Summarizing analysis of all datasets: -

Sr No	Dataset name	Number of rows	Number of features	Number of duplicates	Null records: Y/N	Number of target features	Binary or Multi-class classification	Comments
1	BETH	763144	16	0	N	2	Binary	3 files: - training data validation data testing data This table has records of training data.
2	BrakTooth	9002	5	1909	N	1	Multi-class	
3	Mil-STD-1553	23000	52	0	Y	2	Multi-class	7 files, 1 is of benign data and 6 are of attacks This table has records of benign file.
4	ServerLogs	172838	16	0	N	1	Binary	
5	UNR-IDD	37411	34	1	N	2	Binary, Multi-class	
6	cic	9167581	59	310	N	2	Multi-class	The file is in .parquet format.
7	KDD cup 1999	494021	42	348435	N	1	Multi-class	Imported from sklearn preloaded datasets.

Comparison of all datasets: -

Sr No	Dataset name	Advantages	Disadvantages
1	BETH	1. Large number of records. 2. No duplicates and no null records.	1. Does not allow to build model for multi-class classification.
2	BrakTooth	1. No null values. 2. Moderate number of records 3. Allows to build model for multi-class classification.	1. 21% records are duplicate.
3	Mil-STD-1553	1. Large number of records with very high dimensionality. 2. Allows to build model for multi-class classification.	1. Large number of null records.
4	ServerLogs	1. Large number of records. 2. No duplicates or null records.	1. Does not allow to build model for multi-class classification.
5	UNR-IDD	1. Large number of records. 2. No duplicates or null records. 3. Allows to build model both binary and multi-class classification.	
6	cic	1. Large number of records. 2. Very high dimensionality. 3. Allow to build model for multi-class classification.	
7	KDD cup 1999	1. Large number of records. 2. Very high dimensionality. 3. Allow to build model for multi-class classification.	1. 70.5% records in the dataset are duplicate.

From the initial analysis, we observed two datasets are most suitable for our project: -

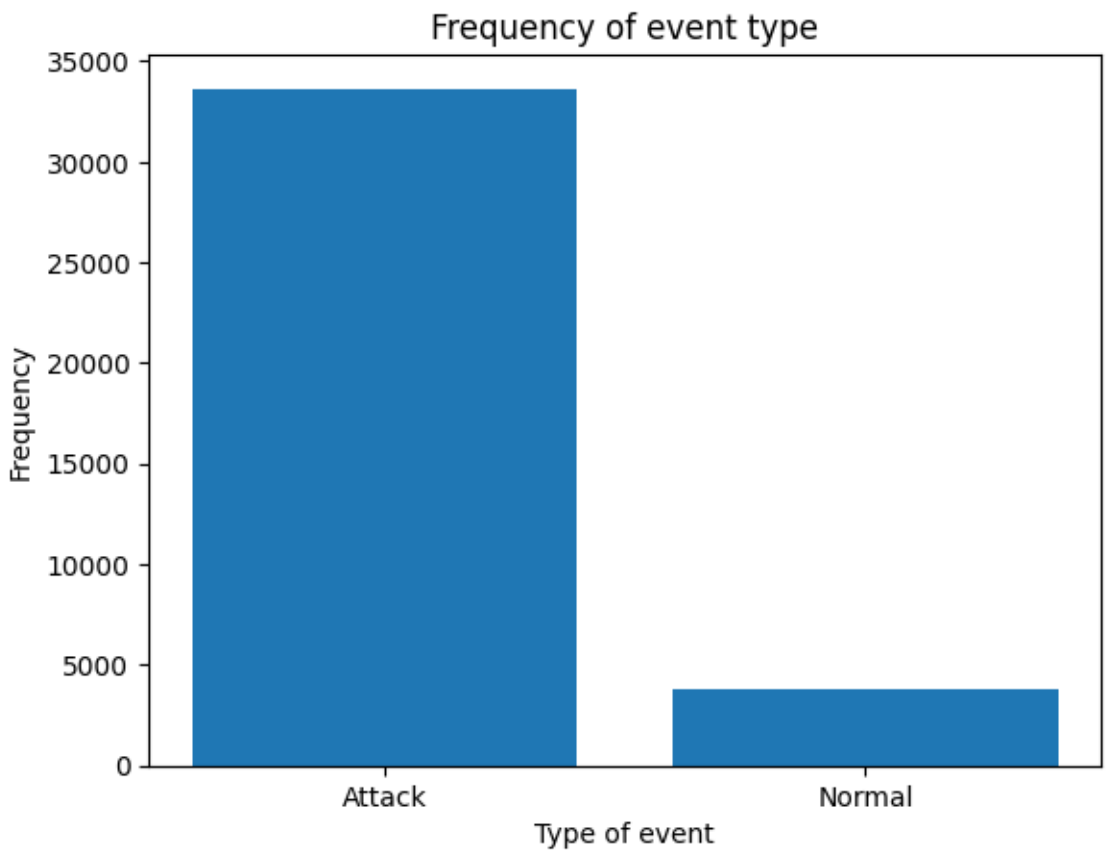
1. UNR-IDD
2. cic

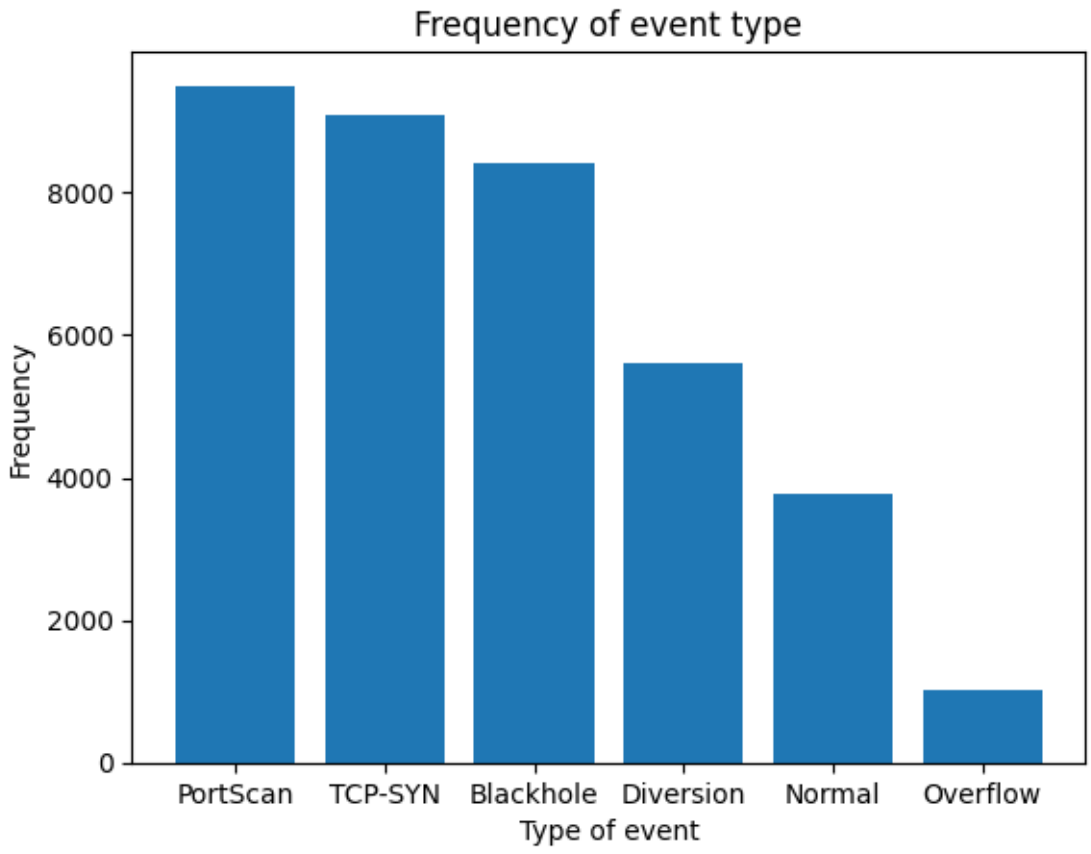
Thus, we further analysed the two datasets to understand their properties.

UNR-IDD dataset: -

Sr No	**Field name**	**Description**		**Type of field**
1	Switch ID	12 switches		High-order Nominal
2	Port Number	4 ports		Low-order Nominal
3	Received Packets	Number of packets received by the port	Port statistics	Scale
4	Received Bytes	Number of bytes received by the port		Scale
5	Sent Bytes	Number of bytes sent		Scale
6	Sent Packets	Number of packets sent by the port		Scale
7	Port alive Duration (S)	The time port has been alive in seconds		Scale
8	Packets Rx Dropped	Number of packets dropped by the receiver		Scale
9	Packets Tx Dropped	Number of packets dropped by the sender		Scale
10	Packets Rx Errors	Number of transmit errors		Scale
11	Packets Tx Errors	Number of receive errors		Scale
12	Delta Received Packets	Number of packets received by the port	Delta port statistics	Scale
13	Delta Received Bytes	Number of bytes received by the port		Scale
14	Delta Sent Bytes	Number of packets sent by the port		Scale
15	Delta Sent Packets	Number of bytes sent		Scale
16	Delta Port alive Duration (S)	The time port has been alive in seconds		Scale
17	Delta Packets Rx Dropped	Number of packets dropped by the receiver		Scale
18	Delta Packets Tx Dropped	Number of packets dropped by the sender		Scale
19	Delta Packets Rx Errors	Number of transmit errors		Scale
20	Delta Packets Tx Errors	Number of receive errors		Scale
21	Connection Point	Network connection point expressed as a pair of the network	Flow entry and Flow table	Scale

		element identifier and port number.		
22	Total Load/Rate	Obtain the current observed total load/rate (in bytes/s) on a link		Scale
23	Total Load/Latest	Obtain the latest total load bytes counter viewed on that link.		Scale
24	Unknown Load/Rate	Obtain the current observed unknown-sized load/rate (in bytes/s) on a link.		Scale
25	Unknown Load/Latest	Obtain the latest unknown-sized load bytes counter viewed on that link.		Scale
26	Latest bytes counter			Scale
27	is_valid	Indicates whether this load was built on valid values.		Binary
28	Table ID	Returns the Table ID values.		Scale
29	Active Flow Entries	Returns the number of active flow entries in this table.		Scale
30	Packets Looked Up	Returns the number of packets looked up in the table.		Scale
31	Packets Matched	Returns the number of packets that successfully matched in the table		Scale
32	Max Size	Returns the maximum size of this table.		Scale
33	Label	Normal: Normal network functionality TCP-SYN: TCP-SYN Flood PortScan: Port Scanning Overflow: Flow Table overflow Blackhole: Blackholde attack Diversion: Traffic diversion attack	Multi-class classification	Target: Multi-class
34	Binary Label	Normal: Normal network functionality Attack: Network intrusion	Binary classification	Target: Binary


Frequency of event type
35000
30000
25000
20000
15000
10000
5000
0
Frequency
Attack
Normal
Type of event


Frequency of event type
8000
6000
4000
2000
0
Frequency
PortScan
TCP-SYN
Blackhole
Diversion
Normal
Overflow
Type of event

Observations from above analysis: -

1. We have a high order nominal field: Switch ID with 12 distinct categories, thus, for which we need to identify if one-hot encoding is feasible or if any other better alternative method can be used for training the model.
2. We have a low order nominal field: Port Number, with 4 distinct categories, thus, we can employ one-hot encoding to use the field while training the model.
3. All other fields for training are numeric, and thus, we can normalize them for training the model.
4. For target features, we have two fields: -
    a. Label: Multi-class classification
    b. Binary Label: Binary classification
5. The dataset is highly imbalanced for target field: Binary Label. We have a greater number of records of type Attack and lesser number of records of type: Normal.
6. The dataset is imbalanced for target field: Label. There are 3 types of attacks having the greatest number of events in the dataset: -
    i. PortScan
    ii. TCP-SYN
    iii. Blackhole

Foreseen challenges with the dataset: -

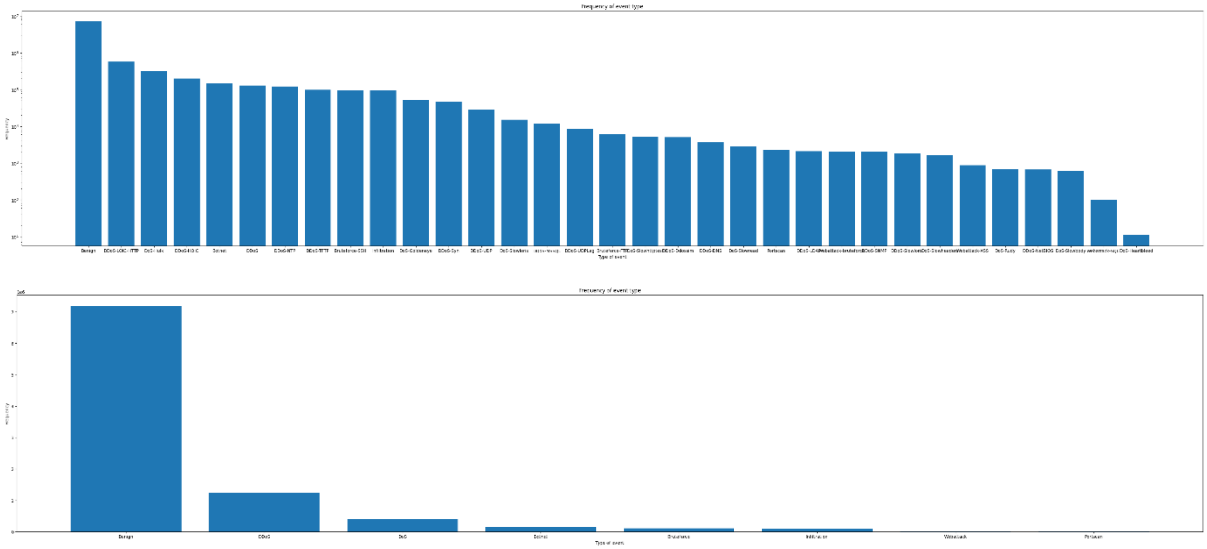
1. Imbalanced nature of target features.
2. High order nominal field: Switch ID.

Cic dataset: -

Sr No	Field Name	Description	Type of field
1	Flow Duration	The duration of the flow.	Scale
2	Total Fwd Packets	Total number of forward packets	Scale
3	Total Backward Packets	Total number of backward packets	Scale
4	Fwd Packets Length Total	Total length of forward packets	Scale
5	Bwd Packets Length Total	Total length of backward packets	Scale
6	Fwd Packet Length Max	Maximum length of forward packets	Scale
7	Fwd Packet Length Mean	Mean length of forward packets	Scale
8	Fwd Packet Length Std	Standard deviation length of forward packets	Scale
9	Bwd Packet Length Max	Maximum length of backward packets	Scale
10	Bwd Packet Length Mean	Mean length of backward packets	Scale
11	Bwd Packet Length Std	Standard deviation length of backward packets	Scale

12	Flow Bytes/s	Flow bytes per second	Scale
13	Flow Packets/s	Flow packets per second	Scale
14	Flow IAT Mean	Mean time between flows	Scale
15	Flow IAT Std	Standard deviation of time between flows	Scale
16	Flow IAT Max	Maximum time between flows	Scale
17	Flow IAT Min	Minimum time between flows	Scale
18	Fwd IAT Total	Total time between forward packets	Scale
19	Fwd IAT Mean	Mean time between forward packets	Scale
20	Fwd IAT Std	Standard deviation of time between forward packets	Scale
21	Fwd IAT Max	Maximum time between forward packets	Scale
22	Fwd IAT Min	Minimum time between forward packets	Scale
23	Bwd IAT Total	Total time between backward packets	Scale
24	Bwd IAT Mean	Mean time between backward packets	Scale
25	Bwd IAT Std	Standard deviation of time between backward packets	Scale
26	Bwd IAT Max	Maximum time between backward packets	Scale
27	Bwd IAT Min	Minimum time between backward packets	Scale
28	Fwd PSH Flags	Forward packets with PUSH flags	Scale
29	Fwd Header Length	Length of header in forward packets	Scale
30	Bwd Header Length	Length of header in backward packets	Scale
31	Fwd Packets/s	Forward packets per second	Scale
32	Bwd Packets/s	Backward packets per second	Scale
33	Packet Length Max	Maximum length of packets	Scale
34	Packet Length Mean	Mean length of packets	Scale
35	Packet Length Std	Standard deviation length of packets	Scale
36	Packet Length Variance	Variance of length of packets	Scale
37	SYN Flag Count	Number of SYN flags	Scale
38	URG Flag Count	Number of URG flags	Scale
39	Avg Packet Size	Average packet size	Scale
40	Avg Fwd Segment Size	Average forward segment size	Scale
41	Avg Bwd Segment Size	Average backward segment size	Scale
42	Subflow Fwd Packets	Subflow forward packets	Scale
43	Subflow Fwd Bytes	Subflow forward bytes	Scale
44	Subflow Bwd Packets	Subflow backward packets	Scale
45	Subflow Bwd Bytes	Subflow backward bytes	Scale
46	Init Fwd Win Bytes	Initial forward window size	Scale
47	Init Bwd Win Bytes	Initial backward window size	Scale
48	Fwd Act Data Packets	Forward packets with actual data	Scale
49	Fwd Seg Size Min	Minimum segment size in forward packets	Scale
50	Active Mean	Mean active time	Scale

51	Active Std	Standard deviation of active time	Scale
52	Active Max	Maximum active time	Scale
53	Active Min	Minimum active time	Scale
54	Idle Mean	Mean idle time	Scale
55	Idle Std	Standard deviation of idle time	Scale
56	Idle Max	Maximum idle time	Scale
57	Idle Min	Minimum idle time	Scale
58	Label	The intrusion type	Target class: Multi-class classification
59	ClassLabel	Subtype of intrusion	Target class: Multi-class classification



Observations from above analysis: -

1. We have high dimensional and large volume dataset.
2. All independent features are of type scale. Thus, we need to normalize them prior training the model.
3. The target features: Label and ClassLabel are highly imbalanced, the greatest number of events are of type Benign.
4. In target feature: Label, there are 7186189 records of type Benign ~ 78% of the total records.
5. Thus, for binary classification, we need to create a new field to differentiate between Benign and Malicious events.

Foreseen challenges with the dataset: -

1. Imbalanced nature of target features.

Selection of dataset: -

We will build the project using **CIC dataset**.

Reason for selection: -

1. All independent features are of type scale. Thus, we can use normalization operation to handle the data.
2. There are no independent features of type: ordinal or nominal, thus, we will not have more than the original number of features to analyse.
3. We will be able to handle high dimensionality of the dataset using optimization approaches during feature selection.