

Fig. 2. Features Correlation in Partial Data Set

II. Deep Learning Training Accuracy and Loss Graphs

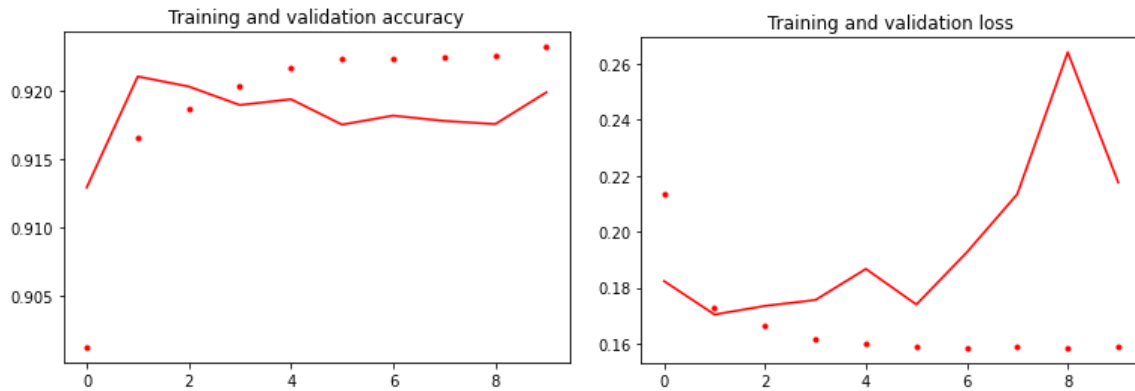


Fig.3. Multi-Layered Feed Forward Neural Network using Partial Data

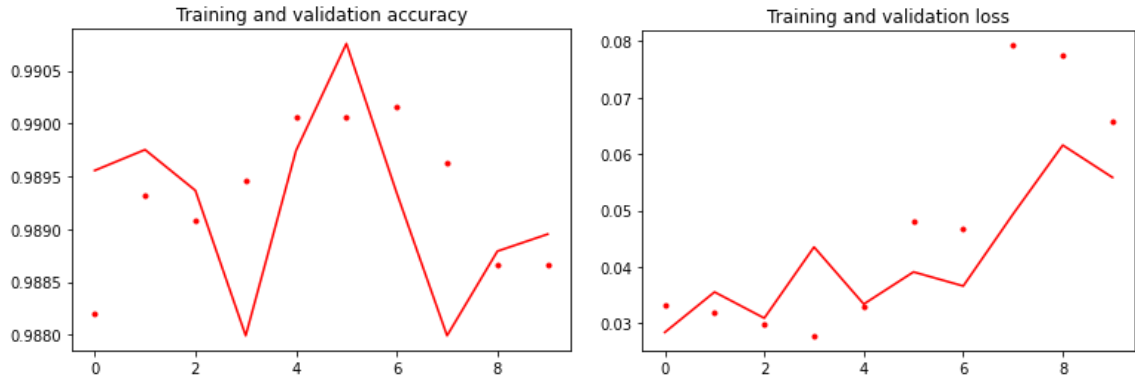


Fig. 4. Multi-Layered Feed Forward Neural Network using Full Data

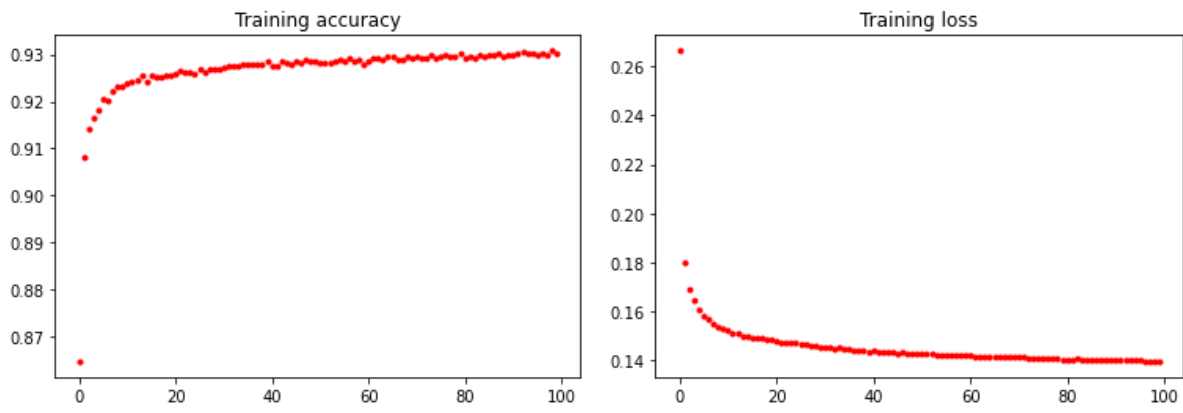


Fig. 5. Deep Autoencoder using Partial Data

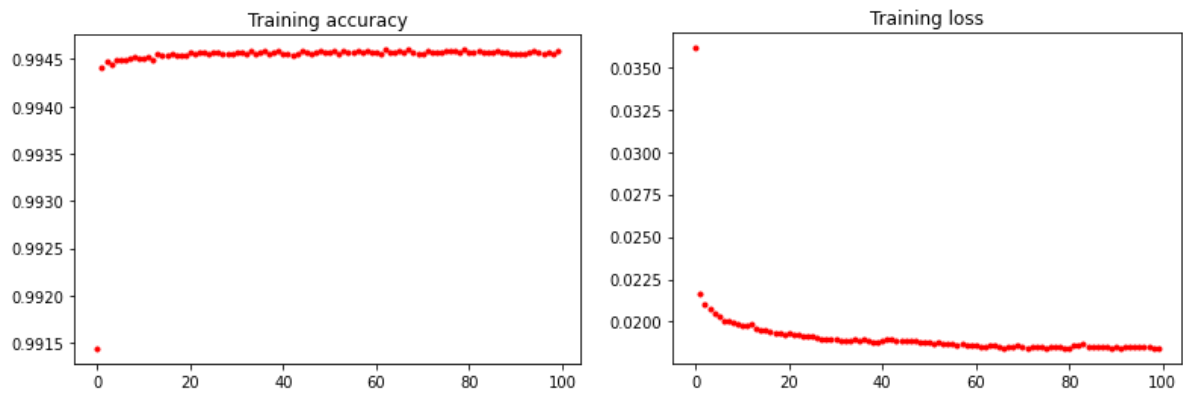


Fig.6. Deep Autoencoder using Full Data

III. Multi-class classification for Machine Learning techniques

TABLE 1. Confusion Matrix for REPTree

Classified as										
a	b	c	d	e	f	g	h	i	j	
751561	158	13	20	630	9	1739	0	4	21	a=Normal
326	13419	206	606	506	3	105	1	6	4	b=Exploits
14	1113	3524	54	8	0	44	0	0	1	c=Reconnais sance
57	4753	39	682	93	0	38	0	4	0	d=DoS
18	914	18	63	72281	0	34	3	2	5	e=Generic
10	13	10	0	462	10	4	0	0	0	f=Shellcode
2921	935	13	73	26	0	4293	0	3	0	g=Fuzzers
1	45	1	0	8	0	0	7	0	0	h=Worms
1	643	0	46	9	0	14	0	69	0	i=Backdoor
149	666	0	42	1	0	9	0	0	33	j=Analysis

TABLE 2. Confusion Matrix for Random Tree

Classified as										
a	b	c	d	e	f	g	h	i	j	
750298	1038	51	51	22	11	2592	0	2	90	a=Normal
324	12148	419	1698	247	5	276	26	21	18	b=Exploits
47	911	3552	170	12	3	54	4	3	2	c=Reconnais sance
62	4172	59	1203	71	1	82	3	8	5	d=DoS
47	791	25	206	72208	2	51	4	0	4	e=Generic
13	465	13	0	3	13	2	0	0	0	f=Shellcode

2676	832	51	159	26	2	4508	1	8	1	g=Fuzzers
0	38	2	1	4	0	0	17	0	0	h=Worms
14	531	2	114	5	0	61	0	55	0	i=Backdoor
92	534	0	127	7	0	61	0	0	79	j=Analysis

IV. Raw Results

Multi-Layered Feed Forward Neural Network - Partial Data

[0.16438362002372742, 0.9221753478050232]

precision recall f1-score support

0 0.91 0.87 0.89 27900

1 0.93 0.95 0.94 49402

accuracy 0.92 77302

macro avg 0.92 0.91 0.91 77302

weighted avg 0.92 0.92 0.92 77302

[[24271 3629]

[2387 47015]]

Training time: 75.95189182501053

Evaluation time: 1.8092629349557683

Prediction time: 1.1350453729974106

Test set shape: (77302, 42)

Multi-Layered Feed Forward Neural Network - Full Data

[0.04428930580615997, 0.9906209111213684]

precision recall f1-score support

0 0.99 1.00 0.99 665629

1 0.97 0.95 0.96 96385

accuracy		0.99		762014
macro avg	0.98	0.97	0.98	762014
weighted avg	0.99	0.99	0.99	762014

[[663179 2450]

[4697 91688]]

Training time: 699.4897618849645

Evaluation time: 16.943989432998933

Prediction time: 11.0986284899991

Test set shape: (762014, 33)

Deep AutoEncoder - Partial Data

[0.14527764916419983, 0.9252232909202576]

	precision	recall	f1-score	support
--	-----------	--------	----------	---------

0	0.91	0.90	0.90	14017
---	------	------	------	-------

1	0.94	0.94	0.94	22933
---	------	------	------	-------

accuracy		0.93		36950
macro avg	0.92	0.92	0.92	36950
weighted avg	0.93	0.93	0.93	36950

[[12566 1451]

[1312 21621]]

AE Training time: 100.89799333899282

FF Training time: 299.74303982098354

Combined Training time: 400.64103315997636

Evaluation time: 1.1435496659833007

Prediction time: 0.6300420350162312

Test set shape: (36950, 42)

Deep AutoEncoder - Full Data

[0.02000698447227478, 0.9946062564849854]

precision recall f1-score support

0 1.00 0.99 0.99 48690

1 0.99 1.00 1.00 80348

accuracy 0.99 129038

macro avg 1.00 0.99 0.99 129038

weighted avg 0.99 0.99 0.99 129038

[[48006 684]

[12 80336]]

AE Training time: 351.4827863779501

FF Training time: 1089.271463925019

Combined Training time: 1440.754250302969

Evaluation time: 2.685133953986224

Prediction time: 1.5305822489899583

Test set shape: (129038, 41)

Decision Tree - J48

Number of Leaves : 194923

Size of the tree : 195936

Time taken to build model: 560.06 seconds

Time taken to test model on training data: 24.83 seconds

=== Error on training data ===

Correctly Classified Instances 2525452 99.4254 %

Incorrectly Classified Instances 14595 0.5746 %

Kappa statistic	0.974
Mean absolute error	0.0087
Root mean squared error	0.0656
Relative absolute error	3.955 %
Root relative squared error	19.7491 %
Total Number of Instances	2540047

=== Detailed Accuracy By Class ===

	TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
	0.997	0.023	0.997	0.997	0.997	0.974	1.000	1.000	0
	0.977	0.003	0.977	0.977	0.977	0.974	1.000	0.997	1
Weighted Avg.	0.994	0.020	0.994	0.994	0.994	0.974	1.000	1.000	

=== Confusion Matrix ===

```

a    b  <-- classified as
2211488  7276 |   a = 0
 7319 313964 |   b = 1

```

Time taken to test model on test split: 5.38 seconds

=== Error on test split ===

Correctly Classified Instances	857750	99.3208 %
Incorrectly Classified Instances	5866	0.6792 %
Kappa statistic	0.9693	
Mean absolute error	0.0097	
Root mean squared error	0.0711	
Relative absolute error	4.3888 %	
Root relative squared error	21.3898 %	
Total Number of Instances	863616	

=== Detailed Accuracy By Class ===

	TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
	0.996	0.026	0.996	0.996	0.996	0.969	0.999	1.000	0
	0.974	0.004	0.972	0.974	0.973	0.969	0.999	0.995	1
Weighted Avg.	0.993	0.023	0.993	0.993	0.993	0.969	0.999	0.999	

=== Confusion Matrix ===

```
a   b <-- classified as
751297 3031 |   a = 0
2835 106453 |   b = 1
```

Decision Tree - REPTree

Size of the tree : 135362

Time taken to build model: 3616.27 seconds

Time taken to test model on training data: 23.44 seconds

=== Error on training data ===

Correctly Classified Instances	2527446	99.5039 %
Incorrectly Classified Instances	12601	0.4961 %
Kappa statistic	0.9774	
Mean absolute error	0.0072	
Root mean squared error	0.0593	
Relative absolute error	3.2706 %	
Root relative squared error	17.8383 %	
Total Number of Instances	2540047	

=== Detailed Accuracy By Class ===

	TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
	0.998	0.025	0.996	0.998	0.997	0.977	1.000	1.000	0
	0.975	0.002	0.986	0.975	0.980	0.977	1.000	0.999	1
Weighted Avg.	0.995	0.022	0.995	0.995	0.995	0.977	1.000	1.000	

=== Confusion Matrix ===

```
a    b  <-- classified as
2214191  4573 |    a = 0
8028  313255 |    b = 1
```

Time taken to test model on test split: 9.43 seconds

=== Error on test split ===

Correctly Classified Instances	857428	99.2835 %
Incorrectly Classified Instances	6188	0.7165 %
Kappa statistic	0.9675	
Mean absolute error	0.0091	
Root mean squared error	0.0713	
Relative absolute error	4.1271 %	
Root relative squared error	21.4319 %	
Total Number of Instances	863616	

=== Detailed Accuracy By Class ===

	TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
	0.996	0.031	0.995	0.996	0.996	0.968	0.999	1.000	0
	0.969	0.004	0.975	0.969	0.972	0.968	0.999	0.996	1

Weighted Avg. 0.993 0.028 0.993 0.993 0.993 0.968 0.999 0.999

=== Confusion Matrix ===

```
a  b <-- classified as
751580 2748 | a = 0
3440 105848 | b = 1
```

Decision Tree - RandomTree

Size of the tree : 3513057

Max depth of tree: 25

Time taken to build model: 593.36 seconds

Time taken to test model on training data: 10.23 seconds

=== Error on training data ===

Correctly Classified Instances	2532739	99.7123 %
Incorrectly Classified Instances	7308	0.2877 %
Kappa statistic	0.9869	
Mean absolute error	0.004	
Root mean squared error	0.0437	
Relative absolute error	1.7906 %	
Root relative squared error	13.149 %	
Total Number of Instances	2540047	

=== Detailed Accuracy By Class ===

TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
0.999	0.015	0.998	0.999	0.998	0.987	1.000	1.000	0
0.985	0.001	0.992	0.985	0.989	0.987	1.000	1.000	1

Weighted Avg. 0.997 0.013 0.997 0.997 0.997 0.987 1.000 1.000

=== Confusion Matrix ===

```
  a   b <-- classified as
2216291 2473 |   a = 0
 4835 316448 |   b = 1
```

Time taken to test model on test split: 3.03 seconds

=== Error on test split ===

Correctly Classified Instances	856927	99.2255 %
Incorrectly Classified Instances	6689	0.7745 %
Kappa statistic	0.9649	
Mean absolute error	0.0085	
Root mean squared error	0.0801	
Relative absolute error	3.8675 %	
Root relative squared error	24.0962 %	
Total Number of Instances	863616	

=== Detailed Accuracy By Class ===

	TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
	0.996	0.032	0.995	0.996	0.996	0.965	0.992	0.998	0
	0.968	0.004	0.970	0.968	0.969	0.965	0.992	0.974	1
Weighted Avg.	0.992	0.028	0.992	0.992	0.992	0.965	0.992	0.995	

=== Confusion Matrix ===

```
  a   b <-- classified as
```

751087 3241 | a = 0
3448 105840 | b = 1

KNN Clustering

=== Run information ===

Scheme: weka.classifiers.lazy.IBk -K 3 -W 0 -A
"weka.core.neighboursearch.LinearNNSearch -A \"weka.core.EuclideanDistance -R first-last\""

Relation:

preparedDataSet-weka.filters.unsupervised.attribute.NumericToNominal-R49-49-weka.filters.unsupervised.attribute.StringToNominal-R2-2-weka.filters.unsupervised.attribute.StringToNominal-R4-4-weka.filters.unsupervised.attribute.Remove-R1-3,7-9,13,16,18,21-23,26,29-36,38-41,43-45,48-weka.filters.unsupervised.attribute.Standardize

Instances: 2540047

Attributes: 20

dsport
proto
state
sttl
dttl
sloss
service
Sload
Spkts
swin
dwin
dmeansz
trans_depth
Sjit
Djit
ct_state_ttl
ct_srv_dst
ct_dst_sport_ltm
ct_dst_src_ltm

Label

Test mode: split 66.0% train, remainder test

=== Classifier model (full training set) ===

IB1 instance-based classifier

using 3 nearest neighbour(s) for classification

Time taken to build model: 0.53 seconds

=== Evaluation on test split ===

Time taken to test model on test split: 608720.48 seconds

=== Summary ===

Correctly Classified Instances	857336	99.2728 %
Incorrectly Classified Instances	6280	0.7272 %
Kappa statistic	0.967	
Mean absolute error	0.0082	
Root mean squared error	0.0727	
Relative absolute error	3.7084 %	
Root relative squared error	21.8589 %	
Total Number of Instances	863616	

=== Detailed Accuracy By Class ===

	TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
	0.996	0.032	0.995	0.996	0.996	0.967	0.996	0.999	0
	0.968	0.004	0.974	0.968	0.971	0.967	0.996	0.989	1
Weighted Avg.	0.993	0.028	0.993	0.993	0.993	0.967	0.996	0.998	

=== Confusion Matrix ===

```

a  b <-- classified as
751525 2803 | a = 0
3477 105811 | b = 1

```

Time taken to test model on test data: 902.88 seconds

=== Error on test data ===

Correctly Classified Instances	5029	100	%
Incorrectly Classified Instances	0	0	%
Kappa statistic	1		
Mean absolute error	0.0002		
Root mean squared error	0.0081		
Total Number of Instances	5029		

=== Detailed Accuracy By Class ===

	TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	0
	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1
Weighted Avg.	1.000	0.000	1.000	1.000	1.000	1.000	1.000	1.000	

=== Confusion Matrix ===

```

a  b <-- classified as
4825  0 | a = 0
0 204 | b = 1

```

Multiclass Deep Learning

[0.10110396891832352, 0.9707748293876648]

/usr/local/lib/python3.6/dist-packages/sklearn/metrics/_classification.py:1272:

UndefinedMetricWarning: Precision and F-score are ill-defined and being set to 0.0 in labels with no predicted samples. Use `zero_division` parameter to control this behavior.

`_warn_prf(average, modifier, msg_start, len(result))`

	precision	recall	f1-score	support
--	-----------	--------	----------	---------

0	0.02	0.82	0.05	803
1	0.00	0.00	0.00	699
2	0.00	0.00	0.00	4906
3	0.70	0.32	0.44	13357
4	0.00	0.00	0.00	7274
5	1.00	0.97	0.99	64644
6	0.99	0.99	0.99	665629
7	0.00	0.00	0.00	4196
8	0.00	0.00	0.00	453
9	0.00	0.00	0.00	53

accuracy			0.96	762014
----------	--	--	------	--------

macro avg	0.27	0.31	0.25	762014
-----------	------	------	------	--------

weighted avg	0.97	0.96	0.96	762014
--------------	------	------	------	--------

```
[[ 657  0  0  82  0  0  64  0  0  0]
 [ 620  0  0  68  0  3  8  0  0  0]
 [ 4086  0  0  742  0  5  73  0  0  0]
 [ 8726  0  0  4333  0  7  291  0  0  0]
 [ 4029  0  0  127  0  6  3112  0  0  0]
 [ 1207  0  0  411  0  62898  128  0  0  0]
 [ 3759  0  0  247  0  2 661621  0  0  0]
 [ 3962  0  0  150  0  6  78  0  0  0]
 [ 407  0  0  0  0  0  46  0  0  0]
 [ 44  0  0  8  0  0  1  0  0  0]]
```

Training time: 567.356115084

Evaluation time: 20.20854228600001

Prediction time: 12.353997421999793

number of predictions: 762014

Multiclass Decision Tree: J48

Number of Leaves : 392875

Size of the tree : 395351

Time taken to build model: 544.71 seconds

Time taken to test model on training data: 65.81 seconds

=== Error on training data ===

Correctly Classified Instances	2498091	98.3483 %
Incorrectly Classified Instances	41955	1.6517 %
Kappa statistic	0.9275	
Mean absolute error	0.0045	
Root mean squared error	0.0466	
Relative absolute error	9.7142 %	
Root relative squared error	30.7449 %	
Total Number of Instances	2540046	

=== Detailed Accuracy By Class ===

TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
0.998	0.027	0.996	0.998	0.997	0.977	1.000	1.000	Normal
0.970	0.011	0.607	0.970	0.747	0.763	0.997	0.833	Exploits
0.700	0.000	0.963	0.700	0.810	0.820	0.998	0.857	Reconnaissance
0.129	0.000	0.857	0.129	0.225	0.332	0.994	0.439	DoS
0.988	0.000	0.998	0.988	0.993	0.992	1.000	0.999	Generic
0.919	0.000	1.000	0.919	0.958	0.958	1.000	0.989	Shellcode

	0.562	0.002	0.770	0.562	0.650	0.655	0.996	0.736	Fuzzers
	0.241	0.000	0.894	0.241	0.380	0.464	0.999	0.323	Worms
	0.122	0.000	0.959	0.122	0.216	0.341	0.994	0.193	Backdoor
	0.114	0.000	0.859	0.114	0.201	0.313	0.994	0.205	Analysis
Weighted Avg.	0.983	0.024	0.986	0.983	0.981	0.965	1.000	0.988	

=== Confusion Matrix ===

a	b	c	d	e	f	g	h	i	j	<-- classified as
2214562	349	76	19	16	0	3720	0	7	14	a = Normal
595	43175	114	261	252	0	116	3	3	6	b = Exploits
61	4063	9787	5	21	0	50	0	0	0	c = Reconnaissance
83	13905	44	2115	143	0	62	0	0	1	d = DoS
46	2433	17	53	212802	0	97	2	2	29	e = Generic
40	41	33	2	0	1388	7	0	0	0	f = Shellcode
7614	2905	82	3	10	0	13632	0	0	0	g = Fuzzers
2	117	4	0	8	0	1	42	0	0	h = Worms
8	2018	6	3	3	0	8	0	283	0	i = Backdoor
279	2081	1	8	0	0	3	0	0	305	j = Analysis

Time taken to test model on test split: 20.64 seconds

=== Error on test split ===

Correctly Classified Instances	846756	98.0477 %
Incorrectly Classified Instances	16860	1.9523 %
Kappa statistic	0.914	
Mean absolute error	0.005	
Root mean squared error	0.0509	
Relative absolute error	11.0021 %	
Root relative squared error	33.6075 %	
Total Number of Instances	863616	

=== Detailed Accuracy By Class ===

	TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
	0.998	0.041	0.994	0.998	0.996	0.967	0.999	1.000	Normal
	0.920	0.012	0.587	0.920	0.717	0.730	0.991	0.772	Exploits
	0.707	0.000	0.933	0.707	0.804	0.811	0.993	0.846	Reconnaissance
	0.097	0.000	0.638	0.097	0.168	0.247	0.987	0.381	DoS
	0.986	0.000	0.996	0.986	0.991	0.990	0.999	0.997	Generic
	0.020	0.000	0.455	0.020	0.038	0.094	0.997	0.158	Shellcode
	0.494	0.002	0.708	0.494	0.582	0.588	0.990	0.657	Fuzzers
	0.177	0.000	0.647	0.177	0.278	0.339	0.900	0.167	Worms
	0.101	0.000	0.898	0.101	0.182	0.301	0.990	0.166	Backdoor
	0.049	0.000	0.564	0.049	0.090	0.166	0.981	0.117	Analysis
Weighted Avg.	0.980	0.036	0.981	0.980	0.978	0.954	0.999	0.985	

=== Confusion Matrix ===

	a	b	c	d	e	f	g	h	i	j	<-- classified as
752349	212	17	45	12	9	1486	0	4	21		a = Normal
584	13970	168	195	184	3	66	3	3	6		b = Exploits
30	1292	3364	10	8	0	53	1	0	0		c = Reconnaissance
50	4937	17	547	86	0	27	0	2	0		d = DoS
7	931	7	45	72296	0	43	2	0	7		e = Generic
467	13	12	0	0	10	7	0	0	0		f = Shellcode
3150	992	16	7	13	0	4086	0	0	0		g = Fuzzers
3	42	3	1	2	0	0	11	0	0		h = Worms
12	682	2	3	2	0	2	0	79	0		i = Backdoor
134	716	0	4	0	0	2	0	0	44		j = Analysis

Multiclass Decision Tree: REPTree

Size of the tree : 136915

Time taken to build model: 4850.94 seconds

Time taken to test model on training data: 37.95 seconds

=== Error on training data ===

Correctly Classified Instances	2498038	98.3462 %
Incorrectly Classified Instances	42008	1.6538 %
Kappa statistic	0.9275	
Mean absolute error	0.0044	
Root mean squared error	0.0464	
Relative absolute error	9.5417 %	
Root relative squared error	30.6604 %	
Total Number of Instances	2540046	

=== Detailed Accuracy By Class ===

TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
0.998	0.026	0.996	0.998	0.997	0.977	1.000	1.000	Normal
0.930	0.010	0.623	0.930	0.746	0.756	0.997	0.855	Exploits
0.768	0.000	0.926	0.768	0.839	0.842	0.999	0.888	Reconnaissance
0.178	0.001	0.559	0.178	0.270	0.313	0.994	0.459	DoS
0.988	0.000	0.997	0.988	0.992	0.992	1.000	0.999	Generic
0.917	0.000	1.000	0.917	0.956	0.957	1.000	0.991	Shellcode
0.589	0.002	0.750	0.589	0.660	0.662	0.996	0.756	Fuzzers
0.190	0.000	0.868	0.190	0.311	0.406	1.000	0.362	Worms
0.109	0.000	0.962	0.109	0.197	0.324	0.994	0.207	Backdoor
0.071	0.000	0.759	0.071	0.129	0.231	0.994	0.183	Analysis
Weighted Avg.	0.983	0.023	0.984	0.983	0.982	0.965	1.000	0.989

=== Confusion Matrix ===

a	b	c	d	e	f	g	h	i	j	<-- classified as
2214021	377	49	26	27	0	4230	0	7	26	a = Normal
612	41386	594	1361	359	0	205	1	1	6	b = Exploits
25	2831	10739	244	15	0	130	3	0	0	c = Reconnaissance
136	12927	103	2911	190	0	82	0	1	3	d = DoS
36	2284	30	183	212829	0	94	1	1	23	e = Generic
34	42	31	1	12	1385	6	0	0	0	f = Shellcode
7028	2681	44	174	27	0	14290	0	0	2	g = Fuzzers
1	124	4	0	10	0	2	33	0	0	h = Worms
5	1885	8	158	2	0	16	0	255	0	i = Backdoor
387	1943	0	147	6	0	5	0	0	189	j = Analysis

Time taken to test model on test split: 10.19 seconds

=== Error on test split ===

Correctly Classified Instances	845879	97.9462 %
Incorrectly Classified Instances	17737	2.0538 %
Kappa statistic	0.9102	
Mean absolute error	0.005	
Root mean squared error	0.0516	
Relative absolute error	10.9582 %	
Root relative squared error	34.0532 %	
Total Number of Instances	863616	

=== Detailed Accuracy By Class ===

TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
0.997	0.032	0.995	0.997	0.996	0.968	0.999	1.000	Normal
0.884	0.011	0.592	0.884	0.709	0.718	0.994	0.808	Exploits
0.741	0.000	0.922	0.741	0.821	0.825	0.993	0.871	Reconnaissance
0.120	0.001	0.430	0.120	0.188	0.225	0.988	0.380	DoS
0.986	0.002	0.976	0.986	0.981	0.979	0.999	0.998	Generic

	0.020	0.000	0.455	0.020	0.038	0.094	0.993	0.137	Shellcode
	0.519	0.002	0.684	0.519	0.590	0.593	0.991	0.656	Fuzzers
	0.113	0.000	0.636	0.113	0.192	0.268	0.942	0.161	Worms
	0.088	0.000	0.784	0.088	0.159	0.263	0.967	0.161	Backdoor
	0.037	0.000	0.516	0.037	0.068	0.137	0.974	0.112	Analysis
Weighted Avg.	0.979	0.028	0.979	0.979	0.977	0.953	0.999	0.986	

=== Confusion Matrix ===

	a	b	c	d	e	f	g	h	i	j	<-- classified as
751561	158	13	20	630	9	1739	0	4	21		a = Normal
326	13419	206	606	506	3	105	1	6	4		b = Exploits
14	1113	3524	54	8	0	44	0	0	1		c = Reconnaissance
57	4753	39	682	93	0	38	0	4	0		d = DoS
18	914	18	63	72281	0	34	3	2	5		e = Generic
10	13	10	0	462	10	4	0	0	0		f = Shellcode
2921	935	13	73	26	0	4293	0	3	0		g = Fuzzers
1	45	1	0	8	0	0	7	0	0		h = Worms
1	643	0	46	9	0	14	0	69	0		i = Backdoor
149	666	0	42	1	0	9	0	0	33		j = Analysis

Multiclass Decision Tree: RandomTree

Size of the tree : 2354821

Max depth of tree: 100

Time taken to build model: 733.61 seconds

Time taken to test model on training data: 14.32 seconds

=== Error on training data ===

Correctly Classified Instances	2514558	98.9966 %
Incorrectly Classified Instances	25488	1.0034 %

Kappa statistic	0.9562
Mean absolute error	0.0025
Root mean squared error	0.035
Relative absolute error	5.4714 %
Root relative squared error	23.1022 %
Total Number of Instances	2540046

=== Detailed Accuracy By Class ===

TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
1.000	0.004	0.999	1.000	1.000	0.996	1.000	1.000	Normal
0.942	0.008	0.691	0.942	0.797	0.803	0.999	0.925	Exploits
0.842	0.000	0.992	0.842	0.911	0.914	0.999	0.923	Reconnaissance
0.401	0.002	0.598	0.401	0.480	0.487	0.997	0.618	DoS
0.991	0.000	1.000	0.991	0.995	0.995	1.000	0.999	Generic
0.985	0.000	0.999	0.985	0.992	0.992	1.000	1.000	Shellcode
0.830	0.000	0.963	0.830	0.892	0.893	0.999	0.951	Fuzzers
0.874	0.000	0.987	0.874	0.927	0.929	1.000	0.985	Worms
0.146	0.000	1.000	0.146	0.254	0.381	0.996	0.260	Backdoor
0.216	0.000	0.995	0.216	0.355	0.464	0.996	0.342	Analysis
Weighted Avg.	0.990	0.004	0.991	0.990	0.989	0.987	1.000	0.994

=== Confusion Matrix ===

a	b	c	d	e	f	g	h	i	j	<-- classified as
2218051	5	11	1	2	0	692	0	0	1	a = Normal
31	41948	13	2491	13	1	27	1	0	0	b = Exploits
7	1814	11777	380	2	0	7	0	0	0	c = Reconnaissance
5	9728	24	6563	11	1	18	1	0	2	d = DoS
5	1539	10	398	213524	0	5	0	0	0	e = Generic
2	2	8	1	7	1489	2	0	0	0	f = Shellcode
1325	2359	21	392	13	0	20136	0	0	0	g = Fuzzers

0	16	0	2	4	0	0	152	0	0		h = Worms
5	1588	3	379	5	0	10	0	339	0		i = Backdoor
2	1684	1	371	33	0	7	0	0	579		j = Analysis

Time taken to test model on test split: 2.72 seconds

=== Error on test split ===

Correctly Classified Instances	844081	97.738 %
Incorrectly Classified Instances	19535	2.262 %
Kappa statistic	0.9018	
Mean absolute error	0.0049	
Root mean squared error	0.0583	
Relative absolute error	10.6394 %	
Root relative squared error	38.4953 %	
Total Number of Instances	863616	

=== Detailed Accuracy By Class ===

	TP Rate	FP Rate	Precision	Recall	F-Measure	MCC	ROC Area	PRC Area	Class
	0.995	0.030	0.996	0.995	0.995	0.963	0.987	0.996	Normal
	0.800	0.011	0.566	0.800	0.663	0.666	0.953	0.691	Exploits
	0.747	0.001	0.851	0.747	0.795	0.796	0.913	0.689	Reconnaissance
	0.212	0.003	0.323	0.212	0.256	0.258	0.935	0.296	DoS
	0.985	0.001	0.995	0.985	0.990	0.989	0.995	0.987	Generic
	0.026	0.000	0.351	0.026	0.048	0.095	0.997	0.150	Shellcode
	0.545	0.004	0.586	0.545	0.565	0.562	0.836	0.413	Fuzzers
	0.274	0.000	0.309	0.274	0.291	0.291	0.684	0.098	Worms
	0.070	0.000	0.567	0.070	0.125	0.199	0.716	0.069	Backdoor
	0.088	0.000	0.397	0.088	0.144	0.186	0.719	0.061	Analysis
Weighted Avg.	0.977	0.026	0.977	0.977	0.977	0.948	0.985	0.976	

=== Confusion Matrix ===

```
  a   b   c   d   e   f   g   h   i   j <-- classified as
750298 1038  51  51  22  11 2592  0  2  90 |  a = Normal
 324 12148 419 1698 247  5 276 26 21 18 |  b = Exploits
 47  911 3552 170 12  3  54  4  3  2 |  c = Reconnaissance
 62 4172  59 1203 71  1  82  3  8  5 |  d = DoS
 47  791  25 206 72208  2  51  4  0  4 |  e = Generic
 13  465  13  0  3  13  2  0  0  0 |  f = Shellcode
2676  832  51 159 26  2 4508  1  8  1 |  g = Fuzzers
 0  38  2  1  4  0  0 17  0  0 |  h = Worms
 14  531  2 114  5  0  61  0 55  0 |  i = Backdoor
 92  534  0 127  7  0  61  0  0 79 |  j = Analysis
```