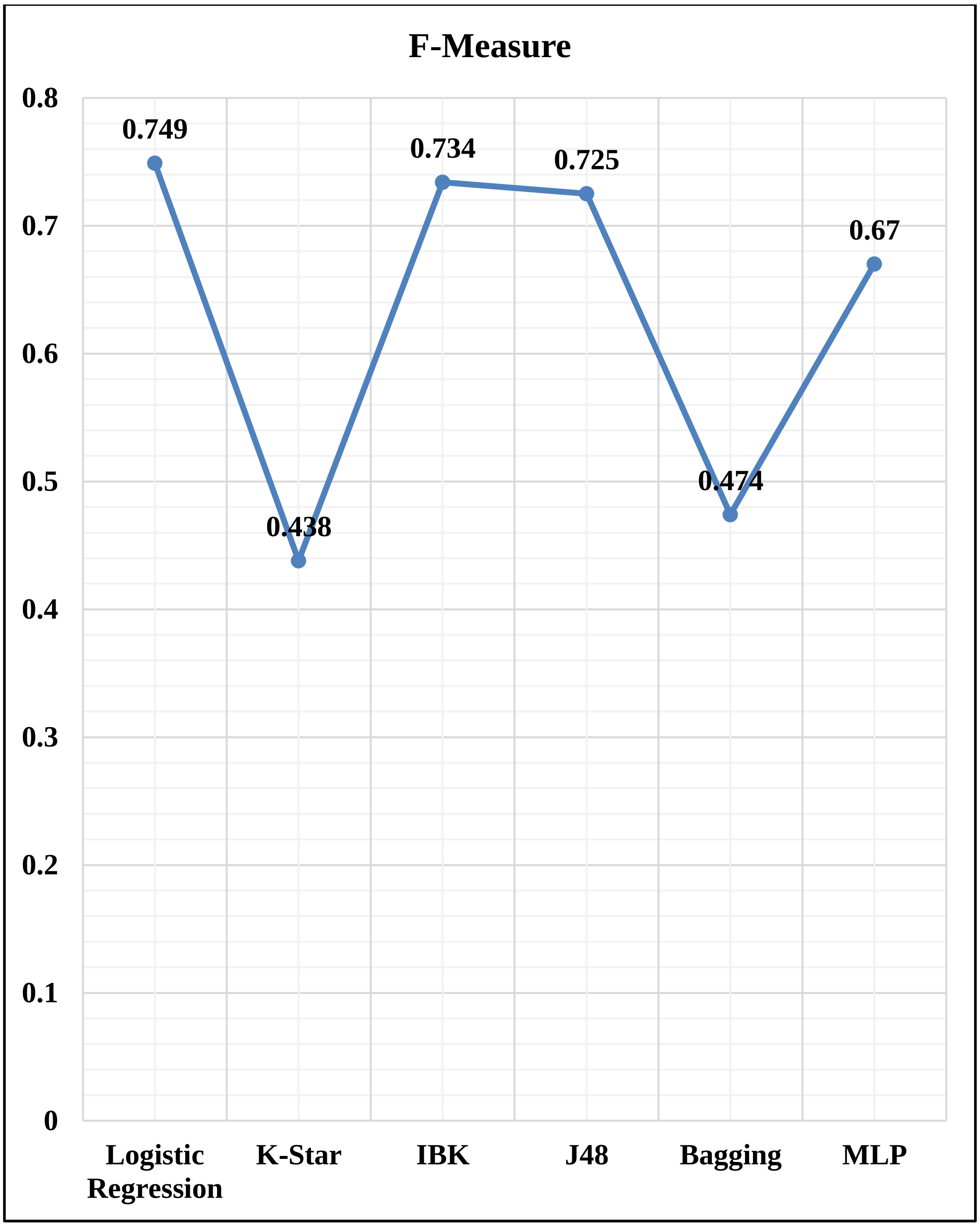

Figure 5.28: F-Measure Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Split-33%)

According to figure 5.28, it can be concluded that at configuration setting spilt 33%, the F-Measure score of the Logistic Regression classifier with value 0.74 is found to be highest followed by IBK and J48 with value 0.73 and 0.72 respectively. The other classification algorithms had to have an F-Measure of about 0.67 in case of MLP classifier, 0.47 and 0.43 for Bagging, and K-Star respectively. The most appropriate classifier based on performance measure F-Measure was found to be LR is 0.74.

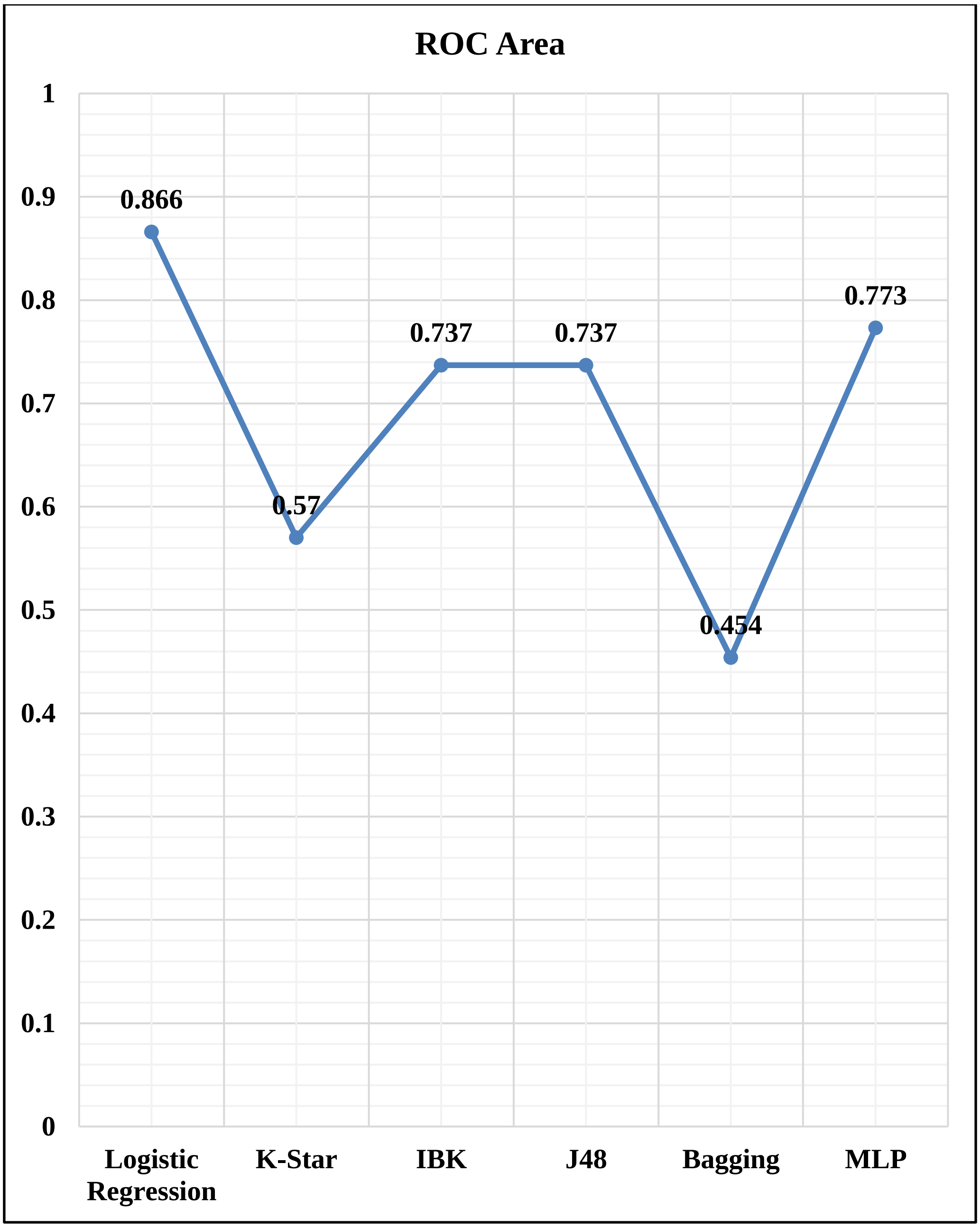

Figure 5.29: ROC Area Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Split-33%)

Figure 5.29, it can be concluded that at configuration setting spilt 33%, the ROC Area score of the Logistic Regression classifier with value 0.86 is found to be highest followed by MLP, IBK and J48 with value 0.77, 0.73 and 0.73 respectively. The other classification algorithms had ROC Area scores of about 0.57, 0.45 for K-Star and Bagging respectively. The most appropriate classifier based on performance measure ROC Area score was found to be LR is 0.86.

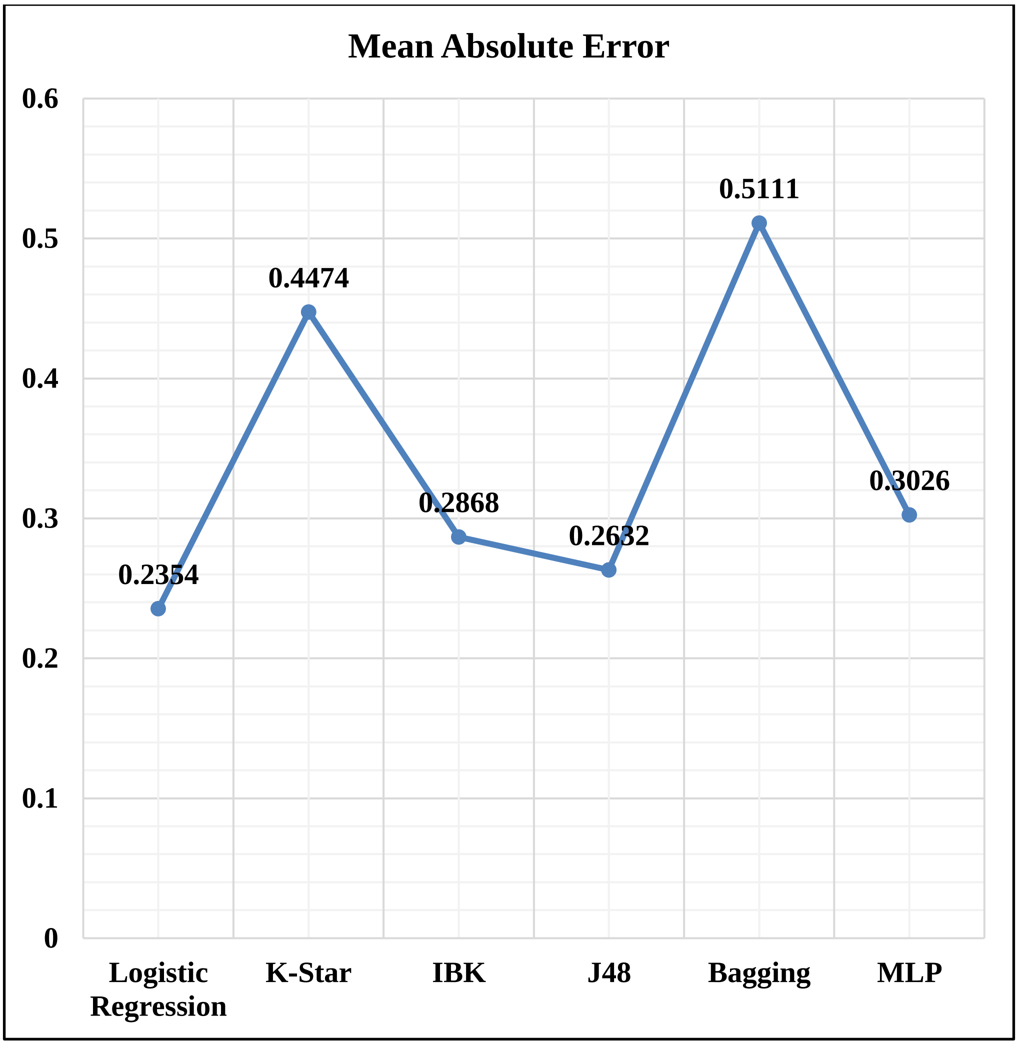

Figure 5.30: MAE Value for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Split-33%)

Figure 5.30, it can be concluded that at the configuration setting split 33%, the Mean Absolute Error of the Logistic Regression classifier with value 0.23 is found to be the lowest followed by IBK and J48 with value 0.28 and 0.26 respectively. The other classification algorithms had MAE value of about 0.30 in case of MLP classifier, 0.44 and 0.51 in case of Bagging and K-Star had to be quite high. The most appropriate classifiers based on performance measure MAE value were found to be LR, IBK and J48 having lesser MAE values as compared to others.

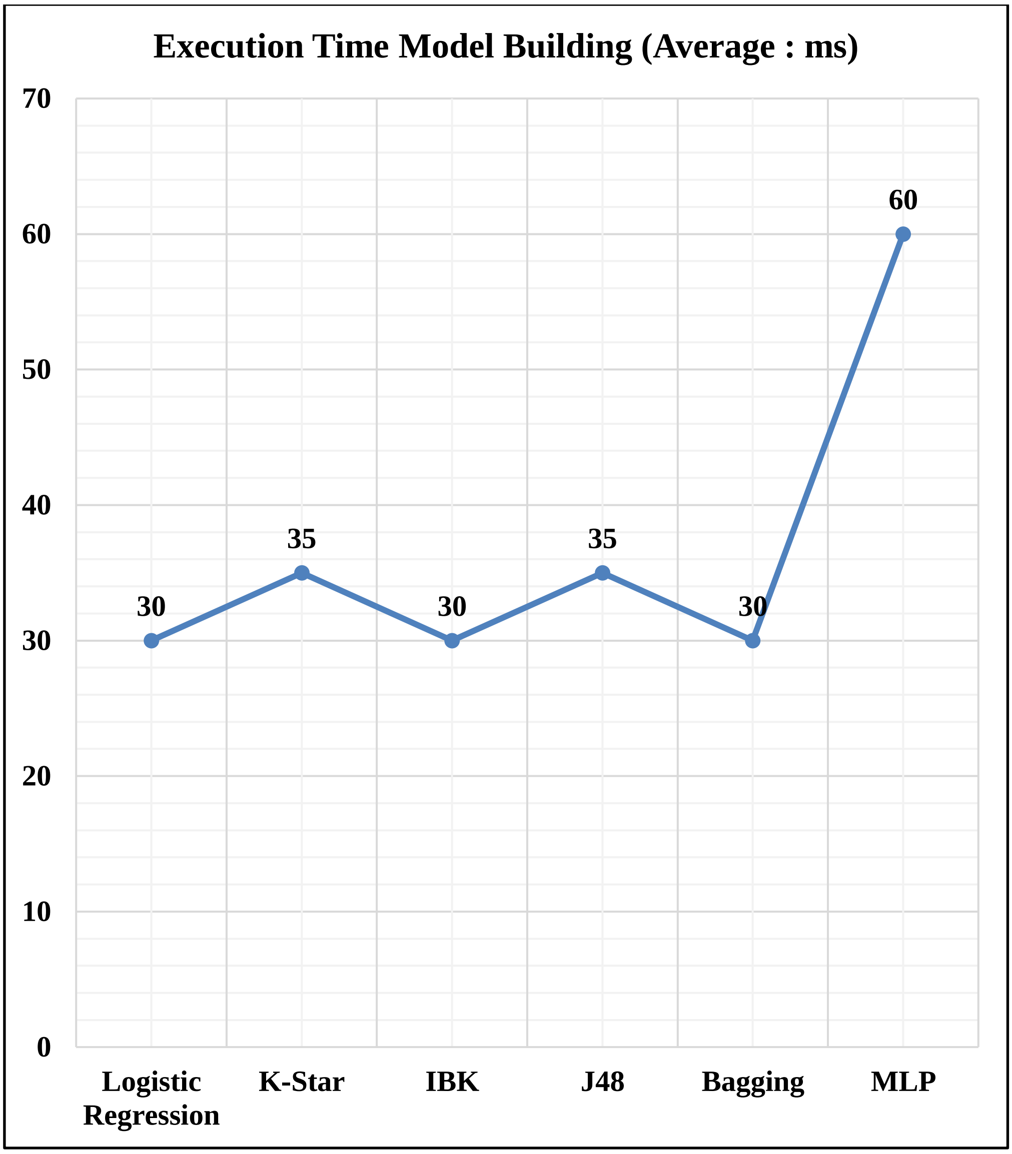

Figure 5.31: Average Execution Time for Classifiers Used in Task Offloading and Resource Management (Configuration Setting: Split-33%)

Figure 5.31, it can be concluded that at configuration setting spilt 33% the average execution time of model building of Logistic Regression, IBK and Bagging classifier were found to be 30 milliseconds for each which is quite less as compared with other classifiers. The other classification algorithms had to have an average execution time of model building of about 35ms in case of J48 and K-Star classifier, and 60ms in case of MLP. The most appropriate classifiers based on performance measure average execution time of model building were found to be Logistic Regression, IBK and Bagging.

5.6 Overall Performance of Classification Algorithms

The overall performance of classification algorithms in task offloading and resource allocation for IoT and fog computing is an active area of research and development. Various algorithms, including decision trees, random forest, support vector machines, K-nearest neighbors, neural networks, naive Bayes, and logistic regression, have been explored for these tasks, each with its strengths and weaknesses.

Table 5.4: Overall Performance of Classification Algorithms Used for Task Offloading

Type of Performance Measure	Logistic Regression	K-Star	IBK	J48	Bagging	MLP
Accuracy	0.80	0.48	0.61	0.75	0.60	0.83
Kappa Statistic	0.60	-0.02	0.23	0.50	0.21	0.67
TP Rate	0.80	0.49	0.62	0.75	0.49	0.84
FP Rate	0.20	0.51	0.39	0.25	0.53	0.16
Precision	0.83	0.49	0.76	0.79	0.48	0.85
Recall	0.80	0.49	0.62	0.75	0.61	0.84
F-Measure	0.80	0.48	0.54	0.74	0.60	0.83
ROC Area	0.82	0.58	0.62	0.77	0.63	0.91
Mean Absolute Error	0.23	0.45	0.39	0.27	0.58	0.17
Execution Time Model Building	53.33	25.00	25.00	33.33	33.33	76.67

Table 5.4, shows that in terms of the Kappa statistic, MLP had the highest value of 0.67, indicating good agreement between predicted and actual classes. J48 and Logistic Regression also showed substantial agreement with Kappa values of 0.50 and 0.60, respectively. However, IBK 0.23 and Bagging 0.21 had a moderate agreement, and K-Star had a negative Kappa statistic -0.02, suggesting lower agreement and potential issues with its performance. The evaluation demonstrates the varying success and limitations of each algorithm, with Logistic Regression and MLP performing relatively well in both accuracy and agreement metrics.

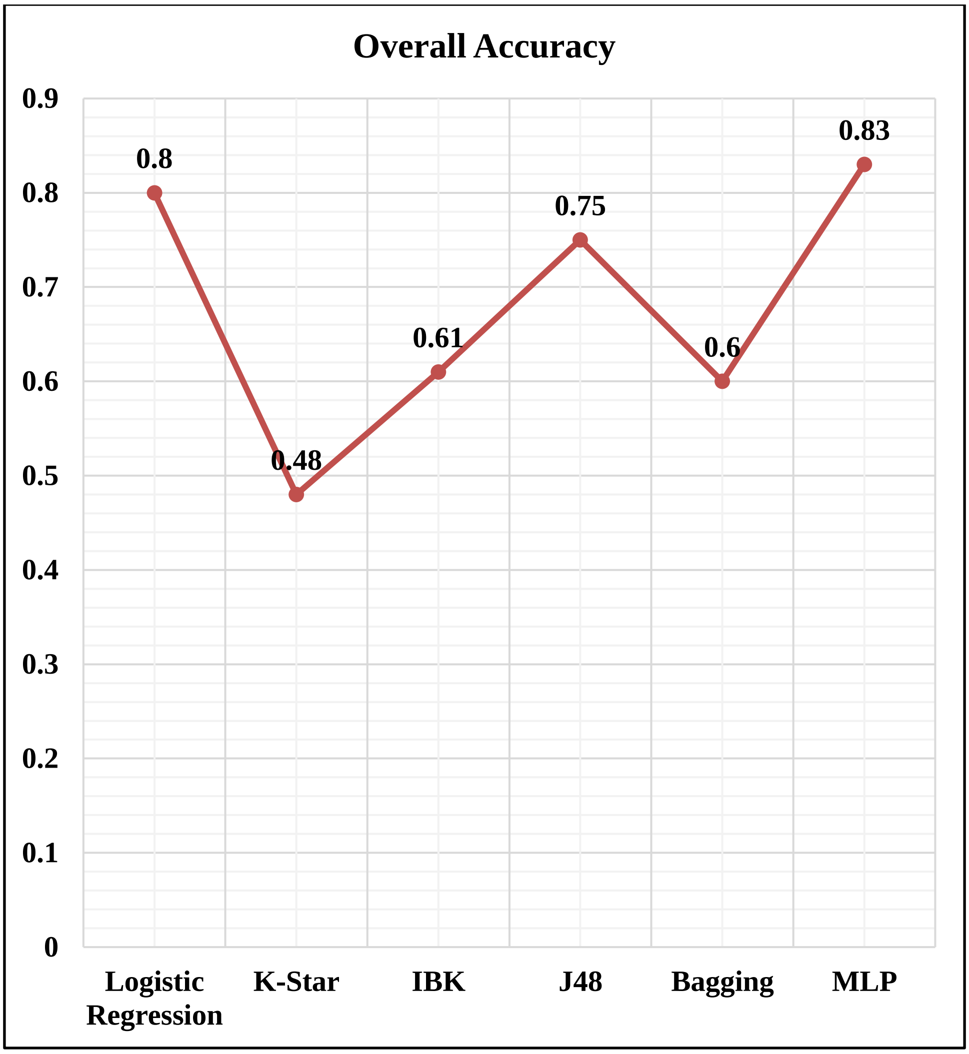

Figure 5.32: Overall Accuracy for Classifiers Used in Task Offloading and Resource Management

Figure 5.32, confirms that the overall accuracy of MLP classifier with value 0.83 is found to be the highest followed by Logistic Regression with value 0.80. The other classification algorithms had to have an overall accuracy of about 0.75 in case of J48 classifier, 0.60, 0.61, and 0.48 in case of Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure overall accuracy were found to be MLP and LR.

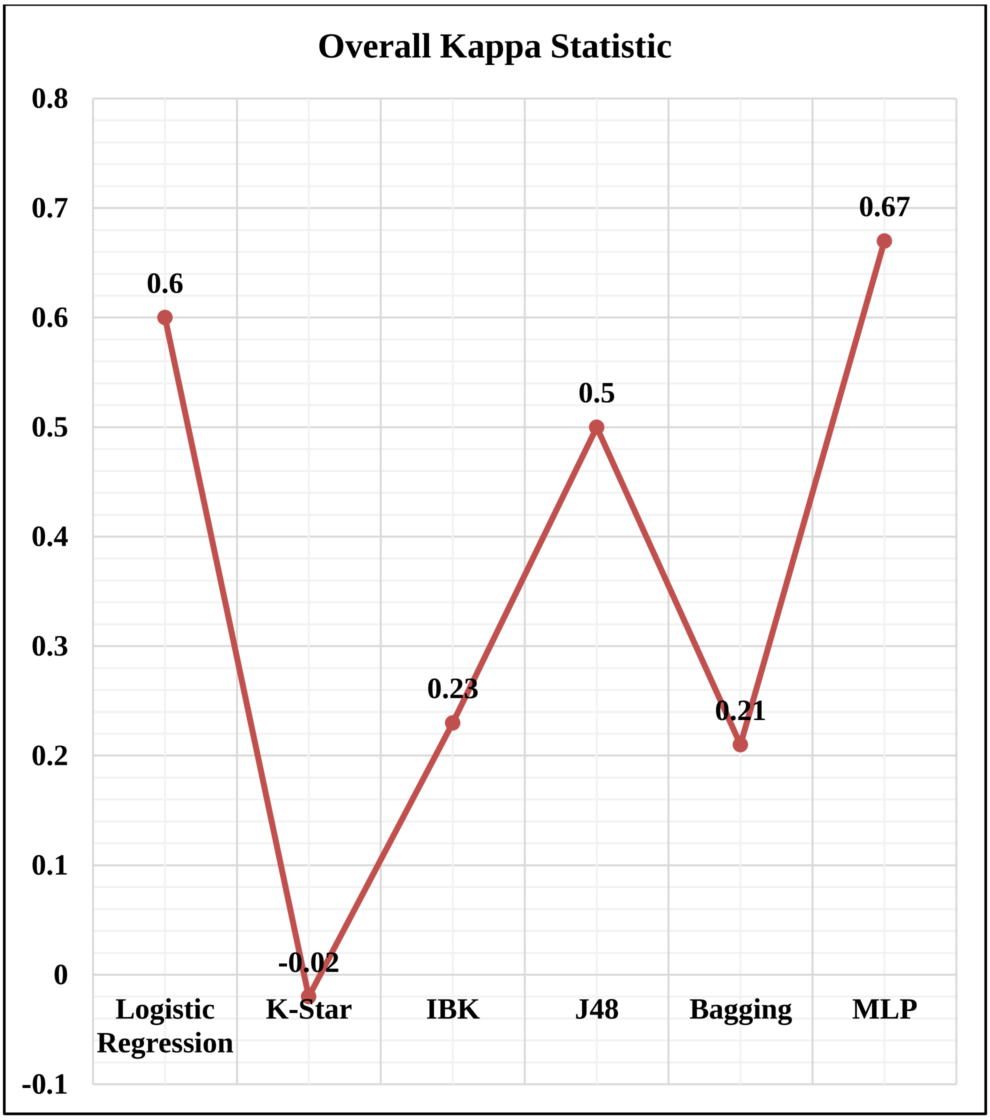

Figure 5.33: Overall, Kappa Statistics for Classifiers Used in Task Offloading and Resource Management

Figure 5.33, shows a comparison of the performance of classifiers based on overall Kappa statistics used for task offloading and resource allocation in case of SMART FOG environment it can be interpreted that higher overall Kappa statistics value of 0.67 in case of MLP and 0.6 in case of MLP and LR suggests that they are the better classifiers as compared to other techniques.

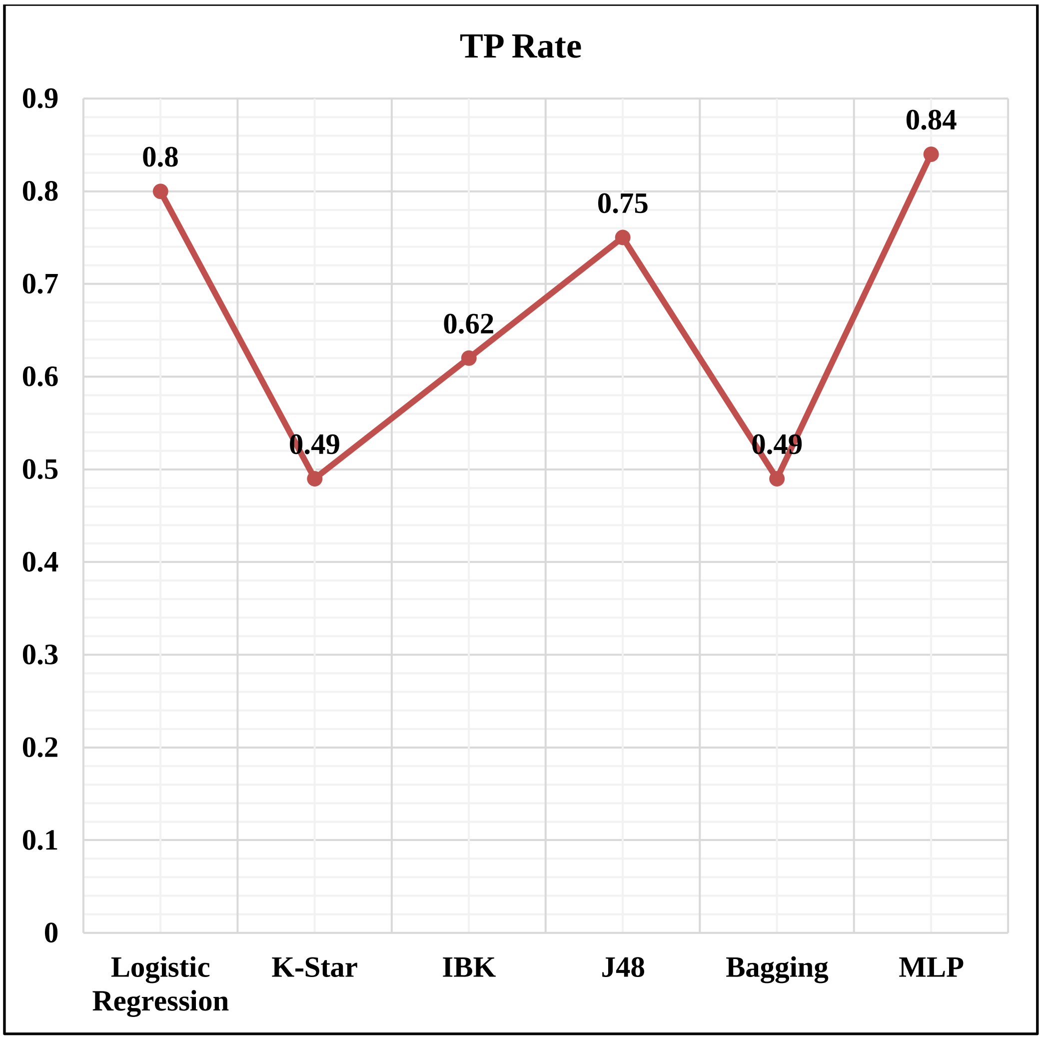

Figure 5.34: Overall TP Rate for Classifiers Used in Task Offloading and Resource Management

According to figure 5.34, it can be concluded that the overall TP Rate of MLP classifier with value 0.84 is found to be the highest followed by Logistic Regression with value 0.80. The other classification algorithms had to have an overall TP Rate of about 0.75 in case of J48 classifier, 0.49, 0.62, and 0.49 in case of Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure overall TP rate were found to be MLP and LR.

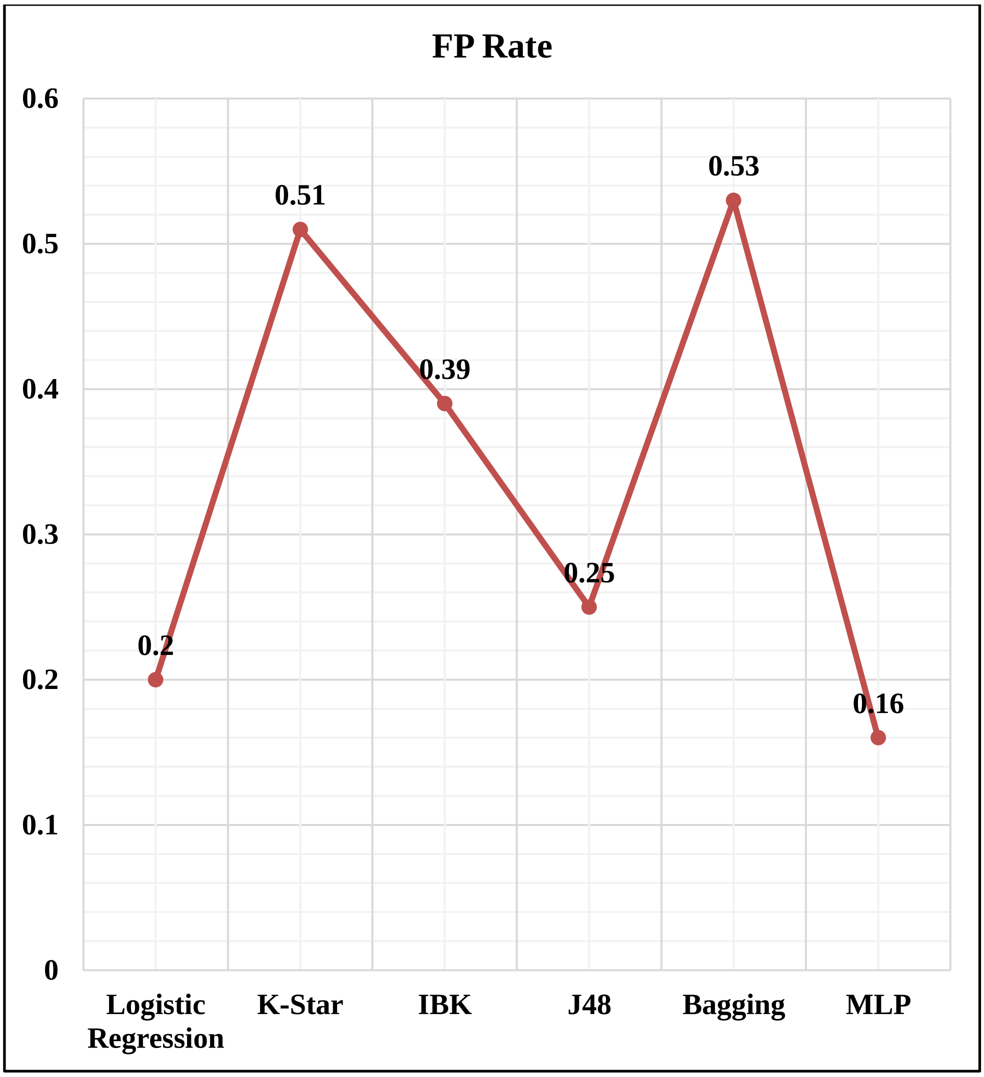

Figure 5.35: Overall FP Rate for Classifiers Used in Task Offloading and Resource Management

Figure 5.35, it can be concluded that the overall FP Rate of MLP classifier with value 0.16 is found to be lowest followed by Logistic Regression with value 0.2. The other classification algorithms had to have an overall FP Rate of about 0.25 in case of J48 classifier, 0,53, 0.39, and 0.51 in case of Bagging, IBK, and K-Star which were found to be quite higher. The most appropriate classifiers based on performance measure FP rate were found to be MLP and LR having lesser overall FP rate values as compared to others.

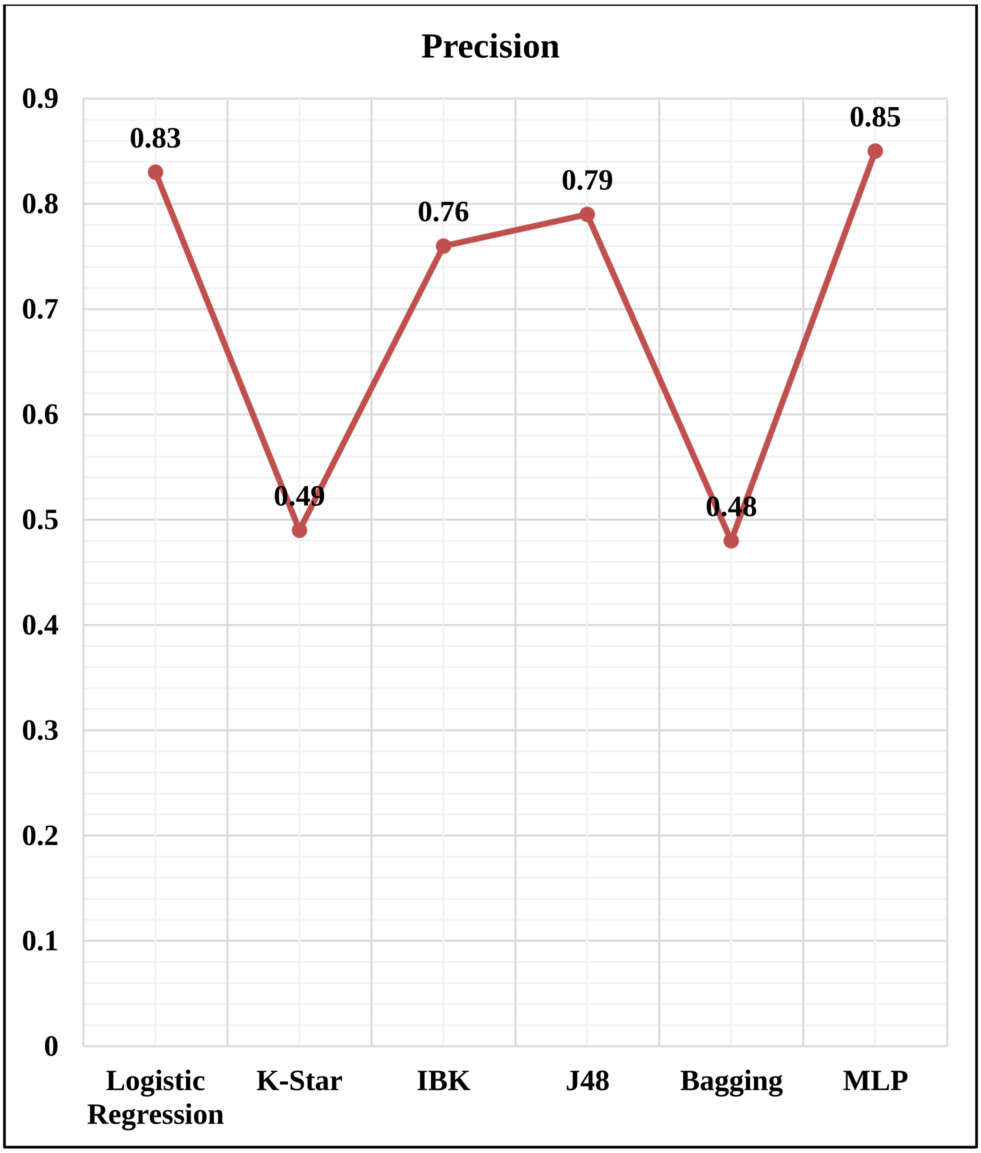

Figure 5.36: Overall Precision for Classifiers Used in Task Offloading and Resource Management

Figure 5.36, it can be concluded that the overall Precision of MLP classifier with value 0.85 is found to be highest followed by Logistic Regression with value 0.83. The other classification algorithms had to have an overall Precision of about 0.79 in case of J48 classifier, 0.48, 0.76, and 0.49 in case of Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure overall Precision were found to be MLP and LR.

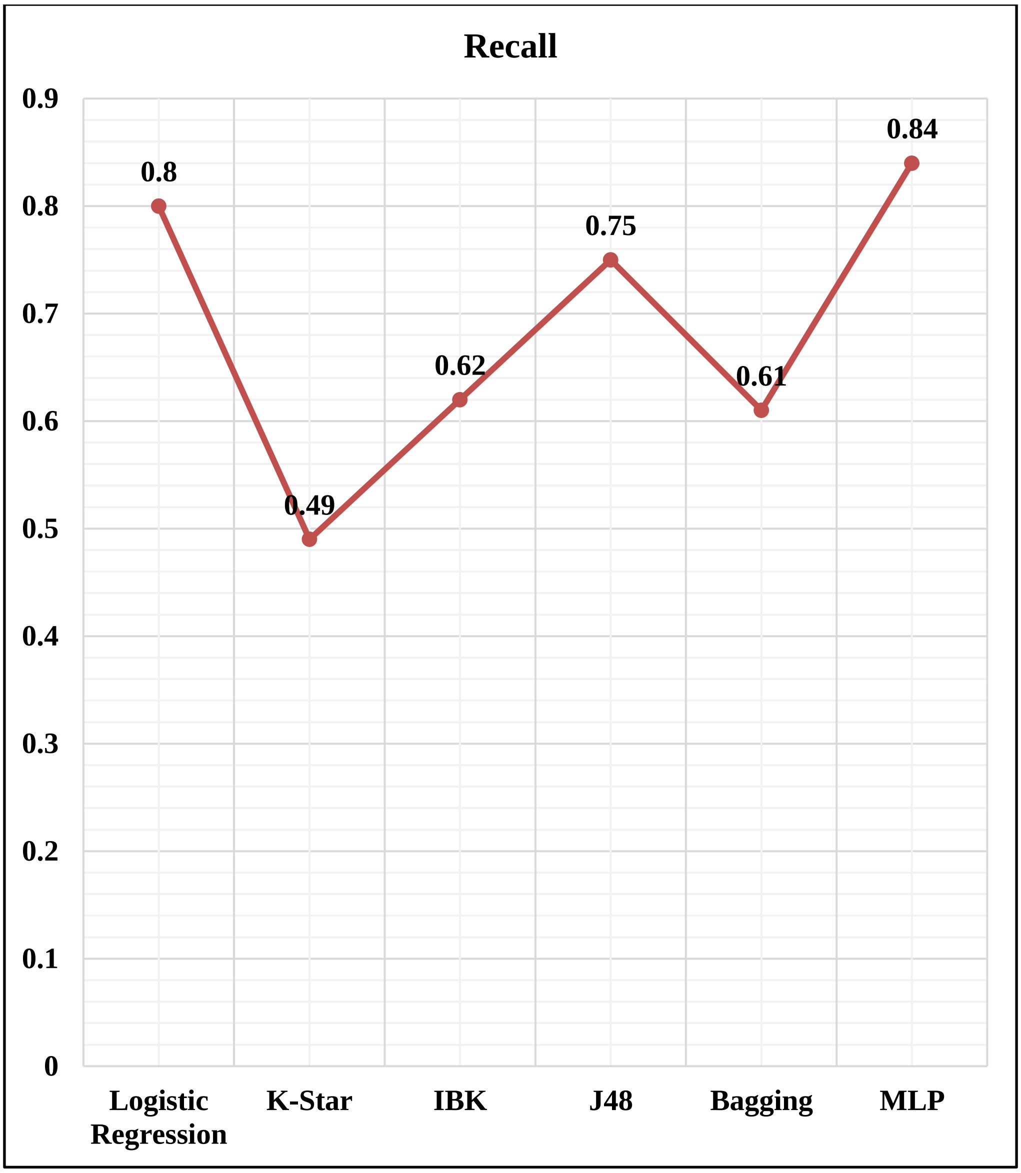

Figure 5.37: Overall Recall for Classifiers Used in Task Offloading and Resource Management

Results as shown in figure 5.37 confirm that the overall Recall of MLP classifier with value 0.84 is found to be the highest followed by Logistic Regression with value 0.80. The other classification algorithms had to have an overall Recall of about 0.75 in case of J48 classifier, 0.61, 0.62, and 0.49 in case of Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure overall Recall were found to be MLP and LR.

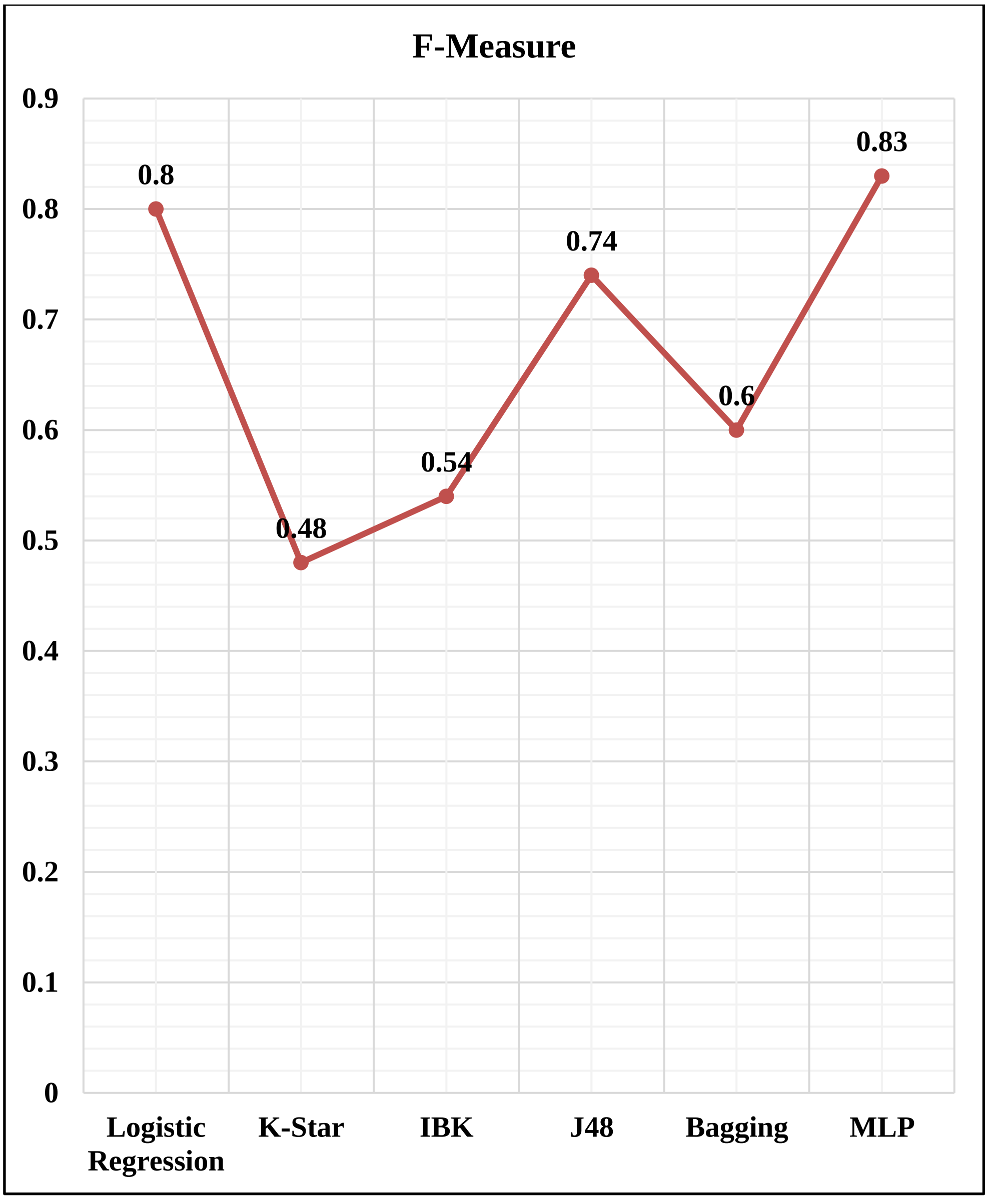

Figure 5.38: Overall F-Measure for Classifiers Used in Task Offloading and Resource Management

According to figure 5.38, it can be concluded that the overall F-Measure score of MLP classifier with value 0.83 is found to be the highest followed by Logistic Regression with value 0.8. The other classification algorithms had to have an overall F-Measure score of about 0.74 in case of J48 classifier, 0.6, 0.54, and 0.48 in case of Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure overall F-Measure score were found to be MLP and LR.

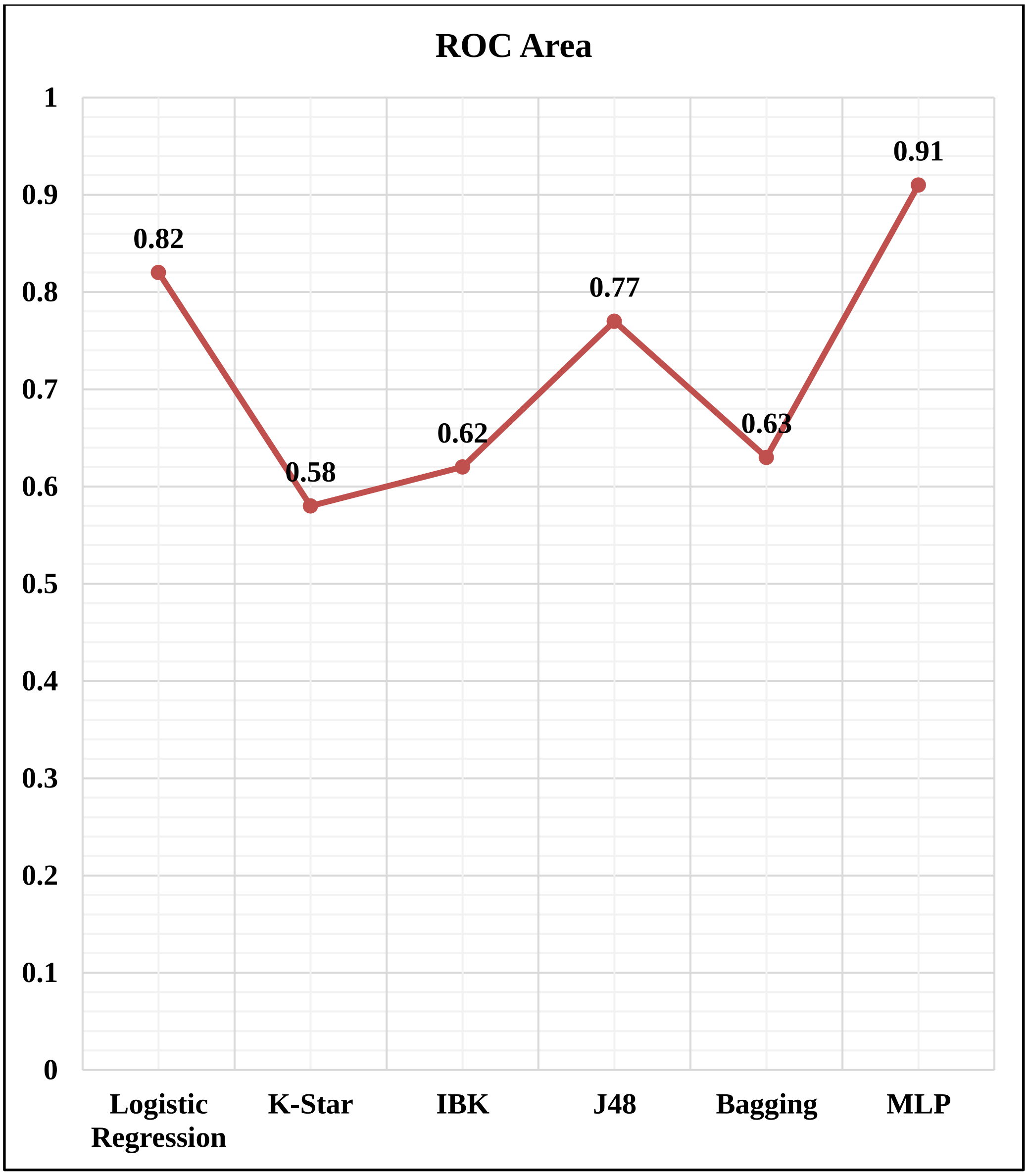

Figure 5.39: Overall, ROC Area for Classifiers Used in Task Offloading and Resource Management

Figure 5.39, It can be concluded that the overall ROC Area of MLP classifier with value 0.91 is found to be the highest followed by Logistic Regression with value of 0.82. The other classification algorithms had to have an overall ROC Area of about 0.77 in the J48 classifier, 0.63, 0.62, and 0.58 in Bagging, IBK, and K-Star. The most appropriate classifiers based on performance measure overall ROC Area were found to be MLP and LR.

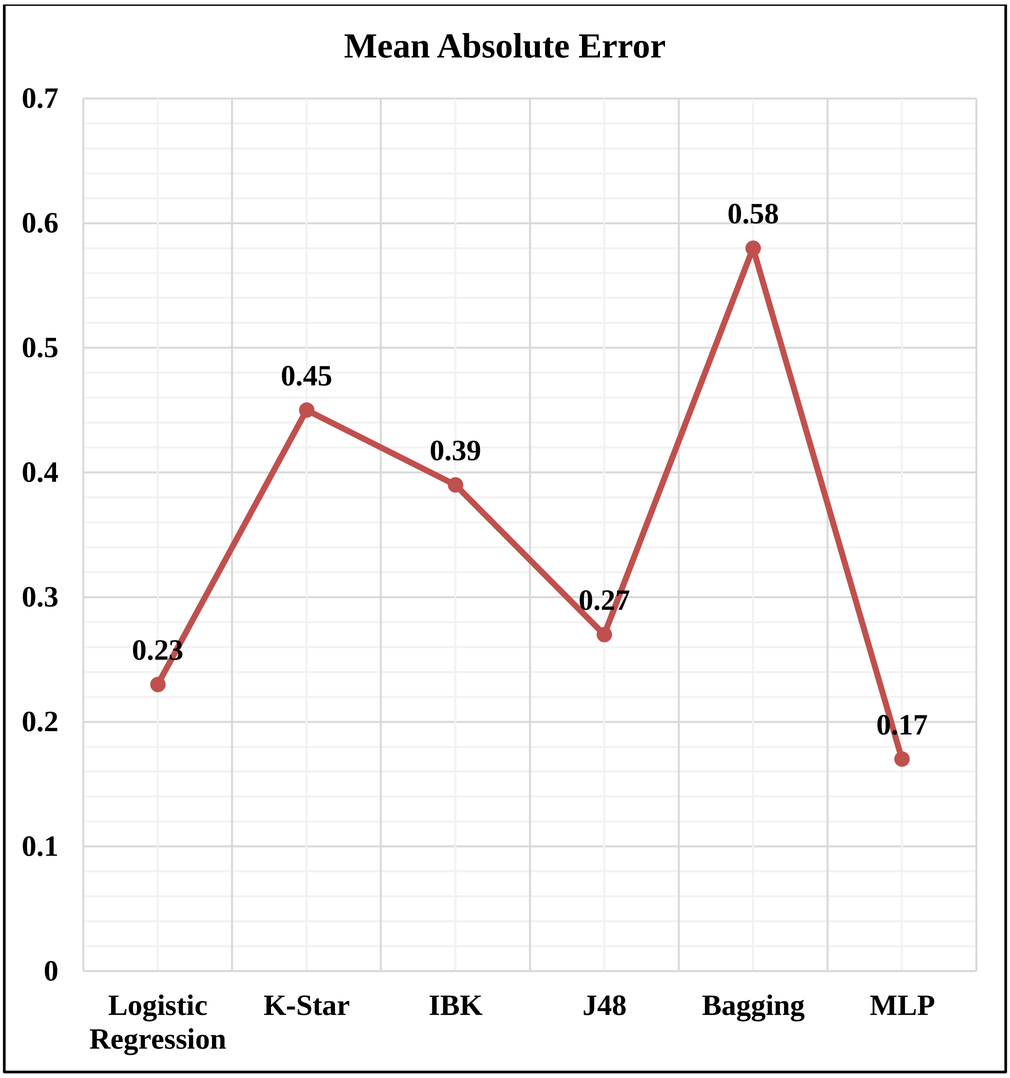

Figure 5.40: Overall, MAE for Classifiers Used in Task Offloading and Resource Management

Figure 5.40, It can be concluded that overall, the mean absolute error value of MLP classifier with 0.17 is found to be the lowest followed by Logistic Regression with value 0.23. The other classification algorithms had to have mean absolute error values of about 0.27 in case of J48 classifier, 0.58, 0.39, and 0.45 in case of Bagging, IBK, and K-Star were found to be quite high. The most appropriate classifiers based on performance measure mean absolute error value were found to be MLP and LR having lesser mean absolute error values as compared to others.

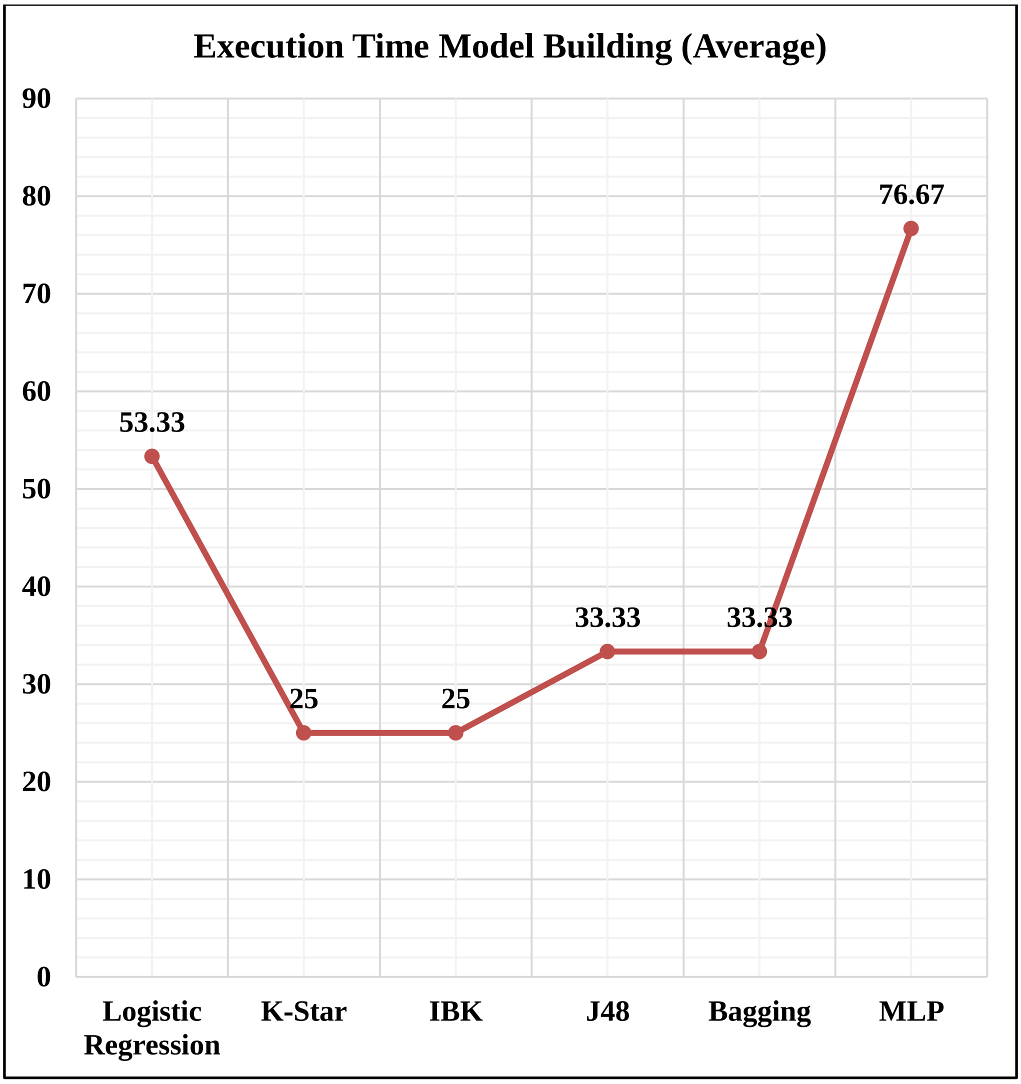

Figure 5.41: Overall Average Execution Time for Classifiers Used in Task Offloading and Resource Management

Figure 5.41, it can be concluded that at configuration setting split 33% the average execution time of model building of K-Star and IBK classifier is found to be 25 milliseconds which is quite less as compared with other classifiers. The other classification algorithms had to have an average execution time of model building of about 33.33 ms in case of J48 classifier, 33.33, 53.33, and 76.67 ms in case of Bagging, LR, and MLP. The most appropriate classifiers based on performance measure average execution time of model building were found to be K-Star and IBK.

In this study, a classification-based intelligent job offloading model is developed in the fog-cloud collaboration network. Initially, an optimization issue involving offloading is solved by considering the threshold values of the relevant cloud data center-related factors. Several application kinds, such as delay-sensitive and computation-intensive ones, must precisely complete their intended duties by the computing resources they demand, which must be provided accordingly. Second, the suggested model uses an intelligent task offloading management system that anticipates the incoming tasks produced by various IoT and mobile devices that are scattered over several remote sites. Simulation findings show that the suggested model can correctly forecast the task delegated to either a fog network or a cloud network with the greatest overall accuracy of 83% and 80% in case of MLP and LR construct. Finally, comparing all the classification algorithms based on various accuracy parameters it can be concluded that MLP and LR are the most appropriate classification algorithms for resource allocation and task offloading although the execution time is higher in both the cases.