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ADVANCEMENT IN MACHINE LEARNING FOR INTERNET TRAFFIC

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ABSTRACT

In progressing year's web accept a great work in advancement and correspondence, causes an exponential improvement of data and development over the web. Web action course of action is a to a great degree pervasive instrument against the information area structure. Though such a noteworthy number of systems had been made to capably bunch web action anyway among them machine learning methods are by and large well known. A compact report on various oversaw and unsupervised machine-learning systems associated by various investigators to comprehend web movement arrange has been discussed. This paper in like manner present diverse issues related to machine learning strategies that may help charmed authorities with working future toward this way.

INDEX TERMS: *Internet traffic, Machine Learning, DBSCAN clustering, Neural Network classifier, K-Means based clustering, Naïve Bayes classifier, C4.5 and C5.0*

I. INTRODUCTION

Internet traffic defines as the density of data or information present on the Internet or in another language we can say it's a flow of data on the internet. Internet traffic classification has the power to solve many network difficulties and manage different type of network problems. There are some basic function provided to government, Internet service provider (ISPs) and network administrator through Internet traffic classification. It is for intrusion detection system by finding patterns of denial of service (Dos) and other attacks. Internet traffic used for intrusion detection system by finding patterns of denial of service (Dos) and other attacks. It can also help to ISPs to monitor network traffic flow and troubleshoot the faults and other problems; it can be in "lawful inspection" of the payload of a packet by a government to obtain users information. There are two types of internet traffic classification techniques Port-based and Payload based techniques. There is infinite number of websites in this world of the internet. There may be different ways to classify these websites depending on the motivation for classification. Like one can classify them from academic perspectives, as educational and non-educational websites. Educational websites used for educational purposes that are to acquire knowledge in any educational field. Similarly, non-educational websites used for entertainment and to keep in touch with people and to get to know more people. IEEE and its members inspire a global community through IEEE's highly cited publications, conferences, technology standards, and professional and educational activities. www.sciencedirect.com, according to Wikipedia (January 2012) Science Direct is a leading full-text scientific database

offering journal articles and book chapters from more than 2,500 peer-reviewed journals and more than 11,000 books. There are currently more than 9.5 million articles/chapters, a content base that is growing at a rate of almost 0.5 million additions per year, www.math.com used for solving mathematical problems, www.novelguide.com used for literary analysis, www.sparknotes.com is used for study guides for literature, poetry, history, film and philosophy etc. Non educational websites like www.bittorrent.com, www.yahoomassenger.com and www.movies.com etc. websites used for chatting purposes and for songs, movies and games download etc. also come under the category of non-educational websites.

Social networking or non-educational surfing is a recent invention that has the Internet still at the edge of its seat due to its popularity with people. This is mostly because it really is for the people. Bringing every kind of social group together in one place and letting them interact is really a big thing indeed. Although there are advantages of social websites like Low Costs, Builds Credibility, Connections. However, there are more dominating disadvantages like Lack of Anonymity, Scams and Harassment, Time Consuming.

Internet service providers as well as enterprise networks require the ability of accurately identify the different applications, for a range of uses, including network operations and management, application-specific traffic engineering, capacity planning, resource provisioning, service differentiation and cost reduction. Machine learning algorithms are becoming more and more popular due to the availability of large volumes of data and the advancements in hardware that makes it possible to analyze these data. There are two ways to address this challenge, either by researching on how to find new, clean, sources of energy for the population, or reduce the actual energy consumption of our devices. It focuses on three counterclaims to develop machine-learning algorithms considering energy efficiency:

i) Reducing the energy consumption of machine learning algorithms does not necessarily lead to a reduction of the overall energy consumption.
ii) Time and energy strongly correlated, thus being redundant to measure the energy consumption since time measured.
iii) It is complicated to measure energy consumption, thus making it time-consuming and impractical.

In WSN limited battery power and their exchangeability energy is the key factor that affects the routing. Hence, our focus is on energy efficient routing in WSN, which is the current goal of the researcher to save energy in WSN. Energy Efficient Routing (EER) is essential for increasing the network lifetime in WSN applications. Most of the routing protocols use clusters in order to extend the network lifetime and to provide energy efficiency. In order to design the routing protocol various challenging factors affecting as minimal computational and memory requirement, automaticity and self-organization, energy efficiency, scalability, architecture matching the characteristics of traffic patterns, and support for in-network data aggregation. Machine learning, a field of artificial intelligence, solved search problems using prior knowledge, known experience, and data. Various solutions to this problem under have studied, such as dimensionality reduction, principle component analysis, support vector machines, and function approximation. Reinforcement Learning is a biologically inspired model using Machine Learning technique (ML), in which an intelligent agent can learn useful knowledge through continuous trial-and-error interactions with the external environment. Within a given environment of the particular application domain, an agent does always attempt to take best actions to maximize long-term rewards achieved from the environment. The long-term reward is actually the desired value of the accumulated reward that the agent expects to receive in the future using the policy, which formulated by a value function. The value function often represented by a look-up table that stores values of pairs of states and actions. The dynamic interaction with the environment and the adaptive learning process are two of the great causes that motivate RL technique used for CWSNs, mainly for routing and spectrum decision tasks. In some cases, various solutions based on RL techniques proved to work better than traditional approaches. However, the large-scale random deployment and distributed operation of the sensors makes the task of sharing the spectrum a non-trivial task.

II. INTERNET TRAFFIC CLASSIFICATION

Port Based Technique:

Port based technique most popular and common technique for traffic classification. In this technique, every packet in IP traffic carries port numbers (source port number and destination port number) which assigned by IANA [11]. The applications have registered port number, which is not necessary that all applications have registered port number, some new generation applications like peer to peer (P2P), online gaming type application do not have registered port numbers, these applications uses random port numbers so due to this it is very difficult to classify such type of application using port based technique.

1.2 Payload based Technique:

Payload based technique overcomes the problems of port based technique. It avoids the total dependency on the semantics of port numbers. A deep packet inspection technique (DIP), in this technique they are matching payload of the packets with the well-known signature. In this technique they can setup constrains or rules according to different application types for payload matching. This technique give very good results, it classify approx. 100 % of packets correctly but only when packets are not encrypted. Payload

based technique is very accurate but it have two major drawbacks. First is it cannot deal with encrypted packets because we cannot apply deep packet inspection(DPI) technique in encrypted packets and second one is it have low processing efficiency, it take too much time to classify the packets. There are many of communication devices accessing resources and getting request to carry out their work and there is a lot of information exchanged over the internet, so accurate classification is very essential not only for QOS (Quality of service) and to maintain availability of resources but also processing of information efficiently.

2. Machine Learning Techniques

Looking to the importance of internet, various machine-learning techniques applied to classify internet traffic accurately and efficiently. There are two types of ML techniques, first supervised learning (Classification) and another one is unsupervised Learning (Clustering).

2.1. Supervised Learning Technique:

Supervised learning based on attributes of a class i.e. in this we choose samples based on attributes collected by the whole data. The machine learning provides with a collection of sample instances, pre-classified into classes. The output of the learning process is a classification model that constructed by examining generalizing from providing instances. In classification approaches mainly have two phases (steps), training and testing. Learning phase that examine the provided data (called the training dataset) and constructs (builds) a classification model. In addition, the model that has built in the training phase used to classify new unseen instances, in this paper we discuss the some well-known supervised machine learning techniques and discuss about issues related to different techniques.

2.2. Unsupervised Learning Techniques

Unsupervised learning techniques use the concept of clustering in n contrast, clustering methods, we create clusters of having same features but clustering does not provided with guidance. In clustering, there is no need of the training phase.

III. Application of Machine Learning Approaches for Internet Traffic Classification – Supervised Learning

. Supervised (classification) Methods Supervised techniques as follows:

A. Bayes Net Method

Bayes Net approaches a Belief Network. It is a Probabilistic model, which uses the graph model to represent the set of random variables and their conditional dependencies. Bayes Net uses the concept of directed acyclic graph (DAG) to represent the set, in which each node represent a variable and edges among the nodes represent the relative dependencies between random variables and these relative dependencies in the graph are calculated by well-known statistical and computational methods. There are two phases of Bayes net approach first phase is learning of network structure, in which uses various types of search algorithm like hill climbing, for identify a good network structure and second is estimate probabilistic table for each random variable.

In [2013], Kuldeep singh et al. [19] uses five machine-learning algorithms (MLP, RBF, C4.5, Naïve Bayes, and Bayes Net) to classify real time IP traffic. In this, they prepared dataset by using a packet-capturing tool Wireshark, captured packets for duration of 2 second, prepared datasets, and now they apply feature selection algorithms to eliminate irrelevant features for this they using correlation and consistency based feature selection algorithms for feature reduction. Correlation based FS (feature selection) algorithm is used for identifying and reducing number of features which are redundant and not defining a particular type of traffic of internet and consistency based FS algorithm first compute different number of subsets of features and after that it select the optimal subset of features which contain less number of features. Result reported in this paper show 91% of classification accuracy of Bayes net.

In 2012 S. Agrawal et al. [4] uses three machine learning algorithm (C4.5, Bayes Net and RBF) to classify internet traffic classification They measure the performance on the basis of classification accuracy and training time, and they got that Bayes Net gives the better performance as compared to other two methods C4.5 and RBF. Bayes Net gives 76.67% classification accuracy with training time of 2 seconds.

In 2012 Jaspreet Kaur et al. [3] uses five well-known machine learning algorithms (Naïve Bayes, C4.5, RBF, MLP, Bayes Net) to classify the educational and non-educational websites. In this paper they use two types of data sets for classification, one is a full feature dataset and another one is reduced feature datasets with CFS (Correlation based feature selection) and CON (Consistency based feature selection) feature reduction algorithms. In case of the full feature dataset, the efficiency was decreases due to large number of features and that is why they use reduced feature dataset. In this Bayes Net gives 96.6% classification accuracy with full feature dataset but the number of samples in a dataset is low.

3.1.2. Feed forward Neural Network classifier

The feed forward neural network show in fig.1 was the first and simplest type of artificial neural network methods. In this network, the information moves in only one direction, forward, from the input nodes, through the hidden nodes (if any) and to the output nodes. There are no cycles or loops in the network.

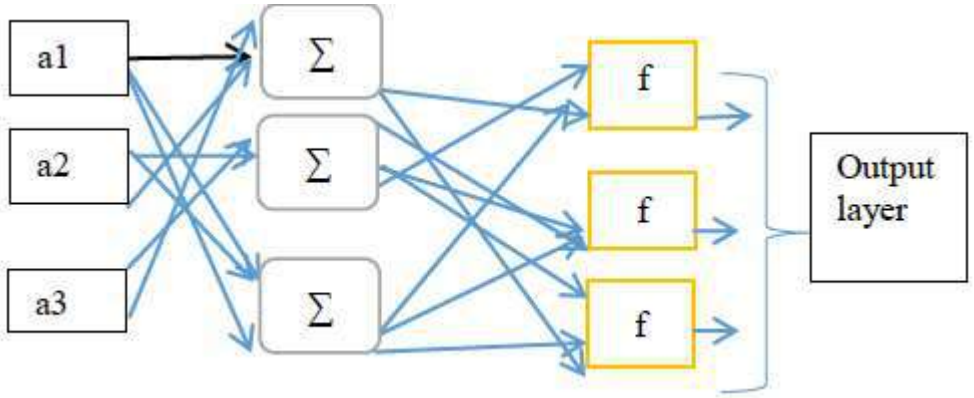


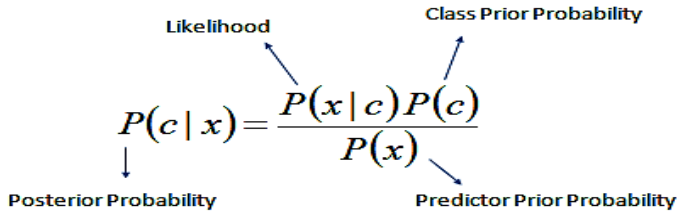
Figure 1: Feed forward Neural Network classifier

Where, Transfer function f is determined by the user
Input = Aj (1 j k)
Weight = Wij (1 i u, 1 j k)
F = transfer function define by user
Output=ji (1 i u)
B bias added = bi (1 i u)
Here transfer function and weight are adjustable according to the output gain.

In 2011 Wengang Zhou et al. [8] proposed an approach based on a feed forward neural network for accurate traffic classification and combined it with FCBF (Fast Correlation Based Feature) feature selection algorithm. FCBF is used for eliminating the redundant features, chosen the valuable features, and feed forward neural network work as classifier. In this Bayesian regularization, technique is used for training and this technique reduces a linear combination of squared errors and squared network parameters to keep safe the model from over-fitting for the datasets. In this paper, proposed method is compared with naïve bayes method and experimented result verifies that the proposed method is more robust and better.

3.1.3. Naive Bayes classifier

A Naive Bayes classifier is a simple classifier based on applying Bayesien theorem with strong and weak independence assumption. In the simplest way a Naive Bayes classifier assumes that the presence or absence of a particular feature of a class has not any relation with the presence or absence of any other features given in the same class variable.



$$P(c \mid X) = P(x_1 \mid c) \times P(x_2 \mid c) \times \cdots \times P(x_n \mid c) \times P(c)$$

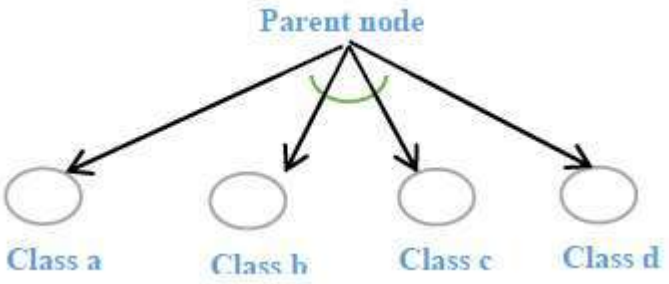


Figure 2: A Naïve-Bayes simple structure

A Naïve-Bays ML algorithm has a simple structure show in Figure.2 in which the class node is the parent node of all other nodes. A basic structure of Naïve Bayes Classifier in which one node class represents main class

and others are like a, b, c and d represents other features or attribute nodes of a particular sample.

In 2011 Kuldeep Singh et al. [22] they use five machine learning algorithm (MLP, RBF, C4.5, Bayes Net, Naïve Bayes) as classifier to classify the real time internet traffic classification along with using different feature selection algorithms which are Correlation based FS, Consistency based FS and Principal Components Analysis based FS algorithms. In this the correlation based FS is used to identify and remove redundant and irrelevant features as possible. It uses an evaluation procedure that examines the usefulness of individual feature along with the level of inter-correlation among the features. The consistency based FS is used to evaluate the subset of features simultaneously and select optimal subset. The Principal Components Analysis (PCA) based FS maps the data points from a high dimensional space to a low dimensional space while keeping all the relevant linear structure unchanged. In this paper C4.5 ML algorithm gives the best result in all above it gives over 90% classification accuracy.

In 2013 Jun Zhang et al. [3] uses classify internet traffic by Aggregating Correlated Naive Bayes Prediction and get high accuracy with this approach. They proposed new (bag-of-flow) BoF-based traffic classification technique is to aggregate the Naive Bayes (NB) predictions of the correlated flow. They proposed a new approach of classification to utilize the information among the correlated traffic flows produced by the traffic. In the approach of classification there are two steps, in a first step the single naïve Bayes predictor generates the posteriori class-conditional probabilities or each flow and in a second step the aggregated predictor aggregates the flow predictions to determine the final class for BoFs.

In 2012 Hamza Awad Hamza Ibrahim et al [5] this paper compared classification accuracy of ten (ZeroR, PART, DecisionStump, J48, J48graft, LADTree, NBTree, Random Forest, RandomTree and REPTree) machine learning algorithm to classifies real time interactive applications such as Online TV and Skype, they capture internet traffic using Wireshark after that select the features from traffic flow like (packet length, packet header etc.) for reducing training time and increase processing efficiency. RandomForest provided the best result as compare to all other algorithms, it gives 99.8% classification accuracy and DecisionStump provide lowest training time is 0.05 seconds but they uses less number of data samples.

3.1.4. C4.5 Decision tree classifier

C4.5 is a popular decision tree Machine Learning algorithm used to develop Univariate decision tree. C4.5 is an enhancement of Iterative Dichotomiser 3 (ID3) algorithm that is used to find simple decision trees. C4.5 is also called a Statistical Classifier because of its good ability of classification. C4.5 makes decision trees from a set of training data samples, with the help of information entropy concept. The training data set contains of a greater number of training samples, which are characterized by different attributes, and it consists of the target class. C4.5 selects a particular attribute of the data at each node of the tree, which is used to split its set of data samples into subsets in one or another class. It is based on the criterion of normalized information gain that is obtained by selecting an attribute for splitting the data. The attribute with the highest normalized information gain is chosen and made a decision. After that, the C4.5 algorithm repeats the same action on the smaller subsets. C4.5 has made various improvements to ID3 like it can handle both continuous attributes and discrete attributes, it can handle training data with missing attribute values, it can also handle attributes with differing costs etc.

In 2012 Dong Shi et al. [6] they used to classify and identify the network with both supervised and unsupervised learning techniques. They use two types of dataset full features based and optimized features based. Here experiment result shows that the supervised ML algorithms give better result with feature reduction algorithms as compare to unsupervised ML algorithms. Simulation result concludes 99% classification accuracy with C4.5 algorithm.

In 2011 LiTing hu et al. [21] presents a machine learning approach for real time internet traffic classification. They use C4.5 decision tree Machine learning algorithm as a classifier and they also used FCBF (Fast Correlation Based Filter) algorithm to reduce the redundant features and increase processing efficiency. Performance matrices used for both i.e. classification accuracy and classification cost (time cost). They use traffic flow statistics for testing, this approach gives us high classification accuracy. Author reported 92.38% classification accuracy with testing time 1412 seconds.

3.1.5. Radial Basis Function Neural Network

Radial basis function (RBF) networks have three layers architecture: an input layer, a hidden layer with a non-linear RBF function it an activation function and a linear output layer. Radial Basis Function (RBF) is a multilayer feed forward artificial neural network, which uses radial basis functions at each hidden layer neuron. The output gain of this RBF neural network is a weighted linear superposition of all these basis functions. The basic model of RBF neural network is shown in Fig.1. In this network, weights for input-hidden layer interconnections are fixed, while the weights for hidden-output layer interconnections are trainable.

In 2013 Mussab M. Hassan et al. [2] uses hybrid statistical traffic classifier to classify the P2P (peer to peer) traffic. Here also the works in two steps, firstly offline heuristics learning corpus generation and second is online statistical classification, In this first part, Heuristic classify the traffic flow and second part machine learning algorithm are used to classify network traffic. They

apply 64 ML algorithms to classify traffic and find that RBF ML algorithms give good result.

3.2. Unsupervised (Clustering) Methods

Clustering is an unsupervised machine learning approach, produces cluster samples according to the similarity of flow feature values. It does not have the training phase like supervised machine learning methods. Clustering focuses on finding patterns in the input data. The main objective of clustering is to group the packets that have similar patterns. In clustering instances having similar properties can be put into the same group.

There are three conditions are made when grouping the packets, which are as follows:

• If group is exclusive then packets can be put into a single group.

• If packets having the properties of multiple groups then packets can be put into many groups. • If the group can be probabilistic then the packet can belong to a group with a fixed probability.

3.2.1 DBSCAN based Approach

DBSCAN (Density-based spatial bunching of uses with commotion) is an information grouping calculation. It is a thickness based bunching calculation; it finds the quantity of groups beginning from the evaluated thickness dispersion of the relating hubs. There are two information parameters here, first is epsilon (Eps) and second is least number of focuses (minPts). Epsilon (Eps) is the space around a specific point question that is utilized to decide its Eps-neighborhood for a given point p and minPts is the base number of focuses inside its eps-neighborhood. The idea of DBSCAN dependent on two parameter thickness reachablity and thickness network, which shaped the bunches in DBSCAN calculation. Thickness reachablity, a point p is thickness reachable from a point q in regard of Eps and minPts if there is an all focuses like p1,p2,p3… … .pn are reachable from point q i.e. p1=q, p2=q… … pn=q is called thickness reachablity. Thickness associated, a point p is thickness associated with a point q if the two points are thickness reachable from a protest point o.

In 2013 Shezad Shaikh et al. [1] they classify network flows using DBSCAN algorithm. In this proposed method, they performed two operations first is clustering and the second is classification. In clustering, the large dataset is divided into small sets of similar data. These small sets are called clusters. They use the available labeled flows to obtain a mapping from the clusters to the different known classes the result. In this method they reported higher percentage of overall classification accuracy

3.2.2. Expectation Maximization based (Autoclass) Approach

It is an iterative method for looking maximizes likelihood parameters and produces clusters. There are mainly two steps in expectation maximization method, first is Expectation step and the second one is Maximization step. In first step estimate that what parameter is using random numbers and in a second step the uses mean and variance to re-estimate the parameter, this process continuously proceeds till then they reached with a local maximize and this process is repeated.

3.2.3. K-Means based Approach

K-Means bunching calculation is a parceled based calculation; it divided objects of a dataset into K disjoint subsets. It augments the homogeneity of the bunch and limits the square-blunder where square-mistake computed as the separation between each question and the inside or mean of a group. The focuses of K group are at first picked haphazardly and after that dataset divided into closest bunch. K-Means iteratively registers new focuses and bunches individually and this procedure proceeds until the point when the groups are settled.

Advantages and Disadvantages of Different types of Approaches

Classification Method	Advantage	Disadvantage
Unsupervised ML techniques		
DBSCAN clustering	handle clusters of different shapes and sizes. Minimal Knowledge requirement to determine input parameter. Work well with large datasets	DBSCAN cannot cluster data sets well with large differences in densities. DBSCAN is not entirely deterministic.
K-Means based clustering	Working process is fast. It is robust and easier to understand.	It does not work well with clusters of Different size and Different density. Difficult to predict K-Value.
Expected Maximization	It is fastest algorithm for learning.	EM algorithm needs to be repeated several times
Supervised ML Techniques		

Naïve bayes classifier	Easy to implement. We are getting good results in most of the cases.	Assumption of class conditional independence. Dependencies among classes cannot be modeled by Naive Bayesian Classifier.
C4.5 and C5.0	• Easy to implement • We Can use it with both values categorical and continuous • It can Deal with noise	• Small variation in data can lead to different decision trees. • Does not work very well on a small training set
RBF	• We use enough number of nodes to find high accuracy. • Simple layer structure.	• Training time is very long and it increases when we increase the numbers of node.
Bayesian Net Classifier	• Implementation is very complicated.	• Processing efficiency is high.

Table 1: Advantages and Disadvantages of Approaches

IV. CONCLUSION

This paper shows upcoming advancement on internet traffic classification based on machine learning techniques. Researcher's works in this area shows the superiority of machine learning techniques over traditional techniques for internet traffic classification. Machine learning overcomes the problems of traditional techniques and also improves its efficiency in this domain. Although many supervised and unsupervised machine-learning techniques had been applied till now, still there is lots of scope to improve the accuracy and processing speed with the increase in the size of dataset.

REFERENCES

1. *Shezad Shaikh1and et al. Implementation of DBSCAN Algorithm for Internet Traffic Classification; International Journal of Computer Science and Information Technology Research (IJCSITR); 2013; p. 25-32.*
2. *Mussab M. Hassan and Muhammad N. Marsono. A Hybrid Heuristics-Statistical Peer-to-peer Traffic Classifier; International conference on computer system and industrial information (ICCSII); 2013; IEEE; p. 1-6.*
3. *Jaspreet Kaur and et al. Internet Traffic Classification for Education Institutions Using Machine Learning; International Journal of Intelligent Systems and Applications (IJISA); 2012; MECS; vol. 4; p. 37-45.*
4. *S. Agrawal and et al. Machine Learning Classifier for Internet Traffic from Academic Perspective; International Conference on Recent Advances and Future Trends in Information Technology (RAFIT); 2012; IJCA; p. 4-9.*
5. *Hamza Awad Hamza and et al. Taxonomy of Machine Learning Algorithms to classify realtime Interactive applications; International Journal of Computer Networks and Wireless Communications (IJCNWC); 2012; IRACST; p. 69-73.*
6. *DONG Shi and et al. The Study of Network Traffic Identification Based on Machine Learning Algorithm; Fourth International Conference on Computational Intelligence and Communication Networks; 2012; IEEE; p. 205-208.*
7. *Bin Hu and Yi Shen. Machine Learning Based Network Traffic Classification: A survey; Journal of Information & Computational Science; 2012; p. 3161- 3170.*
8. *Wengang Zhou and et al. Internet Traffic Classification Using Feed-forward Neural Network; International Conference on Computational Problem-Solving (ICCP); 2011; IEEE; p. 641-646.*
9. *Yu Wang and et al. Internet Traffic Classification Using Machine Learning: A Token-based Approach; Fourteenth International Conference on Computational Science and Engineering (CSE); 2011;IEEE; p. 285-289.*
10. *Murat Soysal and Ece Guran Schmidt. Machine learning algorithms for accurate flow-based network traffic classification: Evaluation and comparison;ELSEVIER; 2010; vol. 67; p. 451-467.*
11. *Abuagla Babiker and et al. Near Real Time Online Flow-based Internet Traffic Classification Using Machine Learning (C4.5); International journal of engineering (IJE); 2009; vol. 3; p. 370-379.*
12. *Yu Liu. A Survey of Machine Learning Based Packet Classification; Symposium on Computational Intelligence for Security and Defense Applications(CISDA),;2009;IEEE.*
13. *Caihong Yang and et al. Internet Traffic Classification Using DBSCAN; WASE International Conference on Information Engineering (ICIE); IEEE; 2009; p.163-166.*
14. *Thuy T.T. Nguyen and Grenville Armitage. A survey of Techniques for Internet traffic classification using Machine Learning; Communications Surveys & Tutorials;IEEE; 2008;vol. 10; p. 56-76.*
15. *Tom Auld and Andrew W. Moore. Bayesian Neural Networks for Internet Traffic Classification; IEEE Transactions on Neural Networks; IEEE; 2007;vol.18; p. 223-239.*

16. *Jeffrey Erman and et al. Internet Traffic Identification using Machine Learning; Global Telecommunications Conference(GLOBECOM);IEEE; 2006; p. 1-6.*
17. *Yibo Xue and et al. Traffic Classification: Issues and Challenges; International conference on computing, networking and communication (ICNC); IEEE, 2013; p. 545-549.*
18. *Jeffrey Erman and et al. Traffic Classification Using Clustering Algorithms; SIGCOMM workshop on Mining network data;ACM 2006; p.281-286.*
19. *Kuldeep Singh and et al. A Near Real-time IP Traffic Classification Using Machine Learning; International Journal of Intelligent Systems and Applications(IJISA); 2013;vol. 5; p 83-93.*
20. *Jun Zhang and et al. Internet Traffic Classification by Aggregating Correlated Naive Bayes Predictions; IEEE transactions on information forensics and security; vol. 8,;2013;p. 5-15.*
21. *LiTing Hu and LiJun Zhang. Real-time Internet Traffic Identification Based on Decision Tree; World Automation Congress (WAC); 2012; IEEE; p. 1-3.*
22. *Kuldeep Singh and S. Agrawal. Performance Evaluation of Five Machine Learning Algorithms and Three Feature Selection Algorithms for IP Traffic Classification; Evolution in Networks and Computer Communication; ; IJCA; 2011; p. 25-32.*
23. *IANA, http://www.iana.org/assignments/port-numbers (as of May 2011).*