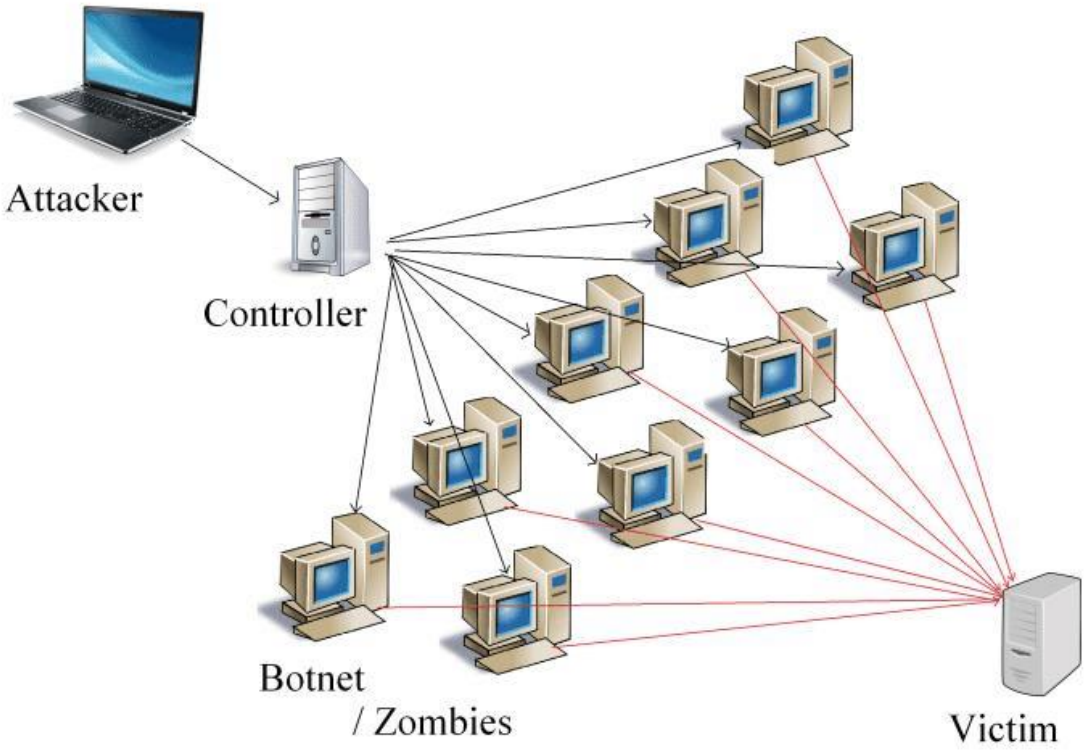
Evaluation of Classification algorithms for Distributed Denial of Service Attack Detection

Maulik Gohil
Sathish Kumar Ph.D.
(Cleveland State University)

Outline

What is DDoS Attack?

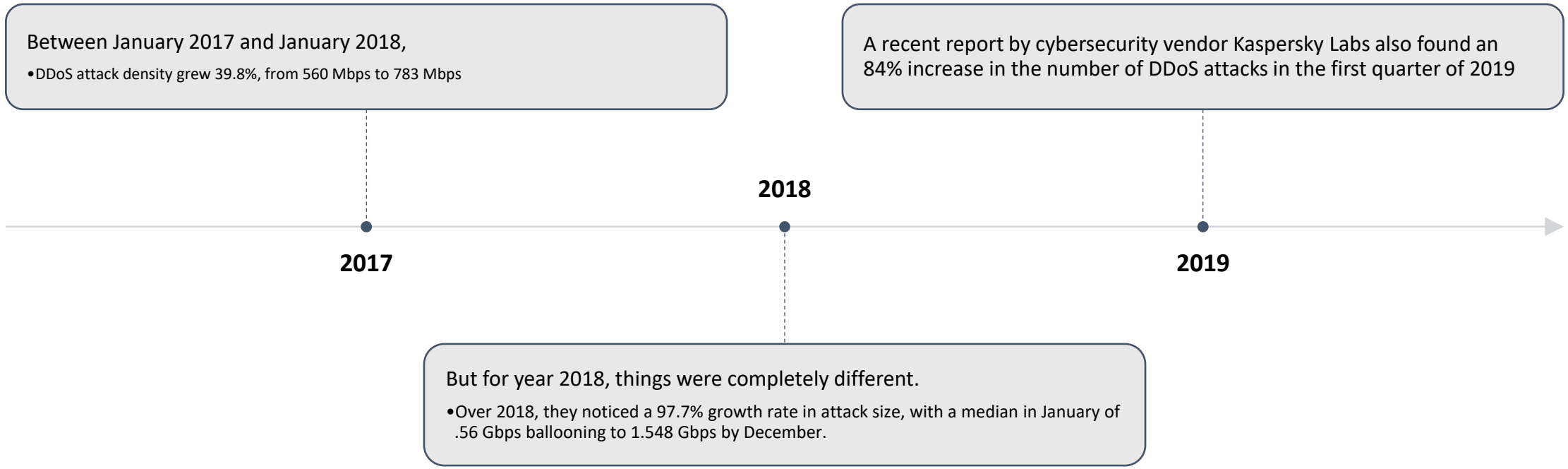
Source: Google Images



How has it started?

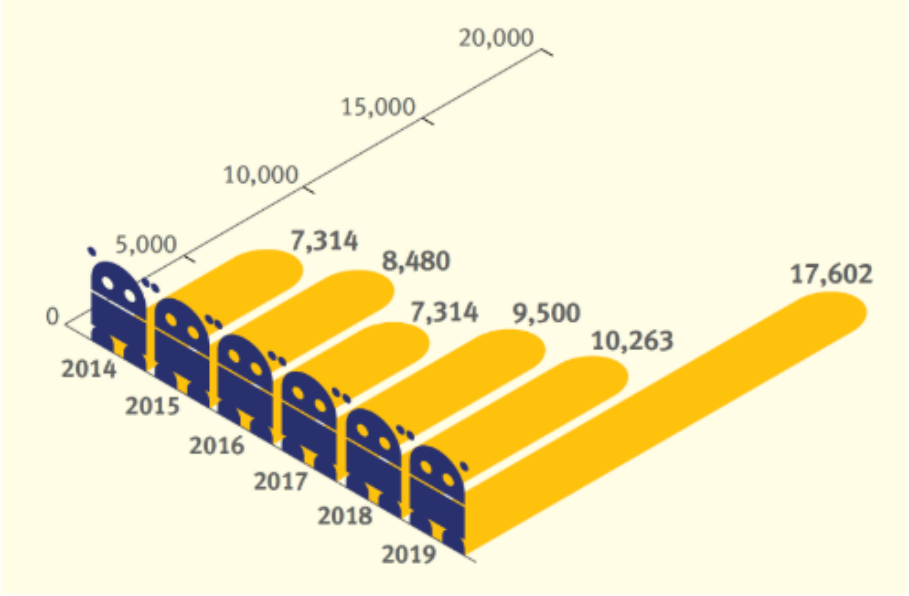
- In July 1999, a set of computers infected with the Trin00 malware **attacked** and took down the network of the University of Minnesota.
- The episode marked the **first** recorded case of a distributed-denial-of-service (**DDoS**) **attack**.

Facts provided by Security Giant Akamai



Spamhaus Report

- Spamhaus Malware Labs identified and blocked 17,602 botnet Command & Control servers hosted on 1,210 different networks in the year of 2019.
  - That is an enormous 71.5% increase from the number of botnet C&Cs seen in 2018.



https://www.spamhaus.org/news/article/793/spamhaus-botnet-threat-report-2019

Impact of DDoS Attack

- A new study conducted by Corero confirmed that the erosion of customer trust and confidence is the single most damaging consequence of DDoS attacks for businesses today

- It is ranked that, the loss of customer trust and confidence as the worst effect of a DDoS attack (42%), followed by data theft (26%), potential revenue losses (13%) and intellectual property theft (10%).

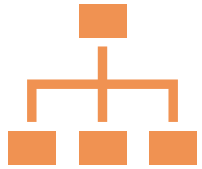
https://www.corero.com/blog/how-ddos-attacks-impact-businesses-across-industries/

Objective

Most of the research papers published in conferences and generals have used old dataset (KDD Cup ’99, DARPA) for doing their analysis which less impactful because as the time passes, the cybercrimes and attacks are taken place in an artful way to intrude the target environment.

So, doing analysis on recent dataset which has all the variety of novel attack signatures, is much better when the security is concerned. Therefore, here I will be using the CICDDoS2019 dataset to do the analysis.

The core objective of this paper is doing data analysis with the most recent dataset specifically of DDoS attack and comparison between different classification algorithms which will be used in the conducting the analysis so that it helps us to reduce the False Positives with highest accuracy.



And this will help any security Administrator/Engineer to get notified in real time that eventually helps in betterment of organization’s availability-production system Uptime, as well as the reputation.

Dataset CICDDoS2019

- It contains benign and the most up-to-date common DDoS attacks, which resembles the true real-world data (PCAPs)
    - Dataset includes12 DDoS attacks includes NTP, DNS, LDAP, MSSQL, NetBIOS, SNMP, SSDP, UDP, UDP-Lag, WebDDoS, SYN and TFTP on the training day and 7 attacks including PortScan, NetBIOS, LDAP, MSSQL, UDP, UDP-Lag and SYN in the testing day
- The dataset has been organized per day. For each day, they recorded the raw data including the network traffic (Pcaps) and event logs (windows and Ubuntu event Logs) per machine.
- In features extraction process from the raw data, we used the CICFlowMeter-V3 and extracted more than 80 traffic features and saved them as a CSV file per machine.

More on Dataset

- The dataset package contains 7 csv files with different DDoS signatures.
- The dataset has more than 20 million of rows in total when we merge all the csv files.
- Each CSV has 88 features with label, and total size of dataset is 8+ Gigabytes.
- Dataset is created by University of New Brunswick and publicly available on the Canadian Institute of Cyber security website.

CSV File Name	Total Rows	Benign Rows
LDAP	2113234	5124
MSSQL	5775786	2794
NetBIOS	3455899	1321
Syn	4320541	35790
UDP	3782206	3134
UDPLag	725165	4068
Portmap	191694	4734
Total	**20364525**	**56965**

Feature Selection

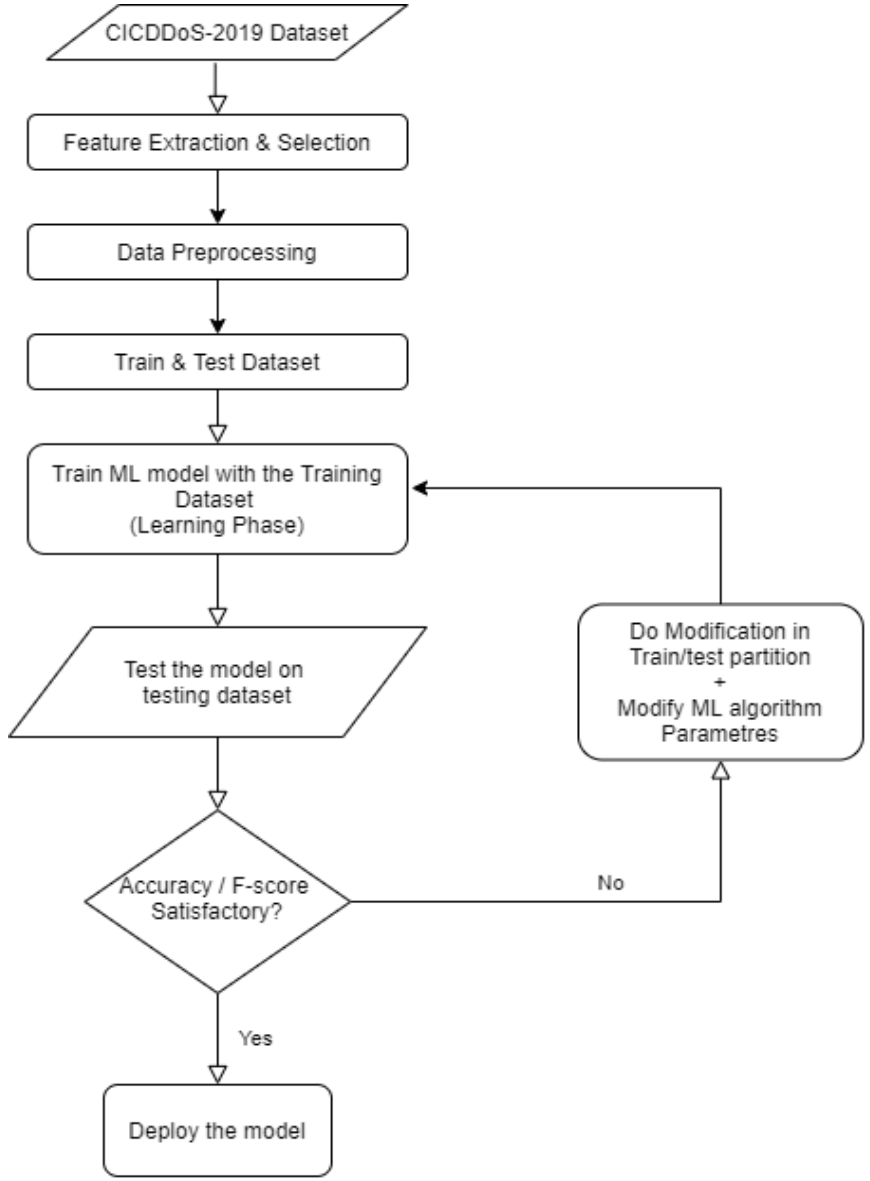
- We have used **SelectKBest** class that helped us to get most correlated features with the Class label.
- For our experiment we used top 25 correlated features as shown.

Feature Name	Description
Source_IP	Source IP address from where attack has been initiated
Source_Port	Source Port number
Destination_IP	IP Address of Target Machines
Destination_Port	Port number of Target Machine
Timestamp	Timestap of the Packet has been receicved form Target machine
Protocol	Which protocol has been exploited for the DDoS Atatck
Flow_Duration	Duration of the flow in Microsecond
Total_Fwd_Packets	Total packets in the forward direction
Total_Backward_Packets	Total packets in the backword direction
Total_Length_of_Fwd_Packets	Total size of packet in forward direction
Total_Length_of_Bwd_Packets	Total size of packet in backward direction
Fwd_Packet_Length_Mean	Mean size of packet in forward direction
Bwd_Packet_Length_Mean	Mean size of packet in backward direction
Flow_IAT_Mean	Mean time between two packets sent in the flow
Fwd_IAT_Mean	Mean time between two packets sent in the forward direction
Bwd_IAT_Mean	Mean time between two packets sent in the backward direction
Fwd_Header_Length	Total bytes used for headers in the forward direction
Bwd_Header_Length	Total bytes used for headers in the backward direction
Packet_Length_Mean	Mean length of a packet
Fwd_Avg_Bulk_Rate	Average number of bulk rate in the forward direction
Bwd_Avg_Bulk_Rate	Average number of bulk rate in the backward direction
Down_Up_Ratio	Download and upload ratio
Average_Packet_Size	Average size of packet
Subflow_Fwd_Packets	he average number of packets in a sub flow in the forward direction
Subflow_Bwd_Packets	The average number of packets in a sub flow in the backward direction
Inbound	Traffic is inboud or not
Label	Class Label

Detection Approaches

- We are analyzing the dataset with 6 different classification algorithms
  - Decision Tree
  - Naïve Bayes
  - Logistic Regression
  - SVM
  - K-NN
  - Random Forest

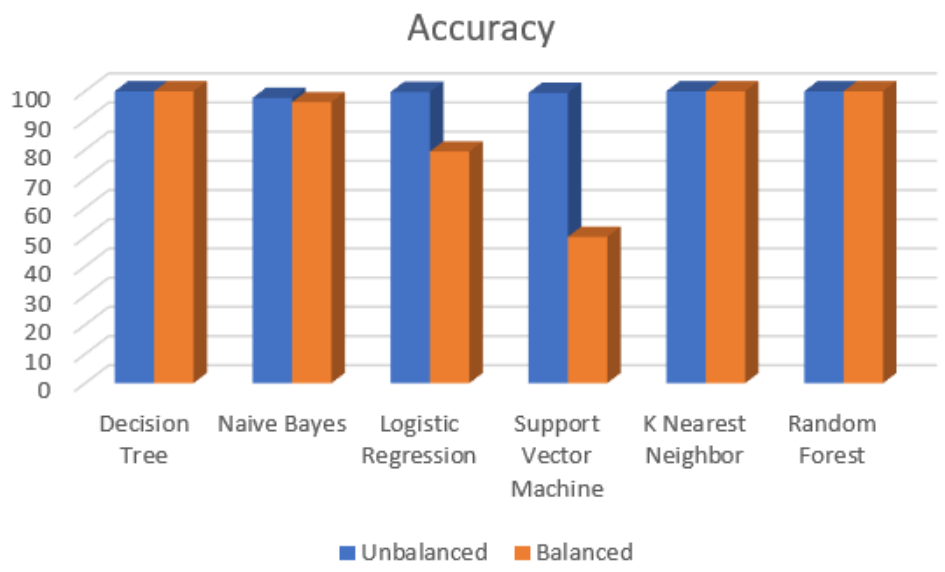
Classification Process

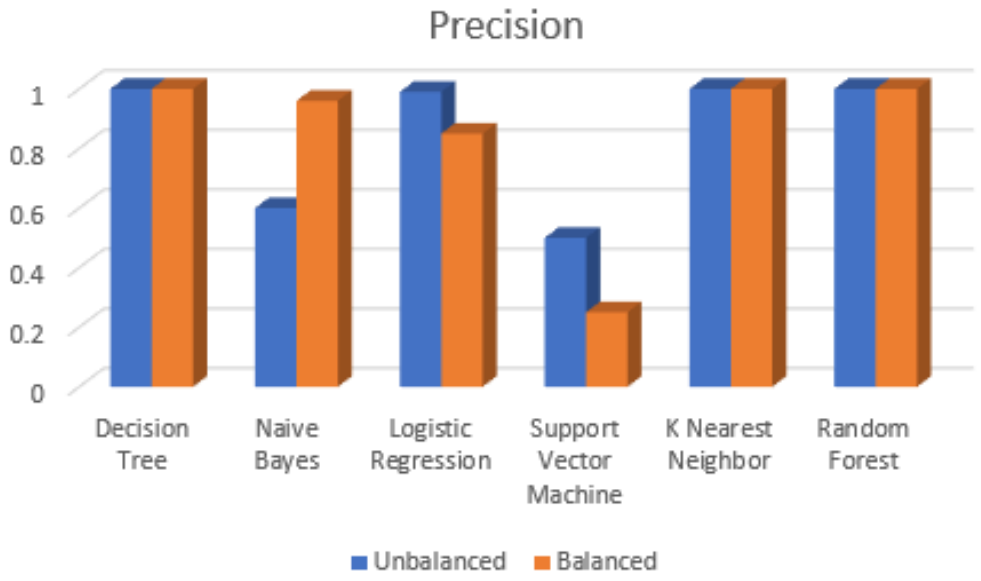


Experimentation

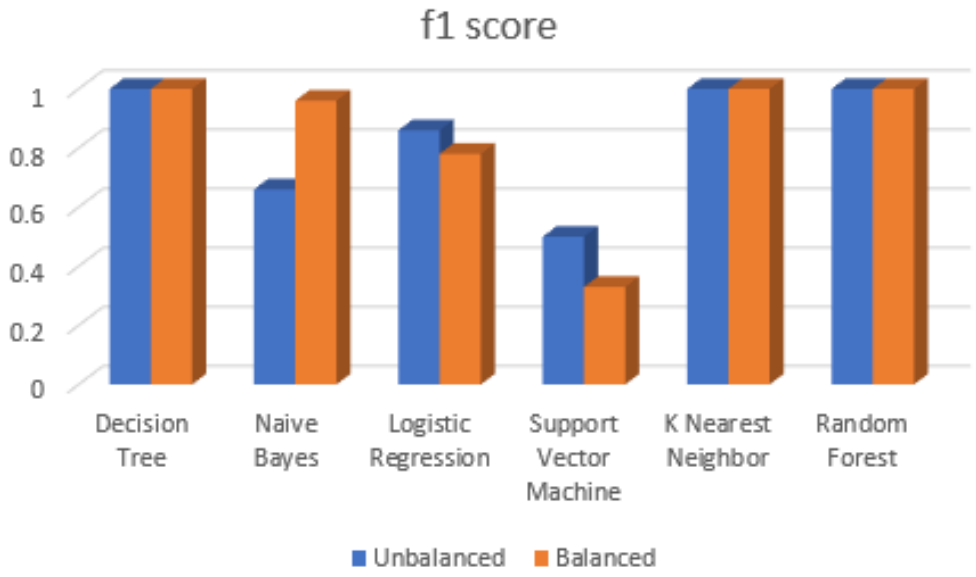
- We have done two experiment one with Balanced Dataset and another with unbalanced Dataset.
- Both dataset consist 200K rows for the experiment.
- We kept train test split ratio to 70:30
- For the balanced dataset, we only had 56965 rows of normal traffic, so We randomly chose 50K attack traffic and 50K benign traffic and then appended the same data to reach 200K rows
- But for unbalanced dataset, we just randomly chosen 200K rows from the dataset. But this was quite biased.

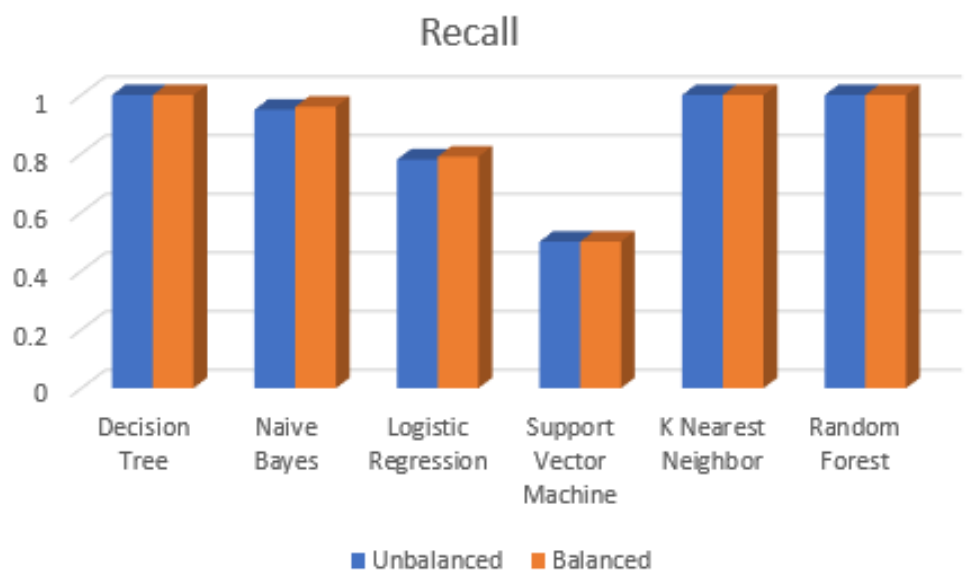
Result -Charts





Result -Charts





Result – Unbalanced Dataset

						macro avg		
Unbalanced Dataset	**TP**	**TN**	**FN**	**FP**	**Accuracy**	**Precession**	**Recall**	**F1 Score**
Decision Tree	62599	398	3	0	99.99523	1	1	1
Naive Bayes	61199	370	31	1400	97.72857	0.6	0.95	0.66
Logistic Regression	62619	213	164	4	99.73333	0.99	0.78	0.86
Support Vector Machine	62663	0	337	0	99.46507	0.5	0.5	0.5
K Nearest Neighbor	62598	401	0	1	99.99841	1	1	1
Random Forest	62602	397	0	1	99.99841	1	1	1

Result – Balanced Dataset

						macro avg		
Balanced Dataset	**TP**	**TN**	**FN**	**FP**	**Accuracy**	**Precession**	**Recall**	**F1 Score**
Decision Tree	31577	31449	0	0	100	1	1	1
Naive Bayes	31387	29278	2290	71	96.25392	0.96	0.96	0.96
Logistic Regression	31276	8730	12819	201	79.34185	0.85	0.79	0.78
Support Vector Machine	31577	0	31449	0	50.10154	0.25	0.5	0.33
K Nearest Neighbor	31477	31549	0	0	100	1	1	1
Random Forest	31477	31549	0	0	100	1	1	1

Conclusion

- We have used CICDDoS2019 dataset which is fairly a recent dataset that includes most recent attack signatures for DDoS.

- The experimentation has been carried out using major supervised classification algorithms to classify the attack accurately from the legitimate flows

- When the results are compared with other algorithms among all classifiers, decision tree, random forest & K-NN performed the best.

Future work

- One can so the same experiment with bigger scale in terms of data.
- We can perform the same experiment with different feature selection techniques.
- Rather than applying classification algorithms directly on mixed data having all the attack signatures, we can keep it separate and then can-do data analysis applying all the six-classification algorithms separately.
  - It might be possible that some attack can be efficiently identified by specific ML algorithm.